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## Update on GPS: New Civilian Accessible Signals – L1C, L2C, and L5

### GPS Overview

A GPS receiver, like an FM radio, can be tuned to interpret certain signals being broadcast at specific frequencies. GPS signals are broadcast from 24 satellites orbiting the earth twice a day. However, in contrast to the high transmitting power output of an FM radio station (about 100,000 watts), GPS satellite signals are transmitted between 20-50 watts; this is the primary reason for the difficulty in receiving a "GPS fix" under dense tree canopy, near tall obstructions, etc. A GPS receiver "listens" to the available satellites to interpret a code (Course/Acquisition code for civilian use) so a time differential can be determined between the satellites' transmitted code and the GPS receiver's reception of that code. This differential, a very small fraction of a second, is then multiplied by the speed of light to calculate the distance between the receiver and the satellite. Determining distances from at least three satellites, the GPS receiver can then compute its location based on a geometric process similar to triangulation.

Courtesy of Garmin Ltd.

Figure 1. GPS Satellite Trajectory.

Originally, only two signal frequencies were broadcast by GPS satellites: **L1** and **L2** ("L" denotes Link). The L1 frequency (1575.42 MHz) is equipped with two super-imposed codes, the Coarse Acquisition (C/A) code for civilian use and the Precision code (P-Code) for military use only. Until recently, the L2 frequency (1227.60 MHz) only broadcasted the P-code. Single-frequency GPS receivers use the L1 frequency and can interpret the C/A code. However, "dual-frequency" receivers, such as some RTK units, use L1 and the signal structure of L2 to achieve their high accuracy.

### GPS Modernization

The US Congress initiated legislation, termed "GPS Modernization," in 2000 to upgrade the GPS system. Objectives for the project included creating additional monitoring stations, new satellites, additional navigation signals for both civilian and military users, and processes to improve the accuracy and availability of GPS. For the end user, the largest impact of this project will be new civilian signals L2C, L5, and L1C.

### L2C: The Second Civilian Signal

The new L2C code (C denoting civilian accessibility) is super-imposed on the current L2 frequency. In order to employ the L2C signal, a GPS unit must be capable of interpreting the signal from at least three visible satellites broadcasting L2C. Only six satellite vehicles (SV's) are currently broadcasting L2C, but 24 L2C-equipped satellites are expected to be in operation by 2016.

The benefit of the L2C for the end user is a stronger signal because it is broadcast at 1227.60 MHz (in the radio-frequency world, a smaller frequency number generally represents a more powerful frequency.) *The stronger signal will minimize error due to obstructions and multipath as well as reducing the amount of power needed by the GPS unit to receive the signal, thereby increasing GPS reliability. In fact, a "GPS fix" may be determined in some indoor environments by utilizing L2C.*

## L5: Third Civilian Signal

In addition to L1 C/A and L2C, a third GPS frequency will be online in the near future. Referred to as L5, this signal will be broadcast at a frequency of 1176.45 MHz. This frequency is even lower than L2 and will provide further *improved accuracy, reliability, and performance within vegetative canopies and around obstructions*. Therefore, accurate and reliable operation under forest canopy may be possible with L5. This signal will also *be more impervious to radio-frequency interference* (RFI). L5, also referred to as the Safety-of-Life signal due to its maritime and aviation implications, will only transmit the C/A code.

Like the L2C-compatible equipment, some manufacturers of high-end GPS surveying and mapping equipment are currently making products capable of interpreting the L5 signal. Availability of this frequency will depend on government funding and timing, but 24 satellites broadcasting the L5 frequency are expected to be online around 2018. Look for companies to provide receivers capable of interpreting L5 in the near future.

## L1C: Fourth Civilian Signal

The final signal upgrade as part of GPS Modernization will be L1C. L1C will be super-imposed onto the L1 signal, and it will be backwards-compatible with the current C/A-code. L1C will be established in order to overcome the deficiencies of L1 C/A. L1C will be interoperable with the Galileo (European Satellite Navigation System) L1 Open Service signal and possibly with the modernized GLONASS (Russian Satellite Navigation System) system, producing a truly international signal. Like L2C and L5, L1C has been designed with unique and innovative features to enhance its robustness for all users, especially in difficult operating environments. The projected launch of the first GPS satellite transmitting L1C could be as soon as 2013.

Table 1. Signal reliability under questionable conditions.

| **Operating Condition** | **Signal Reliability** | | | |
|---|---|---|---|---|
| | ***L1*** | ***L2C*** | ***L5*** | ***L1C*** |
| Under Tree Canopy | No | Yes | Yes | Yes |
| Next to Obstructions | No | Yes | Yes | Yes |
| Multi-path | No | Yes | Yes | Yes |
| Radio Frequency Interference | No | No | Yes | Yes |

## Benefits

GPS Modernization provides numerous benefits to the user such as:

- Increased accuracy and reliability,
- Multipath mitigation,
- Increased signal strength and reception near buildings, trees, and other obstructions,
- True dual frequency and eventually triple frequency (L1, L2, and L5) units, and
- L1C will provide exact GPS time, decreased time for a first GPS fix, and will be an internationally defined civil signal.

## Can My GPS Unit Interpret L2C, L5, and L1C Signals?

When making purchases of GPS equipment, it is imperative to review manufacturer's literature. Figure 2 provides an example of what to identify in a future GPS purchase. Most GPS units purchased before 2005 are not capable of interpreting the new signals. Keep in mind that while the initial input cost of purchasing a receiver with "GPS Modernization" technology may be more than standard GPS technology for the next few years, the investment should be justified for long-term plans. When GPS Modernization is complete, some current technologies may be obsolete. *Remember that in order to utilize these new L2C, L5, and L1C signals, which provide an increase in accuracy and better signal strength, your GPS receiver must be able to receive and interpret them.*

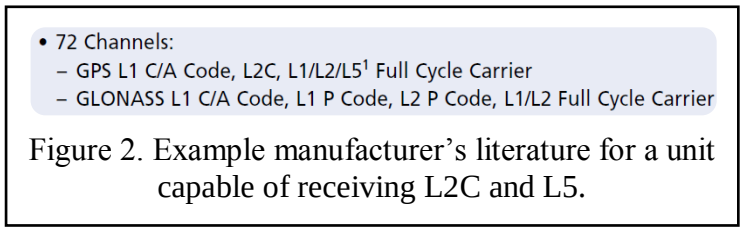


Figure 2. Example manufacturer's literature for a unit capable of receiving L2C and L5.

## Additional Information

Also see ACES Timely Information Sheets *Update on GPS: Explanation of GNSS*.

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