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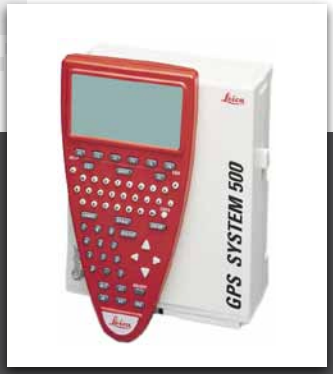

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MYTH BUSTED

Civilian GPS Receivers Actually *do* Have Access to the L2 Frequency

BY MAJ WILLIAM WRIGHT, MICHAEL RUSSELL AND JOHN BROCKHAUS

Rarely does our space cadre professional journal inform the community on technical topics that provide us intellectual insight into our trade. The intent of this article is to add some technical know-how to our space rucksacks. It is the authors' intent to discuss one such topic in this paper and to also encourage more technical discussions of our tradecraft in the future.

Space operations officers are charged to be subject matter experts on Position, Navigation and Timing and on the Global Positioning System (GPS) constellation. In the course of educating FA40s in the Space Operations Officer Qualification Course, in less than three months, students receive as many as six briefs dealing with GPS. These briefs range from introductory to in-depth lessons from Space 200, NAVWAR, Space Operations Officer Qualification Course GPS, the Space Symposium, and a briefing from GPS experts at Los Angeles Air Force Base. In each of the briefs, usually within the first 4-7 slides, these technical experts tell us that the L1 band has the course acquisition (C/A) code with free access to the public, while access to the L2 band is restricted to only those military receivers with encryption to access the P-code. While this was the intended design of the system, it is simply no longer a true statement. For several years, specific civilian GPS receivers have the capability to utilize the L2 GPS band. Therefore, it is important to clarify this misconception and make a recommendation on how, as a community of professionals, the correct knowledge should be disseminated.

While the original design of the GPS was to limit access to the L2 band to users with encrypted access, civilian scientists quickly engineered numerous techniques that work around the encryption and provide access to the L2 band. This is not breaking the encryption but, instead, utilizing the L2 carrier in a way that allows a data point to be derived from the signal itself. Some of these methods use techniques such as signal squaring, Z-tracking, cross-correlation, and code-aided squaring. As a result, many GPS receiver manufactures make dual L1/L2 GPS receivers. Initially, these receivers were restricted to high end, expensive survey grade receivers. However, the newer Block IIR and M Satellite Vehicles are designed to broadcast a C/A code on the L2 frequency. Since civilian access to L2 has been available for some time and the cost to obtain receivers has been going down, we should not be too concerned about the C/A code being on the L2 band. However, we all must be aware that precision Position, Navigation and Timing data is now much easier to obtain.

Dual L1/L2 receivers were used in order to correct for ionospheric errors, but were limited in use in the civilian sector due to the high cost associated with receivers with this capability. Errors associated with the ionosphere are frequency dependant, therefore, by gaining access to data from two different frequencies ionospheric effects can be modeled and the error removed. Over time the cost associated with these receivers has dropped, and now dual frequency receivers are routinely available at much more reasonable prices. Additionally, many of these receivers are

also able to incorporate Global Navigation Satellite System measurements. The incorporation of the Global Navigation Satellite System adds a third frequency, more satellites for good Position Dilution of Precision/geometry, in most cases a better circular error of probability, and in a forest or mountain environment a reduced time to obtain a position fix. Four examples of L1/L2 receivers are listed below. The ranges in price for these receivers are from under $4,500 to over $50,000.

Without knowledge of the P-code, civilian receivers are required to apply a codeless or a semi-codeless technique in order to obtain information from the L2 carrier phase. To do this, the L1 carrier is recovered after C/A code correlation, and the L2 carrier is reconstructed without knowledge of the Y or W-codes. Today, two primary methods are used to obtain access to the L2 frequency, they are cross-correlation and Z-tracking.

What follows is a simplified explanation as to how these techniques work. Cross-correlation multiplies the L2 signal by the L1 signal, resulting in the ability to recover the original L2 signal. Receivers using the cross-correlation method are Standard Positioning Service receivers that demodulate the unknown W-code on the L2 frequency. A digital filter optimizes the signal to noise ratios of the Space Vehicles providing the capability to obtain a cross correlation between each vehicles relative Doppler-frequency difference as well as by "spreading-codes." Ashtech's Z-tracking method utilizes the cross-correlation method but is also able to utilize the timing relationship of the W-code's bits with respect to the P-code. In particular it is able to take advantage of the nearly 20-1 bit ratio of the W-code as compared to the P-code. The accuracy of these dual frequency receivers vary and are largely dependent upon the antenna being employed as well as maintaining signal lock. However, most scholarly articles and work indicate that centimeter level accuracy is obtainable when differentially corrected and better than 30 cm accuracy on the fly with a lower grade antenna.

While the original design of the GPS system was to limit access to the L2 frequency, and in essence restrict access to the higher accuracy GPS position precision obtainable using the P-code, the civilian sector has been able to obtain this frequency and utilize it for highly accurate positioning information. A common drawback with both civil and military receivers is that they are dependent upon obtaining first the L1 lock, then the L2 frequency in order to employ their methods.

As a space community, we must disseminate the latest information and how it impacts operations. The time has come to update our technical information as technology changes and not simply teach our space cadre that the L1 frequency is civilian free access and L2 is a restricted military only frequency. Briefing information in the Army space schoolhouse will be updated to ensure we disseminate the correct information. Though our Liaison Officers at the National Security Space Institute, we will work to add this knowledge to their GPS instruction. In fact, we should include in our running estimates information about these dual frequency receivers as well as the receivers that integrate both L1/L2 and GLONASS into their solutions. In addition, we should consider discussing this with S2/G2s and determine what intelligence we have on our adversaries as to the GPS receivers they use in order to determine the level of accuracy that they are able to obtain and upon what frequencies they are dependant to get Position, Navigation and Timing solutions.

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