



GPS Retransmission: enhancing situational awareness, survivability and mission effectiveness

Increasingly ubiquitous in operations, GPS has certain limitations when actually used in theatre. In this feature, Andy Proctor, Divisional Manager at Chronos Technology Ltd, describes a method to overcome some of these limitations and help ensure a successful operation in the field.

Global Navigation Satellite System (GNSS) technology such as the US Global Positioning System (GPS) is increasingly being used in many different military applications beyond navigation. For instance, soldiers can use GPS to enhance situational awareness on the battlefield with systems such as the forthcoming Dismounted Soldier System (DSS).

GPS applications for airborne soldiers provide guidance to the drop zone in night or inclement weather operations. In the case of airdrop systems GPS guidance receivers provide navigation and steering commands to guide the payload to the drop zone. GPS-enabled asset tracking may also provide current position and status of high-value assets, such as VIPs or weapons for example. In training applications, GPS technology may be used to track the participating assets, scoring the exercise and enabling a far more instructive debrief.

In all of the examples above, and in many other GPS-enabled military applications, it frequently becomes necessary for these GPS receivers to operate in locations where the GPS signals are normally not available, reducing awareness, effectiveness and survivability.

The type of environments where GPS is unavailable include inside ground vehicles such as Bulldog, Warrior, Spartan, MASTIFF 2 and future vehicles such as OCELOT and FRES. GPS-denied environments also exist inside aircraft such as C-130, C-17 and CH-47 (Chinook).

What is GPS Retransmission?

GPS Retransmission (or GPS Repeating) makes live GPS signals available to GPS receivers (handheld, mobile or fixed) at locations where the signals are otherwise not available.

Proven applications include the following:

- In the crew compartment of a military vehicle
- In the cargo compartment of a military aircraft
- In the garage or hangar bay of a military maintenance facility
- In the final assembly stage of a military equipment manufacturer

Applications, benefits and added value

The performance of GPS receivers, or specifically the receiver antennas inside vehicles (aircraft, land vehicles, boats, etc) or buildings without a Line Of Sight (LOS) view of the GPS satellites, will be impacted in the following ways:

- When the soldier carrying the receiver deploys from the vehicle or aircraft, the 'time to first fix' (TTFF) can vary significantly. TTFF can be over five minutes in the worst case, putting the soldier's situational awareness or even their survivability at risk. Placement of, say, a DAGR on a vehicle roof or through an open door also reduces survivability.
- Incorrect coordinates can be given for such as air support; medevac, sniper, etc as the GPS receiver may be in a search mode and displaying an incorrect, historical position.
- GPS receiver battery life while operating inside a vehicle or aircraft is significantly reduced due to the computationally intensive signal acquisition process.
- Lack of signal availability may preclude verification of system operation prior to deployment.

“GPS and GNSS Retransmission brings significant benefits to improve the fighting ability of soldiers”

With a GPS Retransmission system installed and providing GPS signal availability in an otherwise denied environment, then:

- Situational Awareness (SA) is maintained with valid location reporting even when inside a vehicle or aircraft, rather than reporting of 'last known good' location, which would be the location just prior to entering the vehicle or aircraft.

- Delays in TTFF when exiting the vehicle are eliminated, improving mission effectiveness and survivability.
- Cargo payload receivers prior to air drop will indicate the correct data for effective mission success. System verification in the aircraft can also take place.
- Steering commands for air drop cargo can immediately be executed upon exiting the aircraft.
- Position, velocity and elevation of an airborne soldier (using GPS) can be verified prior to free-fall applications.
- GPS receiver battery consumption is reduced.

GPS Retransmission system architectures

GPS Retransmission systems, in their simplest form, include at a minimum the following elements:

- Active Antenna (active meaning the antenna includes an integrated Low Noise Amplifier).
- Interconnecting Coaxial Cable(s).
- Retransmission Amplifier/Signal Conditioner.
- Passive Retransmission Antenna.

In this system, the GPS satellite signals are received by the active antenna, amplified and conditioned by the Retransmission amplifier, and re-broadcast on the GPS frequency or frequencies by the Retransmission antenna. Because the signal delay through the GPS Retransmission system is common for each satellite once the signals are received by the exterior antenna, GPS receivers operating in the retransmitted signal environment will generate a location which will actually indicate the system's receive antenna position. This, however, is not critical for all of the applications described above as the derived location is close enough to accomplish the intended function.

Simple GPS Retransmission systems as detailed above are effective in many applications, such as maintenance facilities and protective shelters. However, successful GPS Retransmission in the confined, irregularly shaped cargo compartment of a military aircraft or in the crew compartment of a military vehicle presents significant challenges. The limited dynamic range of GPS application receivers constrains the retransmitted signal levels in the cargo or passenger compartment; if the retransmitted signal is beyond the dynamic range of the receiver, then the GPS receiver may become saturated, resulting in failure to acquire GPS lock on the signals inside or immediately upon exiting the vehicle or aircraft.

An additional consideration must be made for Selective Availability / Anti-Spoofing

Module (SAASM) capable GPS receivers. If the retransmitted signal is too strong inside the aircraft, this could trigger the Anti-Spoofing capability. Conversely, the signal may be so low as to preclude signal acquisition and GPS lock by the receiver while still inside the aircraft.

Multiple antenna systems

In aircraft the long, narrow dimensions of cargo compartments taken together with rapid signal propagation losses and the limited dynamic range of GPS receivers typically dictates that multiple retransmission antennas will be required for complete, uniform coverage. For example, for coverage in a C130J or C17 aircraft, a multiple antenna configuration is required to ensure that all necessary areas have GPS signal coverage at the appropriate signal level to ensure correct operation of any GPS receiver.


Oscillation detection

If a GPS Retransmission system is installed incorrectly or a system has experienced some kind of failure, an oscillation can occur that results in a spurious emission transmitted by the system at a signal level sufficient to jam not only the GPS receivers operating within the aircraft (including the aircraft's own navigation system), but also other GPS operations for miles around. Consequently, it is imperative that modern GPS Retransmission systems employ some method of detecting an oscillation condition and inhibiting system operation in order to avoid this scenario.

Conclusion

GPS (and GNSS) Retransmission brings significant benefits to improve the fighting ability of soldiers, in particular Special Forces and reconnaissance units when embarked on vehicles. Situational awareness, survivability and mission effectiveness are all improved by the use of this technology, although it is clear that the technology must be fully understood by those providing installation and support to ensure complete operation and interoperability.

Andy Proctor
 Divisional Manager, GNSS Applications & Solutions
 Chronos Technology Ltd.
 Tel: (0)1594 862200
 Email: andy.proctor@chronos.co.uk
 Web: www.chronos.co.uk




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Mike Bowden, tel +44 7525 077538
email: michael.bowden@ifsdefence.com