Brute Krulak Center for Innovation and Creativity 2018 Essay Contest – Second Place

Navigating Without GPS

Changing direction

by Capt James Cole, USAF

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"Database is loaded and good to go!" barked the crew chief over the sounds of the unmanned aerial vehicles (UAVs) spinning up as he ducked into the command post tent. "Alright, let's launch the strike and prepare to relocate," ordered the commander. Seconds later, three UAVs lifted off the rain-soaked grass and began their individual routes to the target many miles away. Mentally preparing for the next movement, he reflected on the developments over the past twenty years that shaped his current mission.

When the first conflict erupted over the enemy's territorial expansion, the Marines responded in defense of their regional allies. They had been mentally preparing for operations in a degraded environment, and problems surfaced as soon as they approached their destination. My predecessors knew they relied on GPS but did not fully understand the depth at which they trusted navigational services until they were not available. Or, as they found out, when it told them incorrect information. They did not realize the enemy was spoofing at first, so they landed on the wrong island beach, delaying the unit's arrival to the objective by an entire day. Once ashore, the units scrambled to find a way to use their GPS-guided precision munitions that were no longer GPS-guided or precision. With no alternatives, they used unguided fires. Some missions failed and others caused the deaths of innocent civilians.

A GPS receiver without satellites is useless. *(Photo by Cpl Aaron Patterson.)*

Shaking his head, the commander strode out of the tent. He scanned the area. From what he had been told, a nightmare did not even begin to describe the frustration and chaos the guys on the ground experienced once they landed ashore twenty years ago. Civilian casualties abruptly turned the world powers against the country's leaders and brought our Nation to the negotiating table. It shamed the Marines to walk away from a fight, but his predecessors took some powerful lessons learned and determined to make themselves and their equipment less GPS reliant.

Their dependence on modern technology demonstrated a glaring weakness that forced them to devolve in one area and advance in others. The thing was, systems to navigate precisely without GPS had existed for years, but they

were not integrated into many systems at the time. World industrial thinking up until that point saw no reason to invest in more complicated systems when they had worldwide reliable and accurate GPS signals from space. It was the best, fastest, and cheapest method for navigation, until they did not have it, and then found themselves with no alternative.

The Marines quickly realized that encrypted directional GPS antennas were a good starting point. They also recognized that if the enemy was to shoot down their satellites, it would not matter if they had the best GPS equipment or shielding techniques. A GPS receiver without satellites is useless. Thus, they invested in four complimentary systems: celestial navigation, imagery navigation, inertial navigation, and background electromagnetic navigation.

The commander grunted as he heaved a box from the mud and trudged toward the loading vehicle. He did not know exactly how the systems they installed on the UAVs worked, but he knew enough. If the UAV could not see the sun, moon, or stars, it could use its camera to see the terrain. It could geolocate itself using electronic signals or use its inertial sensors to calculate its location based on movement. Overall it a very impressive system; one that gave the commander confidence in their mission.

Integration cost millions and several years, but even the skeptics conceded that the Service's gamble paid off after several of the prototype UAVs completed peacekeeping operations while being GPS jammed. Thankfully, our hard work as a Service and country paid off. The next generation of UAVs navigated in any weather, over any terrain, with as good or better accuracy than GPS. Importantly, they were not jammable. There were weaknesses with each individual system but they were designed to work together with or without GPS to provide collaborative positioning to whatever combat system on which they were installed.

Pushing the communications equipment into the vehicle and wiping the brown mud off his trousers, the commander recalled taking apart his father's old laptop. It dwarfed the UAVs's state-of-the-art computer his team had just updated with the latest hardware and intelligence databases. His enthusiastic crew chief had lectured him yesterday about the up-to-date imagery and electronic measurements. If the route was cloudy, GPS was spotty, or the inertial navigation system went on the fritz, the UAV would still know where it was. Then his resident intel Marine had described the artificial intelligence and machine learning systems the aircraft used to analyzed the terrain, even in obscured conditions. It sounded complex, but as long as his smart bombs went where they were told, the commander did not trouble over the intricacies of the new systems. These changes were not solely felt in the Marines; longtime friends in the other Services had shared with him their impressions about this technology on their respective land and sea vehicles and the precision munitions they delivered. No longer would long-range rockets, bombs, UAVs, and other vehicles be sidelined without accurate target and location coordinates. Ships and vehicles anywhere in the world now knew their exact location that could not be denied or spoofed.

The commander smiled again, throwing the last of the equipment into the vehicle. After years of hard work and rigorous testing, his predecessors had changed the direction of modern navigation. A year ago, the brass was at last confident they were no longer dependent on GPS to fight. Twenty days ago, the enemy shot down or disabled twelve of our satellites. Fifteen days ago, Congress declared war, and for the past 72 hours the commander and his team had been launching precision strikes against the enemy. Dropping into his seat, he checked his data pad and grinned. There was not a GPS signal, but he was confident his UAVs would navigate to the target and deliver the precision strikes command had requested. "Let's get to the pickup zone," he growled to his crew chief, slamming the door.