REPORT 766-2*

FEASIBILITY OF FREQUENCY SHARING BETWEEN THE GPS AND OTHER SERVICES

(Question 83/8)

(1978-1986-1990)

1. Introduction

This Report refers to Question 83/8, DECIDES 4, i.e. "Is the sharing of frequencies with other systems feasible, and if so, what other systems and under what circumstances?". The Question is addressed for the radionavigation-satellite system, global positioning system (GPS), which provides accurate——————— timing and position determination via two satellite-to-Earth transmission channels. This Report addresses the feasibility of this system sharing the 1215-1240 MHz and 1559-1610 MHz bands with terrestrial stations.

A more thorough description of the ———— GPS system and the rationale behind the selection of frequencies is presented in Annex I.

2. Frequency sharing considerations

The frequency band 1215-1240 MHz is presently allocated on a primary co-equal basis to the radiolocation and radionavigation-satellite services in all three regions. Thus the feasibility of sharing with these stations has been given primary emphasis. Detailed consideration has also been given to other allocated services, i.e. fixed, mobile and radionavigation.

3. NAVSTAR GPS sharing with the radiolocation and radionavigation services

The radiodetermination services presently operating in the 1215 to 1240 MHz radiolocation band are almost exclusively P0N and XXX type emissions with duty cycles between 10^{-2} and 10^{-3}.

3.1 *Interference to the GPS*

The GPS receiver is designed to operate in a pulsed environment. High-speed, rapid-recovery ———— front-end limiters are used to prevent high-energy pulses from damaging the receiver. In addition, intermediate-frequency clipper circuits essentially maintain the peak pulse voltages at the same level as peak noise bursts.

The modulation structure and system logic are such that the system is essentially invulnerable to normal radar signals. The pseudo-random phase-shift signal with a bit rate in excess of 10 MHz is compressed to an information bandwidth of 50 Hz. This provides an extremely large protection ratio against all types of interference of narrower bandwidth than the GPS emissions. Results of various studies have shown that a system of this type, once synchronized, can function satisfactorily in a pulsed environment which has a duty cycle much higher than any operational environment [USA, 1976].

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* The Director, CCIR, is requested to bring this Report to the attention of the International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO).

3.2 *Interference from the GPS to the radiolocation and radionavigation services*

The signal transmitted from the GPS satellite is of uniform power flux density over the visible portion of the Earth and will appear as a noise-like signal over a band of approximately 20 MHz. The majority of radars operating in the 1215 to 1240 MHz band have IF bandwidths much less than 20 MHz and consequently will receive a noise-like signal with a flat spectral power density over the receiver band pass. The amplitude of this signal will be a function of the radiolocation receiver antenna gain in the direction of the satellite and the impact upon the operation of the radiolocation system will be dependent upon the ratio of this signal amplitude to the receiver noise spectral power density or to the receiver threshold.

The antenna gains and receiver noise figures for the radiolocation equipment operating in the 1215 to 1240 MHz band will vary over a wide range depending upon the system mission. It will be convenient here to utilize the concept of the antenna gain/temperature ratio (G/T) in assessing the impact of the GPS signal upon the radiolocation systems.

3.3 *Radar sensitivity*

Virtually all radars operate very near their noise level in order to maximize the detectability of the system. There is normally a threshold level established between 5 and 15 dB above the noise level, chosen to optimize the trade-off between suppressing noise peaks and other anomalous responses (false alarms) and detecting the desired signals. Interference power from well below the noise level up to just below the threshold level manifests itself as an increasing number of false alarms. The interference power level at the receiver input is given by:

$$(I)_{dB} = (SPFD)_{dB} + (A_e)_{dB} + (B)_{dB} \qquad (1)$$

where

$(I)_{dB}$ means 10 log I,

I: interference power in watts,

$SPFD$: GPS satellite spectral power flux-density at earth surface (W/(m^2 · Hz)),

A_e: effective antenna aperture of the ground receiving antenna in the direction of the satellite,

B: ground receiver bandwidth in Hz,

$$A_e = \frac{G\lambda^2}{4\pi} \qquad (2)$$

where

G: ground receiving antenna power gain,

λ: GPS wavelength = 0.2444 m,

$$(I/N)_{dB} = (I)_{dB} - (kTB)_{dB} \qquad (3)$$

where

k: Boltzmann's constant = 1.38×10^{-23} joule K^{-1},

T: receiver noise temperature (K),

B: receiver noise bandwidth (Hz),

I/N: interference to receiver noise ratio that would produce noticeable degradation.

From equations (1), (2) and (3) we have:

$$(G/T)_{dB} = -205.4 + (I/N)_{dB} - (SPFD)_{dB} \qquad (4)$$

where:

$(G/T)_{dB}$: maximum ratio of gain of ground antenna to receiver noise temperature for which limiting interference to noise ratio will not be exceeded.

The power flux-density from the satellite L2 signal (see Annex I) in a full capability GPS has been determined to be -200.0 dB(W/(m^2 · Hz)). This value includes a margin allowing for satellite ageing, signal fading, etc. Substituting this value into equation (5):

$$(G/T)_{\mathrm{dB}} = (I/N)_{\mathrm{dB}} - 5.4 \tag{5}$$

The value of I/N will vary with the type of radar and some of its basic circuits. For a value $I/N = 0$ dB, the false alarm rate for a simple PPI radar with no clutter, jamming or interference suppression circuits would be degraded from 10^{-n} to $10^{-n/2}$ if the G/T in the direction of the GPS satellite exceeded -5.4 dB [Barton, 1965]. The range of acceptable values of I/N might extend from -10 dB for very sensitive systems to values exceeding $+20$ dB for systems with automatic clutter suppression and anti-jamming circuits.

For the remainder of this discussion, a value of 0 dB will be assumed for I/N.

3.4 *Variation in G/T*

In the band 1215 to 1240 MHz, the antenna sizes range from 1.8 m (6 feet) to 12 m (40 feet) or 15 m (50 feet) for a range of gains 19 dB to 35 dB. Noise figures range from a few dB to $+15$ dB. The G/T for the main beam illumination of the satellite is given below for three representative systems:

- a small transportable radar with a 3 metre antenna and a 9 dB noise figure would have a G/T of -10 dB,
- a large search radar with a 15 metre antenna and a 5 dB noise figure would exhibit a $+10$ dB G/T,
- space tracking systems with phased-array antennas of 30 metres and noise figures as low as 1.5 dB have a G/T as high as $+26$ dB.

Considering the above examples, it appears that small transportable radars could operate with little or no observable degradation while the larger systems might find compatible co-channel operations difficult.

4. Sharing with the fixed and mobile services and other CW type stations

4.1 *Interference from the GPS to the fixed and mobile stations*

Power flux-density limitations on the Earth's surface have been specified for space stations operating in the fixed satellite service which share frequencies with the fixed service. These are stated in Recommendation 357 for frequency bands from 1.7 to 23 GHz. Extrapolation of these data to a lower frequency, i.e. 1.2 GHz, would indicate that a power flux-density of -156 dB(W/(m^2 · 4 kHz)) would suffice for GPS sharing with the fixed and mobile services. The stated GPS L2 requirement of -164 dB(W/(m^2 · 4 kHz)) should cause no problems. Such services are unlikely to be degraded unless high gain antennas are used, as for tropospheric scatter systems.

4.2 EMC analysis of GPS wideband receiver and terrestrial aeronautical public correspondence

This section addresses interference considerations for a basic wideband GPS receiver utilizing both the precision (P) and coarse/acquisition (C/A) pseudo-random noise (PRN) codes. Interference to a narrow-band GPS receiver utilizing only a C/A code is not considered.

As seen from the table of GPS receiver characteristics contained in Annex I (i.e. for a typical, low-cost, navigation-air receiver), there is not much filtering at 1 593 - 1 594 MHz. Many receivers currently in production have at most 3 dB attenuation due to the filter and, as a consequence, the signal from the aeronautical public correspondence (APC) ground-to-air link appears as an interference source. Further study of the achievable RF filter attenuation is needed, especially insofar as this is a critical factor in the frequency sharing.

The first step in determining the required distance separation between aircraft and APC base is to calculate the APC signal strength at the aircraft GPS receiver input after free space propagation loss, using the following equation:

$$P_R = P_T + G_T + G_R - FDR - L_P \qquad (1)$$

where:
P_R = received signal power, in dBm
P_T = transmitter power output, in dBm
G_T = transmitter antenna gain, in dBi
G_R = receiver antenna gain, in dBi
FDR = frequency-dependent rejection, in dB
L_P = propagation path loss, in dB

G_R for the GPS antenna is normally 0 dBi, and FDR is 3 dB. The above equation assumes that there is no shielding from the fuselage, and the receiver is within the line-of-sight of the APC transmitter. The propagation loss, LP, is given by equation (2) below (for free-space propagation loss only):

$$L_P = 20 \log f + 20 \log D - 27.56 \qquad (2)$$

where:
f = transmitted frequency, in MHz
D = distance, in m

Combining and rearranging Equations 1 and 2 to solve for distance and using 30 dBm as the limiter burnout criterion for received power level results in Equation 3:

$$D = \text{Log}^{-1} \{(P_T + G_T - 20 \text{ Log } f - 5.44)/20\} \qquad (3)$$

Assuming a ground based APC transmitter with an EIRP of 46 dBm in the direction of the GPS receiver, the above equation is solved for the distance required to prevent burnout of the high-level clipper. The distance is less than one-tenth meter. Similarly, using -40 dBm as the limiter saturation criterion, the required distance to prevent saturation of the GPS receiver is determined to be 212 m.

If the above minimum required distance separations are met, the GPS receiver will operate without experiencing burnout or saturation; however, the undesired signal strength may still exceed the thresholds for signal acquisition and/or tracking. For normal acquisition by L1 C/A signal, the previously established threshold is -106 dBm. But the APC signal will be spread by the locally generated C/A code replica during correlation. Assuming that the APC signal is narrowband CW, its spectrum will have a $\sin^2 x/x^2$ power distribution of the C/A code. Nulls in the spectrum occur at frequency multiples of 1.023 MHz. The portion of its signal spectrum which falls into the 1 kHz bandwidth of the detection circuit or into the 50 Hz bandwidth of the carrier tracking loop corresponds more or less to the 17th sidelobe because of relative Doppler frequency shift. At $x = 17.5(\pi)$, the signal level is about 35 dB down from that of the main lobe. Adding the 3 dB filter attenuation to this, the total frequency dependent rejection is 38 dB.

In the above calculation, the rejection of the APC signal by the bandwidth narrowing of either the detection circuit or the tracking loop has been excluded because it has already been accounted for in the determination of the tolerable interference signal level. Substituting FDR = 38 dB into Equation 1, and solving the distance separation required for L1 C/A signal acquisition, the answer is 7508 m. ——— Similarly, using the threshold of -99 dBm, the required distance separation for L1 C/A signal tracking is determined to be 3354 m.

The reduction of APC signal due to spreading by the L1 P code in the correlation process is about 17 dB. Hence, FDR is only 21 dB instead of 38 dB for the L1 C/A code. Using the same approach as before and the threshold of -92 dBm, the required distance separation for receiver state 5 operation of L1 P signal is calculated as 10605 m.

Note the above calculations have not taken into account the emission spectrum of the APC signal itself because it is unknown at present. Also, only a single interfering signal is assumed in the above analysis. But under some conditions, multiple emissions from APC transmitters may be present. A more complete analysis is needed to characterize the aggregate interference effects. Further reduction of the required separation distances for compatible operation may be possible by additional attenuation of unwanted signals at 1593-1594 MHz, but it will increase the size, weight and cost of the receiver. The APC transmitter colocated on the aircraft with the GPS receiver should not cause intolerable RFI since the operating frequency (1625.5 - 1626.5 MHz) is outside the 45 dB RF filter bandwidth. Therefore, only standard precautions to ensure isolation between the GPS receiver and APC transmitter should be taken.

5. Conclusion

5.1 *Sharing with the radiolocation and radionavigation services*

There are radiolocation systems which can operate on a frequency sharing co-equal basis with the GPS. However, certain radar equipments with large antenna could suffer interference from GPS signals.

5.2 *Sharing with the fixed and mobile services*

The power flux-density of the GPS signal at the Earth's surface appears to be sufficiently low to preclude interference to these services.

Transmissions of the fixed or amateur service stations can cause degradation to the GPS system over very large areas.

REFERENCES

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ANNEX I

TECHNICAL CHARACTERISTICS OF THE GLOBAL POSITIONING SYSTEM (GPS)

1. GPS system

1.1 Introduction

The US Government is implementing a satellite system for the radionavigation satellite service. The system as proposed will provide accurate position determination in three dimensions anywhere on or near the surface of the Earth.

The system, in its operational form, known as the Global Positioning System (GPS) will consist of 24 satellite positions (21 primary satellites and three on-orbit active spares) with four satellite positions in each of six 55 degree inclined equally spaced orbital planes. Each satellite will transmit the same two frequencies for navigational signals. These navigational signals are modulated with a predetermined bit stream, containing coded ephemeris data and time, and having a sufficient bandwidth to produce the necessary navigation precision without recourse to two-way transmission or Doppler integration.

1.1.1 Frequency Requirements

The frequency requirements for the GPS system are based upon an assessment of user accuracy requirements, space-to-Earth propagation delay resolution, multipath suppression, and equipment cost and configurations. Two channels were selected for GPS operations: 1 575.42 MHz (L1) and 1 227.6 MHz (L2) [United States, 1976]. The L1 channel will be used to resolve a user's location to within 150 m. A second signal transmitted on both L1 and L2 channels, provides the necessary frequency diversity and wider bandwidth for increased range accuracy for Earth-to-space propagation delay resolution and for multipath suppression to increase the total accuracy by an order of magnitude. Telemetry and maintenance signals from US based control facilities to the satellite and return will be accommodated in the allocated telemetry band in the US.

GPS will provide worldwide navigation service. The requirement for navigation safety (refer to RR 953) demanded by such a service underscores the critical importance that APC transmitters not cause harmful interference to GPS receivers.

1.2 System Overview

GPS is a space-based, all-weather, continuous radionavigation, positioning and time-transfer system which will provide extremely accurate three-dimensional position and velocity information together with a precise common time reference to suitable equipped users anywhere on or near the surface of the earth.

The system operates on the principle of passive triangulation. The GPS user equipment first measures the pseudoranges to four satellites, computes their positions, and synchronizes its clock to GPS by the use of the received ephemeris and clock correction parameters. It then determines the three dimensional user position in a Cartesian earth-centered, earth-fixed (ECEF) WGS-84 coordinate system, and the user clock offset from GPS time by essentially calculating the simultaneous solution of four range equations.

Similarly, the three-dimensional user velocity and user clock-rate offset can be estimated by solving four range rate equations given the pseudorange rate measurements to four satellites. The measurements are termed as "pseudo" because they are made by an imprecise user clock and contain fixed bias terms due to the user clock offsets from GPS time.

GPS provides two navigation accuracy levels: the Precise Positioning Service (PPS) and the Standard Positioning Service (SPS). For the PPS, the 95 percentile horizontal, vertical and time accuracies are 18 m , 30 m and 170 ns, respectively. The corresponding SPS accuracies are 100 m , 166 m and 330 ns. The velocity accuracy derived from PPS is almost entirely dependent on receiver design and user dynamics, but a 95 percentile accuracy of 0.2 m/s per axis can be typically achieved.

1.3 System Description

The system consists of three major segments: the Space Segment, the Control Segment, and the User Segment. The principal function of each segment is as follows:

1.3.1 Space Segment

The Space Segment comprises the GPS satellites, which function as "celestial" reference points, emitting precisely time-encoded navigation signals from space. As currently planned, the operational constellation of 21 primary satellites plus 3 active spares will operate in 12-hour orbits with a semimajor axis of about 26,600 km. The satellites will be placed in six orbital planes inclined 55 degrees relative to the equator. There will be 4 satellites per plane. The satellites will be optimally phased to provide visibility of at least five satellites to the users at 5 degrees above the horizon.

The satellite is a three-axis stabilized vehicle. The major elements of its principal navigation payload are the atomic frequency standard for accurate timing, the processor to store navigation data, the pseudo random noise (PRN) signal assembly for generating the ranging signal, and the 1.5/1.6 GHz band transmitting antenna whose shaped-beam gain pattern radiates near-uniform power of signals at the two 1.5/1.6 GHz band frequencies to users on or near the surface of the earth. The dual-frequency transmission is to permit correction of ionospheric delays in signal propagation time.

1.3.2 Control Segment

The Control Segment performs the tracking, computation, updating, and monitoring functions needed to control all of the satellites in the system on a day-to-day basis. It consists of a Master Control Station (MCS) at Colorado Springs, where all data processing is performed, and five widely separated monitor stations at Ascension Island, Diego Garcia, Kwajalein, Colorado Springs, and Hawaii. Co-located with three of the monitor stations are the upload ground antennas for satellite maintenance.

The monitor stations passively track all satellites in view and accumulate ranging and Doppler data. This data is processed at the MCS for calculation of the satellite's ephemerides, clock drifts, and propagation delay and then used to generate upload messages. At least three times per day this updated information is transmitted to the satellites for memory storage and subsequent transmission by the satellites as part of the navigation messages to the users.

1.3.3 User Segment

The User Segment is the collection of all user sets and their support equipment. The user set typically consists of an antenna, GPS receiver/processor, computer and input/out devices. It acquires and tracks the navigation signal from four or more satellites in view, measures their RF transit times and Doppler frequency shifts, converts them to pseudoranges and pseudorange rates, and solves for three-dimensional position, velocity, and system time. User equipments will range from relatively simple light-weight, manpack receivers to sophisticated receivers which are integrated with other navigation sensors or systems for accurate performance in high-dynamic environments.

1.4 GPS Signal Structure

The GPS navigational signal transmitted from the satellites consists of two modulated carriers: L1 at center frequency of 1575.42 MHz (154 f_o) and L2 at center frequency of 1227.6 MHz (120 f_o), where f_o = 10.23 MHz. f_o is the output of the on-board atomic frequency standard to which all signals generated are coherently related.

The L1 signal is modulated with both a precision (P) and a coarse/acquisition (C/A) pseudo-random noise (PRN) code, each of which is modulo-2 added to a 50 bit/s binary navigation data stream prior to phase modulation. The P code is a long binary pseudo-random sequence of zeros and ones with a clock rate of 10.23 MHz and a period of exactly 1 week. Every Saturday/Sunday midnight, it restarts, serving as running indicator of time of the week in the space vehicle. The C/A code is a short code, having a clock rate of 1.023 MHz and period of exactly 1 msec.

The L2 signal is bi-phase modulated with either the P or C/A code, as selected by ground command. The same 50 bps data stream is modulo-2 added to the code prior to phase modulation as is done on the L1 signal. During normal operations, the P-code will be transmitted on L2.

The operation of biphase modulation onto the carrier maps the binary PRN code sequences into sequences of plus and minus ones, and turns the modulo-2 addition into multiplication. Thus, the L1 and L2 signals transmitted by the satellite can be described as a function of time.

The functions of the PRN codes are twofold: (1) they provide good multiple access properties among different satellites since all satellites transmit on the same two carrier frequencies and are differentiated from one another only by the unique pair of P and C/A codes they transit, and (2) their correlation properties allow precision measurement of time of arrival and rejection of multipath and interference signals.

The 50 bit/s data stream provides the navigation message which is formatted in five subframes of 6 seconds in length. Each subframe, consisting of ten 30-bit words starts with a telemetry word (TLM) and the C/A to P-code handover word (HOW). The latter permits the C/A to P transfer to be made at the termination of any six-second subframe. The first three subframes contain the clock correction and ephemeris data of the particular satellite being tracked. These messages are normally valid for a 4-hour period.

Subframes 4 and 5 contain the almanac information that defines the less precise ephemerides of all the satellites in the constellation, as well as satellite health status, special messages, offset of GPS time from Universal Time Coordinated (UTC), etc. There are 25 pages of data each for Subframes 4 and 5, and they are transmitted on a rotating page basis. It, therefore, takes 6 seconds to receive one page and 2.5 minutes to receive all 25 data pages.

1.5 Signal Power & Spectra

The GPS satellites employ a shaped-beam antenna that radiates near-uniform power to system users. Transmitted signals are right-hand circularly polarized with the ellipticity for L1 no worse than 0.7 dB and for the L2 no worse than 2.0 dB for the angular range of +/- 14.3 degrees from boresight. For satellite elevation angle >= 5 degrees, the minimum guaranteed power is specified as -133 dBm for the L1 P-code component and -130 dBm for the L1 C/A code component. The corresponding L2 power level carrying only P-code is at least -136 dBm. The actual power received from the satellites is currently 4-5 dB higher than the specified values.

2. Operating Frequency

Primary operation (L1) is in a segment of band 9 allocated to Radionavigation-Satellite.

3. Telemetry Functions

The GPS is a passive system. There is no need for a navigational up link. Therefore, spectrum is conserved by placing telemetry and housekeeping functions in bands allocated for such use.

4. **Receiver Characteristics**

Different GPS receiver configurations are suitable for different applications having various levels of host vehicles dynamics and interference environments. The typical characteristics of an inexpensive, unsophisticated receiver are used for this EMC analysis between APC and GPS (See Table 1).

A typical GPS user equipment is comprised of four principal components: antenna, received/processor, computer, and the CDU (control and display unit). The antenna in most cases is a relatively simple element providing hemispheric coverage of both L1 and L2 frequencies. This omnidirectional antenna will have no need for pointing to receive all visible satellite signals, but it will also not have much capability to discriminate spatially against interference.

The RF front end of the receiver typically consists of a bandpass filter, a preamplifier, and a multi-state down-converter. The bandpass filter is to provide rejection of out-of-band signals. To prevent high-power interference from damaging the receiver, the preamplifier/filter assembly will also have a diode limiter.

After amplification and down-conversion to a convenient IF, the receiver then generates and attempts to match the incoming code pattern for a particular satellite. The process is called correlation or code despreading. After code despreading, the receiver bandwidth is reduced whereas any interference signal will be spread by the locally generated replica code. The normal acquisition is to synchronize to the C/A signal and then transfer to P. This is the most vulnerable operating state of the receiver (state 1) to outside interference because it has not yet locked onto the code.

Once the code is acquired, the alignment or synchronization of the incoming signal and the locally generated replica is maintained by both the code and carrier tracking loops. With the carrier and code loops in lock, the receiver can demodulate the data, measure the pseudorange and pseudorange rate. This operating state of the receiver (state 5) can be maintained if the interference signal level is 41 dB higher than either L1 P or L2 P signal, and 31 dB higher than L1 C/A signal. Most receiver designs convert their correlator outputs into digital form and perform their tracking loops plus other receiver control logic with software.

5. Interference Thresholds

The GPS receiver is susceptible to two forms of interference. The first interference mechanism affects the high-level limiter diode in the RF front end. The diode will saturate and prevent burnout of the following receiver stages when the peak RF power level at the receiver input equals or exceeds -40 dBm, causing a temporary loss of signal. If the average RF power at the receiver input exceeds 1 watt or peak RF power exceeds 10 watts, the high-level clipper diode may fail because of burnout.

The second interference mechanism affects the detection process of the GPS receiver. When the interference adds noise to the receiver it affects the acquisition and tracking performance by reducing the signal-to-noise ratio in the detection circuitry or in the tracking loops. The maximum interference level tracking performance can tolerate without significantly increasing its acquisition time is 24 dB above the L1 C/A signal level. By comparing this interference level to the specified minimum received L1 C/A signal power, the interference threshold for normal acquisition is determined to be -106 dBm. At levels above this, acquisition time becomes degraded. Similarly, the interference thresholds for state 5 operation are -92 dBm for the L1 P and -99 dBm for the L1 C/A signal.

6. Work in CCIR

The development of such systems has been under careful study of the CCIR for a number of years, several Reports and Recommendations have been approved.

TABLE 1

GPS RECEIVER CHARACTERISTICS
(For typical, low-cost navigation-air receiver)

L1 Carrier Frequency	1575.42 MHz
L2 Carrier Frequency	1227.6 MHz
P Code Chip Rate	10.23 Mbit/s
C/A Code Chip Rate	1.023 Mbit/s
Navigation Data Rate	50 bit/s
Undetected Bit Error Rate	10^{-5}
Minimum Received Power Level (L2, P)	-136 dBm
Minimum Received Power Level (L1, P)	-133 dBm
Minimum Received Power Level (L1, C/A)	-130 dBm
Preamplifier Limiting Level	-40 dBm
Preamplifier Burnout Level	30 dBm Ave. 40 dBm Peak
Overload Recovery Time	1 s
RF 3-dB Filter Bandwidth	+/- 17 MHz
RF 45-dB Filter Bandwidth	+/- 50 MHz
Isolation Between L1 and L2	40 dB
Receiver Noise Figure	3 dB
Normal Acquisition I/S Margin (L1, C/A)	24 dB
State 5 Tracking I/S Martin (L1, C/A)	31 dB
State 5 Tracking I/S Margin (L1, P)	41 dB