PHELPS DODGE MORENCI, INC.
FCC Form 442
Application for Modification of License
Station WB2XIG

Attachment 1

By the instant application, Phelps Dodge Morenci, Inc. ("PDMI") respectfully requests Commission consent to modify the license for Station WB2XIG (the "Station"). Specifically, Commission consent is sought to the relocation of the six (6) previously authorized terrestrial GPS pseudolites to an area less than one (1) mile from their currently authorized locations. As explained in its original application, PDMI intends to utilize these facilities to determine whether and to what extent pseudolites can support safety of life applications in the area of mining operations. Relocation of the pseudolites is necessary, as set forth in this application, because PDMI has completed its mining activities in the previously authorized locations and is moving its mining operations to the locations specified in the instant application. By relocating the pseudolites to the new geographic coordinates specified herein, PDMI will be in a position to continue its previously authorized experiments utilizing the Station's facilities.

It is noted that, other the relocation of the pseudolites to the new geographic coordinates specified herein, PDMI is not requesting any other modifications to the technical aspects of the Station's facilities. In that regard, for the convenience of the Commission, attached to this Attachment (and incorporated herein by reference) are Exhibits 1, 2 and 3 to PDMI's previous application for authorization of the Station's facilities.

PHELPS DODGE MORENCI
Experimental License Application

EXHIBIT 1

In this Exhibit, Phelps Dodge Morenci presents an explanation of the spectrum which is proposed to be used under this experimental license.

The Global Positioning System (GPS) currently broadcasts on two frequencies (1575.42 MHz and 1227.60 MHz). These are known as the L1 and L2 frequencies, respectively. A third frequency (1176.45 MHz), known as L5, has been approved for future use. Phelps Dodge Morenci requests an experimental license to broadcast signals at the L-1 frequency to be used by GPS receivers of current design to improve their navigation accuracy and reliability.

The existing GPS satellite signals are spread spectrum signals occupying a band 24 MHz wide centered on each of the above frequencies. The signal from each satellite occupies essentially the entire band. Signals from individual satellites are distinguished using Code Division Multiple Access (CDMA) techniques.

Phelps Dodge Morenci intends to experiment with signals identical to the existing GPS satellite signals, occupying the same bandwidth. Phelps Dodge Morenci also intends to experiment with signals slightly different than the existing GPS satellite signals, with the goal of minimizing interference with the satellite signals. Exhibit 2 describes these signals in detail.

Because the intent of this experiment is to broadcast signals identical or similar to the existing GPS satellite signals, Phelps Dodge Morenci requests an experimental license covering the same spectrum as those existing signals (i.e. 24 MHz centered on 1575.42 MHz).

In an experimental license application filed in May 1998, file number 6167-EX-PL-98, Trimble Navigation applied for experimental use on the same spectrum, in conjunction with the same tests Phelps Dodge Morenci will be involved with. We are attaching as Attachment A, information from the FAA regarding the project that led to the experiments with pseudolites.

EXHIBIT 2

In this exhibit, Phelps Dodge Morenci presents an explanation of the signal formats which are proposed to be used under this experimental license. More detail on the existing GPS signal formats (P-code and C/A-code) can be found in the GPS Interface Control Document (ICD-200), available on the Web at http://gps.laafb.af.mil/y2000/icd200c.pdf.

The GPS system transmits two signals known as the clear/access (C/A-code) signal and the precise (P-code) signal. (The P-code is currently encrypted for broadcast into another code known as Y-code. Phelps Dodge Morenci does not contemplate any use of Y-code under this application.)

<u>C/A-code</u>

The C/A code signal is a spread-spectrum signal produced by binary phase shift keying (BPSK) modulation of a carrier signal by a digital bit stream known as the C/A code. The C/A code is a repeating bit sequence 1023 bits long chosen from a particular family of so-called •Gold codes.• Each GPS satellite transmits a different Gold code from this family as its C/A code. Gold codes are used because the maximum interference (•cross-correlation•) between any two Gold codes from the same family is known to be small. The GPS satellites all transmit their C/A codes on the same frequency, but this cross-correlation property allows each signal to be distinguished from the others. This technique is known as code division multiple access (CDMA).

The C/A code is transmitted using BPSK at a rate of 1.023 Mbps, so that it repeats exactly 1000 times per second. This generates a (sin x)/x type of signal with a main lobe and smaller side lobes. The nulls between the side lobes are located at the center frequency plus or minus N times 1.023 MHz, where N is any integer. The occupied bandwidth of this signal (47 CFR 2.202), computed by direct numerical integration of a mathematically perfect unfiltered signal, is approximately 21.2 MHz. The actual C/A-code signal transmitted by the GPS satellites is transmitted through the same filter used for the P-code signal (described below). The occupied bandwidth of the resulting signal is slightly narrower at approximately 20.5 MHz.

The C/A code signal is further modulated by stream of navigation data bits transmitted at 50 bps. This data bit stream is synchronous with the C/A code so that exactly 20 repetitions of the C/A code are transmitted during each data bit. The data bits are transmitted by inverting the C/A code during data bits equal to •one•.

Although the •necessary bandwidth• (47 CFR 2.202) is part of the •emission designator• (47 CFR 2.201), the method for calculating the necessary bandwidth of the C/A code signal is not obvious from the regulation. Using the occupied bandwidth rather than the necessary bandwidth, the emission designator for the C/A code signal as transmitted by a GPS satellite would be 21M2G1D or perhaps 20M5G1D.

P-Code

The P-code signal is a spread-spectrum signal produced by binary phase shift keying (BPSK) modulation of a carrier signal by a digital bit stream known as the P-code. The P-code is an extremely long pseudo-random bit stream generated by combining the outputs of four feedback shift registers. The P-code repeats once per week because the generator is reset once per week. Further details of the P-code generator are available in ICD-200.

The P-code is transmitted using BPSK at a rate of 10.23 Mbps. Again, this generates a (sin x)/x type of signal with a main lobe and smaller side lobes. The nulls between the side lobes are located at the center frequency plus or minus N times 10.23 MHz, where N is any integer. The GPS satellites filter this signal so that only the main lobe is transmitted. The main lobe is 20.46 MHz wide. Because no filter is perfect, the frequency allocation for each GPS frequency is a total of 24 MHz wide including guard bands. The actual filter characteristic for the GPS satellites is not specified in ICD-200. Reasonable guesses for the occupied bandwidth of the actual transmitted P-code signal range from 20.5MHz to just under 24 MHz.

Split Spectrum

The GPS user community has proposed a signal format for use by pseudolites which combines features of C/A-code and P-code. This new format is known as •split-spectrum• or occasionally •G-prime mode.• The goal of the split-spectrum format is to minimize interference with the existing GPS satellite C/A-code and P-code signals. It does this by moving the signal power of a standard C/A-code signal into the nulls of the P-code main lobe at 10.23 MHz above and below the carrier frequency. This can be accomplished in the analog domain by using the C/A-code bit stream to modulate a 10.23 MHz sine wave and then using this composite signal to modulate the main carrier. Alternatively, the split-spectrum signal can be generated in the digital domain by combining the C/A-code bit stream with a 10.23 MHz square wave and then modulating the main carrier with this composite digital signal. The split-spectrum signal must be filtered with a bandwidth of at least 2.2 times 10.23 MHz, or 22.51 MHz, to preserve both main lobes of the split C/A-code signal. Again using the occupied bandwidth, the emission designator for a split-spectrum signal would be 22M5G1D.

The GPS user community has proposed a modification of the split-spectrum signal for use in certain applications. This modified signal consists of either the high-frequency lobe or the low-frequency lobe of the split-spectrum signal, but not both together. While such a signal could be considered as simply a C/A-code signal transmitted on a frequency 10.23 MHz higher or lower than the nominal center frequency, the GPS user community prefers to think of such a signal as being simply one-half of the more complete split-spectrum signal transmitted at the nominal center frequency.

Pulsed Transmissions

The GPS user community has long proposed that pseudolites transmit in short pulses, to minimize potential interference with the GPS satellite signals. Several pulse patterns have been proposed, but the optimum pulse pattern or format has never been identified. Much experimentation remains to be done.

The previously proposed pulse patterns include:

- Even spacing, 1 kHz pulse rate
- Even spacing, 3 kHz pulse rate
- Pseudo-random spacing, 1 kHz average pulse rate (•RTCM• 104• pattern)
- Pseudo-random spacing, 2 kHz average pulse rate (•RTCA SC•159• pattern)
- Pseudo-random spacing, 3 kHz average pulse rate

These pulse patterns (and others to be determined) will be tested with pulse widths which produce average pulse duty cycles from one percent to fifteen percent.

The appropriate emission designator for a pulsed 22M5G1D signal appears to be 22M5V1D.

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EXHIBIT 3

Explanation of the Project

Technical Characteristics:

The experimental program described in this application involves the establishment of terrestrial GPS pseudolites operating at the standard GPS L1 frequency as described in Exhibit 1. The pseudolites will transmit various combinations of the signal formats and pulse formats described in Exhibit 2. These combinations cannot be completely specified in advance, because the object of this experimentation is to determine the optimum combinations. The starting point for these experiments will be the signal format and pulse format defined by the RTCA SC•159 committee. Emissions will be confined to the bands previously allocated for GPS signals (bands 24 MHz wide, centered on the L1 frequency).

In general, the pseudolite signals will be transmitted in pulses less than fifteen percent duty cycle, to minimize interference with existing GPS receivers. The peak transmitted power (EIRP) will be 2 Watts or less. One objective of the program is to investigate the required power levels and pulse patterns with the purpose of minimizing power used.

Program Description/Objectives:

In this application, Phelps Dodge Morenci is seeking experimental authority to operate pseudolites at this location. There are six locations filed simultaneously to engage in similar tests. Operations at these facilities will take place during the period immediately following grant of this application.

The applicant•s experimental program responds to an invitation from the federal agencies responsible for administration of the GPS system to companies that are interested in producing pseudolite systems that augment basic GPS satellite services. Such companies were, as shown in Attachment A to this applications invited to test, document and demonstrate prototypes that have been developed using RTCA SC-159 standards. Phelps Dodge Morenci recognizes that it is to bear its own costs in this program. If the tests prove successful, however, and many applications could be discovered for this technology.

Contribution to the Development, Extension, Expansion or Utilization of the Radio Art:

The experimental program is based upon the precept that the use of pseudolites at the GPS L1 P(Y) code nulls is an augmentation of GPS that will lead to an improvement of GPS services. See Attachment A. Pseudolites clearly have the ability to support aviation, particularly aviation safety in low visibility conditions. The objective of this experiment is to determine whether and to what extent pseudolites can also support other safety of life applications, including improved safety in mining operations. They are a complementary use to GPS of the aeronautical radio-navigation service/radio-navigation satellite service spectrum in the 1559-1610 MHz band and they enhance the already substantial value of the dual-use GPS utility.