CHAPTER 2 GPS PRINCIPLES

CHAPTER CONTENTS

Refer to this chapter for the following:

- A description of the NAVSTAR GPS segments.
- An explanation of the GPS navigation message.
- A list of available public GPS information services.

About NAVSTAR GPS

OVERVIEW

The NAVigation Satellite Timing and Ranging (NAVSTAR) GPS is an all weather, radio based, satellite navigation system that enables users to accurately determine 3-dimensional position, velocity, and time worldwide. The overall system consists of three major segments: the space segment, the ground control segment, and the user segment.

Space Segment

The space segment is a constellation of satellites operating in 12-hour orbits at an altitude of 20,183 km (10,898 nmi). The constellation is composed of 24 satellites in six orbital planes, each plane equally spaced about the equator and inclined at 55 degrees.

Ground Control Segment

The ground control segment consists of a master control center and a number of widely separated monitoring stations. The ground control network tracks the satellites, precisely determines their orbits, and periodically uploads almanac ephemeris, and other system data to all satellites for retransmission to the user segment.

User Segment

The user segment is the collection of all GPS user receivers (such as your Motorola Oncore GPS Receiver) and their support equipment. Navigation with the receiver is accomplished by passive multilateration. More simply, the GPS Receiver's position is determined by the geometric intersection of several simultaneously observed ranges (satellite to receiver distances) from satellites with known coordinates in space. The receiver measures the transmission time required for a satellite signal to reach the receiver. Transit time is determined using code correlation techniques. The actual measurement is a unique time shift for which the code sequence transmitted by the satellite correlates with an identical code generated in the tracking receiver. The receiver code is shifted until maximum correlation between

User Segment (Continued)

the two codes is achieved. This time shift multiplied by the speed of light is the receiver's measure of the range to the satellite. This measurement includes various propagation delays, as well as satellite and receiver clock errors. Since the measurement is not a true geometric range, it is known as a pseudorange. The receiver processes these pseudorange measurements along with the received ephemeris data (satellite orbit data) to determine the user's three-dimensional position. A minimum of four pseudorange observations are required to mathematically solve for four unknown receiver parameters (i.e., latitude, longitude, altitude, and clock offset). If one of these parameters is known (for example, altitude fixed) then only three satellite pseudorange observations are required and thus only three satellites need to be tracked.

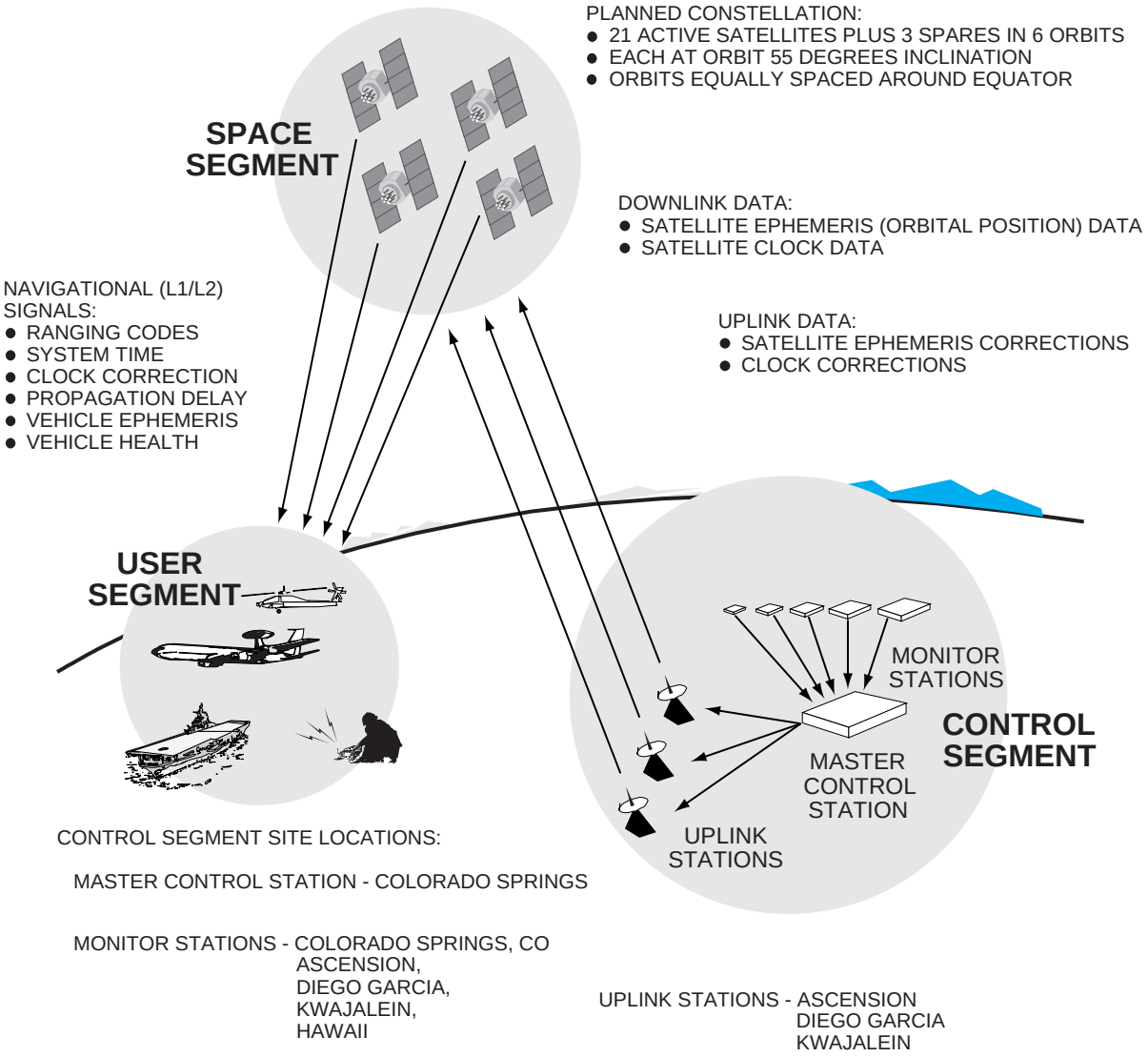

Figure 2.1: NAVSTAR GPS Segments

About the GPS Navigation Message

GPS NAVIGATION MESSAGE

The GPS navigation message is the data supplied to the user from a satellite. Signals are transmitted at two L-band frequencies, L1 and L2, to permit corrections to be made for ionospheric delays in signal propagation time in dual frequency receivers.

The L1 carrier is modulated with a 10.23 MHz precise (P-code) ranging signal and a 1.023 MHz clear acquisition (C/A code) ranging signal. These are pseudo random noise (PRN) codes in phase quadrature. The L2 signal is modulated with the P-code only. Both the L1 and L2 signals are also continuously modulated with a data stream at 50 bits per second. The P-code is a PRN sequence with a period of 38(+) weeks. The C/A code is a shorter PRN sequence of 1023 bits having a period of one millisecond. The P-code is intended for military use and is only available to authorized users. Access to GPS by civilian users is provided through the C/A coded signals.

The navigation message consists of a 50 bit per second data stream containing information enabling the receiver to perform the computations required for successful navigation. Each satellite has its own unique C/A code that provides satellite identification for acquisition and tracking by the user.

Additional Information Sources

PUBLIC INFORMATION SERVICES

There are several GPS related sites on the World Wide Web (www) that are excellent sources to obtain further information about GPS and the current status of the satellites.

U.S. Coast Guard Navigation Center
Civilian GPS service notices, general system information, and GPS outage reporting:
www.navcen.uscg.mil/gps/GPS.HTM

U.S. Naval Observatory
General USNO information and links to USNO timing and other useful sites:
www.usno.navy.mil

NAVSTAR GPS Homepage
General GPS information and links to other useful GPS sites:
www.laafb.af.mil/SMC/CZ/homepage

National Marine Electronics Association (NMEA)
For information on the NMEA protocol specification:
www.nmea.org

Radio Technical Commision Marine (RTCM)
For information on the RTCM specification for DGPS corrections:
www.navcen.uscg.mil/dgps/dgeninfo/RTCM104.txt

General GPS Information
Glossary of GPS terms:
www.gpsworld.com/resources/glossary.htm

Helpful equations and code snippets and other useful information:
www.utexas.edu/depts/grg/gcraft/notes/gps/gps.html

Oncore GPS Information
For the latest information on Oncore GPS products:
www.oncore.motorola.com