

Mitigating the Threat of GPS Jamming

Anti-Jam Technology for Land Vehicles

NovAtel White Paper – June 2011

Executive Summary

Developed in the 1970s by the U.S. Department of Defense, the global positioning system (GPS) was created for military navigation and is widely credited with helping the U.S.-led coalition win the first Gulf War through improved land vehicle navigation.¹ As a critical element in military operations and weapons systems, GPS provides position, navigation, and time (PNT) information for a variety of strategic and tactical military applications. GPS has also become a critical element in PNT applications across many civilian industries. GPS signals, however, are inherently weak and subject to both accidental and deliberate interference. GPS jamming devices are easy to obtain and jamming is growing more common. Recent examples of jamming—both innocent and malicious—have given the military cause for concern. If GPS jammers were deployed in an attack scenario, for example, an enemy could block an entire troop's ability to determine and transmit their location and could prevent emergency vehicles from navigating to battlefield destinations.

A robust and cost-effective solution is needed to protect military land vehicles from GPS jamming. This white paper discusses GPS jamming and introduces a new, high performance GPS anti-jam technology, developed in collaborative partnership by NovAtel Inc. and QinetiQ Ltd. GAJT™ (pronounced “gadget”) is a single-unit, GPS interference mitigation system that fits any land vehicle.

GAJT is an antenna that nullifies jamming signals and allows GPS receivers to acquire and track satellite signals needed to ensure accurate battlefield position. Designed as a compact standalone system, GAJT provides anti-jam performance comparable to larger, multi-component Controlled Reception Pattern Antenna (CRPA) systems currently used by military organizations but at a significantly lower cost. The rugged, exterior-mounted unit easily integrates into new platforms and is compatible with existing GPS receivers and vehicle navigation systems.

GAJT ensures that positioning capabilities are retained when jamming occurs during combat or training missions, which protects soldiers' lives, increases situational awareness, and improves strategic battlefield performance. Manufactured using commercial, military-grade technology from Canada and the UK, GAJT provides an off-the-shelf solution for military applications.

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An Introduction to GPS Jamming

Originally developed in the 1970s by the U.S. Department of Defense, the global positioning system (GPS) was created so that military units would always know their exact location and the position of other units. GPS is widely credited with helping the U.S.-led coalition win the first Gulf War in 1991.¹ During Operation Desert Storm, military vehicles relied on GPS to navigate without reference to roads or other fixed landmarks. This enabled a strategic battle of maneuver rather than a battle of encounter because soldiers could determine their own locations and target locations quickly and reliably. Then, the military could coordinate an attack based on a known target location rather than just searching on the ground for enemy forces.

GPS has become critical to nearly all military operations and weapons systems.

GPS has become critical to nearly all military operations and weapons systems.² By providing location and time information in all weather conditions, GPS signals are also used in a variety of civilian industries – from construction and surveying to telecommunications, oil and gas, and even agriculture. The system is maintained by the U.S. government and is freely accessible to anyone with a GPS receiver. There are currently an estimated one billion GPS receivers worldwide with hundreds of applications.³

GPS signals are vulnerable to both accidental and deliberate interference.

GPS signals are transmitted on published radio frequencies from satellites that orbit 20,000 km above the Earth. The GPS transmit levels are only about 50 W at the satellite and weaken further as they approach Earth. This fundamental weakness makes the signals vulnerable to both accidental and deliberate interference. Jammers can prevent a tracking device from determining and reporting a vehicle's location and speed, rendering GPS inoperable. These devices are illegal but easy to obtain. In fact, detailed instructions for building jammers can be found online and simple models plug into a 12 volt car receptacle connector and can be purchased for as little as \$30 online.³

A Growing Problem

As GPS jammers become more widely available, jamming occurs more frequently. For example, in late 2009, engineers at Newark airport in New Jersey noticed that GPS receivers used in a new navigation aid were suffering brief, daily breaks in reception. After two months of investigation, the Federal Aviation Administration (FAA) determined the cause was a nearby truck driver who had installed an inexpensive GPS jammer on his truck.⁴ His daily commute past the airport was causing the interference, which shows how easily unintended GPS jamming occurs.

Armed forces are increasingly aware that hostile jamming severely impacts navigation capabilities.

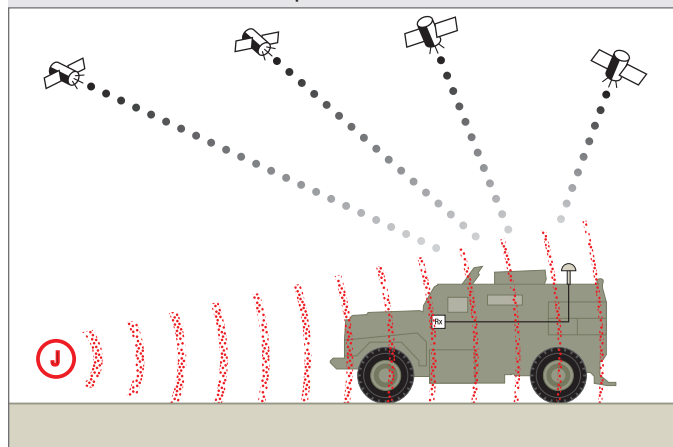
Military land vehicles are especially vulnerable to GPS jamming because almost all light armored vehicles and personnel carriers contain and rely on GPS.

Not all GPS jamming occurs innocently, however. The military's reliance on GPS for navigation makes the system a target for sabotage. Military land vehicles are especially vulnerable because almost all light armored vehicles

and personnel carriers contain and rely on GPS for navigation. Deliberate jamming prevents proper vehicle navigation, both from the perspective of operation and from a command center's inability to coordinate troop location. (See Figure 1). This vulnerability is particularly acute for vehicles involved in targeting air and artillery strikes. If GPS jammers are deployed in an attack scenario, for example, an enemy could foreseeably block the location determination capabilities of an entire troop, rendering them invisible to the command control center. This prevents strategic troop deployment and protection in enemy territory. Jammers can also prevent military emergency vehicles from navigating to their required battlefield destinations.

It is disconcerting that a satellite navigation system that costs billions of dollars can be easily disrupted with an inexpensive, portable ground transmitter, yet it happens. Iraqi defense forces used jammers in the second Gulf War around Baghdad⁵ and in November 2007, Newsmax.com reported that China had produced vans equipped with jammers that could be deployed to deny GPS signals.⁶

Figure 1 A jammer overwhelms the weak GPS signal and prevents the determination of vehicle position and time.



Defense officials in South Korea and other military organizations report that the North Koreans are capable of disrupting GPS receivers. Reports document signals emanating near the North Korean city of Kaesong that recently interfered with South Korean GPS military and civilian receivers. The jammers were repeatedly switched on for 10 minute periods for several hours over three days. Defense officials in South Korea, Japan, and the United States have expressed concern about Pyongyang's suspected ability to disrupt GPS navigation.⁷

Armed forces are increasingly aware that hostile jamming can severely impact navigation capabilities. As early as 2005, a U.S. Department of Defense paper presented a test perspective on GPS vulnerabilities and their potential impact on critical infrastructure. The paper stated that “over-reliance on GPS for critical applications could leave us vulnerable to future asymmetric attacks.”⁸

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Given the proven success and accuracy of GPS navigation, reliance will not change, so a new solution is needed to protect the military from GPS jamming. America’s Space-Based PNT Advisory Board has taken a similar stance, issuing a report in November 2010 that recommends several strategies be used to combat jamming, including a call to manufacturers to harden GPS receivers and create antennas that null interference.⁸

The Solution – GPS Anti-Jamming Technology

NovAtel Inc. and QinetiQ Ltd. have partnered to create a solution for military land and security applications encountering GPS jamming. High performance GAJT (GPS Anti-Jam Technology)

is a single unit, GPS interference mitigation antenna that fits any land vehicle (see Figure 2). GAJT uses a concept similar to that of noise-cancelling headphones, canceling jamming signals and allowing GPS receivers to acquire and track the satellite signals needed to calculate an accurate position.

GAJT can create six, independent antenna nulls.

Designed as a compact standalone system (just under 290 mm in diameter), GAJT provides anti-jam performance that is comparable to much larger, multi-component CRPA systems, but at a significantly lower cost. The rugged, exterior-mounted GAJT integrates easily into new platforms and, most importantly, is compatible with existing GPS receivers and vehicle navigation systems.

How GAJT Works

GAJT mitigates interference by creating “nulls”, or deliberate blind spots, in antenna gain patterns in the jammer’s direction to allow satellite signals to reach the receiver (see Figure 3).

GAJT provides anti-jam performance comparable to much larger, multi-component systems at a lower cost.

Figure 2 GAJT is a single-unit rugged antenna that protects the reception of GPS signals.

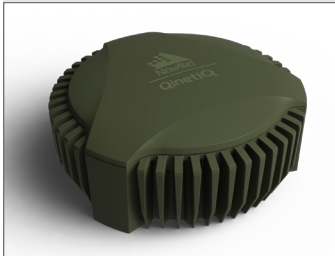
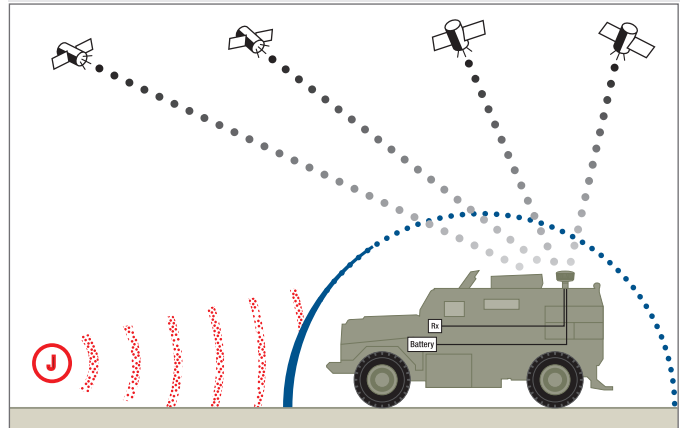


Figure 3 GAJT generates antenna “nulls”, or deliberate blind spots, to mitigate the jammer and allow GPS signals to reach the receiver.



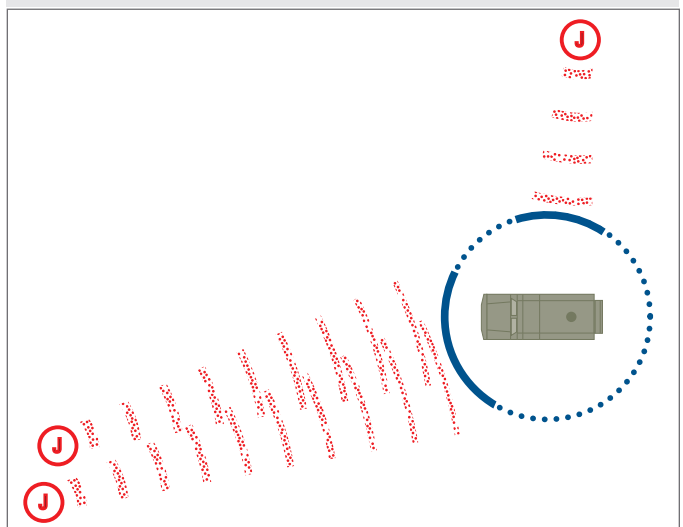
GAJT uses NovAtel’s seven-element, small footprint Pinwheel™ antenna to receive GPS signals in the L1 and L2 bands. These frequencies are down-converted to intermediate frequency for high-speed, digital sampling and processing by QinetiQ’s gain-pattern shaping algorithms. The algorithm

GAJT improves situational awareness, protecting soldier’s lives and improving strategic battlefield performance.

optimizes the power and phasing of the seven independent signals to create a single, high quality output signal that mitigates jamming sources in up to six directions. Then, the output is up-converted to the original GPS frequencies. The clean output signal is delivered through a standard antenna connector via a coaxial cable to any standard new or legacy GPS receiver through the external antenna input port. GAJT accommodates wide bandwidth, ensuring future compatibility with the 24 MHz M-Code GPS signal.

As shown in Figure 4, GAJT is also capable of creating multiple nulls to protect against several jamming sources.

Figure 4 By generating multiple antenna nulls, GAJT defeats multiple jammers.



The Benefits of GAJT

Without GPS anti-jam technology, a simple one watt jammer can overpower GPS signals over a large area, denying a position solution from the victim receiver, as shown in Figure 5. GAJT improves the GPS jamming immunity of the connected receiver, significantly decreasing the jammers' reach and ensuring that positioning capabilities are retained during combat, training, or other vehicle-based missions.

Figure 5 Without GAJT, troops and commanders are blind to operational deployment and status.

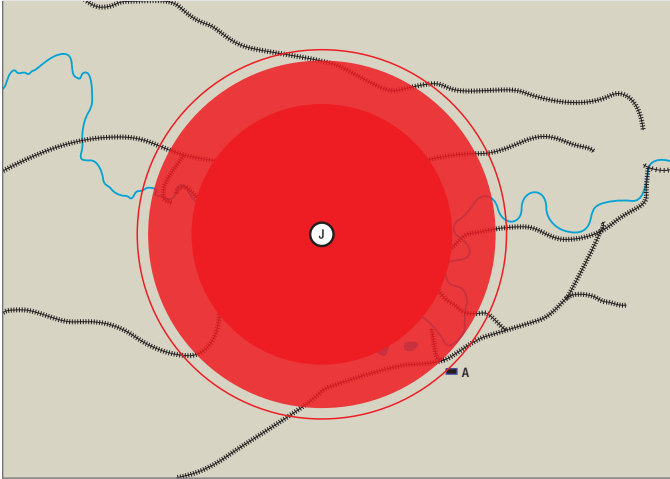
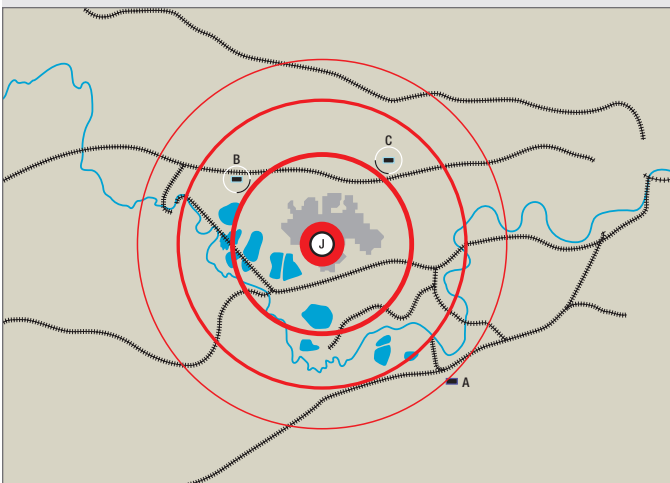


Figure 6 With GAJT, operations proceed unobstructed by jammers.



The GAJT system suppresses GPS jamming, which ensures that positioning capabilities are retained during combat or training. This promotes situational awareness, protecting soldier's lives, and improving strategic battlefield performance.

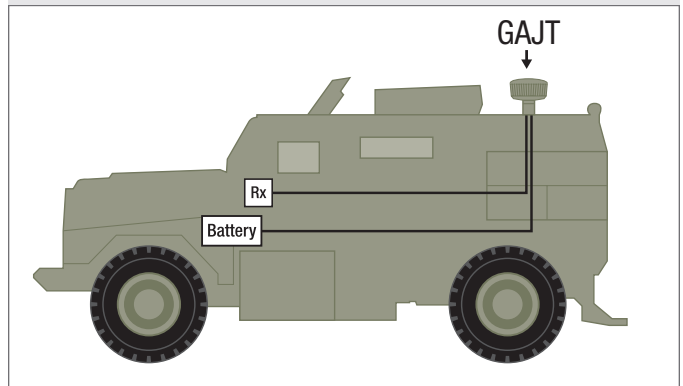
GAJT provides a single-unit solution for faster installation, minimizing vehicle downtime and making it easy to integrate or retrofit existing and legacy fleets with the new antenna.

Compact Size, Easy to Integrate

GAJT is less than 290 mm in diameter and the antenna elements on NovAtel's CRPA are set at GPS near quarter-wavelength separation. This makes it easy to retrofit GAJT on to vehicles as it simply replaces the old antenna and minimal vehicle alterations are needed. Operator training is not necessary because the original GPS unit remains in place.

As shown in Figure 7, GAJT is externally mounted, requiring no additional electronics inside the vehicle – only power and a single RF cable. As a single unit, GAJT provides an all-in-one solution unlike other anti-jam systems that typically feature more than one component. This minimizes vehicle downtime and makes it easier to integrate or retrofit existing and legacy fleets with the new GAJT antenna.

Figure 7 GAJT requires only power and an existing antenna cable to replace a legacy antenna.



Off-the-Shelf Solution

GAJT is manufactured using Canadian and UK military-grade technology, providing an off-the-shelf solution for military applications. GAJT only requires Canadian and UK export approval, making it easy to order and export to authorized customers.

Conclusion

GPS technology has revolutionized modern warfare. GPS jammers, now available for sale on the Internet, are increasingly used to degrade and block the satellite signals required to determine position. GPS jamming is, unfortunately, a growing problem that must be addressed, especially as it begins to affect ground troops. NovAtel and QinetiQ have combined their world-leading research and manufacturing capabilities to develop GAJT (GPS Anti-Jam Technology)— a compact, cost-effective system that is essential to maintain GPS signal acquisition for land vehicle navigation. GAJT delivers anti-jam performance comparable to that of much larger, multi-component CRPA systems used by military organizations, but at a significantly smaller size and lower cost. For more information about GAJT, please visit www.novatel.com/GAJT.

About NovAtel, Inc.

NovAtel's Global Navigation Satellite System (GNSS) technology is inside many of the world's most innovative positioning applications. As the world's leading OEM GNSS supplier, NovAtel has well-established relationships with both ally governmental military organizations and commercial defense contractors. Offering the broadest GNSS product line in the industry, NovAtel meets a wide range of military requirements, including high precision GNSS receiver boards, high performance GNSS antennas, augmented positioning systems such as SPAN™ GNSS + INS technology, and the GPS Anti-Jam Technology (GAJT) system.

About QinetiQ Ltd.

QinetiQ is a leading international provider of technology-based services and solutions to the defense, security, and related markets. QinetiQ develops and delivers services and solutions for government organizations, predominantly in the UK and U.S., including defense departments, intelligence services, and security agencies. In addition, QinetiQ provides technology insertion and consultancy services to commercial and industrial customers around the world.

Endnotes

- 1 "Final Report to Congress: Conduct of the Persian Gulf War," National Defense University, April 1992.
<http://www.ndu.edu/library/epubs/cpgw.pdf>.
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- 4 "GPS Jamming, No Jam Tomorrow," The Economist, March 10th, 2011.
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- 8 Major David Hoey and Paul Benshoof, 746th Test Squadron "Civil GPS Systems and Potential Vulnerabilities," October 25, 2005.