WHITEPAPER

Assured Mission Continuity for Group 3–5 ISR UAS in GPS-Denied Airspace

Executive Summary

Persistent airborne intelligence, surveillance, and reconnaissance (ISR) gives the joint force a way to observe, characterize, and monitor activity across wide areas while supporting commanders, targeting organizations, and maneuver forces. U.S. Air Force (USAF) doctrine describes ISR as a continuous, high-demand activity that supports commander decision-making and produces information for operational use. The value of airborne ISR is its ability to collect repeatedly, and provide timely, geographically meaningful information that can support target development, operational decisions, and assessment.

Across Group 3-5 unmanned aerial systems (UAS), that capability ranges from responsive tactical collection to longer-range and persistent surveillance, depending on the platform, payload, endurance, and operating concept. The common value is the ability to place uncrewed sensing capacity where the force needs it. The aircraft and payload are only part of that system. The mission critically depends on trusted position and geolocation so that the force can understand where an observation occurred, maintain the required collection geometry, and recover it safely.

All UAS platforms use GPS as a primary external navigation reference. GPS jamming or spoofing can therefore create more than an aircraft-control problem. A UAS may remain airborne while losing confidence in its position, route, station, sensor geolocation, or recovery margin. Prolonged loss of trusted position can reduce the usefulness of collected information, increase the risk of airspace deviation, and constrain recovery decisions. The impact of GPS denial is not necessarily immediate loss of controlled flight, but rather the progressive erosion of the margins and information quality on which the ISR mission depends.

Why AQNAV

SandboxAQ developed AQNav to solve this critical gap. AQNav is a software-first, fully passive Magnetic Navigation (MagNav) system that provides GPS-independent positioning by matching real-time magnetic measurements against Earth's natural crustal magnetic signature – an immutable frame of reference.

GPS jamming overwhelms satellite signals with noise, alerting the crew to switch modes. GPS spoofing mimics the signal to feed the receiver a false position without triggering that alert and, like jamming, it is executable from standoff range. AQNav does not remove this threat outright: jamming or spoofing can still force a GPS-primary platform to revert to unaided inertial navigation with unbounded drift. Instead, with AQNav, the aircraft gains a continuously available, physics-anchored absolute position reference, AQNav shields the platform against the worst effects of GPS denial.

Spoofing AQNav's reference would require an adversary to place a powerful magnet within meters of the platform's magnetometer sensors, a far more difficult attack to mount than standoff GPS denial, with a fundamentally different threat profile. MagNav still depends on a trusted, high-integrity positioning source, and that trust can break down two ways: (1) residual platform or environmental magnetic interference, or (2) a stale or low-fidelity magnetic reference map. Neither is an adversary attack; both are data-quality and data-integrity problems. AQNav accomplishes this through physics-based AI models, sensor fusion, and real-time integrity monitoring. This combination is what makes AQNav a trusted, assured Positioning and Navigation (PN) source, built on open architecture to integrate with third-party hardware where required.

Three Value Propositions for Group 3-5 ISR UAS:

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Hold the ISR Orbit When GPS Goes Dark: Group 3-5 ISR UAS can remain airborne yet lose mission effect if degraded positioning, navigation and timing (PNT) causes route or station drift. AQNav adds an independent magnetic reference that can be evaluated and fused with INS to preserve collection during prolonged GPS degradation.

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Get the Aircraft Home When the Primary PNT Source Fails: GPS loss far from base can reduce recovery margin even when the aircraft remains controllable. AQNav runs as a complementary source, available for navigation-integrity logic to assess when GPS becomes unavailable or untrusted. AQNav bounds inertial error during return-to-base.

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Know When GPS Is Lying Before the Sensor Picture Moves: Spoofing can provide plausible but false position information and corrupt sensor geolocation. AQNav provides an independent reference that can be compared against to detect spoofing.

Architecture

Software-first Integration

AQNav operates within an Open Container Initiative (OCI)-compliant Docker container hosted directly on existing platform compute. Requiring zero additional compute hardware, AQNav ingests data from existing platform magnetometers and IMUs, applies proprietary AI/ML electromagnetic interference (EMI) removal, and outputs continuous Position, Velocity, and Attitude (PVA) solutions via open-architecture protocols.

How AQNav Works: Physics + AI

AQNav processes raw sensor data through a streamlined three-stage pipeline:

Sense → Denoise → Estimate

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Sense: Onboard magnetometers capture and Ingest raw magnetic data from the surrounding environment.

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Denoise: A physics-informed AI stack removes platform EMI (which can exceed the crustal field signal by >1,000x) and solar/ionospheric EMI using integrated space-weather modules.

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Estimate: Fuses the clean crustal field magnetic signal and onboard magnetic reference maps with inertial data to output continuous PVA along with real-time covariance and integrity bounds.

CONOPS: Group 5 ISR UAS Mission

Strategic Context & Core Capability

A representative Group 5 ISR UAS launches from a forward operating location, transits to a maritime surveillance area, maintains the sensor geometry required for collection, accepts approved retasking, and returns to base. The mission depends on trusted position for route management, orbit control, sensor geolocation, and recovery.
AQNav runs in the background as a complementary magnetic navigation reference alongside the aircraft's existing navigation and mission systems. When GPS becomes unavailable or untrusted, the platform can evaluate AQNav against its integrity requirements and, when valid, use it to help maintain position confidence.

Scheme of Maneuver (Operational Execution)

Execution spans five operational phases:

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Phase I (Pre-Flight): Theater magnetic reference maps are loaded alongside standard mission planning products.

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Phase II (Mission Start): AQNav runs continuously in the background as a backup absolute reference navigation source upon takeoff.

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Phase III (Contested Transit): Upon entering degraded corridors, AQNav's integrity engine compares all navigation sources and confirms the loss of GPS integrity. AQNav automatically shifts flight management to AQNav-aided INS, maintaining route accuracy without dependence on any external infrastructure (e.g., satellites, beacons, or VOR/TACAN) or signals that can be jammed, spoofed or denied.

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Phase IV (Preserve the ISR Mission): AQNav continuously provides an independent position reference that can be compared with the primary navigation solution during operations. AQNav ensures the platform maintains the position confidence needed for collection geometry, track maintenance and sensor geolocation while GPS remains unavailable or untrusted.

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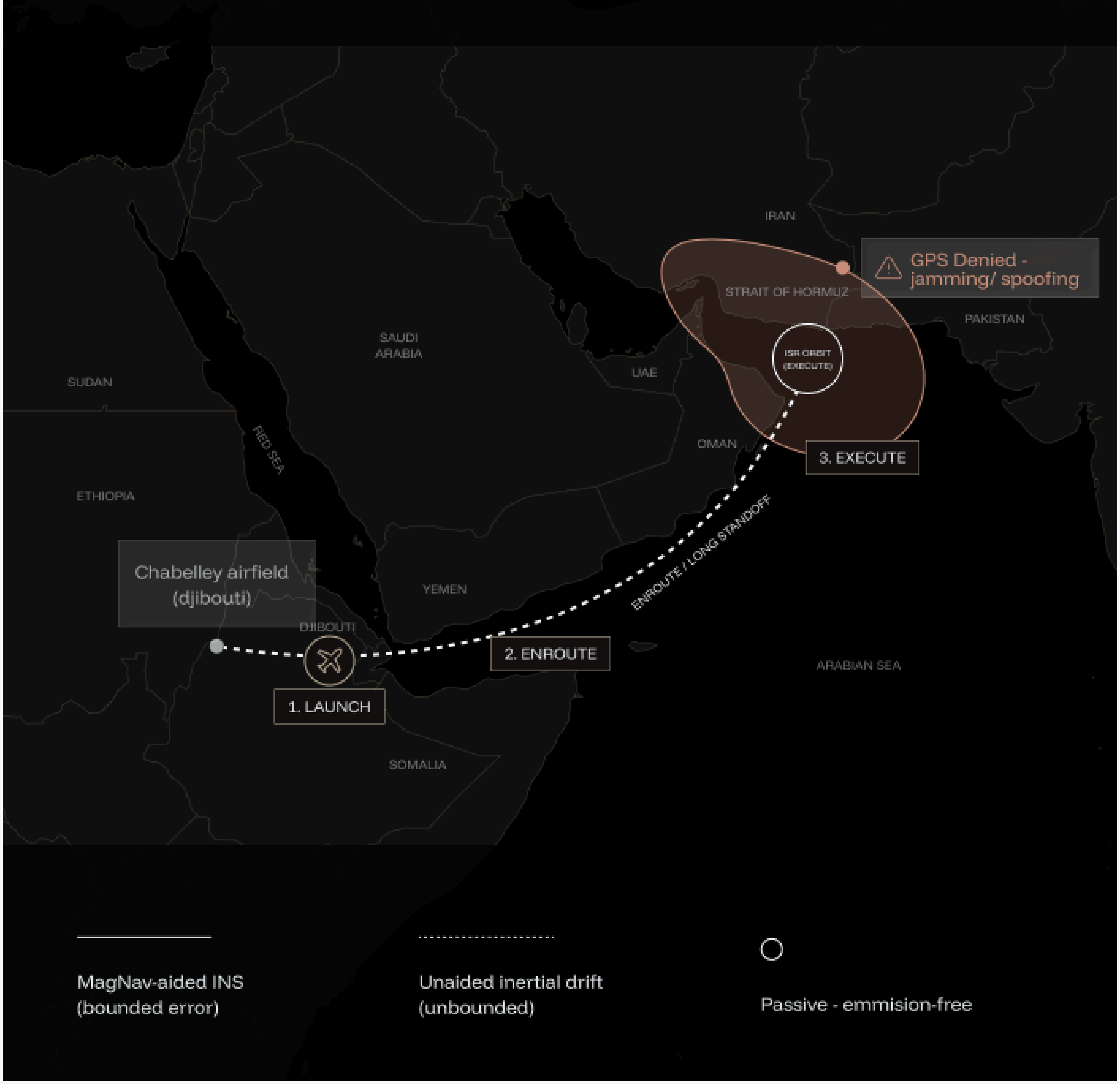
Phase V (Return to Base): AQNav continues to provide independent position references throughout the return leg, supporting approaches into main operating bases or austere Agile Combat Employment (ACE) airfields without ground or satellite navigation aids.

Desired End State

A representative Group 5 ISR UAS preserves useful collection geometry, geospatial confidence, and recovery decision margin through a defined GPS-degraded condition by evaluating an additional, integrity-monitored navigation reference within its approved architecture.

Figure 1: Group 5 ISR GPS-denied CONOPS



Technical Specification and Adoption Pathway

Specification	Detail
Performance	Best Accuracy: 74 m Average Representation: ~0.5 nm (~925 m)
Sensor-agnostic	Magnetometers: scalar and vector types. IMU/INS: MEMS, tactical, and navigation grades.
Software Interfaces	ASPN-I, MavLink, and Onboard API for third-party interfaces
Physical Interfaces	MIL-STD-1553, ARINC-429, RS-232/422/485, Ethernet, USB
Compute	CPU: 1 CPU core (depending on configuration) RAM: < 2 GB Latency: < 10ms
Output Solution	Continuous PVA; position plus bounded-uncertainty estimate (covariance / 1-sigma)
Output Destinations	Mission Computer, Flight Management System, Electronic Flight Bag
Architecture (MOSA)	AQNav is built to the Modular Open Systems Approach (MOSA) that DoD acquisition policy increasingly requires: it integrates through open, published interfaces rather than a proprietary stack, adapts to whatever hardware and API the platform already has, and does not replace or lock out the existing navigation architecture.
Integrity	Per-fix covariance / 1-sigma, integrity monitoring with protection levels, fault detection and exclusion, graceful degradation

AQNav

Integrate AQNav into your navigation stack.

www.sandboxaq.com/solutions/aqnav