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Autonomous Navigation Solutions

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**WHITE PAPER**

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# When GNSS Heading Isn't Enough

## Why Adding the IMX-6 Upgrades a GNSS Compass into a Continuous, Full-Attitude Heading Reference

*A dual-antenna GNSS compass can look sufficient on a clear-sky spec sheet. This paper explains where GNSS heading alone falls short — in dynamics, obstructions, vibration, tight antenna baselines, and roll — and how adding the IMX-6 inertial solution fundamentally improves the heading you can actually rely on.*

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## Executive Summary

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Many teams evaluating a heading source look at a dual-antenna GNSS compass, see a tenth-of-a-degree number quoted under open sky, and conclude that an IMU is unnecessary. That conclusion is correct only for the exact conditions of the benchmark: a clear view of the sky, low dynamics, a generous antenna baseline, and no need for roll. Real deployments rarely stay there.

A GNSS compass is an excellent absolute heading reference when it has an unobstructed sky and time to average. But it updates slowly, arrives with latency, drops out the instant the sky is blocked, ties its accuracy to the physical distance between its antennas, and cannot fully observe roll. Each of these is a structural limitation, not a tuning problem — no firmware setting removes them.

Adding the **IMX-6** is not merely a backup. Its tactical-grade IMU supplies heading at up to 1000 Hz, carries it continuously through GNSS outages, delivers full three-axis attitude, and achieves 0.09° dynamic heading without depending on baseline length. Fused with the GNSS compass, the result is a heading solution that is simultaneously accurate, continuous, high-rate, and complete. The sections below make that case dimension by dimension.

### 1. How a GNSS Compass Produces Heading

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A GNSS compass derives heading from two antennas separated by a fixed baseline. By comparing the carrier-phase measurements at each antenna, the receiver solves for the vector between them, which yields heading and pitch. Unlike a single-antenna receiver — which can only infer course-over-ground while the platform is moving fast enough, and reports the direction of travel rather than the direction the platform is pointed — a dual-antenna compass produces a true heading even at a standstill.

Under open sky, with a long baseline and a moment to settle, a GNSS compass is genuinely accurate. That is not in dispute. The relevant question for a real platform is what happens outside those conditions — because for most platforms, those conditions describe the easiest part of the mission, not the whole of it.

### 2. Where GNSS Heading Alone Runs Into Trouble

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#### Update rate and latency

A GNSS compass typically outputs heading between 1 and 20 times per second, and that solution arrives after the measurement instant. A platform that rotates quickly — a gimbal, a pan-tilt antenna, an agile vehicle — is mis-pointed between updates and throughout the latency window. The faster the dynamics, the larger the error the rate and latency introduce.

#### It disappears when the sky is obstructed

Dual-antenna heading requires both antennas to track enough satellites simultaneously. Urban canyons, foliage, tunnels, bridges, nearby structures, and covered or indoor operation all break that condition — and the heading solution vanishes precisely in the environments where a vehicle most needs to know where it is pointed. There is no graceful degradation: the output simply stops.

### Accuracy is hostage to your antenna baseline

GNSS heading error scales inversely with the distance between the antennas. As a rule of thumb, roughly a centimeter of relative antenna-position error over a one-meter baseline corresponds to about half a degree of heading error; halve the baseline and you double the error. Compact platforms that cannot accommodate a long baseline pay for it directly in heading accuracy — a geometry constraint no amount of signal quality can overcome.

### Multipath corrupts the estimate

Reflections from surfaces near roof-mounted antennas bias the carrier-phase measurements and therefore the heading. The resulting error depends on the surroundings, varies as the platform moves, and is difficult to predict or calibrate away.

### Roll is not observable

A single antenna baseline yields heading and pitch, but rotation about the baseline axis — roll — is unobservable from two antennas alone. Any platform that stabilizes a payload, points an antenna or camera, or compensates for vehicle motion needs all three attitude axes, and a GNSS compass can supply only two of them.

### Interference and spoofing

Heading derived purely from GNSS can be denied by jamming or falsified by spoofing, with no independent source to maintain continuity or flag the discrepancy.

## 3. What the IMX-6 Inertial Solution Adds

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An IMU measures rotation directly. A tactical-grade gyroscope knows how fast and in which direction the platform is turning — instantly, continuously, and with no dependence on the sky. Fused with a GNSS compass, it converts a good-but-fragile absolute reference into a robust and complete one.

- **High-rate, low-latency heading.** Up to 1000 Hz IMU and 500 Hz INS output, so heading tracks fast rotation with no perceptible lag.
- **Continuity through outages.** The gyro carries heading through tunnels, canyons, and foliage, and the GNSS compass re-bounds it on reacquisition. Heading never disappears.
- **Full three-axis attitude.** Roll, pitch, and heading together — the complete orientation that pointing and stabilization require.
- **Baseline-independent accuracy.** The IMX-6 delivers 0.09° dynamic heading without needing a long antenna separation, freeing the mechanical design.

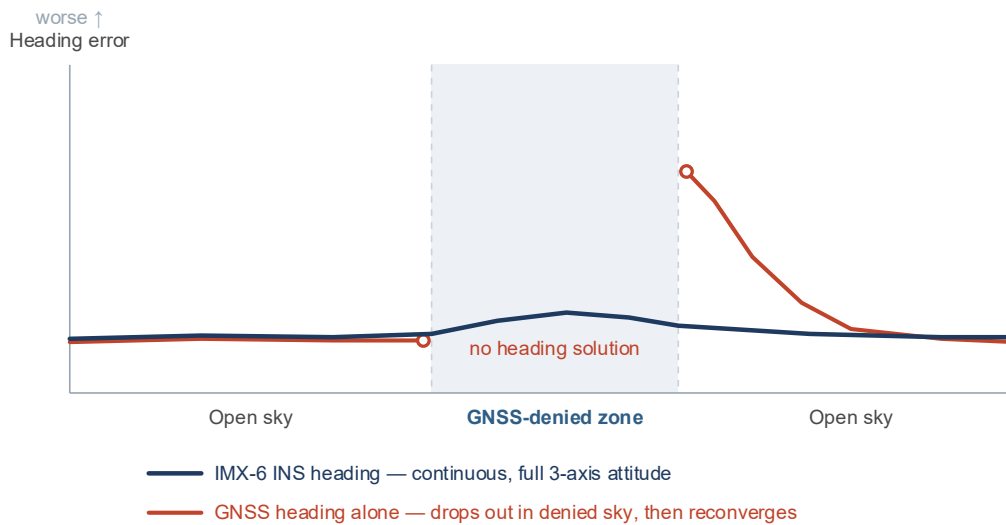
- **Noise and multipath rejection.** The inertial solution smooths momentary GNSS errors and multipath glitches instead of passing them straight to the controller.
- **Independent resilience.** Inertial heading continues through jamming or spoofing of the GNSS signal, providing an independent check.

The relationship is complementary, not redundant. The GNSS compass supplies the absolute north reference that bounds long-term gyro drift; the gyro supplies the rate, continuity, and full attitude that GNSS cannot. Neither alone is as good as the two fused — which is exactly what the IMX-6 does onboard.

## 4. The Comparison at a Glance

The table below summarizes how a stand-alone GNSS compass and an IMX-6 inertial solution differ across the dimensions that decide whether a heading source holds up in the field.

Dimension	GNSS heading alone	IMX-6 inertial solution
<b>Update rate</b>	~1–20 Hz	500 Hz INS · 1000 Hz IMU
<b>Latency</b>	Solution arrives late	Effectively instantaneous
<b>Obstructed or denied sky</b>	Heading drops out	Coasts on inertial — continuous
<b>Accuracy vs. geometry</b>	Tied to antenna baseline	0.09° dynamic, baseline-independent
<b>Compact / short baseline</b>	Degrades to ~0.5–1° or worse	Holds 0.09° dynamic heading
<b>Attitude provided</b>	Heading + pitch (roll unobservable)	Full roll, pitch, heading
<b>Multipath</b>	Biases the heading estimate	Rejected and bridged inertially
<b>Jamming / spoofing</b>	Vulnerable, no continuity	Independent inertial continuity



**Figure 1.** Conceptual heading error across a route. GNSS heading alone drops out in the denied zone and overshoots on reacquisition; the IMX-6 inertial heading stays continuous with small, bounded error.

## 5. “But My Baseline Is Long and My Sky Is Clear”

It is worth meeting the strongest version of the objection head-on. Suppose the platform really does have a generous antenna baseline and operates under open sky. Three things are still true.

- **The easy case is still incomplete.** Even under a perfect sky, a GNSS compass is still low-rate and latent, still provides no roll, and still ties its accuracy to antenna geometry. The IMU resolves all three regardless of sky conditions.
- **The easy case rarely lasts.** Vehicles pass under structures, vessels heel and pitch, drones vibrate, and antennas get shadowed by their own payloads. The IMU is what makes heading dependable across the entire mission rather than only its open stretches.
- **The IMU can shrink your baseline.** Because inertial heading is not bound by antenna separation, you can specify a shorter baseline — saving space, weight, and cost — and still improve heading accuracy. The IMU buys back mechanical freedom.

In other words, the IMU helps even when GNSS heading is at its best, and it helps most when GNSS heading is at its worst. There is no operating point at which it does not improve the result.

## 6. The IMX-6 Advantage

The IMX-6 is built to deliver this fused heading in a single, easy-to-integrate module.

- **Tactical-grade IMU.** 1.3 °/hr gyro bias instability and 0.11 °/√hr ARW. This low drift is precisely what lets the module hold heading accurately through a GNSS outage.

- **Full-attitude performance.** 0.09° dynamic heading and 0.03° dynamic roll/pitch, at 1000 Hz IMU and 500 Hz INS output rates.
- **Compass plus inertial, integrated.** The IMX-6 accepts dual-antenna GNSS for compass heading and fuses it with the IMU onboard, so the absolute reference and the inertial continuity arrive together from one device.
- **Drop-in integration.** Reflow-compatible and pin-compatible with the IMX-5, with an open SDK and rugged RUG-4 enclosure options offering RS-232, RS-485, CAN, and RTK.

## 7. Conclusion

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A GNSS compass answers “which way am I pointed” slowly, intermittently, in two axes, and only under open sky. Adding the IMX-6 answers the same question continuously, at high rate, in all three axes, and everywhere the platform actually goes. For anything that points, stabilizes, or maneuvers, that is the difference between a heading that works in the demonstration and a heading that works in the field.

**Evaluating a heading source for your platform? Contact Inertial Sense — a Hexagon company — to request the IMX-6 datasheet, an evaluation kit, or an integration consultation at [www.inertialsense.com](http://www.inertialsense.com).**