From left to right, U.S. Air Force Airman 1st Class Sanjay Budhathoki, Staff Sgt. Brandon Schoenborn, and Airman 1st Class Yuxin Chen, all assigned to the 4th Civil Engineer Squadron engineering section, stand with their Global Positioning System (GPS) equipment after completing a training survey at Seymour Johnson Air Force Base, North Carolina, Aug. 14, 2024. Airmen assigned to the 4th CES GeoBase section are vital in delivering trusted geospatial engineering data, maps, and services to build, maintain and recover power projection platforms. *(U.S. Air Force photo by Tech. Sgt. Christopher Hubenthal)*

From Tech to Tactics

Integrating the Multi-Source Positioning (Part 3 of 3)

By Lieutenant Colonel David Paddock, Captain Bradley Warren, and Dr. Bhiksha Ramakrishnan

The final article in this series shifts focus from technical solutions to strategic and tactical implementation. It analyzes the operational trade-offs of these new navigation systems, makes the case for why the Engineer Regiment must lead this transformation, and outlines the imperatives required to create a force where using GPS is a choice, not a dependency.

Trading Risks

The promise of an artificial intelligence (AI)-enabled path integration model lies in its ability to provide resilient navigation in a degraded or denied Global Positioning System (GPS) environment. However, the system is not without tactical costs. Chief among these is the risk of increased electromagnetic (EM) signature. Any distributed mesh that requires data exchange—whether for error correction, confidence weighting, or real-time imagery updates—creates emissions that an adversary can detect, intercept, or exploit. Even low-power burst transmissions can compromise force concealment when operating against a near-peer adversary with robust electronic warfare (EW) capabilities. The very resilience gained from cooperative data fusion could inadvertently expose maneuver elements to targeting, creating a trade-off between positional certainty and survivability.

Another challenge emerges in featureless or rapidly changing environments. Terrain association depends on stable, identifiable features that can be matched against stored imagery or models. In deserts, oceans, or polar regions, where distinctive landmarks are sparse, AI-driven models may struggle to achieve reliable matches.

Strength	Limitations
Highly reliable against jamming, spoofing, or constellation degradation.	EM signature risk is increased during mesh communication in high-EW environments.
Passive operation allows for navigation without emitting detectable signals.	Featureless or dynamic terrain, such as deserts or snowfields, reduces terrain-association reliability.
Scalability using inexpensive sensors compatible with existing platforms.	Potential for adversary deception through multispectral obscurants or altered terrain features.
Compatibility with autonomous systems and AI-driven decision aids.	Significant training and calibration burden for units integrating diverse sensor packages.

Similarly, environments characterized by frequent change, such as seasonal vegetation shifts, snow cover, or even large-scale construction, can degrade confidence in terrain correlation. In these conditions, reliance on AI may create a false sense of certainty, leading the system to produce a "best fit" that appears authoritative but is, in fact, misleading.

Compounding this risk is the possibility of adversary deception. Just as camouflage and decoys have been used to defeat visual reconnaissance for centuries, modern adversaries could alter terrain signatures through multispectral obscurants or artificial structures designed to confuse automated systems. In featureless areas, even minor alterations could create significant positional drift when compounded across a formation. Thus, while AI may extend the life of path integration models beyond their traditional limits, it can also introduce new vulnerabilities if commanders overestimate the system's reliability in austere environments.

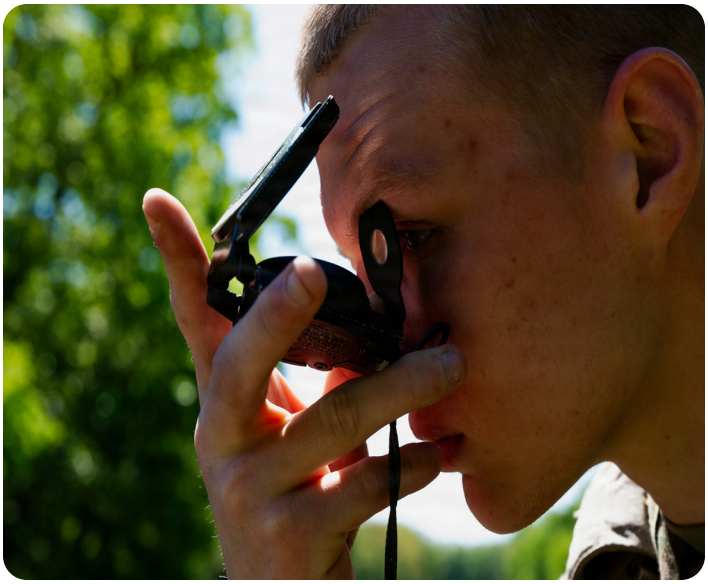
Strengths and Limitations of AI-Enabled Navigation in DDIL Environment

Ultimately, the trade-off is clear: an AI-enabled navigation mesh can buy freedom of maneuver when GPS is degraded, but it may do so at the expense of EM discipline and positional accuracy in precisely the environments where redundancy is most needed. Effective doctrine would require commanders to balance the benefits of a shared navigation picture with the risks of detectability, while also maintaining low-tech alternatives like compass work, celestial fixes, and disciplined dead reckoning as a hedge against the limits of even the most advanced systems.

Why This Matters for the Engineer Regiment

Engineers are doctrinally charged with enabling freedom of maneuver, and in a degraded, denied, intermittent, or limited (DDIL) future, assured navigation becomes inseparable from assured mobility. The same branch that clears obstacles, constructs bridges, and shapes terrain must now also ensure that formations can orient and synchronize when GPS is degraded or denied. As geospatial imagery and terrain data become the foundation of AI-enabled navigation, the Engineer Regiment emerges as the custodian of both the physical and digital terrains—the keeper of the keys for integrating AI into assured positioning and movement.

Meeting this responsibility requires deliberate action across the Doctrine, Organization, Training, Materiel, Leadership and education, Personnel, Facilities, and Policy (DOTMLPF-P) spectrum. Doctrine



A defender assigned to the 509th Security Forces Squadron conducts land navigation training using a lensatic compass at Whiteman Air Force Base, Missouri, May 1, 2026. The training was conducted to enhance Airmen's ability to navigate and survive in environments where electronic GPS systems may be unavailable or compromised.
(U.S. Air Force photo by Senior Airman Bryce Moore)

must embed DDIL navigation within core engineer tasks for mobility, counter-mobility, and survivability. Organizational structures will need to determine how DDIL capabilities are nested within brigade and division engineer elements. Training pipelines must reinforce the importance of DDIL navigation, inertial systems, and terrain-association procedures in engineer reconnaissance team operations and mission planning. Materiel efforts should prioritize the acquisition of flexible architecture capable of integrating a variety of lightweight sensor suites, including Simultaneous Localization and Mapping (SLAM)-ready sensors. Leadership development and professional education must prepare engineers to assess terrain signatures, evaluate sensor fidelity, and advise commanders on positional confidence. Personnel policies should ensure that Soldiers possess the technical literacy needed to employ and sustain AI-enabled systems. Facilities, especially the National Training Center, must be updated to simulate realistic DDIL environments for both individual and collective training and be able to support the Army's efforts to stress and evaluate both emergent and fielded systems through iterative experimentation.

A Choice to Use GPS

The U.S. military has operated in a highly permissive space domain for over six decades. The GPS constellation requires maintenance and protection, and jamming has long been a concern. Unfortunately, the security of the GPS service has never been as at risk as it is today. Developing, fielding, and employing alternative positional models provides commanders additional decision space, including the option to intentionally degrade the constellation.

The concept is not novel—from the time President Reagan released GPS (then Navistar) for civilian use in 1983 until 2000, the positional accuracy of the system was intentionally degraded. Military GPS receivers at the time were designed to unmask the signals to derive a more accurate location than civilian receivers.

Today, the constellation supports far more than military operations. An adversary attack against the GPS service would hinder not only our ability to prosecute conflict, but also its use in the homeland—not just during the conflict, but for decades afterward, depending on debris density and orbital altitude—and would complicate efforts to rebuild the constellation. Tools would depreciate the value of such an attack. They would enable commanders to disable the constellation to prevent enemy employment and to selectively employ the system to synchronize AI-supported models or to support a high-value operation, increasing the likelihood that the system will be available to support commercial development and reconstruction following hostilities.

The primary benefits of developing an alternative means of navigation are the additional options it provides commanders: the decision to choose which navigational model to use, the decision to degrade

Airmen from the 139th Civil Engineer Squadron navigate through terrain during Exercise Northern Strike 26-2 at Alpena Combat Readiness Training Center, Michigan, August 5, 2026. During the exercise, Airmen trained in a contested, multi-domain environment designed to simulate the complex challenges of a military conflict. (U.S. Air National Guard photo by Senior Airman Samuel Al-Nimri)

one model or the other, and the ability to change decisions as competition—or conflict—matures and evolves. Without a sufficient demand signal from senior leadership in the Department of War, industry will continue improving existing technology instead of developing parallel technologies that could enable commanders to generate dilemmas for our adversaries and depreciate the value of an attack on the positioning, navigation, and timing (PNT) system that supports so much of our commercial and industrial base.

The Way Ahead

The Army has entered a chapter in which the freedom of maneuver once guaranteed by GPS is no longer assured. Emerging AI-enabled navigation tools like SLAM, inertial correction models, multispectral terrain association, and distributed sensor meshes offer viable pathways for the future force. The Engineer Regiment must lead the integration, testing, and employment of these systems in large-scale combat operations. By embracing these technologies now, the Regiment ensures that commanders retain the initiative when GPS is denied, degraded, or destroyed. Key to that effort is the development of defined capability requirements that will enable funding for research and product development both by industry and through efforts at the Army AI Integration Center across standard research, development, test, and evaluation funding lines. This would better prepare efforts to transition capability solutions to programs of record.

The future battlefield will challenge every assumption about how we move, fight, and survive. Engineers must stand ready to clear the way—whether GPS is available or not.

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Endnotes:

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The contents of this article do not represent the official views of, nor are they endorsed by, the U.S. Army, the Department of War (DoW), or the U.S. Government.

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