NAVSTAR

GLOBAL POSITIONING SYSTEM

PROGRAM MANAGEMENT PLAN

15 JULY 1974



SAMSO/YE

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DEPARTMENT OF THE AIR FORCE

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ATTNOF: YE

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SUBJECT: Program Management Plan (PMP)

Mr. R. Easton, Naval Research Lab/Code 7960, WASH, D.C. 20375

1. The attached Program Management Plan for the NAVSTAR, Global Positioning System (GPS) is provided to you for use during the definition, design, development, testing, acquisition, and operation of the GPS. This document is the Joint Program Office (JPO) operating plan for system management throughout the life cycle of the program beginning with Phase I, Concept Validation. As the program progresses, the PMP will be updated to reflect current status and progress and to eincorporate recommended changes approved by the Joint Program Manager.

2. For further information you may contact Maj H. S. Hughes, SAMSO/YEC (Ext. 32737).

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BRADFORD W. PARKINCON, Colonel, USAF Deputy for Space Navigation Systems



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Approved by Braches W. Carkinson, BRADFORD W PARKINSON, Col, USAF Program Manager, NAVSTAR Global Positioning System

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FORWORD

This Program Management Plan (PMP) establishes Joint Service Program Office (JPO) executive policies and implementing procedures for the management and acquisition of the NAVSTAR, Global Positioning System (GPS). It provides Executive Service guidance for all Services/Agencies engaged in the definition, design, development, testing, acquisition, and operation of the GPS and further implements the single manager principles of DOD Directive 5000.1.

This document will be the operating plan for system management and acquisition throughout the life cycle of the program beginning with Phase I, Concept Validation. As the program progresses, this document will be annually updated to reflect current status and progress. A formal revision cycle will automatically be initiated by the JPO upon publication of a new Program Management Directive.

The PMP and subsequent revisions shall not be used either by the Government or Contractors as a specification document. Specifications and requirements may be repeated herein, but only as a convenience to implementing and supporting agencies.

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SECTION I

PROGRAM SUMMARY AND AUTHORIZATION

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SECTION I

PROGRAM SUMMARY AND AUTHORIZATION

1.1 BACKGROUND

Since the early 60's, both the Navy and the Air Force have actively pursued the idea that navigation and positioning could be performed using radio signals transmitted from space vehicles. The impetus for such a space-based system was the potential for a universal positioning and navigation system which could meet the needs of a broad spectrum of users. In addition, definite cost benefits would accrue by reducing the proliferation of specialized equipments responsive only to particular mission requirements.

Each service embarked upon an extensive technology program of studies, experiments, and tests to demonstrate the feasibility of a Defense Navigation Satellite System (DNSS). The Navy sponsored two navigation satellite programs: TRANSIT, now operational, and TIMATION, a technology program to advance the development of high stability oscillators, time transfer, and three dimensional navigation. The Air Force concurrently conducted preliminary concept formulations and system design studies for a highly accurate three dimensional navigation system called System 621B. The System 621B concept and system techniques were verified in a series of tests and experiments at Holloman Air Force Base and the White Sands Missile Range.

A key step in the integration of these activities was the memorandum issued by the Deputy Secretary of Defense on 17 April 1973. The memo designated the Air Force as the Executive Service to coalesce the concepts proposed for a DNSS into a comprehensive and cohesive DOD system. A system

concept designated NAVSTAR, Global Positioning System, emerged as the synergistic combination of the best features of the previous navigation satellite concepts and included the Army Pos/Nav requirements.

1.2 PROGRAM AUTHORIZATION

The Development Concept Paper (DCP) #133, 15 April 1974, proposed two alternative programs leading to the **acquisition** of a Global Positioning System (GPS). The GPS program was briefed to the Defense Systems Acquisition Review Council (DSARC) on 13 December 1973. On 22 December 1973, the Deputy Secretary of Defense, in a memo to the Secretaries of the Military Departments, approved the NAVSTAR, GPS program. 1.3 APPLICABLE DOCUMENTATION

Deputy Secretary of Defense Memorandum "Defense Navigation
 Satellite Development Program", 17 April 1973.

2. Development Concept Paper #133, NAVSTAR, Global Positioning System, 15 April 1974.

3. Deputy Secretary of Defense Memo "NAVSTAR Global Positioning System" 22 December 1973.

4. Program Management Directive No. R-S 4-075-(1) "NAVSTAR Global Positioning System" 2 May 1974:

5. AFSC Form 56 : 375-1-74-33, 24 June 1974.

6. System Specification for the NAVSTAR Global Positioning System Phase I, Including Appendices I & II. SS-GPS-101B CI-07868, 15 April 1974.

*7. System Segment Specification for the Control System Segment of the MAVSTAR Global Positioning System, Phase I. SS-CS-101A, CI-07868, 25 April 1978.

*8. User System Segment Specification for the NAVSTAR Global Positioning System, Phase I, SS-US-101A, CI-07868, 3 April 1974.

9. System Segment Specification for the Space Vehicle System Segment of the NAVSTAR Global Positioning System, Phase I, SS-SVS-101A, CI-07868, 26 June 1974.

10. Program Test Plan for the NAVSTAR Global Positioning System Phase I, Annex I, Integrated Logistics Support Plan. YEN-74-102A, CI-07868, 15 April 1974.

*11. Specification for the NAVSTAR Global Positioning System Inverted Range. STE-IR-101A, CI-07868, 15 April 1974.

12. Joint Service Global Positioning System Integrated Logistics Support Plan for User Equipment, 15 April 1974.

*13. Specification for the NAVSTAR Global Positioning System Test Pod, STE-TP-101A, CI-07868, 15 April 1974.

14. "User Equipment Design to Cost/Life Cycle-Cost Program," YEN-74-105, 5 April 1974.

*These documents will be re-published on 30 September 1974.

1.1 IMPORTANCE CATEGORY

The GPS Importance Category is 2 (IC-2).

1.5 NAVSTAR SYSTEM DESCRIPTION

The Global Positioning System (GPS) is a space-based radio positioning and navigation system that will provide extremely accurate three-dimensional position and velocity information and system time to suitably equipped users anywhere on or near the earth. The GPS consists of three major segments: Space System Segment; Control System Segment; and User System Segment.

1.5.1 <u>Space System Segment</u>: The operational GPS will deploy three planes of satellites in circular, 10,000 nautical mile orbits, with an inclination of 63°. Each plane would contain eight satellites. This deployment will provide the satellite coverage for continuous, three dimensional positioning and navigation. Each satellite will transmit a composite signal at two L-band frequencies consisting of a protected navigation signal and a clear navigation signal. The signals contain navigation data such as satellite ephemeris, atmospheric propagation correction data, and satellite clock bias information which is provided by the master control station. The second L-band navigation signal will permit the user to determine the iobospheric group delay or other Electro Magnetic disturbances in the atmosphere.

1.5.2 User System Segment: Using the navigation signal from each of four satellites, the user receiver measures four independent pseudo-ranges and pseudo-range rates to the satellites. The user receiver/processor will



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then convert these pseudo-range and pseudo-range rates to threedimensional position, velocity, and system time. This position solution is in earth-centered coordinates, which can be converted to any coordinate frame or units of measure the user requires. 1.5.3 <u>Control System Segment</u>: Four widely separated Monitor Stations (MS) will passively track all satellites in view, and accumulate ranging data from the navigation signals. This information is processed at a Master Control Station (MCS) to use in satellite orbit determination and systematic error elimination.

The orbit determination process derives progressively refined information defining the gravitational field influencing the spacecraft motion, solar pressure parameters, the location, clock drifts and electronic delay characteristics of the ground stations, and other observable system influences.

An upload station (ULS) located in the Continental United States, will transmit the satellite ephemerides, clock drifts, and propagation delay data to the satellites as required.

1.6 ACQUISITION APPROACH

Several acquisition approaches were presented in DCP #133 for the GPS. The alternative selected by the DSARC is an evolutionary, design-to-cost, development and test program leading in successive phases to an operational Global Positioning System. Each phase is designed to build and expand on the previous phase in an integrated and cohesive manner. The decision at DSARC I was to proceed with Phase I, which concentrates on validation of design concepts through Development Test & Evaluation (DT&E) of user

equipment. Follow-on efforts in Phase II, System Validation, will complete the Initial Operational Test and Evaluation (IOT&E) of user equipment and lead to an early Limited Operational Capability of the GPS. Finally, Phase III, Production, will develop the full, global capability of the system. (Figure 1.2)

1.6.1 GPS Phase I

Phase I will encompass the first of three design-build-test-design cycles to determine preferred user equipment configurations and validate life cycle cost models in the design-to-cost process. During this phase, Generalized Development Models (GDMs) of user equipment will be designed, fabricated, and tested. Each will have the capability to functionally simulate several user equipment requirement classes which satisfy a variety of mission applications. Six classes of user equipment requirements have initially been identified by the Services (Figure 1.3). Final determination of operational user classes will result from tests on development models and review of missions to be performed. Thus, the generalized development models will be testbeds to investigate and evaluate alternative design concepts. The user equipment will incorporate a high degree of subassembly commonality through the use of common modular components.

Sufficient quantities of user equipment sets will be procured to support comprehensive DT&E. Particular emphasis is being placed on developing prototype low cost, reliable user equipment which can be used by the largest user population segment in DOD. In addition, sets of the more sophisticated types of user equipment will also be developed. Initial

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GPS PROGRAM SCHEDULE

FIGURE 1.2



GPS User Classes

testing of user equipment will be supported by extensive use of an inverted range (ground based simulation facility). Testing will transition to the space-based system as satellites become available. By the end of Phase I, prototypes of the low cost user equipment will have started IOT&E and the more sophisticated classes of equipment will have completed DT&E.

During Phase I, the space segment will consist of four subsynchronous, processing satellites: three Navigation Development Satellites (NDS 1-3) launched in CY 77, and a Navigation Technology Satellite (NTS-2) launched in CY 76. The NDS satellites will be prototypes of the operational satellites. Satellite survivability from radiation will be investigated in the early stages of the prototype design. A spare satellite and launch vehicle will be procured for backup capability. The Navy will sponsor two Navigation Technology Satellites (NTS).

MTS-1 will investigate long term stability of Rubidium frequency standards and provide initial space-based testing of navigation signals and validation of signal characteristics transmitted to earth from space. NTS-2 will provide navigation signals compatible with the prototype NDS satellites and continue experiments to space qualify advanced frequency standards. This satellite constellation (NTS-2 and NDS 1-3) will provide a four-in-view geometry similar to the global system, and permit testing periods of up to three hours per day over selected test areas.

The ground station, to be used for tracking and control of the satellites, will be developed and tested as a prototype of an operational ground station. The space and control segments together will provide a test environment representative of the operational system to perform the DT&E of the user equipment. In addition, limited demonstrations of operational utility will be conducted. These consist of:

a. Coordinate bombing

b. Terminal navigation and landing approach capabilities

c. Airborne refueling operations

d. Navy coordinated sea operations

e. Army land operations

f. Special operational techniques for A-J margins and system vulnerability.

Progressive demonstration of additional operational objectives will be accomplished as the maturity of user equipment develops to support each phase of the joint test program.

1.6.2 GPS Phase II

A decision to continue into Phase II, System Validation, could be made at DSARC II in FY 78. Phase II includes: (1) IOT&E and initial production of the low cost class of user equipment; (2) fabrication and completion of IOT&E for all other classes of equipment; and (3) development, fabrication, and initial production of operational (hardened) satellites. During Phase II, additional satellites will be launched to augment those of Phase I to provide a constellation of three satellites in each of three orbit planes. This configuration will provide up to eight hours per day of continuous, four-in-view test

time. After the IOT&E of user equipment is completed, the satellites will be uniformly distributed in their orbit planes to provide worldwide, continuous, two-dimensional (2-D) navigation and positioning information Initial production of the low cost user

equipment would be started at this time. This equipment would be compatible with the fully operational system configuration. The ground station would be placed in its operational configuration, so that by the end of Phase II, a global 2-D Limited Operational Capability (LOC) would be available for suitably equipped users (Figure 1.4).

1.6.3 GPS Phase III

Phase III builds upon the two-dimensional navigation capability. All user equipment classes will be procured in production lots, as determined by individual user requirements. Operational satellites will be launched to augment the constellation deployed during Phase II. The number of satellites will be determined by the exact orbit altitude, the coverage required, and consideration of other performance issues including vulnerability. The ground station will include the operational equipment developed in Phase II, expanded and retrofitted at the component level, as necessary, to accommodate full system operation. Operational testing will be continued in this phase to insure optimum system operation, and to obtain additional information on the utilization of all types of user equipment for new military applications and tactics.

In summary, each phased deployment provides extensive legacy value for the next evolutionary step in the development of GPS.



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FIGURE 1.4

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System Engineering

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SECTION 2 System Engineering

2.0

System Engineering

This section provides a technical description of the Global Positioning System (GPS) and the overall approach to be taken in system engineering. The System Description provided in section 2.1 describes how a position solution is determined by the GPS, defines the measure of performance and values expected and defines the navigational signal structure. In the System Engineering Management paragraph 2.2., the Phase I mission of the Engineering Directorate is stated and the directorate organization is described. System and system segment development concepts are described. These include topics such as system legacy from a development consideration, the user equipment development plan, and the approach to provide required satellite clock accuracies. Specific engineering disciplines such as reliability and maintainability, electromagnetic compatibility, etc., are described in paragraph 2.3, System Effectiveness. The objective is to utilize these disciplines in complementary relationships directed toward system performance and cost goals.

2.1 System Description

2.1.1 <u>Concept</u>. The GPS is a space-based

radio navigation system that will provide GPS-equipped users with the capability to precisely determine their three-dimensional position, velocity and time. Each GPS space vehicle (SV) will generate and transmit two GPS Navigation Signals. Also, each GPS user receiver will generate a replica of the SV generated navigation signal. When the

ident's signal matches in time the received SV generated signal, a measurement of signal transmit time and user clock asynchronization will be available. All signals emanating from the GPS space vehicles will be synchronized by the GPS Control Segment.

The only signal requiring synchronization will be the user's locally generated signal. Users with very precise clocks could range to three different space vehicles and determine their own position as the calculated intersection of three spheres with centers at the space vehicles. However, to avoid requiring each user to be equipped with a very precise clock, an additional independent range measurement is utilized. Thus, measurement data from four space vehicles will be used to determine the user's three dimensional position and system time (see Figure 2.1). In addition, the user measures doppler shift of the four independent navigation signals to determine his three dimensional velocity and the drift of his clock. When more than four (4) satellites are within the user's line of sight, the user will select a subset of four satellites to use in his position determination. Some of the criteria that may be used to select this subset are:

4. Relationships of satellites to user to insure optimum

b. Minimum ionospheric and tropospheric delay uncertainty.view time of space vehicle.





Figure 2.1

CPS Performance. The user's single position fix accuracy is a function of the user's position relative to the GPS GV constellation. The relationship between the user's navigation accuracy and his relative position to the space vehicle constellation is

referred to as Geometric Dillution of Precision (GDOP). User Equivalent Range Error (UERE) is. defined the uncor-\$3.52 related portion of the observed user range error. Thus, the user's actual navigation accuracy is obtained by multiplying the UERE by the GDOP for the user's position. During Phase I with only four space vehicles available, the user's single position fix navigation accuracy will be approximately three times the UERE (average GDOP of 3). The components of UERE for Phase III and Phase I of the GPS are shown in Table 2.1. The Space Vehicle Group Delay component of the Phase I Error Budget will be applicable for two hours after all SVs are updated. All other components of the Error Budget will be applicable for twentyfour hours after all SVs are updated. All values are one signal (1σ) errors given in meters.

TABLE 2.1 GPS ERROR BUDGET

	Phase III	Phase I
Space Vehicle Ephemeris	1.6	1.9
Atmospheric Delay	2.6 to 5.6*	2.6 10 5.1*
Space Vehicle Group Delay	1	• • (*
Receiver Noise	1.6	1.0
Multipath	1.3 to 3.0*	1.3 to 3.0*
Total R.S.S.	3.9 to 6.9	5.9 to 8.2

*These error quantities represent the use of different atmospheric delay correction methods and different user environmental conditions. Value in meteor.

2.1.2.1 GPS Error Analysis

Ephemeris. Space vehicle ephemeris error is defined as the difference is actual satellite ephemeris and the satellite ephemeris computed by the user from the data provided in the Navigation Signal data frame. Since the GPS satellites will be in 12-hour orbits, the effect of satellite in track and cross-track ephemeris errors will be reduced. For example, a three foot ephemeris in-track error projects to a one foot error in range. Thus, the primary error source that will effect the user's position determination is satellite radial position error. In addition, ephemeris errors common to the four range measurements will cause a user clock calibration error rather than a user position error because the user clock asynchronization is common to all four measurements.

The Naval Weapons Laboratory's operational experience with orbit determination for Transit satellites (600 nmi altitude) has produced the following conclusions.

a. Observed versus predicted values in the orbit determination process check within 2 m (rms).

b. Extremely accurate laser tracking by NASA of Transit satellites agrees with the NWL ephemerides within 1 - 2 m (rms).

c. Long baseline interferometry experiments conducted by MIT agree with Transit/Geoceiver surveys to within 1 m (rms).

Based upon NWL's experience and the more favorable geometry of GPS satellites, there should be low risk in achieving the satellite ephemeris accuracies specified in the Error Budget.

Propagation Errors

Atmospheric delay error is defined as the difference between actual signal propagation delay through the ionosphere and troposphere and the delay determined by the user employing suitable ionosphere and troposphere models. Since the ionospheric delay is a function of frequency, two coherent signals can be used to calibrate the delay. In this dual frequency calibration mode, the ionosphere delay uncertainty is a function of the different in noise in the receiver channels. The variation with frequency is shown in Figure 2.2. For GPS, the ranging error is at most three times the interchannel noise. A sophisticated modeling process can produce an equivalent error. It is currently anticipated that users demanding the best GPS accuracy will use dual frequency calibration. A less sophisticated ionospheric model will be available for medium accuracy users. The tropospheric propagation delay model will probably be contained in the user software. A conservative estimate for a user's tropospheric model requiring no external data indicates a vertical uncertainty of 1 meter (1σ) with satellites at the zenith increasing to $3\frac{1}{2}$ meters (1 σ) for a satellite at a 5-deg. elevation angle.

Space Vehicle Delays

Space vehicle group delay error is defined as the sum of delay uncertainty in the SV, such as unmodelled clock drift and uncalibrated delay in signal equipment. The satellite group delay is undistinguishable from clock errors and will be accounted for in the clock calibration process.



FREQUENCY DEPENDENCE

Immediately after a probit determination solution, the satellite clock uncertainties will be the same for each satellite and so highly correlated between satellites there is little or very slight effect on the user. After two hours the magnitude of the accumulated clock drift will be approximately 7 nanoseconds (7 feet using a 1 x 10^{-12} clock in each satellite. User Errors

Receiver noise and resolution errors are the contributions of noise and measurement errors in the user navigation receiver hardware and software which perturb the correct navigation solution. The User Equipment Definition and Experiments test program at White Sands Missile Range demonstrated that a receiver noise level of five feet is conservative and obtainable.

Multipath error is the affect of several propagation paths from the SV to the user which corrupt the measurement of line-of-sight distance. Operational environments may cause multipath arrivals that are comparable in amplitude to the line-of-sight signal. However, the GPS receiver searchs for the first signal to arrive and not the most powerful signal. Therefore, the likelihood of tracking a multipath signal that is delayed more than $l\frac{1}{2}$ code chips (\approx 49 m for P code) is drastically reduced. If the time of arrival is sufficiently close to that of the line-of-sight signal (less than $l\frac{1}{2}$ chips) the user receiver will not be able to discriminate between the signals. The magnitude of the resulting ranging error will depend strongly on the location and nature of reflecting surfaces in the user environment.

2.1.2.2 <u>Signal Structure.</u> The Global Positioning System (GPS) Navigation Signal is a composite waveform consisting of a Protected (P) Signal and a Clear/Acquisition (C/A) Signal transmitted in phase quadrature. The P Signal is used by the precision military user and will resist jamming, spoofing, and multipath and will be deniable to unauthorized users by employing transmission security (TRANSEC) devices. The C/A Signal will serve as an aid to the acquisition of the P Signal, and will also provide a navigation signal in the clear to both the military and civil user.

The navigation signals are transmitted on two channels: L_1 and L_2 . Channel L_1 , the Primary Navigation Signal, is nominally centered at 1575 MHz and shall carry both the P and the C/A Signals. Channel L_2 , the Secondary Navigation Signal, is nominally centered at 1230 MHz and shall carry the P Signal or C/A signal. On the L_2 channel, either P or C/A can be selected through a telemetry controlled switch.

Both the P and the C/A Signals are pseudonoise biphase shift keyed (PN/BPSK) continuous sinusoidal carriers. Both signals carry system data. The chipping rates of the PN codes are 10.23 Mbps and 1023 Kbps for the P and the C/A Signals respectively. The system data rate is 50 bps. Each Space Vehicle is assigned a unique set of PN codes. The P code repeats each seven (7) days, and the C/A code repeats each m second. This waveform is specifically designed to allow system time to be conveniently and directly extracted in terms of standard units of days, hours, minutes, and interger multiples and submultiples of the second.

The system data contains information which allows the user to maximite successfully with GPS. It will provide space vehicle ephemerides, system time-of-week, space vehicle clock behavior data, system status messages, and C/A to P Signal handover information. The data stream will be common to both the P and the C/A Signals on both L_1 and L_2 .

The P Signal is a continuous sinusoidal carrier, biphase modulated according to the modulo-2 sum of a PN code and a synchronous data bit stream. The P codes will be generated such that no space wehicle shall duplicate the output of any other space vehicle before seven (7) days have elapsed in system time. The period of the code will be sufficiently long (267 days) to accommodate 32 different initial code phases, each displaced by a minimum of seven (7) days (i = 1, 2, ..., 32). The same basic code generator will be used by all GPS P Signal transmitters with each one assigned one of the 32 possible unique code phases.

The C/A Signal is a continuous sinusoidal carrier, biphase modulated according to the modulo-2 sum of a 1023 bit Gold code sequence, a Manchester code, and a synchronous data bit stream. One of 32 different codes within the 1023 bit Gold code family will be used for each C/A Signal transmitter. The codes will be selected to have low envelope cross-correlation with any other code in the Gold family for all possible shifts of the code and doppler conditions.

2.2 Phase I System Segment Descriptions

2.2.1 Phase I User System Segment

Each user equipment set will receive the navigation signals transmitted by the GPS satellites and provide the operator with threedimensional pos/nav information, and system time-of-week. A typical user equipment set will consist of an antenna, receiver, data processor, control/display, power supply, and interface units. Figure 2.3 depicts how these units are functionally related. The functions are:

a. Detect and acquire the navigation signals generated by the GPS satellites.

b. Track the acquired signals.

c. Discriminate against multipath signals.

d. Provide immunity against intentional jamming and spoofing.

e. Perform corrections for ionospheric signal delay, either by mathematical modeling or through RF signal measurement techniques.

f. Extract the data contained in the received navigation signals.

g. Accomplish the pseudo-range and pseudo-range-rate measurements as required.

h. Compute and output the user's three-dimensional position and velocity and system time in the required format.

The antenna assembly directs available signals to the RF input of the receiver assembly. The antenna assembly includes the antenna, transmission lines, filters, RF pre-amplifiers and antenna gain pattern controls.

USER SYSTEM SEGMENT FUNCTIONAL FLOW DIAGRAM



Figure 2.3



The receiver assembly accepts and operates on the output of the antenna assembly. The receiver outputs the pseudo-range, pseudo-range rate, and system data extracted from navigation signals to the data processor via appropriate interface device(s). Each receiver accepts data from the data processor to aid in the acquisition of the available navigation signals.

The data processor (a) accepts and processes the outputs of receiver, control/display, auxiliary sensors (if any) via their respective interface devices, and (b) outputs the proper quantity, quality, and form of data required by the remaining elements to support the operations of the set. As a minimum, the processor will:

(1) supply navigation signal acquisition and tracking aiding data to the receiver through the interface, (2) accept mode control commands from the control/display unit and provide for altering the processing of computer programs or other equipment functions,
(3) convert the system data and pseudo-range/range-rate measurements into system time and three-dimensional position and velocity, and (4) accept supporting navigational data from auxiliary sensors (if integrated) to refine the navigation solution and support user set operations as well as monitor and control self test (BIT) diagnosis. The processor has executive control of all user equipment set functions.

The control/display unit (a) displays and disseminates the data required by the operator in the required quantity and form and (b) provides manual control over selected user equipment functions.

The power supply unit provides, controls, conditions and distributes the power required to support all functions of the user equipment set.

The interface unit enables all elements of the set to interact mechanically and electrically as required. The interface units also support interactions between the set and the host vehicle. 2.2.1.1 UE Development

The emphasis in user equipment development during Phase I is on the receiver. The other components will be off-the-shelf existing equipment where possible.

Three types of user equipment called User Equipment Sets X, Y, and Z will be developed during Phase I. The data processor, control and display unit, power supply and interface unit will be identical for development models of Sets X and Y. Prototype Set Z user equipment to be developed in Phase I will not be constrained to off-the-shelf components.

Figure 2.4 summarizes the attributes of User Equipment Sets X, Y, and Z. Both X and Y are required to have operating modes that allow the set to (a) receive navigation signals on L_1 and L_2 , (b) navigate with either the P or the C/A signal, (c) acquire the P navigation signals through the use of the C/A signal or directly, (d) make dual frequency measurements or use a static model to correct for ionospheric signal propagation delay. The Set X receiver shall be capable of simultaneously operating on four or more different navigation signals.

USER EQUIPMENT SET ATTRIBUTES AND OPERATING MODES

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The Set Y receiver is only required to operate on one or more different navigation signals at a time. Equipment Set Z operates on the C/A signal only. It is required to operate on one or more different navigation signals at a time in a continuous or sequential manner as required. The primary attribute of User Equipment Set Z is that it be a low cost user set.

User equipment Sets X and Y will consist of 3 boxes plus the antennas and interconnecting cables, depicted in Figure 2.5. The Z prototype user sets, for initial operational test and evaluation, are expected to fill a 3/4 ATR box. The 3/4 ATR box contains the receiver, processor, interface unit, and power supply. The antenna, interconnecting cables and control/display unit are separate.



2.2.2 Phase I Control System Segment

2.2.2.1 General

The Control System Segment is composed of a Master Control Station (MCS), an Upload Station (ULS), and three Monitor Stations (MSs). The segment is supported by the Naval Weapons Laboratory (NWL) and the Air Force Satellite Control Facility (AFSCF). The MCS and ULS will be located on Vandenberg AFB. MS's will be located on Guam and in the states of Hawaii and Alaska (see Figure 2.6).

The monitor station receivers perform dual frequency pseudo range measurements to the space vehicles using user system segment receiver. Locally collected meteorological data and the space vehicle tracking data are forwarded to the MCS via data communications circuits. The MCS processes the MS collected data to correct the reference ephemeris provided by NWL for each space vehicle. The MCS processing also determines clock performance for each space vehicle, and accounts for the effects of systematic influences, e.g., relativity, ionospheric delay, biases, etc.

The major data product from the MCS is an update message which is forwarded to the ULS for transmission to the space vehicle.

The MCS periodically forwards MS tracking data to NWL where an existing ephemeris program generates the reference ephemeris used by the MCS. The MCS is capable of accepting processed telemetry data from the AFSCF. The MCS can send the AFSCF the space vehicle update messages for upload to the space vehicles should a ULS failure occur.



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The MCS and ULS will jointly occupy the PRELORT Building 22104 at Vundenberg Tracking Station. This building will be adapted to house the radio frequency and data processing equipment and personnel needed for the MCS and ULS functions. An engineering conception of the Control System Segment hardware is depicted in Figure 2.7. A building under the control of the 1931st Comm Gp at Elmendorf AFB, a building under the control of Navy Astronautics Gp at NAVCOMSTA Honolulu, and the Mobile Tracking Station area at Guam Tracking Station have been tentatively identified to house MS's. The Guam installation will probably use a transportable shelter or van due to the lack of available buildings.

2.2.2.2 Monitor Station

Each Monitor Station includes a user equipment receiver (either Class X or Y), a computer, a meteorological sensor, test and calibration equipment, data communications equipment, a Cesium clock, a time base generator, and stand-by power supplies for critical items. The computer may be supplied as a portion of the user equipment set. This equipment will be housed in two 19 inch width racks. A teletype unit is part of the test interface with the computer. With the exception of the receiver and some of the test equipment, this equipment is commercially available.

2.2.2.3 Upload Station

The Upload Station consists of one kilowatt S-band and SGLStype transmitter, a computer with disc storage, an operator's CRT display, a user receiver, all other equipment needed to complete a Monitor Station, and a radome-enclosed 14-foot parabolic antenna with its

CONTROL SYSTEM SEGMENT EQUIPMENT

