GPS AND THE MANEUVER SOLDIER

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Throughout the last decade of continuous conflict, our armed forces have become increasingly dependent on space-based systems. Services like space-based missile warning, satellite imagery and the worldwide relay of communications — much to the credit of operational service-support personnel — have remained largely transparent to Soldiers at the tactical level. We are confident that the "giant voice" will alert us to an incoming missile; that Force XXI Battle Command Brigade and Below (FBCB2) data will be with us on the move; and that relevant imagery will be available when requested.

We often lose sight of the source of these services, and in doing so, we cheat ourselves of an opportunity to leverage a deeper understanding of them. In the current fight, space services have remained largely uncontested, but because our adversaries are becoming increasingly capable of fielding their own space systems while attempting to deny us the use of ours, a functional understanding of space-based systems is more necessary than ever. Despite this reality, Soldiers, officers and staffs at all levels are often not aware of how to leverage space systems and Army space professionals to the maximum benefit of their units.

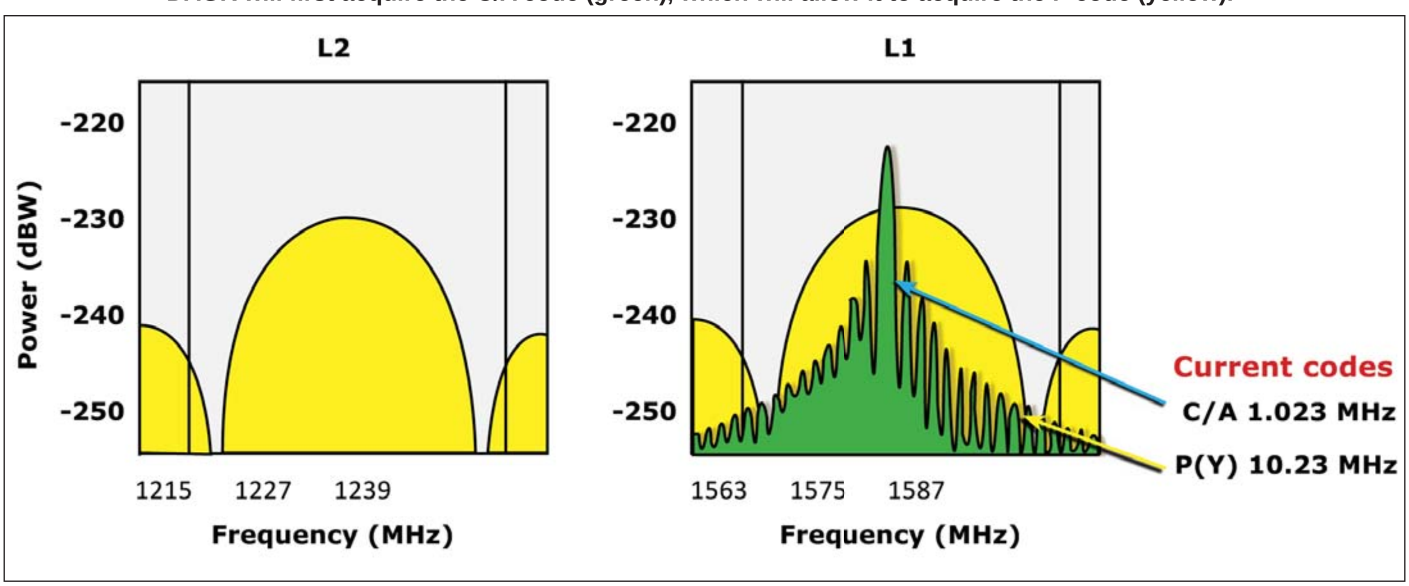
Although space-based systems and the individuals trained to exploit their capabilities provide diverse services such as those discussed in the preceding paragraphs, the one space-based system that is most vital to the maneuver Soldier is the Global Positioning System (GPS). It is the constellation of GPS satellites that provides a Defense Advanced GPS Receiver's (DAGR) positional data, enables navigation through the FBCB2 and provides a time source for radio encryption. These devices are so common and they work so well that we often take position, navigation, and timing (PNT) services for granted. Soldiers rarely, if ever, consider the satellites that provide the data or the possibility that a technologically advanced enemy would be able to deny them the ability to precisely know their position. However, even a basic understanding of GPS capabilities, along with a discussion of some tactics, techniques, and procedures (TTPs), will enable maneuver Soldiers, leaders, and planners at all echelons to more effectively conduct operations.

From a space professional's perspective, there are several things about the GPS constellation and handheld receivers that Soldiers and leaders need to know. First, DAGRs receive two separate radio frequencies, L1 and L2, from any GPS satellite in view. These frequencies contain codes. To acquire precision PNT data, a DAGR must acquire two codes: the coarse acquisition (C/A) code and the precision (P) code. A GPS satellite will typically only transmit the C/A code on the L1 frequency. The DAGR will acquire the C/A code first, which will then allow it to acquire the P code. The P code is normally broadcast on both the L1 and L2 frequencies, and when it is encrypted with the appropriate communications security (COMSEC), the P code becomes a P(Y) code.

Other things Soldiers and leaders should know:

Encrypt your DAGR to ensure protection against jamming. The dual signal itself accounts for part of the

Figure 1 — A DAGR will acquire frequencies in the L1 and L2 bands from any GPS satellite in its field of view. The DAGR will first acquire the C/A code (green), which will allow it to acquire the P code (yellow).



Graphic courtesy of the U.S. Army Space and Missile Command

DAGR's security. While DAGRs will function with no encryption loaded in them, leaders must ensure that Soldiers are loading the proper encryption to allow the receiver the best chance of resisting jamming activity, specifically a type of jamming called spoofing (Figure 2).

To protect your Soldiers and your mission, use only military-grade receivers. Largely due to shortages in military-grade GPS receivers, the practice of using civilian GPS receivers in a combat environment has been fairly common for the past decade. Individuals should not use civilian GPS receivers in a combat zone (or in training, for that matter). Civilian GPS receivers only receive one frequency, do not support encryption and are not secure. Making matters worse, many civilian GPS receivers actually transmit a signal. An enemy can use the same model of receiver to monitor your channel and determine your location. The risk of endangering your Soldiers and your mission could very well outweigh any benefit gained from the additional situational awareness offered by using commercial receivers.

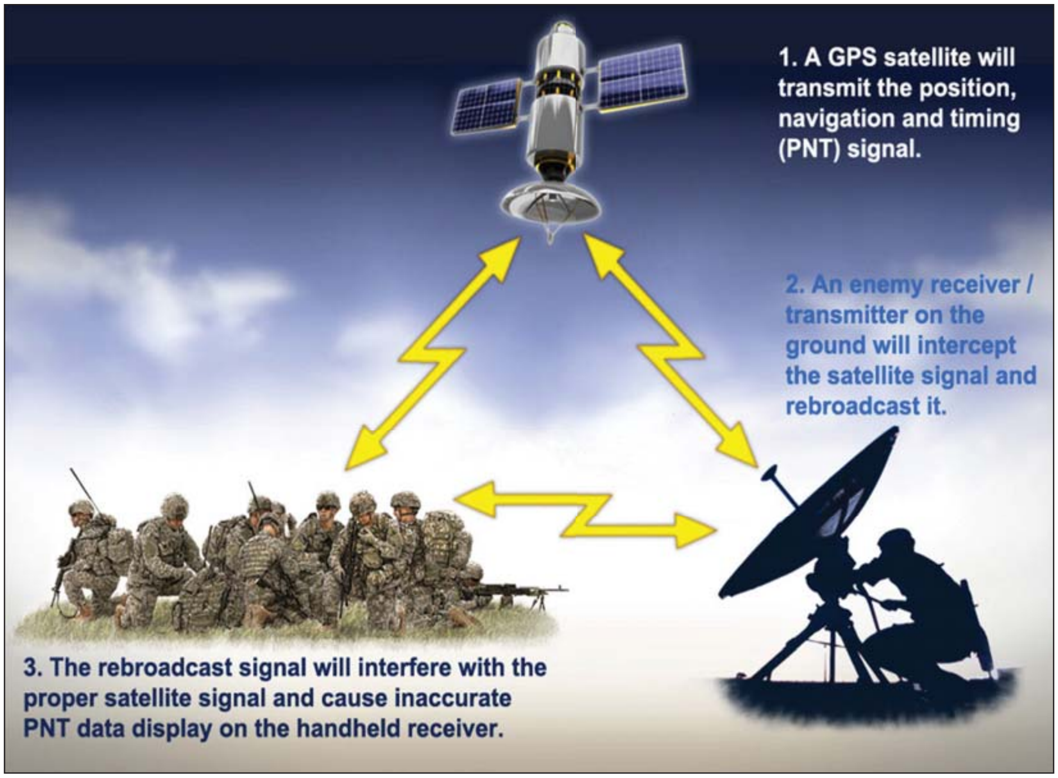


Figure 2 — Spoofing

Even though military GPS receivers are capable of being encrypted, the signals they receive from satellites are relatively weak. In fact, anyone can purchase a GPS jammer from the Internet. (Please note that using a jammer of any kind can lead to extremely serious legal consequences.) Furthermore, adversarial nations understand our dependence on GPS and are equipped with military-grade jammers — equipment that could potentially show up in current areas of operations and will certainly play a large role in future conflicts. What does a Soldier do if he is being jammed or suspects he is being jammed?

If your DAGR loses its GPS signal, attempt to reacquire the satellites' signals. Your GPS signal is coming from the sky, and the jammer is likely ground-based, so any way of blocking the jammer's energy will help keep your DAGR locked on friendly GPS signals. If the jamming signal is extremely strong or extremely near, you must be prepared to conduct operations in a degraded environment. If the jamming signal is weak, place your body, a vehicle, or a terrain feature between your DAGR and the jammer's suspected location. If you are not sure where the jamming is coming from, digging a shallow hole and placing your DAGR in the hole might protect your DAGR enough to allow it to reacquire the GPS signal.

If you suspect jamming, report it up the chain sooner rather than later. Soldiers tend to dismiss signal loss, nonsensical location or elevation readings, or a jammer warning on the DAGR screen as equipment errors. These are all indications of signal interference. Blue-on-blue (unintentional) interference is common; many U.S. and allied systems (for example, certain radars) emit frequencies that can interfere with GPS receivers' ability to properly receive signals. In these instances, space personnel, in conjunction with other staff elements and government agencies, will be able to assist in deconflicting the interference. If an enemy is responsible for the interference, their jammer may be locatable and targetable.

Prepare for a jamming threat; train with a map and compass. Knowledge of your position is a necessity, and because DAGR and FBCB2 systems depend on GPS input, the loss of a GPS signal may mean the loss of situational awareness. Spoofing is a kind of jamming that intercepts friendly GPS signals and retransmits them to your receiver, causing the receiver to lock on to the jammer and not the satellites. This causes the DAGR to report that you are somewhere other than where you actually are. Fire support and medical-evacuation support depend on precision location; a false sense of location could lead to serious consequences. Without the availability of GPS, the map and compass are a Soldier's best bet.

Prepare for a jamming threat; train for degraded communications. The encryption on your radio is probably using the time reference provided by your DAGR (that is to say, the time reference transmitted by the GPS satellites to the DAGR) to stay synched with all the other radios in the unit. If the timing in your radios drifts and jamming prevents you from receiving the time as provided by an accurate GPS signal, you may eventually be unable to talk in an encrypted mode. If your COMSEC is compromised, you may need to resort to using a Terrain Index Reference System (TIRS) or Grid Index Reference System (GIRS), or you can assume the risk of operating over an unencrypted frequency. Leaders must incorporate training for degraded operations.

In the United States, we are accustomed to commercial GPS receivers that will tell us our location with great precision and great consistency, but when planning and executing missions in austere environments, it is essential to understand that GPS does not always produce a consistent level of precision. The position your DAGR reports may very well be your true position, but it could also be off by 100 meters or more. The reason we enjoy such accuracy in the United States has less to do with the space-based segment of GPS than with the ground-based benchmarks that augment it. These reference emitters know their location and never move. A dashboard GPS receiver, for example, takes the satellite input, compares it to the reference emitter's input, and calculates a precise location for the vehicle by accounting for the difference in the two signals. Countries like Afghanistan do not have this ground-based infrastructure, so GPS positioning there depends solely on space-based assets, which increases the probability of imprecision.

To complicate the matter, GPS satellites are continually passing overhead. Contrary to one common misconception, GPS satellites do not remain over one fixed ground location the way an aerostat blimp might. As a result of multiple satellites passing overhead and dipping below the horizon, DAGRs are constantly losing the signal from one satellite and reacquiring the signal from another. To display a valid four-dimensional solution (latitude, longitude, elevation and time), a DAGR must receive a signal from at least four satellites. More satellites in view of a receiver means increased precision, but the way that the satellites are arrayed in space also affects the DAGR's precision. For example, if you are able to "see " four satellites, but two of them are near the horizon, your solution will be less accurate than if your DAGR is receiving signals from four satellites spaced evenly across the viewable sky (Figure 3).

Similarly, if your receiver is able to "see" four satellites, but they are all directly overhead or if they are all near the horizon, your solution will not be as precise as if you have four satellites spaced evenly across the viewable sky.

Add in the effects of terrain, and the solution worsens. If you are in a valley surrounded by mountains or in an urban area full of buildings, for example, the terrain is blocking the signals of all satellites except those that can "see" down into the valley (Figure 4); the satellite geometry is unfavorable. Thankfully, planners can mitigate the negative effects of the shortcomings in the GPS system through an understanding of terrain and space support capabilities.

If you suspect a jamming environment, request a navigational-accuracy (NAVAC) model. Division space-support personnel use a software program called the GPS Interference and Navigation Tool (GIANT) to analyze satellite availability, effects of terrain and potential effects of jammers. GIANT will model the accuracy of a GPS signal at a given location at a given time or over a given time period. Commanders and planners will be able to wargame the operational effects of GPS availability and jamming activity.

Although a degraded GPS signal will probably not stop a patrol, it may inform route selection, rehearsals, and the plan for employing precision-guided munitions (PGMs). For example, if at 11 p.m. the GPS signal will provide accuracy only to within 100 meters of the desired impact point, a commander may choose not to employ a PGM at that time. If, however, the satellite geometry at 11:30 p.m. indicates accuracy down to within 10 meters of the target, it may be prudent to wait the extra 30 minutes for the more probable mission success. The employment of Joint Precision Airdrop Systems (JPADS), GPS-guided unmanned aerial systems (UAS), GPS-aided Joint Direct Attack Munitions (JDAMs) or any other GPS-dependent system requires similar consideration.

If you suspect that GPS degradation due to terrain will be a problem, request a Satellite Tool Kit (STK) model. STK, like GIANT, is also a software program space-support personnel can use to model GPS accuracy, but STK's capability for building models is vastly more expansive. In STK, for example, one can build an animated model — a sort of miniature movie — of an MQ-1 Predator flying through a mountain valley in Afghanistan. The simulated Predator can be designed to include, among other attributes, a camera

Figure 3 — Favorable Satellite Geometry

This graphic depicts satellites at varying heights, depths, and horizontal distances relative to the Soldiers. Satellites arrayed throughout a disbursed volume of sky will provide PNT data that is more accurate than a less disbursed configuration.

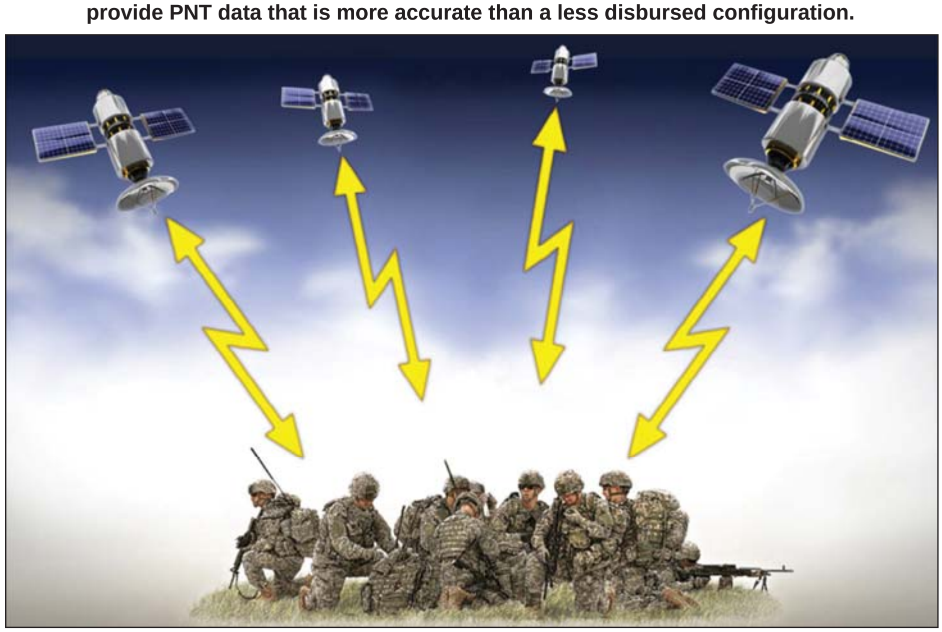


Figure 4 — Effects of Terrain
Naturally occurring or man-made terrain features can block or reflect GPS signals, reducing the number of satellites in view and preventing your handheld device from receiving the data necessary to get a good geo-location. Leaders should address such potential effects during mission planning.

of specified quality, memory storage of specified size and a fuel tank of specified capacity. Also, because the software reads Digital Terrain Elevation Data (DTED) data and allows for imagery overlays, the animation is quite realistic and provides an excellent product for mission briefs and rehearsals. When the GPS constellation is included in the model, STK reports will predict at what point the UAS will lose the GPS signal, and mission planners can adjust its flight path and/or timeline accordingly.

A discussion of STK's full capability is beyond this article's scope. However, STK is a very powerful tool that can be used to model different sizes or types of forces, radio-frequency propagation, and many other battlefield elements.

Conclusion

Although Soldiers use space-based capabilities like GPS every day at the tactical level, we often do so without the level of understanding necessary to maximize the potential of these capabilities. We take capabilities like GPS for granted, but our adversaries understand our dependence on space and will continue to direct training and assets against them. We must be prepared for their eventual success in denying or degrading our space capabilities.

Currently, the first echelon at which a unit has organic space professionals is the division (the space support element). During deployments, Army space support teams will often augment division and corps staffs, and depending on the organization and the issue at hand, space-support requests may go through operational (S3), intelligence (S2) or signal (S6) channels. This construct, however, should not deceive us into thinking that space-based products and services are only for use by the upper echelons, nor should it discourage a company commander or a battalion planner to request that support. On the contrary, space-based capabilities like GPS were developed with tactical operations in mind, and a leader or planner at any level who understands the military applications of space systems will enjoy greater mission success as adversaries become increasingly capable of challenging U.S. supremacy in the space domain.

At the time this article was written, **CPT Jerry V. Drew II** was attending the Maneuver Captains Career Course at Fort Benning, Ga. His previous assignments include serving as battalion assistant S3, 1st Space Battalion, Peterson Air Force Base, Colo.; commander of Bravo Detachment, 1st Space Company, 1st Space Battalion, 1st Space Brigade, Camp As Sayliyah, Qatar; deputy team leader, Army Space Support Team 6, 2nd Space Company, 1st Space Battalion, 1st Space Brigade, Peterson Air Force Base; and Headquarters and Headquarters Company executive officer and scout platoon leader, 1st Combined Arms Battalion, 5th Brigade, 1st Armored Division (Army Evaluation Task Force), Fort Bliss, Texas.