Galileo – Global Navigation Satellite System (GNSS)

Galileo is a global navigation satellite system (GNSS) currently being built by the European Union (EU) and European Space Agency (ESA). The system is both alternative to and complementary to the U.S. Global Positioning System (GPS) and the Russian GLONASS. The project is underway now and the system should be operational in 2014 (possibly sooner).

Within Galileo, four separate navigation services and one service to support Search and Rescue operations have been identified:

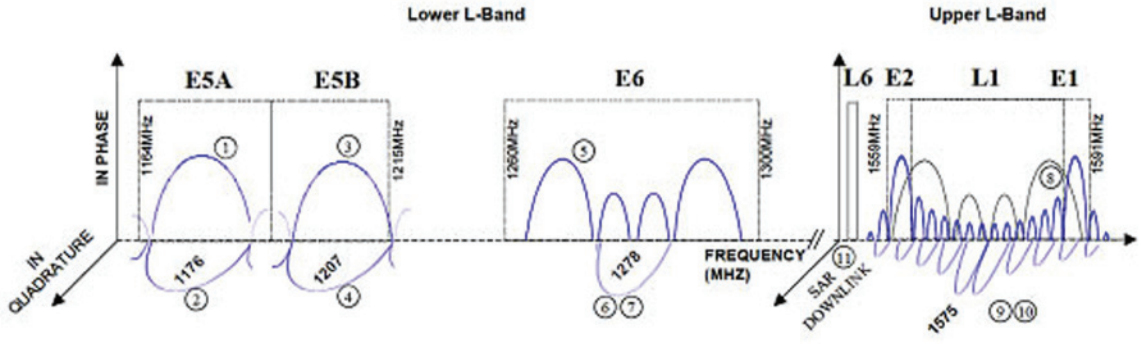
i. *The Open Service (OS)* results from a combination of open signals, free of user charge, and provides position and timing performances competitive with other GNSS systems. The OS signals will be broadcast in two bands: 1164 – 1215 MHz and 1559 – 1591 MHz. Receivers will achieve an accuracy of 4 m horizontally and 8 m vertically if they use both OS bands. Receivers that use only a single band will still achieve 15 m horizontally and 35 m vertically, comparable to what the civilian GPS C/A service provides today. It is expected that most future mass market receivers, such as automotive navigation systems, will process both the GPS C/A and the Galileo OS signals, for maximum coverage.

ii. *The Safety of Life Service (SoL)* improves the open service performances through the provision of timely warnings to the user when it fails to meet certain margins of accuracy (integrity). It is envisaged that a service guarantee will be provided for this service. SoL will be targeted at safety–critical transport applications (air–traffic control, automated aircraft landing, etc.).

iii. *The Commercial Service (CS)* provides access to two additional signals, to allow for a higher data rate throughput and to enable users to improve accuracy. It is envisaged that a service guarantee will be provided for this service.This encrypted service will be available for a fee and will offer an accuracy of better than 1 m. The CS can also be complemented by ground stations to bring the accuracy down to less than 10 cm. This signal will be broadcast in three frequency bands, the two used for the OS signals, as well as the 1260 – 1300 MHz band.

iv. *The Public Regulated Service (PRS)* provides position and timing to specific users requiring a high continuity of service, with controlled access. Two PRS navigation signals with encrypted ranging codes and data will be available. PRS will be targeted at security authorities (police, military, etc.).

v. *The Search and Rescue Service (SAR)* broadcast globally the alert messages received from distress emitting beacons. It will contribute to enhance the performances of the international COSPAS–SARSAT Search and Rescue system. The Search and Rescue Transponder on Galileo satellites detects the distress alert from any COSPAS–SARSAT beacon emitting an alert in the 406 – 406.1 MHz band, and broadcasts this information to dedicated ground stations in the 1544 – 1545 MHz band [see signal (11) in the figure].



Galileo Signals-in-Space Description. Refer to signals (1), (2), …, (11) in the text.

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Galileo – Global Navigation Satellite System (GNSS) (cont.)

Galileo will provide 10 signals in the frequency ranges 1164 – 1215 MHz (E5A and E5B), 1215 – 1300 MHz (E6), and 1559 – 1592 MHz (E2-L1-E1). Details are described below.

Four signals will be transmitted in the band 1164–1215 MHz:

- One pair of signals centered on 1176.450 MHz, in the 1164 – 1188 MHz frequency range (E5A)[π]:
  - 1 signal carrying a low data rate navigation message (25 bps), represented by the signal (1). 1 signal without any data (so–called pilot signal) for increased tracking robustness at receiver level, represented by the signal (2).

- One pair of signals centered on 1207.140 MHz, in the 1188 – 1215 MHz frequency range (E5B):
  - 1 signal carrying a navigation message of 125 bps, also supporting integrity and SAR data, represented by the signal (3).
  - 1 signal without any data (so–called pilot signal) for increased tracking robustness at receiver level, represented by the signal (4).

- The signals in E5A and E5B would be generated coherently, therefore giving the possibility to process them together for (a) increased accuracy, and (b) redundancy (to mitigate interference from DMEs).

[π]Note: This band, also called “L5”, will also support GPS modernized signals which, together with Galileo signals will allow cheap bi–mode GPS/Galileo receivers able to track up to 60 satellites.

Three signals will be transmitted in the band 1260 – 1300 MHz (E6), centered on 1278.750 MHz:

- 1 split-spectrum[τ] signal, secured through government-approved encryption, designed for government applications requiring a continuity of service even in times of crisis, represented by the signal (5).

- One pair of quadrature signals protected through commercial encryption providing high ambiguity resolution capabilities for differential applications, among which:
  - 1 signal carrying a navigation message of 500 bps supporting value–added data for commercial purpose, represented by the signal (6).
  - 1 signal without any data (so–called pilot signal) for increased tracking robustness at receiver level, represented by the signal (7), employing the same waveform as the previous signal (6).

[τ]Note: Split-spectrum signals are used either for selective service denial or for interference minimization between two radio navigation satellite systems sharing the same central frequency carrier.

Three signals will be transmitted in the band 1559 – 1591 MHz (E2–L1–E1), centered on 1575.42 MHz:

- 1 flexible split-spectrum signal secured through government–approved encryption, designed for government applications requiring a continuity of service even in times of crisis, represented by two different waveforms [see signal (8)].

- One pair of quadrature signals[r], as follows:
  - 1 signal carrying a navigation message of 100 bps, also supporting integrity and SAR messages, represented by the signal (9).
  - 1 signal without any data (a so–called “pilot signal”) for increased tracking robustness at the receiver level,

Galileo – Global Navigation Satellite System (GNSS) (cont.)

represented by the signal (10), employing the same waveform as the previous signal (9).

[f]Note: This band is already supporting GPS SPS signals, which, together with Galileo signals will allow cheap bi–mode GPS/Galileo receivers able to track up to 60 satellites.

GLONASS – Global Orbiting Navigation Satellite System

GLONASS is a Russian space–based navigation system comparable to the American GPS system. The operational system contains 21 satellites in 3 orbital planes, with 3 on–orbit spares. GLONASS provides 100 meters accuracy with its C/A (deliberately degraded) signals and 10–20 meter accuracy with its P (military) signals. The GLONASS navigation signals are now transmitted over 25 FDMA (frequency division) channels separated by 0.5625 MHz intervals in 2 frequency bands:

- *L1 (1602.5625 – 1615.5 MHz)*
- *L2 (1242.9375 – 1251.6875 MHz)*

Note: GLONASS has been almost constantly undergoing planned improvements, other changes, and maintenance.

References:

Much of the Galileo information shown above is from official European Commission documents.