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The Texas Instruments 4100 (TI4100) receiver collects data from the US Defense Department's NAVSTAR Global Positioning System of Satellites (GPS). The Defense Mapping Agency (DMA) and a number of other organizations have utilized these receivers to exploit GPS for a variety of geodetic applications. This report provides a comprehensive set of operational procedures and guidelines for the estimation of geodetic point positions (absolute positions) from data collected with the TI4100 receiver. The specific algorithms which are addressed here have been developed into efficient, portable FORTRAN 77 programs which are known as **STARPREP** and **GASP**. The name *STARPREP* is a contraction for GEOSTAR PREProcessor while *GASP* is an acronym for Geodetic Absolute Sequential Positioning program. These two programs are designed to work in concert to exploit GPS data for geodetic point positioning applications. A few other utility programs are also addressed which perform functions such as data transfer, data screening and data analysis. A set of minimum observation requirements are specified such that a geodetic point positioning survey can be planned and conducted efficiently.

This report does not address the use of GPS data which has been subject to Selective Availability (SA) or Anti-Spoofing (AS). This report will be updated when guidelines and standard operating procedures have been established for such data.

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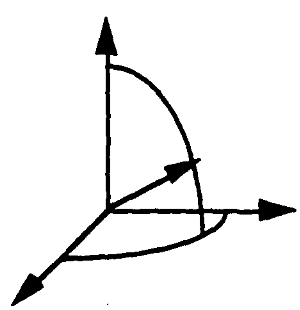
GUIDELINES, OPERATIONAL PROCEDURES, AND QUALITY CONTROL

FOR

THE ESTIMATION OF GEODETIC POINT POSITIONS FROM GPS DATA COLLECTED WITH THE TI4100 RECEIVER



Stephen Malys and Major Peter A. Jensen
Defense Mapping Agency
November 1989
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1. INTRODUCTION

The Texas Instruments 4100 (TI4100) receiver collects data from the US Defense Department's NAVSTAR Global Positioning System of Satellites (GPS). The Defense Mapping Agency (DMA) and a number of other organizations have utilized these receivers to exploit GPS for a variety of geodetic applications. This report provides a comprehensive set of operational procedures and guidelines for the estimation of geodetic point positions (absolute positions) from data collected with the TI4100 receiver. The specific algorithms which are addressed here have been developed into efficient, portable FORTRAN 77 programs which are known as **STARPREP** and **GASP**. The name *STARPREP* is a contraction for GEOSTAR PREProcessor while *GASP* is an acronym for Geodetic Absolute Sequential Positioning program. These two programs are designed to work in concert to exploit GPS data for geodetic point positioning applications. A few other utility programs are also addressed which perform functions such as data transfer, data screening and data analysis. A set of minimum observation requirements are specified such that a geodetic point positioning survey can be planned and conducted efficiently.

This report does not address the use of GPS data which has been subject to Selective Availability (SA) or Anti-Spoofing (AS). This report will be updated when guidelines and standard operating procedures have been established for such data.

1.1 GPS Geodetic Point Positioning Applications

For the last few decades, DMA has exploited the Navy Navigation Satellite System (NNSS) (TRANSIT, Doppler) for geodetic point positioning. Over 6000 geodetic point positions have been estimated in a global reference frame and have been effectively utilized for activities such as mapping control, estimation of transformation parameters (regional datums to World Geodetic Systems), and other MC&G activities. Since the NNSS is scheduled to terminate operations when GPS becomes fully operational, and since there is a continuing requirement to generate geodetic point positions, DMA has developed an ability to utilize GPS data for the estimation of individual geodetic point positions.

While many organizations have developed algorithms and programs for relative positioning, only DMA and the US Naval Surface Warfare Center (NSWC) have developed proven methods to exploit GPS for point positioning. The relative positioning (differential positioning) and point positioning (absolute positioning) concepts are shown graphically in Figure 1. Relative positioning can be described as the estimation of the vector (baseline) connecting a known station to an unknown station while point positioning can be described as the estimation of the vector connecting the origin of a global reference frame with an unknown station anywhere on the surface of the Earth. The NSWC GPS point positioning algorithm has been described by Hermann [1987] while the DMA algorithm has been presented in Malys and Ortiz [1989] and Malys and Jensen [1989].

Before planning a tracking campaign, geodetic users of GPS data must decide on the accuracy and precision goals of the survey as well as the logistics requirements of the personnel and equipment. In general, a relative positioning survey requires a large degree of coordination among field party members since simultaneous tracking is essential for the success of all baseline estimation algorithms. In contrast, point positioning surveys can be conducted with little or no coordination among field parties. Any relative positioning survey requires a minimum of two receivers while point positioning surveys can be conducted with a single receiver.

While most relative positioning software packages offer the potential of centimeter-level baselines, the coordinates assigned to the unknown end of a baseline are limited in accuracy by the accuracy of the "known" (fixed) end of the baseline. When the fixed end of a baseline is a very well-known station (a fiducial site) the baseline to the unknown station can be estimated with sub-centimeter accuracy if special care is given to cycle-slip repair and atmospheric modeling. If on the other hand, the station at the fixed end of a baseline is not very well-known, the baseline will suffer scale distortion at a level proportional to the error in the assumed fixed-site coordinates [Hilla, personal communication, 1988]. In many cases, reliable error estimates for the coordinates of the fixed end of a baseline will not be available.

Since GPS point positioning is generally simpler and less costly in terms of logistics, many geodetic GPS users will find it desirable to design and conduct point positioning surveys instead of the more complicated relative positioning surveys. This is particularly true when the positioning results will be used as as basis for mapping control. Moreover, when GPS positions are to be used in the estimation of transformation parameters between the World Geodetic System 1984 (WGS 84) and a local datum, these GPS positions must be expressed in the WGS 84 reference frame. Once the NNSS is removed from service, the only direct method of obtaining WGS 84 station coordinates will be by estimating point positions with GPS data. Any other methods will be subject to a complicated sequence of error propagations which will undoubtedly be difficult to perform with any degree of confidence.

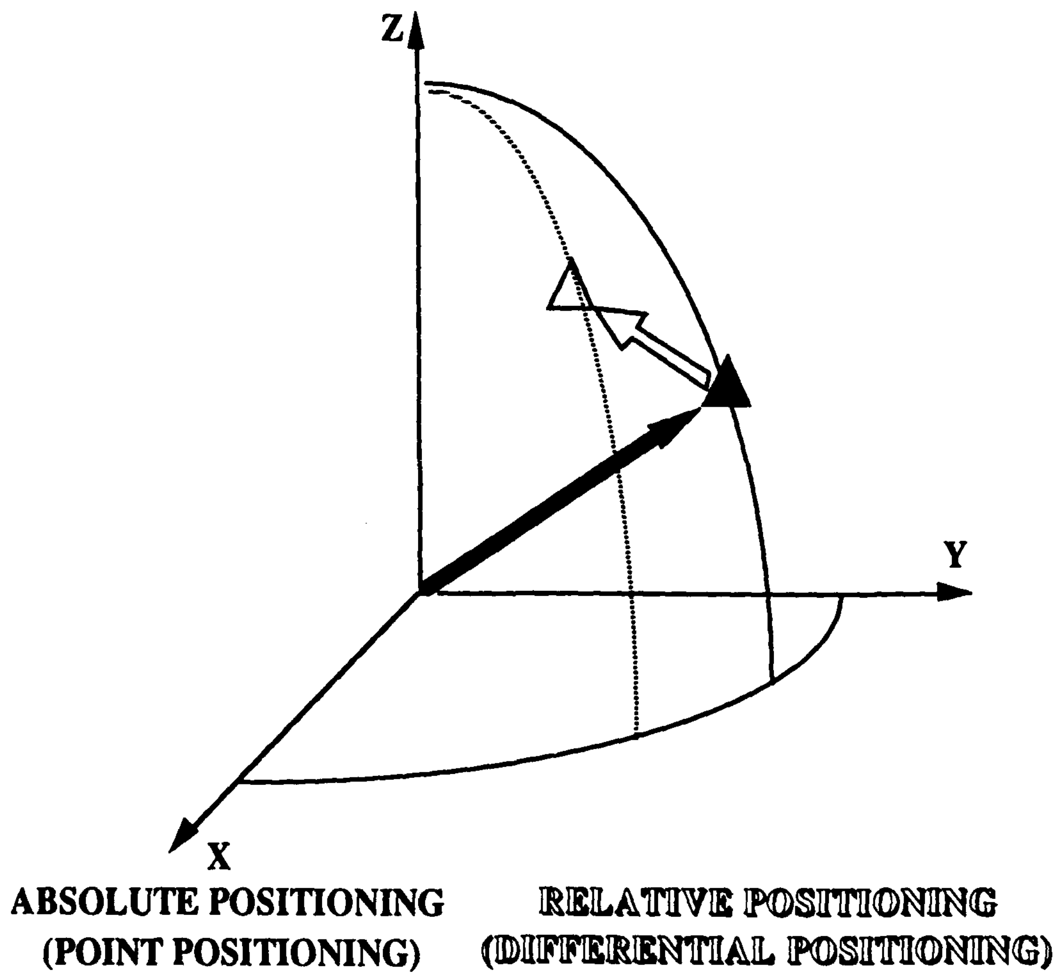


Figure 1. Relative and Absolute Positioning

1.2 Processing Flow Overview

A streamlined process has been developed for the flow of tracking data from the field to the DMA point positioning program (GASP). This process is summarized below in Figure 2.

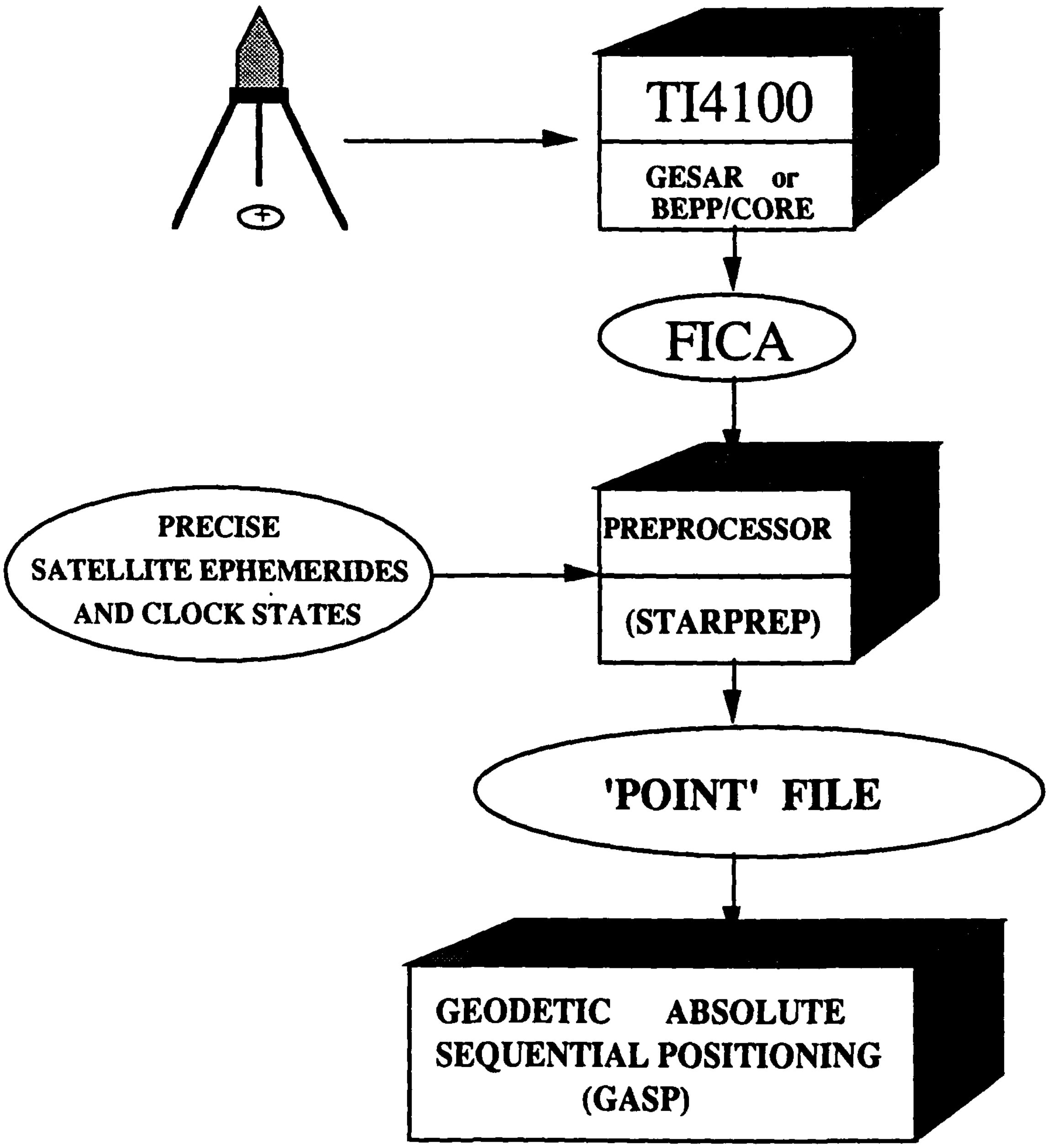


Figure 2. Generalized Data Flow Diagram

The flow diagram depicted in Figure 2 is generalized in the sense that it shows the main components of the process. For readers who are unfamiliar with the components shown in Figure 2, the following descriptions will be helpful:

GESAR: An operating system for the TI4100. GESAR was developed by the Naval Surface Warfare Center (NSWC) and is loaded into the TI4100 memory when in use. It was designed to collect GPS data with geodetic applications in mind. Details regarding its operation and outputs can be found in Darnell [1987].

BEPP/CORE: An operating system for the TI4100 developed by the Applied Research Laboratories of the University of Texas at Austin (ARL/UT) for the environment where the receiver is driven by a personal computer. Such an environment exists at the five DMA GPS fixed tracking sites which support GPS precise orbit determination. The BEPP (Basic External Processor Program) resides in the laptop PC while CORE resides in the TI4100.

FICA: An acronym for Fixed, Integer, Character, ASCII formatted data files. This data structure was developed by ARL/UT for a variety of receiver types. A series of specific block identifiers has been assigned for specific uses. For example, FICA Block 6 contains the pseudorange and carrier beat phase data from the four trackers of the TI4100 when GESAR is used. FICA Block 55 contains this information (with additional quantities) when BEPP/CORE is used. This file structure preserves the original data recorded by the receiver and is thus suitable for archiving purposes. It is also suitable, in many cases, for data exchange with other organizations. A non-ASCII (machine dependent binary) structure (FIC) is also available if desired. A complete description of the FICA structure can be found in ARL/UT [1987].

EPHEMERIDES AND CLOCKS: The 'post-fit' (*precise*) GPS ephemerides and satellite clock state estimates are obtained from DMAHTC/GG as output from the weekly (8-day) orbit determinations using the OMNIS program. The satellite position and velocity vectors are given in the WGS 84 reference frame at 15 minute intervals while the clock state estimates are given at hourly intervals. A complete mathematical formulation of OMNIS is found in Swift [1987]. Note that the *broadcast* ephemerides and clock state predictions are available in the FICA (or FIC) file. An assessment of the weekly precise ephemerides and clock states has been presented by Gouldman et. al. [1989].

STARPREP: The GEOSTAR PREPROCESSOR described in Section 6.

POINT FILE: A binary file produced by STARPREP which contains identifying information, the corrected tracking data, individual correction values, and interpolated GPS ephemerides and clock states.

GASP: The Geodetic Absolute Sequential Positioning program described in Section 7.

Users of the algorithms and programs described here will find it highly desirable to perform as many steps as possible on the same computer equipment. Experience has shown that transfer of data files from one machine to another causes the most delay in the processing flow.

2. MISSION PLANNING AND OBSERVATION REQUIREMENTS

Since the TI4100 receiver is limited to collecting data from 4 satellites at a time, a range of possible tracking geometries will be available. The user must design a data collection scheme which will maximize the geodetic utility of the data set. Primarily, this involves selecting the appropriate hours for tracking and the specific satellite combinations that are to be tracked. This process is referred to as selecting scenarios. Ideally, a geodetic user would like to encounter a geometric situation where GPS satellites are present in all four quadrants of his local horizon. Moreover, the satellites should be observed through a range of elevation angles. Sky-plots such as those shown in Figure 3 are very helpful when performing mission planning. They allow an easy visualization of azimuth and elevation angle. The tracking geometry during any particular data collection period will primarily be a function of geographic location. The GPS orbital characteristics cause the current (Block I) constellation to be available, at any given location, approximately 4 minutes earlier each day. This rule of thumb can be used to avoid generating mission planning plots for each day of a tracking campaign. The distribution of the Block I satellites purposely optimizes the tracking geometry for stations located in the southwestern US. Although plots such as those shown in Figure 3 are helpful during the planning phases of a survey, one should be aware of the limitations of such plots. For example, they do not reflect the local environment where the receiver is to be placed and thus cannot account for local obstructions such as mountains, buildings, heavy forestation, power lines, towers, fences, etc. The field personnel may find that local conditions such as these severely affect the planned data collection scenario. The field personnel should attempt, if possible, to remove all obstructions such that the receiver can successfully track (with minimal multipath) down to ten degrees elevation angle. If obstructions cannot be cleared, construction of a tower may be necessary to raise the antenna above the obstructions.

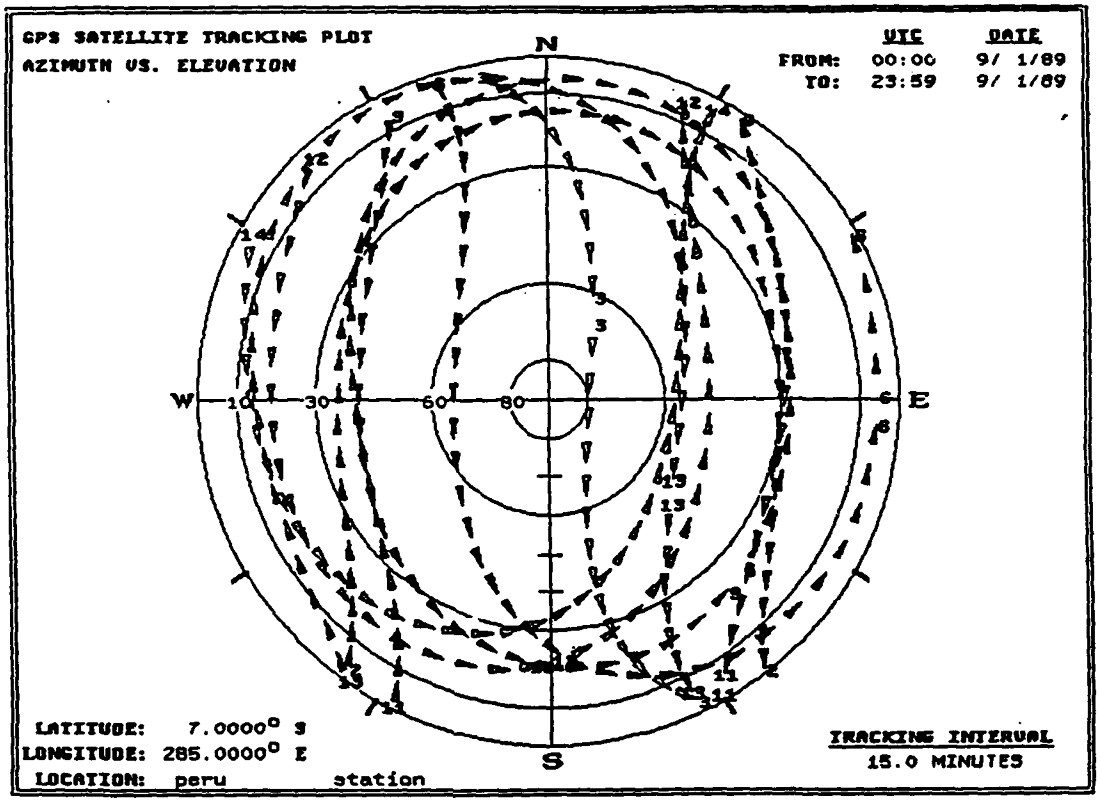
Note that the elevation angles shown in Figure 3 (and similar plots) are measured from the tangent to the ellipsoid (or sphere) and thus do not account for the geoid or the local terrain.

Experience has shown that the quantity known as *Position Dilution of Precision* (P-DOP) can be helpful in evaluating the geometric situation. This quantity, along with a subset of similar quantities (G-DOP,H-DOP, etc.) is available from some survey planning packages. For point positioning as well as relative positioning, a falling *P-DOP* is highly desirable. The tracking schedule should always be organized around the times of falling P-DOP.

Since the TI4100 tracks only four satellites at a time, and more than four satellites may be in the user's sky during a tracking session, a change in scenario during a tracking session is possible. These scenario changes are desirable for point positioning since they provide an expanded range of geometries during the tracking session. Experience gained to date indicates that a geodetic-quality point position (a position with a standard deviation on each component of less than one meter) can easily be obtained with the GASP algorithm when the data set spans a period longer than about 4 hours. If, however, the geometric situation is very favorable, a geodetic-quality point position can be achieved with GASP from a smaller amount of data. The GASP output contains a number of quality control measures which the user can examine to evaluate the precision of the estimated position. The minimum observation requirements for geodetic point positioning are summarized in Table 1.

Since the differencing algorithm employed in GASP removes most of the effects of the receiver's clock, there is no requirement to utilize an external frequency standard with the TI4100 receiver. Experiments have been performed which compared results obtained from receivers which operated on quartz crystal and rubidium oscillators. No difference in the quality of positioning results was detected. This issue will have to be reexamined when data is collected in the AntiSpoofing / Selective Availability (AS/SA) environment. All developmental testing and evaluation of the GASP and STARPREP algorithms has been done with the data collection interval set at 30 seconds.

The a priori (starting) station coordinates which STARPREP and GASP use are usually assumed to have standard deviations of 1/2 kilometer in each component. In general, the starting coordinates will be more precise than this. These coordinates are contained in the FICA file (Block 101 with GESAR or Block 124 with BEPP/CORE). They are input by the TI4100 operator at the beginning of the tracking session. They can be updated or edited in the FICA file if necessary.



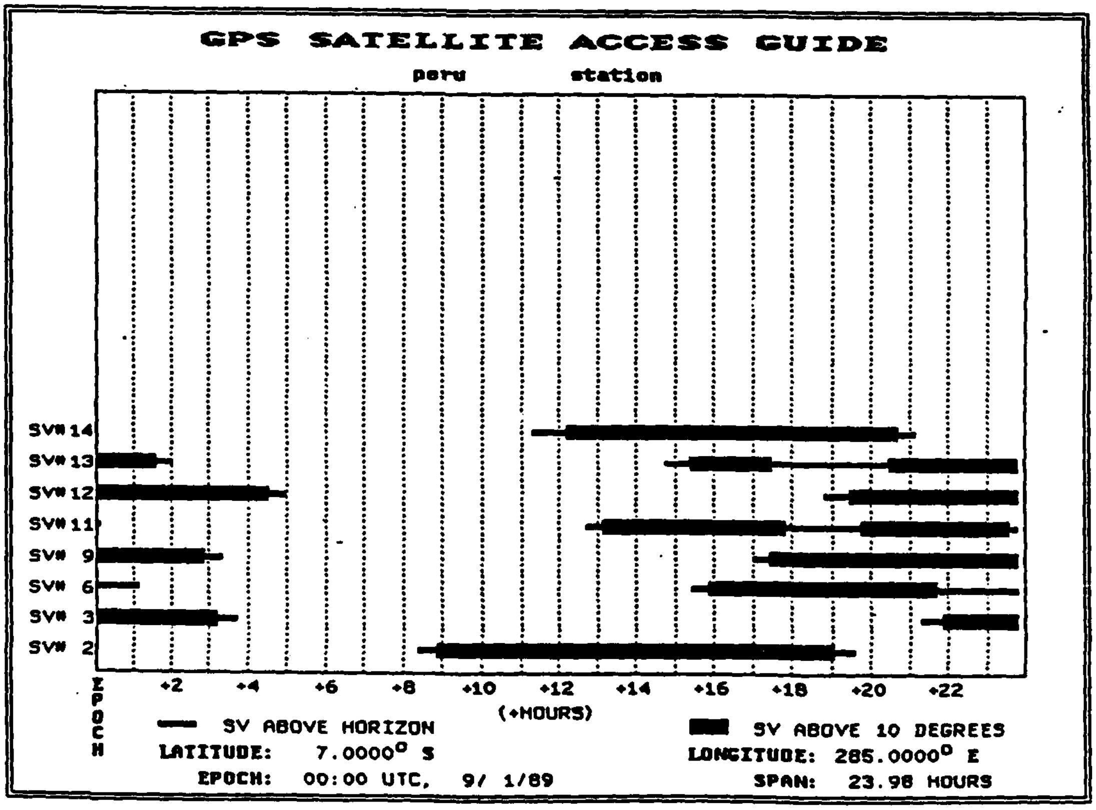


Figure 3. Mission Planning Aids

Table 1. Minimum Observation Requirements for Geodetic Point Positioning with the TI4100

Criteria \ Desired Precision	Standard Deviation (1 Sigma in each position component) 0.75 meters	1.5 meters
Minimum observation period	240 minutes	90 minutes
Data collection interval	30 seconds	30 seconds
Minimum number of SVs to be tracked simultaneously	4	4
Minimum number of scenarios of 4 satellites	2	1
Minimum number of SV orbit planes	2	2
PDOP	PDOP for each scenario is to fall as much as possible over the period of observation. For the last 40 minutes, the PDOP should be less than 10 and no greater than 5 at the end of the tracking session.	
Satellite geometry	The SVs should be distributed in all four quadrants of the observer's sky. At least one SV should appear within 5^{o} of the prime vertical, anywhere within the elevation angle range of 10^{o} to 50^{o}. All observations are to be above 10^{o} elevation angle.	
TI4100 operating system	GESAR or BEPP / CORE	
Frequency standard	Internal crystal or external atomic	
Minimum crystal oscillator warm-up time	1 hour	1 hour
Meteorological observations	Recorded at commencement, each hour, and on completion of tracking session. Temperatures are to be accurate to $\pm 1^{o}C$ barometric pressure to ± 1 mb and relative humidity to $\pm$ 5%.	
Antenna heights and local survey ties	Height from the monument to the base of the antenna is to determined to ± 1cm. All local survey ties should also be accurate to ± 1 cm. An annotated sketch of the local survey is essential.	

3. FIELD VALIDATION

Before leaving a remote tracking site, a TI4100 user should know that the data collected will be geodetically useful. If the mission planning stage is performed correctly, the tracking session followed the mission plan, and the equipment performed normally, there would be no need for any in-field validation. Of course, a number of unexpected events can occur before or during a tracking session which necessitate a change in plans. Such events could include a satellite becoming 'unhealthy', a delay in getting personnel to a remote tracking site, malfunctioning equipment, severe environmental conditions, etc.

Most forms of in-field validation require computer resources and a power supply. If the TI4100 data is recorded on a cassette tape, a tape reader may also be necessary. If resources such as these are available in the field, a number of software packages can be utilized to verify that the data will be geodetically useful. These packages include but are not limited to:

PROGRAM NAME	SOURCE	BASIS FOR VALIDATION
a. GS2FIC and FICFICA	ARL:UT	Detects certain errors Provides number of data blocks recorded ASCII (FICA) file can be examined directly
b. PRTN	DMASC/EG	Summarizes all data collected Predicts data quality using GDOP, PDOP Detects anomalies and receiver errors
c. DSUMI'Y	ARL:UT	Summarizes data blocks, satellites, observation periods

Each of the above computer programs is operational on an IBM PC/XT (or compatible equipment). In the event that computer resources are not available in the field, the DSUMRY program can be loaded on the TI4100 memory and used to verify the data file's contents.

In all cases, the field personnel must record accurate field notes regarding the local conditions and report any anomalous incidents such as thunderstorms, a weather front passing through, electronic malfunctions, power failures, etc. The following information is essential in the post-processing stage:

√ Receiver operating system system and version number (ex: GESAR v1.5, BEPP/CORE v2.0)
√ Type of frequency standard used (internal crystal; external rubidium, cesium, maser)
√ Weather observations; Time, Temperature (°C), Pressure (mb), Relative humidity(%)
√ Accurate antenna height measurements (from monument to base of antenna)
√ Accurate local survey tie data, if applicable, including detailed sketch
√ The TI4100 navigation solution and any other reliable a priori position estimate

Even when information such as this is recorded in the data set itself, a set of accurate field notes is to be maintained which clearly record this important information. Standard field log forms have been developed for this purpose. A complete set of field log forms is given in Appendix A.

4. TRANSLATION OF GESAR OR BEPP/CORE TO THE FICA STRUCTURE

4.1 Overview

If the tracking data collected with the GESAR or BEPP/CORE operating systems is to be used for GASP point positioning, it must be translated into the FICA file structure. This is the structure required by the STARPREP preprocessor. If the original data is a GESAR file on cassette tape, a minimum of three utility programs must be executed in order to accomplish this translation. These programs are named MFERD, GS2FIC (GESAR to FIC or BEPP/CORE to FIC) and FICFICA (FIC to FICA). These translation programs have been developed by ARL/UT. If the original data file was generated with BEPP/CORE, the file will be on a diskette. In this case, only the GS2FIC and FICFICA utilities are used. Versions of these programs for a personal computer are available. As mentioned above (section 3), this translation process can serve as a type of field validation if it is performed before the data set is sent for post-processing. Upon execution of the GS2FIC program, a tabulated summary of FIC block types is presented. A detailed set of standard operating procedures for this translation and electronic transfer of the data files is given below.

4.2 Data Translation: Operating Procedures

This section describes a routine procedure for transforming TI4100 GESAR or BEPP/CORE tracking data from cassette tape (GESAR) or diskette (BEPP/CORE) to 9-track magnetic tape for transport to a computer where the point positioning program (GASP) and its preprocessor (STARPREP) reside. These procedures were developed from Ison [1988] and Yambot [1988], and are specific to the MS-DOS based Zenith PC and the DEC MicroVAX computer equipment at the DMAHTC/GGSC facility.

The FICA file structure requires about 5 times more storage space than the original binary data (GESAR or BEPP/CORE). The FICA structure facilitates portability since these ASCII files are machine independent. The STARPREP preprocessor was designed to read these FICA files. If a continuous data set is stored as a series of files on the Zenith PC, they should be concatenated in chronological order before conversion to FIC and FICA structures. With the Block I GPS constellation, this usually only occurs with BEPP/CORE data from the DMA fixed sites.

Note: To avoid confusion on the instructions of the remainder of this section (4.2), the responses by the operator will be shown in boldface type.

4.2.1 Reading GESAR Data From the Cassette Tape to the Zenith PC

a. Connect the interface cable from the MEMTEC 5450XL reader to the back panel of the Zenith PC. The port at the Zenith PC is the first one from the left viewed from behind (ports and connectors should be properly labeled).
b. On the surge suppressor box (or the power protector box) turn the power switch on.
c. On surge suppressor box only, press the Reset button.
d. On the MEMTEC cassette tape reader, turn power on.
e. Load data cassette tape into MEMTEC tape reader. Make sure the cassette tape is at the beginning. If not, press the "**RWND**" button on the MEMTEC reader to rewind it to the beginning.
f. On the Zenith PC, access the D disk drive by typing in: **D: <Return>**
g. To change the directory to the FICA directory, type in: **CD FICA <Return>**

h. Execute the program that reads the cassette tape by typing: **MFERD** <Return>

i. The program prompts for the output file name. Type in a file name of twelve characters in the following way:

Character 1, "G"	indicates GESAR data, "B" indicates BEPP/CORE data
Character 2, "B"	indicates binary image file
Character 3-6,	last four digits of station ID
Character 7,	cassette number or session letter
Character 8,	last digit of the year
Character 9, "."	period required by MS-DOS
Character 10-12,	Day number of year, when data was collected

For example, the file GB5271A9.148, will represent GESAR binary data from station 85271, cassette session A, of year 1989 on day 148.

(Enter input file name) <Return>

j. Now the program asks for the type of dump. Zero (0) for binary and one (1) for hexadecimal. Select binary by typing in: **0** <Return>

k. Press "**Load Point**" button on the cassette reader.

l. Press the "**Return**" key.

m. Reading process starts when the "Busy", "Data", and "Ready" indicators flash and "BIN" button flashes on the MEMTEC reader. When reading is completed the prompt: "Stop - Program terminated" appears. After this message appears, press the "**RWND**" button to rewind the cassette tape.

n. Remove the cassette tape.

o. Check the new file name and its number of bytes on the disk directory by typing: **DIR** <Return>

p. Log the file name and the number of bytes on a processing log sheet.

4.2.2 Creating the FIC file

The GESAR or BEPP/CORE binary files may be translated to FIC and FICA on either the Zenith PC or the DEC MicroVAX. If the latter is used, the data is transferred from the PC to the MicroVAX using the procedures in section 4.2.4. The FIC file is then created following steps c through i in this section. The MicroVAX command procedures are located in the directory: [GSGC.HTLRM. EXPORT.COMMAND]

a. If the current disk is not the D drive, type in: **D:** <Return>

b. Access the FICA directory by typing: **CD FICA** <Return>

c. To execute the necessary program, type in: **GS2FIC** <Return> (**@GS2FIC** <Return> on MicroVAX)

d. The program prompts for the "INPUT FILE NAME". This is the file that was read from a cassette tape (GESAR) or diskette (BEPP/CORE) onto the Zenith PC. **(Enter input filename)** <Return>
(on the MicroVAX, the file name is: **[GSGC.DEPOT.FICA]filename** <Return>)

e. The program now prompts you for the "OUTPUT FILE NAME". A maximum of twelve characters is allowed. Use the naming convention specified in Section 4.2.1 except on Character 2 where "B" will become "F" to define a FIC output file. **(Enter output filename)** <Return>
(on the MicroVAX, the file name is: **[GSGC.DEPOT.FICA]filename** <Return>)

f. Next, the program prompts for "ORBIT FILE NAME". Type in: NUL <Return>

g. Then, the program asks for header information with the message "ENTER TITLE UP TO 37 CHARACTERS". This header will become the first record in the FIC and FICA file. This step is critical since this record is the only means of identifying the file's contents once it is put on a 9-Track tape. Enter the information in the following way:

Character 1-9,	Project Name;
Character 10-19,	Station Number or Station Name;
Character 20-29,	Year;
Character 30-37,	Day of year, when data collected started;

It is left justified. Leave blanks in remaining spaces. Here is an example:

GREENLAND81399 1989 176

Press the "**Return**" key.

h. While the program is running, messages describing skipped data will be displayed. These error messages are, in most cases, normal and are the result of the method by which data is recorded. When finished, several messages appear on screen . One of them states "GS 2 FIC CONVERTED".

i. Log the created file name and number of bytes on the file management sheet (a sample of a file management sheet is given in Appendix A).

NOTE: Files in the FIC format cannot be transferred from one machine to another since this structure is machine-dependent binary.

4.2.3 Creating the FICA file

The computer which created the FIC file must be used to create the FICA file. If the MicroVAX was used to create the FIC file, follow steps c through f in this section to create the FICA file. The MicroVAX command procedures are located in the directory: [GSGC.HTLRM.EXPORT.COMMAND]

a. If the current disk is not the D disk drive. Type in: **D:** <Return>
b. Change into the FICA directory by typing: **CD FICA** <Return>
c. Execute the program by typing: **FICFICA** <Return> (**@FICFICA** <Return>on the MicroVAX)
d. The program prompts you for the input file name. This is the FIC file that was created in an earlier process (see Section 4.2.2). **(Enter input filename)** <Return> (on the MicroVAX, the file name is: **[GSGC.DEPOT.FICA]filename** <Return>)
e. The program now prompts for the output file name. Again, a maximum number of twelve characters is allowed. The input and output file names should be identical except on Character 2 where "F" (for FIC) will become "A" (for FICA). The "A" represents ASCII. **(Enter output filename)** <Return> (on the MicroVAX, the file name is: **[GSGC.DEPOT.FICA]filename** <Return>)
f. When finished: "FIC TO FICA: TRANSLATED ## RECORDS" will appear on the screen. Here, "##" represents an integer number that is displayed and it is the total number of translated records. Log the file name and number of records on the file management sheet.

4.2.4. Transferring GESAR, BEPP/CORE or FICA Files from the Zenith to the MicroVAX

a. Connect the gray interface cable from the MicroVAX computer to the first port from the left as viewed from behind on the back panel of the Zenith PC.
b. Set the directory where the files to be transferred are located. This will usually be the FICA directory on the D disk. The transfer program is KERMIT. To execute this program, type in this name and a pre-defined directory path will take you directly into KERMIT. With any prompt, type in:
   KERMIT <Return>
c. The KERMIT prompt will appear. Connect to the MicroVAX computer by typing:
   Kermit-MS>**CONNECT** <Return>
d. Hit the **Return** key two or three times. The screen will clear.
e. The MicroVAX computer will ask you for your username and password. Type these in:
   Username: **GSGC** <Return>
   Password: **(Enter your password here)** <Return>
f. After access is gained to the MicroVAX system, the **$** prompt will appear. Type and enter the directory name where the file is to be sent. Enter: **$ FICA (directory-name)** <Return>

g. Next, enter: **$ KERMIT** <Return>

h. If file to be transferred is ASCII (an FICA file) type, skip to step i. If the file is binary (a GESAR or BEPP/CORE file), then type and enter: Kermit-32>**SET FILE TYPE BINARY** <Return>

NOTE: FIC files cannot be transferred; only GESAR, BEPP/CORE or FICA can.

i. Type and enter: Kermit-32>**SERVER** <Return>

j. A long message will appear on bottom of the screen. Depress the **CTRL** and the right bracket] keys simultaneously and then release them. Then press and release the C key:

k. Send the file of your choice from the Zenith to the MicroVAX by typing:
Kermit-MS>**SEND D:\FICA\filename** <Return>

Here, "filename" is the name of the file being sent. Immediately the screen is cleared, and transfer information is displayed. For example, if the file GB5271A9.148 is being transferred, the top of the screen will appear as follows:

File name: GB5271A9.148
KBytes transferred: 3
Percent Transferred: 25%
Sending: In progress

Some of the numbers will be changing fast and continuously. When "Percent transferred" reads 100% and "Sending" reads Completed, the transferring is finished.

If another file(s) is to be transferred, repeat this step (k) with the new file name(s).

l. Then type: Kermit-MS>**FINISH** <Return>

m. Now, just type: Kermit-MS>**C** <Return>

n. Press the "**Return**" key to connect back to the MicroVAX computer. The '$' prompt will appear.

o. To verify a successful transfer, check the file name(s) in the directory. Type and enter:
$ DIRECTORY <Return>

p. If a FICA file was transferred, verify the first few Blocks in the transferred FICA file by viewing it with the editor: **$edit [GSGC.DEPOT.FICA]filename**
Exit the MicroVAX editor by typing **SHIFT and PF1 keys simultaneously, then press Q**

q. If transferring is complete, just repeat steps g, i, j, and exit from Kermit by entering:
Kermit-MS>**BYE** <Return>
This will return control to the Zenith PC in the directory: D:\FICA

4.2.5 Saving a Blocked FICA File Onto 9-Track Tape From the MicroVAX

a. This procedure can be performed either from the Zenith (as a MicroVAX terminal) or the MicroVAX computer. If the Zenith is used, follow steps **a** through **e** of Section 4.2.4 to connect to the MicroVAX. If using the MicroVAX directly, follow from step **e** in that same section.

b. Set the default directory as follows: **$SET DEF $DISK2:[GSGC.DEPOT.FICA]**

c. If the file name needs to be changed, type and enter the following:
$ RENAME (Old filename) (New filename)<Return>

d. To get the total number of records of the file, call the line counter program by typing:
$REC (filename)<Return>

e. Repeat step **d** until all the number of records for all of files are logged.

f. The files can now be written on 9-track tape. Load a blank tape with write ring on, into the Digital TS05 Tape Drive (press the "**Load** and "**On-Line**" soft padded buttons).

g. Execute the program to save and block the files by typing this:

$ @[GSGC.DEPOT]100BLOCK.COM <Return>

This program will write ASCII records (80 characters long) in 100 record tape blocks until the entire file has been written to tape. An end of file mark will be placed at the end of the file.

h. The program will prompt for the file name to be saved on tape. Enter the file name you want. Note that the default directory has already been set in step b so the entire path name need not be specified.

$ **(Enter filename)** <Return>

i. At the message "MOUNT THE TAPE& PRESS <RETURN> TO CONTINUE:", press the **Return** key.

j. At the message "NUMBER OF FILES TO SKIP?" enter the appropriate number of files to skip over which may have already been written on the tape. If the tape was blank and this is the first file being written this question will not be asked. If you are writing over a previously used tape, enter 0, for the second file enter 1, for third enter 2, etc. Press the "**Return**" key after your answer. The file will then be written to the tape.

k. When finished, the screen will display the number of input records and the number of output records (or the number of blocks). Log these numbers. Compare number of input records here with the one obtained from the line counter program for the same file. Make sure they are the same. If they are not, check the tape, the tape drive, or get help from the MicroVAX room personnel.

l. Upon completion, the following message is displayed on the screen:
DO YOU WANT TO COPY ANOTHER FILE? <YES OR NO>.

If other files are to be written, answer **YES** and repeat steps **h** through **l**. If no further files are to be copied answer NO. The tape will be rewound and unloaded automatically. Press the "**Return**" key after all answers.

m. Remove the tape from the tape drive when finished with all files and log off from the MicroVAX by typing: $ LO <Return>

4.3 FICA Files From 9-Track Tapes

Once the translation is successfully performed, the FICA file may have to be transported to another computer. Typically, the 9-track tape generated for this transfer will also be used for data archiving. The recommended tape density is 1600BPI since this capability is common to most equipment. If the data is exchanged with another organization at a later date, regenerating the tape will not be necessary (a simple ASCII tape copy utility can be used). Experience has shown that 30 to 40 FICA files (each containing 6 hours of 30 second data) can fit on one 2400ft 9-track tape when 1600BPI is used and the tape is blocked at 100 records per tape block. Each record contains 80 ASCII characters. Simple utility programs for writing and reading blocked ASCII files are necessary for this task. Once a FICA file is loaded into a mass storage file from the 9-track tape, it can be treated the same as any other FICA file.

A FICA file naming convention has been established within DMA. The structure of the FICA file name is as follows:

Example: GEOSTAR*GA271A9148.

Where 'GEOSTAR*' is the Unisys qualifier and thus would not be necessary on non-Unisys equipment. The remainder of the file name is the critical part:

Character	1	'G'	indicates Gesar, 'B' indicates BEPP/CORE
	2	'A'	indicates ASCII file
	3-5	'271'	indicates last 3 digits of station ID
	6	'A'	cassette or data subset, sequencing A,B,C. etc.
	7	'9'	last digit of year data was collected
	8-10	'148'	day number of year that data was collected
	11		use 'E' for edited file if the file is a subset of the original

On DEC (VAX or MicroVAX) equipment, the file name extension '.DAT' should be used.

5. SCREENING AND EDITING FICA FILES

Once a FICA file is loaded onto the computer where it will be processed, it can be examined and manipulated in a number of different ways. The simplest tool one can use is any appropriate ASCII file editor. An analyst can simply browse through the file and visually verify that the file contains the properly structured, necessary information. The analyst must be familiar with the FICA block identifiers. For example, when working with a BEPP/CORE - created file, the Block 10's should be checked to verify that the weather observations in the data file match those recorded on the field sheet. If no Block 10's are present (the case when GESAR is used), the weather data from Block 101 will be used for the entire data set. If necessary, the editor can be used to modify the contents of the file.

Since manually screening a data file is very tedious and provides only a limited amount of information, a comprehensive screening program has been written at DMA to allow analysis and editing of FICA files and provide a summary of a data file's contents. This program has been designated **PRTN**, which is a contraction for PaRTitioN a data file (s). This utility program can screen and partition an individual data set or a pair of simultaneous data sets which will be used for baseline estimation programs. A user's guide for PRTN has been prepared by Ayrandjian [1989]. The point positioning user may desire to split up a data set before processing, if for example, a significant part of a data set is to be discarded (if it contains only 2 satellites for example).

PRTN provides a comprehensive summary of a FICA file's contents and allows selective editing of a file(s) by choosing options from a menu. One essential piece of information obtained from PRTN is a list of satellites which are present in the data set being analyzed. The user will always need to know which satellites are present before giving the data to STARPREP. Moreover, if the FICA file contains less than 4 satellites for significant periods during the data span, these periods may be removed from the data set. Whenever PRTN performs any editing of an FICA file, it maintains the original FICA file contents and creates a new FICA file which will contain the updated contents. The label 'UPD' is added to the new (edited) FICA file name. The placement of this identifier depends on which computer equipment PRTN is being used on. If PRTN is used to modify the contents of a file, the updated FICA file is to be used from that point on.

Independent of PRTN, another utility program, named EDITFICA, may also be used to divide a FICA file into subsets. This relatively simple program prompts the operator for the start and end times of the data subset being created. This program is especially useful when operating on BEPP/CORE, DMA fixed-site data sets since it filters out the numerous weather blocks (Block 10s) and keeps only one weather block per hour. STARPREP can handle up to five weather blocks in any single FICA file.

When analyzing the contents of a FICA file for positioning use, the following items must be checked:

1. A valid antenna height (From Block 101 or Block 124). This antenna height must be the measured distance from the monument to the base of the TI4100 antenna. GASP applies the calibrated distance from the base of the antenna to the mean electrical center of the TI antenna. The value in the FICA file should agree with the value written on the field sheets. Note that this antenna height may change from day to day if the receiver occupied a site for repeated days.

2. Valid weather data (From Block 101 or Block 10) If default values are used, a degradation in positioning results will occur which is difficult to detect by the user. If default values are found, or any error is detected in the values in the FICA file, the user should correct these errors before continuing with processing. The weather values in the FICA file should be checked against the values written on the field sheets. The barometric pressure values can be checked for gross errors by comparing to a crude value for atmospheric pressure which can be estimated from the station's elevation above mean sea level. Charts are available for this conversion. If a gross error is detected, it may be due to the use of a barometer that has not been calibrated. If this occurs, the user of the data should not resort to a default atmospheric pressure. Instead, the user should use a value implied by the station's elevation above mean sea level.

When the GESAR operating system has been used, one set of weather values will be found in Block 101 of the FICA file. When BEPP/CORE has been used to record data, a series of weather Blocks (Block 10) will be present in the data.

3. The year and the day number (Block 101 or Block 124) that the data file was recorded should be noted so the user can assign the appropriate precise ephemeris files when the preprocessor is run. If the FICA file contains data after 12:00 UT on a Saturday (561600 seconds into the GPS week), 'HALF-WEEK' precise ephemeris and clock files must be used. These 'HALF-WEEK' precise ephemeris and clock files are specifically designed to allow processing of data which was collected through a week-crossover. The standard precise ephemeris files distributed by DMAHTC consist of one full GPS week (00:00:00 Sunday to 24:00:00 Saturday, plus 1/2 day overlap on each end). The 'HALF-WEEK' precise ephemeris files begin at 00:00:00 Wednesday and end at 24:00:00 on Tuesday. There is no smoothing performed across the two separate GPS weeks when the HALF-WEEK files are created.

4. The user should take note of any week-crossovers (Block 101 or Block 124) in the data files. If a satellite other than the first available satellite in the file experiences a week crossover and the first available satellite data span falls completely into the later of the two weeks, it is necessary to edit the file such that the edited file begins in the later of the two weeks. The day number in the Block 101 of the edited file must be modified to represent the first day of the later week. If the first satellite tracked experiences a week crossover, there is no need to edit the file ('HALF-WEEK' precise ephemeris and clock files must be used).

5. The a priori station coordinates (Block 101 or Block 124) should be verified. The nominal accuracy of these coordinates is assumed to be half of a kilometer in each component. If GASP rejects a large percentage of data on the basis of the RMS edit, or if the residual plots produced by GASP do not appear random on the third iteration, there is probably a gross error in these a priori coordinates in the FICA file. If improved coordinates are not available, STARPREP and GASP should be run to completion and the resulting position estimate should be put into the FICA file as new a priori coordinates. Note that STARPREP must be run again (*with the improved* a priori coordinates) because some of the data corrections are a function of these coordinates. If the a priori coordinates are too far off, some of the data correction applied by STARPREP will be biased.

6. The PRN numbers of the satellites tracked (Block 101 or Block 124) and the number of satellites in the data set should be noted. Moreover, any data gaps or periods where less than 4 satellites have been tracked should be noted. The length of the data span should also be noted.

7. The following FICA Blocks must be present in the data file for STARPREP and GASP to produce a valid point position estimate:

	GESAR DATA	BEPP/CORE DATA
One	Block 101 (Configuration)	Block 124 (Configuration)
One or more	Block 9 (For Broadcast Ephemeris)	Block 9 (For Broadcast Ephemeris)
Many	Block 6 (Data Blocks)	Block 55 (Data Blocks)
One or more		Block 10 (Weather)

The configuration Block (101 or 124) must appear before any data blocks.
The first weather block (BEPP/CORE only) must appear before any data blocks.
Any FICA Blocks not shown above are ignored by STARPREP and GASP.

After verifying these essential pieces of information discussed here, the FICA file is ready for preprocessing in STARPREP. If the FICA file was edited in any way, the new (edited) file must be checked for these essential elements before proceeding. If more than one configuration Block (101 or 124) exists in a file, only the first one will be used by STARPREP.

6. PREPROCESSING (STARPREP)

6.1 Overview

The GEOSTAR PREPROCESSOR program is designed to accomplish a number of essential, routine functions which are necessary to exploit the data for the maximum precision possible. A list of the standard data corrections applied by STARPREP and their functional dependencies is shown in Table 2. A detailed mathematical formulation of these corrections can be found in Malys and Ortiz [op.cit.]. The main function of STARPREP is to create the 'POINT File' which GASP uses to perform point positioning. The POINT File contains the corrected L1 tracking data, the interpolated satellite ephemerides and clock states and the values for the individual data corrections which were applied. It also contains a header which identifies the data set. Sample STARPREP runstreams are given in Section 6.2.

TABLE 2. Data Corrections and Their Functional Dependencies

Correction / Function of	Data Values	Surface Weather Obs.	A priori Position Estimate	Adopted Ephemerides/ Clock States
1. Epoch of Receipt to Epoch of Transmission	√			
2. Satellite Clocks				√
3. Receiver Offsets*				
4. Ionosphere	√			
5. Troposphere		√	√	√
6. General Relativity				√
7. Earth Rotation			√	√
8. Satellite Antenna Offsets			√	√

* The TI4100 frequency offsets of -6000 Hz and +7600 Hz are modeled away by adding 6000(Δt) cycles and subtracting 7600(Δt) cycles to/from the L_1 and L_2 recorded carrier beat phase respectively, where Δt represents the time interval (seconds) between the data value epoch and the current reference epoch for a particular satellite.

6.2 Sample STARPREP Runstreams

Sample runstreams which specify the selection of broadcast or precise ephemerides/clocks are given in Figure 4. The following 7 data corrections are to be applied for all geodetic positioning applications:

- Range Ionosphere (IR)
- Doppler Ionosphere (ID)
- Earth Rotation (ER)
- Hopfield Troposphere (TH)
- Satellite Clock (SC)
- General Relativity (GR)
- Satellite Antenna Offset (SA)

These corrections are selected in the STARPREP runstream by the use of their two-letter codes shown above. The 'CMPUTCOR' card image in the runstream designates which corrections are to be computed, while the 'APPLYCOR' card image designates which corrections are to be applied to the pseudorange and converted, carrier beat phase data. The 'PLOTCORR' card image in the STARPREP runstream is used to designate which corrections are to be plotted.

The corrections for the TI4100 receiver frequency offsets are automatically applied in conjunction with the doppler ionosphere correction. Further details regarding the frequency offset correction are given in Malys and Jensen [op.cit.], and in the note at the bottom of Table 2.

Occasionally, there may be reason to believe that a particular GPS satellite was behaving erratically or experienced some anomaly during the collection of a given data set. By modifying the STARPREP runstream, any particular satellite(s) may be excluded from the point positioning process. **Satellites which operated on a quartz crystal frequency standard during the data span must always be excluded.** To accomplish this exclusion, the user removes all lines in the runstream which refer to the PRN number of the satellite(s) to exclude. The unit numbers for the file assignments must be modified such that they are continuous, sequential, in ascending order and commence at 11 and 51 (for broadcast preprocessing) or 11, 21, and 51 (for precise preprocessing). The excluded satellite(s) must also be removed from the satellite selection list represented by the 'SELECTSV' card image. The sequence of PRN numbers in the 'SELECTSV' card image must match the sequences of PRN numbers in the file assignments. Examples are given in Figure 5.

In all cases, only satellites which are known to contribute to the FICA file are allowed to be referenced in the STARPREP runstream. If a particular satellite is listed in the STARPREP runstream and this satellite is not present in the FICA file being processed, the preprocessor will fail. The overall STARPREP processing time for a typical FICA file is only about 2 to 5 minutes (on Unisys equipment).

STARPREP PLATTVILLE DAY 223 1989

```
@HDG,P **UNCLASSIFIED**
@PRT,S     ESGT*MALYS.NEWSTAR/RUNBALL
@XQT  GPS*FICASTARPREP.PTSTARPREP/PCLOCK
ASGFILES    4    GEOSTAR*STATIONLOG.
ASGFILES    7    GEOSTAR*GASPLAA9223.
ASGFILES   10    GEOSTAR*PTPLA9223B.
ASGFILES   11    GEOSTAR*038SPLA9223T.
ASGFILES   12    GEOSTAR*068SPLA9223T.
ASGFILES   13    GEOSTAR*098SPLA9223T.
ASGFILES   14    GEOSTAR*118SPLA9223T.
ASGFILES   15    GEOSTAR*128SPLA9223T.
ASGFILES   16    GEOSTAR*138SPLA9223T.
ASGFILES   31    GEOSTAR*MT8SPLA9223P.
ASGFILES   32    GEOSTAR*RC8SPLA9223P.
ASGFILES   33    GEOSTAR*SV8SPLA9223P.
ASGFILES   34    GEOSTAR*ST8SPLA9223P.
ASGFILES   41    GEOSTAR*MMET.
ASGFILES   42    GEOSTAR*MRCV.
ASGFILES   43    GEOSTAR*MSAT.
ASGFILES   44    GEOSTAR*MSTA.
ASGFILES   51    GEOSTAR*PT03223LOUT.
ASGFILES   52    GEOSTAR*PT06223LOUT.
ASGFILES   53    GEOSTAR*PT09223LOUT.
ASGFILES   54    GEOSTAR*PT11223LOUT.
ASGFILES   55    GEOSTAR*PT12232LOUT.
ASGFILES   56    GEOSTAR*PT13223LOUT.
PPROCSEQ    EDIT   TTAGCOR   DATACOR
CMPUTCCR    ID   IR   ER   TC   SC   GR   SA   TH
APPLYCCR    ID   IR   ER   TH   SC   GR   SA
PLOTCCRR    ID   IR   ER   TH   SC   GR   SA
EPHEMRIS    B
EDCNTRCL    RCVOPT   TOLOPT
DEBUGSCN    DBUG
LOGICALS    SETERM
SELECTSV    3  6  9  11  12  13
ENDINPUT
```

```
@HDG,P **UNCLASSIFIED**
@PRT,S     ESGT*MALYS.NEWSTAR/RUNPALL
@XQT  GPS*FICASTARPREP.PTSTARPREP/PCLOCK
ASGFILES    4    GEOSTAR*STATIONLOG.
ASGFILES    7    GEOSTAR*GASPLAA9223.
ASGFILES   10    GEOSTAR*PTPLA9223P.
ASGFILES   11    GEOSTAR*038SPLA9223T.
ASGFILES   12    GEOSTAR*068SPLA9223T.
ASGFILES   13    GEOSTAR*098SPLA9223T.
ASGFILES   14    GEOSTAR*118SPLA9223T.
ASGFILES   15    GEOSTAR*128SPLA9223T.
ASGFILES   16    GEOSTAR*138SPLA9223T.
ASGFILES   21    GPS*EF038921B.
ASGFILES   22    GPS*EF068921B.
ASGFILES   23    GPS*EF098921B.
ASGFILES   24    GPS*EF118921B.
ASGFILES   25    GPS*EF128921B.
ASGFILES   26    GPS*EF138921B.
ASGFILES   31    GEOSTAR*MT8SPLA9223P.
ASGFILES   32    GEOSTAR*RC8SPLA9223P.
ASGFILES   33    GEOSTAR*SV8SPLA9223P.
ASGFILES   34    GEOSTAR*ST8SPLA9223P.
ASGFILES   40    GPS*PC89218.
ASGFILES   41    GEOSTAR*MMET.
ASGFILES   42    GEOSTAR*MRCV.
ASGFILES   43    GEOSTAR*MSAT.
ASGFILES   44    GEOSTAR*MSTA.
ASGFILES   51    GEOSTAR*PT03223LOUT.
ASGFILES   52    GEOSTAR*PT06223LOUT.
ASGFILES   53    GEOSTAR*PT09223LOUT.
ASGFILES   54    GEOSTAR*PT11223LOUT.
ASGFILES   55    GEOSTAR*PT12223LOUT.
ASGFILES   56    GEOSTAR*PT13223LOUT.
PPROCSEQ    EDIT   TTAGCOR   DATACOR
CMPUTCCR    ID   IR   ER   TC   SC   GR   SA   TH
APPLYCCR    ID   IR   ER   TH   SC   GR   SA
PLOTCCRR    ID   IR   ER   TH   SC   GR   SA
EPHEMRIS    P
EDCNTRCL    RCVOPT   TOLOPT
DEBUGSCN    DBUG
LOGICALS    SETERM
SELECTSV    3  6  9  11  12  13
ENDINPUT
```

Figure 4. Broadcast and Precise STARPREP Runstreams

```
@HDG,P **UNCLASSIFIED** STARPREP   PLATTVILLE  DAY 223 1989 NO PRN 9
@PRT,S    ESGT*MALYS.NEWSTAR/RUNPALL
@XQT GPS*FICASTARPREP.PTSTARPREP/PCLOCK
ASGFILES    4    GEOSTAR*STATIONLOG.
ASGFILES    7    GEOSTAR*GA5PLAA9223.
ASGFILES   10    GEOSTAR*PTPLA9223PE.
ASGFILES   11    GEOSTAR*0385PLA9223T.
ASGFILES   12    GEOSTAR*0685PLA9223T.
ASGFILES   13    GEOSTAR*1185PLA9223T.
ASGFILES   14    GEOSTAR*1285PLA9223T.
ASGFILES   15    GEOSTAR*1385PLA9223T.
ASGFILES   21    GPS*EF0389218.
ASGFILES   22    GPS*EF0689218.
ASGFILES   23    GPS*EF1189218.
ASGFILES   24    GPS*EF1289218.
ASGFILES   25    GPS*EF1389218.
ASGFILES   31    GEOSTAR*MT85PLA9223P.
ASGFILES   32    GEOSTAR*RC85PLA9223P.
ASGFILES   33    GEOSTAR*SV85PLA9223P.
ASGFILES   34    GEOSTAR*ST85PLA9223P.
ASGFILES   40    GPS*PC89218.
ASGFILES   41    GEOSTAR*MMET.
ASGFILES   42    GEOSTAR*MRCV.
ASGFILES   43    GEOSTAR*MSAT.
ASGFILES   44    GEOSTAR*MSTA.
ASGFILES   51    GEOSTAR*PT03223LOUT.
ASGFILES   52    GEOSTAR*PT06223LOUT.
ASGFILES   53    GEOSTAR*PT11223LOUT.
ASGFILES   54    GEOSTAR*PT12223LCUT.
ASGFILES   55    GEOSTAR*PT13223LOUT.
PPROCSEQ   EDIT  TTAGCOR  DATACOR
CMPUTCCR   ID  IR  ER  TC  SC  GR  SA  TH
APPLYCCR   ID  IR  ER  TH  SC  GR  SA
PLOTCCRR   ID  IR  ER  TH  SC  GR  SA
EPHEMRIS   P
EDCNTRCL   RCVOPT  TOLOPT
DEBUGSCN   QBUG
LOGICALS   SETERM
SELECTSV   3  6 11 12 13
ENDINPUT
```

Figure 5. STARPREP Runstreams for Excluding a Satellite (PRN 9 has been excluded)

6.3 Broadcast or Precise Ephemerides and Satellite Clock States

The STARPREP preprocessor allows the user to choose from two sources of GPS ephemerides and satellite clock state estimates. These two sources are referred to as *broadcast* and *precise*. The broadcast ephemerides and clock states are predictions which are derived from the 5-station network operated by the US Air Force while the precise ephemerides and clock states are weekly post-fit estimates computed at DMAHTC using the OMNIS program. The precise ephemerides and clock states are estimated from data collected at the 5 DMA fixed sites and the 5 Air Force sites. This combined 10-station network provides a globally distributed, balanced station set and thus considerably improves the estimated ephemerides and clock states. While the broadcast and the precise ephemerides/clocks are both generated using the WGS 84 system of constants and models, the geodetic user must remember that the broadcast messages are predictions of where the satellite will be in the future and can never be as precise or accurate as the post-fit estimates which are generated by OMNIS. The disadvantage of using the precise ephemerides/clocks is the delay of a few weeks before the precise ephemerides/clocks are available. This is rarely a problem in geodetic surveying.

The STARPREP algorithm is designed to use precise satellite clock states which were estimated along with the precise ephemerides. The only time the broadcast clock states are used is when the broadcast ephemerides are selected. This selection occurs automatically in the STARPREP algorithm.

One of the reasons for maintaining the option to process broadcast ephemerides/clocks is the possibility of using STARPREP/GASP in the field on an appropriate portable computer. Field use would require the use of broadcast ephemerides/clocks. While the positions estimated in the field would be inferior to those estimated from the precise ephemerides, they would be adequate for validating the data set and would provide initial coordinates for the fixed end of a baseline. In the usual post-processing environment, the use of broadcast orbits can facilitate the resolution of problems with a data set and provides an opportunity to evaluate the broadcast data if the station coordinates are precisely known in advance. **For routine, precise geodetic point positioning, the DMA precise ephemerides and satellite clock states must be used.**

6.4 The Point File

The primary file which is generated by STARPREP is referred to as a 'POINT FILE'. This point file contains the corrected L_1 data, the interpolated ephemerides and satellite clock states and identifying information which indicate the corrections that were applied and the source of the ephemerides and clock states. A sample of the ASCII form of a point file (generated by the utility program PTDUMP) is given in Figure 6. Note that the point file form used by STARPREP is binary. The structure for the contents of a point file is also given in Figure 7. The ASCII form can be visually inspected if problems occur.

A POINT file naming convention has been established within DMA. The structure of the name is as follows:

Example: GEOSTAR*PT2719148PA.

Where 'GEOSTAR* is the Unisys qualifier and would not be necessary on non-Unisys equipment. The remainder of the file name is the critical part:

Character	1-2	'PT'	indicates a POINT file
	3-5	'271'	last 3 digits of station identifier
	6	'9'	last digit of year data was collected
	7-9	'148'	day number of year that data was collected
	10-12	'PA'	'P' indicates Precise ephemeris/clocks, 'B' indicates broadcast ephemeris/clocks 'A' (optional) or some other designator indicates which subset of the original data set was used.

For DEC (VAX or MicroVAX, the file name extension '.PNT' should be used.

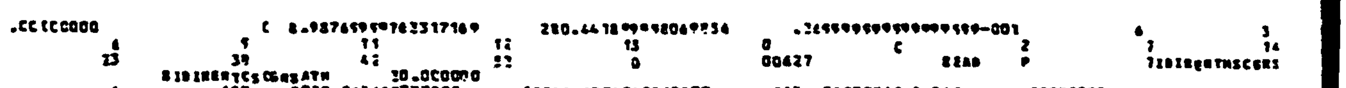


Figure 6. Sample of a Portion of a Point File

POINT FILE RECORD DESCRIPTION

RECORD #1 (FILE HEADER, 1 PER FILE)

WORD #	VARIABLE	TYPE	DESCRIPTION
1	STID	I	STATION NUMBER
2	SITID	S	STATION NUMBER
3	STLATI	D	STATION COORDINATE, LATITUDE (DEG)
4	STLONI	D	STATION COORDINATE, LONGITUDE (DEG)
5	STHTI	D	STATION COORDINATE, HEIGHT (KM)
6	NUMSV	I	NUMBER OF SATELLITES IN DATA FILE
7	ISVLIST	I	LIST OF SATELLITES IN DATA FILE
15	SVRECN	I	ADDRESS FOR EACH SATELLITE'S DATA (NOT USED)
23	DATEP	C*6	PROCESSING DATE
24	IYR	I	YEAR OF START OF DATA
25	MSTYPE	C*2	MEASUREMENT TYPES ON FILE
26	EPHTYP	C*2	EPHEMERIS TYPE
27	NCORRA	I	NUMBER OF CORRECTIONS APPLIED
28	CORRA	C*2	LIST OF CORRECTIONS APPLIED
29	NCORRC	I	NUMBER OF CORRECTIONS COMPUTED
30	CORRC	C*2	LIST OF CORRECTIONS COMPUTED
31	RRMTI	S	REQUESTED MEASUREMENT INTERVAL, SEC
32-52	COMMNT	C*80	COMMENTS ON FILE HEADER

RECORD #2 (DATA RECORDS, 1 FOR EVERY DATA POINT)

WORD #	VARIABLE	TYPE	DESCRIPTION
1	PRN	I	SATELLITE PRN NUMBER
2	NWKN	I	GPS WEEK NUMBER
3	T	D	MEASUREMENT TIME OF TRANSMISSION, SEC
4	RC	D	CORRECTED RANGE MEASUREMENT,
5	DC	D	CORRECTED DOPPLER MEASUREMENT,
6	TCUM	D	CUMULATIVE TIME
7	XSAT(1)	D	INTERPOLATED SATELLITE POSITION, X-COMPONENT
8	XSAT(2)	D	INTERPOLATED SATELLITE POSITION, Y-COMPONENT
9	XSAT(3)	D	INTERPOLATED SATELLITE POSITION. Z-COMPONENT
10	DOPOFF	D	DOPPLER OFFSET CORRECTION, KM (NOT USED)
11	EROT	D	EARTH ROTATION CORRECTION, KM
12	GENREL	D	GENERAL RELATIVITY CORRECTION, KM
13	IONCR	D	RANGE IONOSPHERIC CORRECTION, KM
14	IONCD	D	DOPPLER IONOSPHERIC CORRECTION, KM
15	ANTOFF	D	ANTENNA OFFSET CORRECTION, KM
16	SVCLK	D	SATELLITE CLOCK CORRECTION, KM
17	TROPCH	D	CHAO TROPOSPHERIC CORRECTION, KM
18	TROPHO	D	HOPFIELD TROPOSPHERIC CORRECTION, KM
19	TOFF	D	TIME BIAS UPDATE, KM
20	RVAR	S	RANGE MEASUREMENT VARIANCE, KM**2
21	DVAR	S	DOPPLER MEASUREMENT VARIANCE, KM**2

Figure 7. Point File format

6.5 Quality Control - Analysis of STARPREP Output

Selected output from a normal STARPREP run is shown in Appendix B. The collection of input files which were used to generate the output shown in Appendix B is available as a test data set. The input files consist of the FICA file, the DMA precise ephemeris files, and the precise satellite clock file. The PLOTCORR option should always be invoked in the STARPREP runstream. This option produces plots of all applied data corrections, by satellite, as part of the STARPREP output. These plots are very helpful in understanding the corrections. They are also very helpful in resolving problems with a particularly difficult data set. Note that the plots do not contain values for every data point. Only every nth point is used to generate the plots. Each STARPREP output plot should be examined for the following characteristics:

Plots to check: (Note that all corrections plotted in the output are in units of kilometers)

> 'Uncorrected range vs time' and 'Uncorrected Doppler vs time': The plots should be linear or 2nd order curves with possible gaps where no data was collected from a particular satellite. Discontinuities in the Doppler plot should correspond to cycle slips or scenario changes.

> 'Satellite # range iono vs time': Corrections plotted on this graph should range between 0 and -15 meters. All corrections should be negative. The random nature of these corrections reflects the normal pseudorange noise.

> 'Satellite # Doppler iono vs time': These ionospheric corrections are used to identify cycle slips in either L_1 or L_2. These cycle slips appear as steps in the correction values. While these cycle slips normally do no harm in the GASP algorithm, they are of interest for further detailed analysis. These corrections should be in the range of 0 to ± 15 meters.

> 'Satellite # sat. clock vs time': This graph should appear linear or vary smoothly over the span of data. These corrections are interpolated from the precise satellite clock biases and serve to correct the individual satellites to GPS time. When broadcast ephemerides and clocks are used, these corrections are computed from the polynomial coefficients found in the FICA Block 9s.

> 'Satellite # relativity vs time': This plot should vary smoothly over the data span. The plot should be linear, or a 2nd or 3rd order curve.The correction values should range between 0 and ± 15 meters.

> 'Satellite # earth rotation vs time': This plot should be linear, or a 2nd or 3rd order curve. The correction values should be in the range 0 to ± 40 meters.

> 'Satellite # sat. antenna vs time': This small correction should be linear, or a 2nd or 3rd order curve. The correction values should be less than 1 meter.

> 'Satellite # Hopfield troposphere vs time': The plot should be linear or a 2nd or 3rd order curve. This correction is dominated by the elevation angle and as such, should vary smoothly over the span. A spike or discontinuity may indicate that an incorrect ephemeris file was assigned in the runstream. Correction values should be in the range 0 to 30 meters.

Other items to check:

> Check that the 'Ephemeris Source' is 'Reference' if the DMA precise ephemerides and clock states were selected in the runstream. In the rare cases when STARPREP encounters a problem locating the proper precise ephemeris and satellite clock files, it will default to the Broadcast ephemeris and clocks. This will be noted in the 'Ephemeris Source' message.

> Check that the 'Corrections : Computed Applied' are as expected.

> Check and note 'Output File Name' as the Point File name which will be used to input to GASP.

7. POINT POSITION ESTIMATION (GASP)

7.1 Overview and Sample Runstream

Two files which STARPREP produces are required inputs to the point positioning program (GASP) (The Geodetic Absolute Sequential Positioning Program). These files are the point file and the station file. The only information needed from the station file is the antenna height (monument to base of antenna). STARPREP obtains this antenna height from the FICA file Block 101 or Block 124. Recall that the antenna height should be verified against the field sheets when the data set is reviewed. GASP automatically applies the constant, known offset from the base of the TI antenna to the mean electrical center (0.22733 meters).

The standard GASP runstream is much simpler than STARPREP's. Only two files are assigned and unless some experiments are being conducted, the standard options (A) are all that need to be specified. An example of the standard GASP runstream and an example of a GASP runstream which allows selection of non-standard options are shown in Figure 8. A complete sample GASP output is given in Appendix C.

Typical overall processing time for GASP is only 1 to 2 minutes (Unisys equipment).

```
@HDG UNCLASSIFIED          GASP  PLATTEVILLE       DAY 223   ---PRECISE EPHM---
@PRT,S GSGT*MALYS.RUNSTD
@ASG,T 35.
@ERS 35.
@XQT GPS*GASP.GASP
GEOSTAR*FTPLA9223P.
A                     (CHOOSE STANDARD OPTIONS)
GEOSTAR*ST85PLA9223P.
```

```
@HDG UNCLASSIFIED GASP   PLATTEVILLE DAY 223     ---PRECISE EPHM---
@PRT,S GSGT*MALYS.RUNGASP
@ASG,T 35.
@ERS 35.
@XQT GPS*GASP.GASP
GEOSTAR*FTPLA9223P.
B                  (CHOOSE OPTIONS)
P                  (PLOT TO PRINTER)
15                 (ELEVATION ANGLE CUTOFF, DEGREES)
3.00               (RMS SCREENING MULTIPLIER)
5.00               (PSEUDORANGE EDITING TOLERANCE, METERS)
N                  (DO NOT ESTIMATE 4TH PARAMETER)
2                  (USE A MINIMUM OF "N" SVS PER EPOCH PAIR:2,3,OR4)
N                  (NO OFFSET TO APRIORI STATION POSITION)
20.0               (STD DEV ON GASP OBSERVABLES, CM)
0.05               (STD DEV ON APRIORI POSITION COMPONENTS, KM)
00                 (PRN # AS "BASE" SAT, DEFAULT IS 00 (SEQUENCES))
GEOSTAR*ST85PLA9223P.
BAT
C3
SEQ
C1
END
```

Figure 8. Sample GASP Runstreams

7.2 Algorithm Description

The corrected carrier beat phase data is known to contain biases, integer cycle ambiguities and other undesirable characteristics which are dependent on factors such as initial acquisition epoch, cycle slips and receiver frequency standard fluctuations. Moreover, common errors may be inadvertently introduced through the application of less than perfect data corrections such as those associated with the atmosphere, and less than perfect estimates of the satellite ephemerides and clock states. In an attempt to remove these undesirable contributions, the GASP algorithm is designed around a differencing scheme which cancels common errors in the corrected data and adopted satellite ephemerides and clock states.

The first step in forming an observable is to difference two consecutive carrier beat phase observations (converted to kilometers) of the same satellite. Typically, the interval between consecutive observations is 30 seconds. This between-epoch difference (a biased delta-range) is then differenced with a corresponding between-epoch difference from another satellite. One 'GASP observable' is formed from data collected at one station from two satellites at two consecutive epochs. Since the TI4100 receiver tracks up to four satellites simultaneously, a given pair of data epochs can yield up to three 'GASP observables'. A graphic representation of this differencing scheme is given in Figure 9. For each pair of data epochs utilized, one satellite is used as the reference from which the others are differenced.

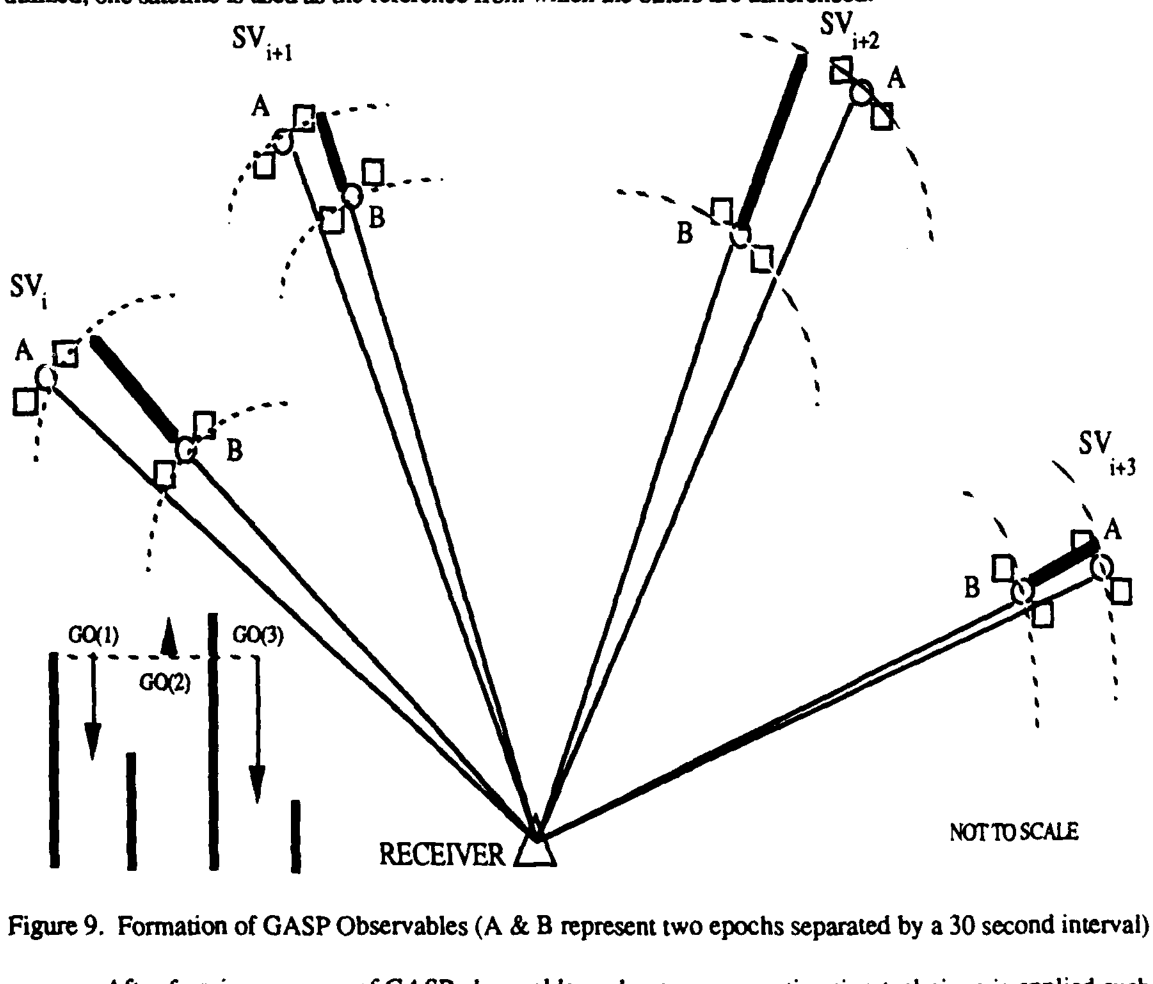


Figure 9. Formation of GASP Observables (A & B represent two epochs separated by a 30 second interval)

After forming an array of GASP observables, a least squares estimation technique is applied such that the vector of estimated parameters contains an 'alteration' to the a priori Earth-centered, Earth-fixed Cartesian station antenna position components. No other parameters are estimated. After three iterations of the non-linear model, the estimated parameters, their scaled variance-covariance matrix and the RMS of residuals are passed to a sequential estimation algorithm. This sequential technique (a Kalman filter) utilizes the RMS of residuals from the least squares fit as the variance of a GASP observable. In the sequential estimation technique, a parameter update is performed after each observable is processed. This allows plots to be generated which show the position component estimates as a function of the data set span. The level of convergence in the plots is one indication of the precision of the position estimate. Analysis of residual plots and of a posteriori variance-covariance matrices are also helpful in evaluating an individual result.

7.3 Pseudorange Minus Carrier Beat Phase Biases

Before the GASP observables are formed, each satellite is analyzed for consistency between its pseudorange data and its carrier beat phase data. A delta-range is computed for each pair of data epochs by subtracting two corrected pseudorange observations and also by subtracting two corrected, converted carrier beat phase observations. Theoretically, these two delta-ranges should be equal. Since however, there are different noise levels associated with these two data types, they will not, in general, be equal. A mean difference between these two types of delta ranges is computed for each satellite in a point file. These mean differences are listed in the beginning of the GASP output. These mean differences are referred to as *delta pseudorange minus delta carrier beat phase biases.* These mean values are removed from each observable tested in the procedure which edits data based on a 5 meter tolerance. (They are removed only for the tolerance test, not in the construction of the observable.) Occasionally, the list of these biases will reflect a problem with a particular satellite in the data set. Quality control criteria regarding these biases is presented in Section 7.8.

7.4 Reference Satellite Sequencing

Whenever the GASP standard options are used, the reference satellite is selected sequentially, such that for every new pair of epochs processed, the next higher available PRN number is used as the reference in the differencing scheme. The choice cycles back to the lowest available PRN number after the list of tracked satellites has been exhausted.

Before adopting this sequential reference satellite selection process, the authors tested the concept that the satellite with the most stable clock should be used as the reference throughout the data span. Comparison of statistics from repeated estimates however, indicated that the sequential approach offered many more benefits. These benefits are rationalized in terms of reduced correlation among the observables. The implementation of this sequential reference satellite selection process improved day to day repeatability, the RMS of residuals (for most fits), and the variance-covariance and correlation matrices of the estimated parameters by up to 30%. In particular, the GASP-estimated longitudinal component reaped almost all of the benefits. There remains an option in GASP which allows the user to override the automatic sequencing of reference satellites. This option is only meant for experimental purposes.

7.5 Rejected Data

Two kinds of data editing are performed by GASP. The first kind, discussed briefly in Section 7.3, relies on a comparison of delta pseudoranges with delta 'converted carrier beat phase'. If these two kinds of delta ranges differ by a user-selected tolerance (5 meters), the GASP observable (composed of two delta converted carrier beat phase observations) is rejected from the data set. This kind of editing is referred to as pseudorange editing. A second editing method uses an RMS screen of 3 times the previous iteration's RMS of residuals (the RMS is initialized before the first iteration). Any observables which have a residual greater than 3 times this RMS are rejected from the data set.

Experience with GASP has shown that the pseudorange editing process generally performs most of the editing. The RMS screening process usually only edits significant amounts of data when the a priori coordinates are very poor or if a particular satellite is behaving erratically. Quality control criteria regarding rejected data are given in Section 7.8.

7.6 Batch Least Squares versus Sequential Estimation

As described in Section 7.2, GASP utilizes two different estimation methods. The first is a 'batch' least-squares technique and the second is a sequential technique, usually referred to as a Kalman filter. Since each of these methods offers specific advantages, they are used together to maximize the extraction of useful information from the adjustment process. The standard options in GASP employ three iterations of the batch least squares method, then one iteration through the sequential method. Results from the batch method provide all the inputs to the sequential method. The estimated station coordinates from the batch method serve as a priori coordinates for the sequential method. The uncertainty on the coordinates entering the sequential stage are de-weighted to avoid constraining them to the batch results. The standard deviations are multiplied by 100 before they are used in the sequential processor. Most importantly, the batch method provides a measure of data noise to the sequential processor. The final RMS of residuals from the batch processor is used as the standard deviation of one GASP observable processed through the sequential filter. Any data that was rejected in the batch processor remains rejected in the sequential processor.

Since the sequential processor updates the estimated station coordinates as each new observable is processed, a series of estimated station coordinates can be plotted as a function of the data span used. These plots are provided as part of the standard options. The level of convergence in these plots (one each for the X,Y and Z components) serves as an indication of the precision of the final estimated coordinates.

7.7 Variance-Covariance and Correlation Matrices

The batch least squares and sequential estimation techniques both provide for the estimation of uncertainties on the estimated parameters. In our application, the estimated parameters are the three Earth-centered, Earth-fixed (ECEF) Cartesian station coordinates. An estimate of uncertainty on these coordinates can be obtained from the variance-covariance matrix for the estimated parameters. A measure of linear independence among the estimated parameters is obtained by developing the correlation matrix of estimated parameters. The variance-covariance matrix and the correlation matrix are symmetric matrices.

A posteriori standard deviations for the estimated ECEF station coordinates are obtained by taking the square root of each diagonal element of the variance-covariance matrix. These diagonal elements represent the estimated variance of each ECEF component. Experience has shown that these standard deviations are realistic estimates of the precision of the estimated point position components. The user will notice very good agreement between the standard deviations estimated in the batch least squares processor and the sequential processor.

The off diagonal elements of the variance-covariance matrix are the covariances and are used to compute the linear correlation coefficients which make up the correlation matrix.

7.8 Quality Control - Analysis of GASP Output

The output from each GASP run is to be analyzed to ensure that the estimated position and relevant statistics are reliable. The following list describes the items which must be checked.

\> 'The selected options that will be used are': Check all values. For normal, standard processing, the reference satellite should be 00 to indicate reference satellite sequencing.

\> 'Echo of station file' (unit 34)': Check station file name and a priori station coordinates.

> 'Distance From Ground Mark to Base of TI4100 Antenna': Check against height from field notes.

> 'Summary of Reference Satellite Selections': All PRN's in the associated STARPREP run should be shown. When reference satellite sequencing is used (as it should be in all standard runs) the 'No. of Times Used' should be approximately commensurate with the amount of data available from each PRN.

> 'Mean of Delta Pseudorange - Delta Carrier Beat Phase for Each Satellite in this Data Set': In general, a good data set will yield values for these biases which are in the range of a few centimeters to a few tens of centimeters. Values higher than about 50 centimeters indicate a problem with that particular satellite or a small amount of data from that particular satellite. If any of these biases is orders of magnitude different from those of the other satellites, go back to STARPREP and exclude the outlier satellite from the data set.

> 'Rejected Data': Whenever an observable is rejected by GASP the following information is provided to the user:

Reason for rejection: PSR EDIT=> Pseudorange edit tolerance failed; RMS EDIT=> Residual outside of RMS screen
Observable location in the data array (DPAR) (two locations, this array is arranged in matched pairs)
Satellite PRN numbers (two different PRN numbers representing the between satellite difference)
Time tags (these should always differ by the data collection rate, usually 30 seconds)
Difference of delta ranges for each satellite (for a PSR edit)
Residual and RMS screen limit (for an RMS edit)

In very rare cases, large systematic values for a PRN# in PSR EDIT> are found. This condition indicates a problem with the data (anomalous pseudorange or carrier beat phase data values have entered the Point file). Since each PRN number is sequentially paired with other PRN numbers to form the observables, a large amount of data from 'good' satellites can be thrown away. If the anomalous data values cannot be located and removed, the satellite must be excluded in the STARPREP run. This problem is sometimes eliminated by altering the data span by 30 seconds.

7.8.1 After Three Batch Iterations Check the Following:

> 'A Posteriori Variance of Unit Weight': Should be in the range 0.8 to 1.2. This insures that a valid measure of data uncertainty has been passed to the sequential estimation module.

> 'Correlation Matrix of Cartesian Estimated position': If any off-diagonal correlation coefficient is near 1 in absolute value (>0.8), a problem should be suspected. The geometry of the data set should be analyzed along with the data rejected by GASP.

> 'Estimated Standard Deviations on X,Y,Z (m)': These standard deviations should be less than 1.5 meters. The Z component is usually smaller than X or Y.

> 'Current RMS of (Mean(O-C)-(O-C))': Should be less than 5 cm. 'O-C' is Observed minus Computed where 'O' is the GASP observable constructed from the corrected L1 carrier beat phase data and 'C' is the predicted (modeled ,computed) value, obtained from knowledge of the satellite state vectors and the a priori station position vector.

> Number of GASP observables Used': Should be greater than 220.

> 'Percentage of Data Rejected': After each iteration, the percentage of rejected data is given. Typically, this percentage is between about 5 and 15%. Before each new iteration is started, a summary of the remaining data epoch pairs, sorted by satellite, is listed. By analyzing the rejected data and the

remaining epoch pairs list, it may be found that a particular satellite is being nearly completely rejected from the data set. If more than 25% of the data was rejected, go back to STARPREP and regenerate the point file with the troubled satellite excluded.

> Check the Plot: 'OMC(km) vs Time (secs) for # 3 Iteration' These 'residuals' must be of a random nature on the 3rd iteration. Note that in the first iteration, poor a priori station coordinates will produce systematic traces on these plots, this condition presents no problem as long as a normal amount of data was rejected. The 'O-C' plot on the third iteration must always appear random. Bad data or incorrect ephemerides will also produce systematic traces.

7.8.2 After the Sequential Filter Processing, Check the Following:

> All items listed in section 7.8.1 (there will only be one 'OMC vs Time' plot and no a posteriori variance of unit weight)

> "Mean of Delta pseudorange - Delta carrier beat phase for each satellite in this data set': as described in section 7.8.

> Plots of 'X,Y and Z Coordinate (km) vs Time (secs)': These important plots show how the Kalman filter estimate converges over the data span. If any of these components appear to 'wander around' beyond the level of 1 meter after a few hours of data has been processed, the user should suspect a problem and begin examining the data set. The user might find, for example, that the receiver tracked only 2 satellites for some period of time. This period may correspond to the period where the station coordinate estimates are 'wandering'. If such a situation occurs, the data set should be edited (to keep only periods where 4 or more satellites were tracked) or discarded.

> Compare the filter's position estimate to the estimate given at the end of the batch processor. The numeric comparison is already done where the 'Initial - Final Station Differences' are given. In the case when the sequential processor is used, the 'initial' station position estimate is provided by the batch least squares processor. These two position estimates should not differ in any component by more than 30 cm. Theoretically, if no further data is rejected in the sequential processor, and if the 'Q'ing is set to zero in the filter, these two position estimates should be equal.

8. PRECISION AND ACCURACY

8.1 Definitions

The terms 'precision' and 'accuracy' have distinct meanings and should not be interchanged in any discussion of geodetic positioning results. The precision of an estimated parameter is a measure of the degree to which the results are repeatable. In general, it is acceptable to interchange the terms 'repeatability', 'internal consistency', and precision. The standard deviations of the estimated station coordinates which GASP generates are measures of precision.

In order to evaluate accuracy, a well-known, independent standard of known higher accuracy must be available. In other words, some 'truth' values must be available for comparison. In geodetic positioning work, these 'truth coordinates' might be obtained from other advanced satellite geodesy methods such as Satellite Laser Ranging (SLR). If no such independent standards of accepted higher accuracy are available, there is no direct way to evaluate the accuracy of positioning results. Even when highly accurate standards are available, reference frame differences may be present which will complicate the evaluation.

Figure 10 graphically portrays the distinction between accuracy and precision for a 2-dimensional example. In the diagram shown on the right side of Figure 10, the offset between the cluster of estimates and the 'truth' position is referred to as a 'bias'.

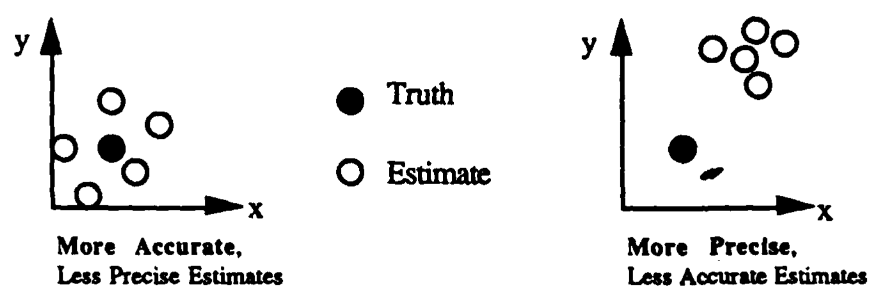


Figure 10. Graphic Example of Accuracy and Precision

To quantify the precision and accuracy of GASP position estimates, an extensive study was conducted by Malys and Jensen [1989]. Using over 200 data sets and the standard operating procedures outlined in this document, the overall level of precision, measured by the standard deviation of repeated positioning results, was found to be 73 centimeters in each component. An accuracy assessment was performed by comparing a small number of GASP results to positioning results obtained through VLBI/SLR methods. The mean difference between a GASP component and a VLBI/SLR component, in absolute value, was 76 centimeters. These levels of precision and accuracy are achievable on a routine basis by following the guidelines presented here.

8.2 Reporting Positioning Results

Since there are a number of methods available for geodetic positioning with GPS data, results must always be carefully documented and cataloged in a way which clearly shows which kind of positioning was performed (absolute, static relative, or kinematic relative) and which software packages were used. Since many GPS positioning algorithms are still under development and undergoing enhancements, the software version numbers should also be recorded. For point positions estimated by GASP, the following minimum specifications should be entered into the user's data base or whenever the results are provided to another organization:

Station Name:	DMA123
Method:	GPS WGS 84 Absolute Point Positioning
Software:	STARPREP (version 1.0), GASP(version 1.0)
Ephemerides and Satellite Clock States:	Precise WGS 84 EF##89246, PC89246
Date(s) of Occupation:	Day 247, 1989
GPS Receiver:	TI4100 using GESAR (version 1.9)
Date of Point Position Estimation:	05, December, 1989
Data Collection Span:	4.5 Hours
PRN Numbers Tracked:	3,6,9,11,12,13
Final Number of GASP Observables:	350
Percentage of Data Rejected:	11.2%
RMS of Residuals:	4.1 cm

WGS 84 Estimated Station Coordinates

Monument (X,Y,Z) (meters):	327259.205	-6340165.804	612494.684
Standard Deviations (X,Y,Z) (meters):	0.732	0.643	0.451

Geodetic coordinates (monument): ϕ= 5° 32' 51.284" λ= 272° 57' 17.293" h= 144.823 meters

Antenna Height (monument to electrical center of antenna): 1.523 meters

The standard deviations listed above can be used in number of ways to express statistical probabilities regarding the positioning result. Under the assumption that the errors in a positioning result are normally distributed, one standard deviation ($\pm 1\sigma$) represents 68.27% of the area under the normal distribution curve. If one wishes to express a 90% confidence level for a positioning result, the standard deviations listed above should be multiplied by 1.6449. Ninety percent of the area under the normal distribution curve is represented by 1.6449 σ. For example, using the sample Cartesian position component uncertainties listed above, one can state: 'There is a 90% probability that these components have precisions better than 1.2, 1.1, and 0.7 meters in X,Y and Z respectively.' Note that this is linear error for each component and not circular or spherical error.

Further details regarding statistical statements and probabilities can be found in ACIC Reference Publication No. 28 [1971].

9. Summary

The guidelines and procedures presented here provide a detailed overview of the STARPREP/GASP GPS geodetic point positioning process. The specific versions of STARPREP and GASP which this document addresses have each been designated version 1.0. These initial 'production' versions are based on well documented, thoroughly tested, easily-maintained, portable FORTRAN 77 source code.

As of October, 1989, over 200 STARPREP/GASP point positions have been estimated using version 1.0. If the procedures presented here are followed, very few operational problems are expected. Users of the STARPREP/GASP software packages are encouraged to communicate with the authors of this document if any discrepancies or anomalies are encountered when using the software with these guidelines.

Future upgrades of the STARPREP/GASP algorithms are anticipated. These upgrades would involve refinements such as the inclusion of a stochastic zenith tropospheric delay parameter in GASP and the ability to process new FICA configuration Blocks from BEPP/CORE data. As significant changes, enhancements or modifications are made to the algorithms or software, this set of guidelines will be updated as required.

Acknowledgments. The authors wish to express gratitude to their past and present colleagues at The Defense Mapping Agency who contributed to the development of the procedures, algorithms and software described in this report. Most notably, these include John Bangert, Gail Cherochak, Barbara DeNoyer, Carol Finn, Marilynn Ison, Seth Israel, Brett Merritt, Theodore Meyer, Richard Moore, Frank Mueller, Maria Ortiz, Robert Pereira, James Slater, Denise Stutzman, Brian Tallman, George Tennis and Cesar Yambot. Moreover, the cooperation of colleagues at the Naval Surface Warfare Center is sincerely appreciated.

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Appendix A. Field Logs and File Management Sheet

GPS FIELD LOG INSTRUCTIONS (OCTOBER 1988)

This GPS Field Log will be used with all GPS receivers, and serves as the official record of observations. The form has been designed to provide complete documentation of each tracking session, allowing the analyst to identify the data collected, the operational scenario and any notable events that occurred during tracking.
The form is organized as follows:

- Tracking Session Identification (top of each page)
- Weather Data
- Station Identification
- Operator Identification
- Receiver Information
- Tracking Scenarios
- Real-time Receiver Position & Clock Solutions
- Chronology of Events Log
- GPS Antenna Height Worksheet

Complete this form for each tracking session. A "tracking session" is defined as a continuous collection of data during which there are no intentional, deliberate or planned breaks in the tracking. It begins at a specific time when recording begins and it ends at a specific time when recording is terminated. Any number of changes in scenarios may occur during one tracking session. Tracking sessions differentiate data sets taken on the same day.

For items that are Not Applicable, enter "N/A".

For items that are Unknown, enter "Unknown".

Enter page numbers at the bottom of each sheet.

TRACKING SESSION IDENTIFICATION (ALL PAGES)

PROJECT ID: Name of the project or campaign. Example: JPL Casa Uno Campaign Jan 88.

STATION NO. (DMA): Station number assigned by DMA. If unassigned, leave blank for later assignment during processing. Example: 85269.

DATE (UT): Day-Month-Year for the Universal (UT) GMT date when the tracking session began.
Example: 23 Jul 88.

DAY of YEAR: Day number for the Universal (UT) GMT date when the tracking session began.
Example: 209.

SESSION NO.: Letter code to distinguish one tracking session from another on the same date

1st tracking session	A
2nd tracking session	B
3rd tracking session	C, etc.

NO. OF CASSETTES: Total number of cassettes used during this tracking session. (Cassettes should be numbered sequentially for a given tracking session, station and date.)

DATA FILE NAME: File naming convention for data stored in computer or on diskettes. Use an 11-character filename in the form "TXXXXYSF.DDD" where

T = file type : ASCII . . . . A
Binary . . . . B
XXXX = rightmost 4 characters of DMA station no.
Y = last digit of the year
S = tracking session no.
F = disk file no. : 1st file this tracking session 1
2nd file this tracking session . . . . 2, etc.
DDD = Day no. (UT) for this session

Example: B52698A1.209

STATION IDENTIFICATION

ALTERNATE STATION NO.: Note other station numbers assigned to this station (benchmark, antenna site) either before or during this project. Example: 11761.

STATION MARK AS STAMPED: Record the stamped information (not original castings) and type of mark (brass, iron rod, cross chiseled in stone, unmarked, etc.).
Example: Herndon Optrack Army Map Service 1965.

MONUMENT ESTABLISHED BY: Organization responsible for establishing the monument; use the station description card if available; otherwise use the casted identification or agency that set the mark.
Example: U.S. Corps of Engineers.

LOCAL DATUM: Local datum associated with the station mark and description card.
Example: NAD 27.

LOCATION: Address, site, town, province, state, country, as appropriate.
Example: DMA Herndon Facility, 925 Springvale Rd., Great Falls, Fairfax County, Virginia, U.S.A.

LATITUDE: Station latitude in degrees-minutes-seconds; Indicate North (N) or South (S). Use any available source -- map, receiver solution, geodetic control sheet, etc.
Example: N 31 deg 25 min 13 sec.

LONGITUDE: Station longitude in degrees-minutes-seconds; Indicate East (E) or West (W). Use any available source -- map, receiver solution, geodetic control sheet, etc.
Example: E 243 deg 10 min 44 sec.

HEIGHT: Station height in meters. Enter either ellipsoid height or mean sea level height as used for receiver input.
MSL = estimated mean sea level height (can use map)
ELLIPSOID = height above the reference ellipsoid, if known.
Example: 56.2 m.

COORDINATE SOURCE: Source of latitude, longitude and height coordinates. If map sheet, record series, date, agency, scale; If receiver, give manufacturer and model.
Examples: ONC E-19, 5/76, DMAAC, 1:1,000,000 or mission planning package.

REFERENCE DATUM: Datum to which the above coordinates are referred. Example: WGS 84.

IS THIS A BASE (REFERENCE) STATION?: Enter yes, no, or N/A as follows --

Yes.... This station is a primary survey point or control point and will be used as one of the primary geodetic positions for processing the data.

No...... This station is a secondary survey point not used as a primary reference station for geodetic coordinates.

N/A... Not Applicable. This station is an independent point being computed as an absolute position.

OTHER STATIONS TRACKING SIMULTANEOUSLY:
Station numbers of other stations simultaneously tracking during this session.

ANTENNA LOCATION: Antenna height in meters, as computed on the GPS Antenna Height Worksheet. This value is entered into the receiver. Antenna height is measured from the top of the station mark to the base of the GPS antenna. This does not include the distance between the electrical center of the antenna and the base. Example: 1.68 m.

OPERATOR IDENTIFICATION

OPERATOR'S NAME: Name of operator of receiver. Example: I. M. Smart.

OPERATOR'S ORGANIZATION: Organization with which the operator is affiliated.
Example: DMA.

RECEIVER INFORMATION

RECEIVER MANUFACTURER, MODEL, SERIAL NO.: Identify completely the receiver unit used.
Example: Texas Instruments, TI 4100, SN 85000555183.

ANTENNA MANUFACTURER, MODEL, SERIAL NO.: Identify completely the antenna used.
Example: Texas Instruments, TI 4100, SN 4141.

CLOCK MANUFACTURER, MODEL, TYPE, SERIAL NO.: Identify completely the external oscillator used, if applicable.
Example: Efratom, FRK-30, Rubidium, SN 8585.

____NO EXTERNAL OSCILLATOR USED:
If no external oscillator was used, check here on the form.

NAVIGATION PROCESSOR SOFTWARE NAME AND VERSION:
Name and version of navigation processor software used inside the receiver to track satellites and make measurements.
Example: GESAR Version 1.9.

MEASUREMENT INTERVAL:

MEASUREMENT RECORDING INTERVAL:
Rate (interval) at which measurements are recorded or written to tape or disk. Example: 30 sec.

REAL-TIME SOLUTION INTERVAL:
Rate (interval) at which the real-time navigation solution (position) is computed or updated by the receiver. Example: 30 sec.

TRACKING SCENARIOS

For each scenario provided by the lead organization, enter the following information:

START TIME (UT) : Enter the SCHEDULED start time and the ACTUAL start time. Example: 1020 1030.

SATELLITES TRACKED: Enter the PRN numbers of the satellites tracked. Example: 6 9 11 13.

WEATHER DATA

At planned, regular intervals, record the following weather data and key into the receiver if required:

TIME (UT) : UT time of the weather station readings. Example: 1430.

TEMPERATURE (^{o}C) : Wet bulb and dry bulb temperatures in degrees Celsius. Example: 24.6 / 36.8.

PRESSURE (Mb) : Barometric pressure in millibars. Example: 984.

RELATIVE HUMIDITY (%) : Relative humidity in percent. Example: 59.

REAL-TIME RECEIVER POSITION & CLOCK SOLUTIONS

During the tracking session, it is useful to record the position and clock solutions in order to monitor changes in the receiver's position and clock estimates for quality control purposes. This should be done at planned, regular intervals.

TIME (UT) : UT time at which the real-time receiver position and clock solutions are entered on the form. Example: 2330.

LATITUDE (deg, min, sec) : Latitude displayed by the receiver in degrees, minutes and seconds. If the receiver only displays positions in decimal degrees, use decimal degrees. Example: 62 - 25 - 40 or 62.4278.

LONGITUDE (deg, min, sec) : Longitude displayed by the receiver in degrees, minutes and seconds. If the receiver only displays positions in decimal degrees, use decimal degrees. Example: 288 - 30 - 18 or 288.5050.

HEIGHT (m) :Ellipsoid height displayed by the receiver in meters. Example: 141.3

CLOCK BIAS (time units) : Receiver clock offset from GPS time displayed by the receiver in seconds. Example: -0.1407 microsec.

CLOCK DRIFT (time/time units) :Receiver clock drift (frequency offset) displayed by the receiver in sec/sec, microsec/hr, etc.
Example: 0.7671 microsec/hour.

CHRONOLOGY OF EVENTS LOG

TIME (UT) :UT time at which an event occurred. Example: 1317.

COMMENTS: Record error messages. Describe special actions taken, note if and when the receiver was left unattended, document interruptions to tracking, etc.

GPS ANTENNA HEIGHT WORKSHEET

Compute the height of the antenna base above the mark as indicated on the worksheet. Measure heights in both meters and inches. Use the antenna constants provided on the worksheet or supply new ones as appropriate for the antenna being used. Record any new constants on this worksheet. Transfer the "Computed Antenna Height" to page 1 of this log form under the item labeled "Antenna Location".

GPS FIELD LOG

Station No. (DMA)________________
Date (UT) ________________
Day Number________________
Session No. ________________
No. of Cassettes________________
Data File Name________________

Project ID________________________

STATION IDENTIFICATION

Alternate Station Number________________

Latitude __________deg__________min__________sec

Longitude__________deg__________min__________sec

Station Mark as Stamped________________

____

Height (meters)

MSL ________________

Monument Established by________________

Ellipsoid ________________

Local Datum ________________

Coordinate Source________________

Location________________________

____

Reference Datum________________

Is this a base (reference) station? _____Yes _____No _____N/A

Other stations tracking simultaneously:

Station No.____________ Station No.____________ Station No.____________

Station No.____________ Station No.____________ Station No.____________

Antenna Location

Antenna Height (meters)________________
(see attached worksheet)

OPERATOR IDENTIFICATION

Operator's Name________________ Operator's Organization________________

RECEIVER INFORMATION

	Manufacturer	Model	Type	Serial No.
Receiver	______	______	XXXXXXXXX	______
Antenna	______	______	XXXXXXXXX	______
Clock	______	______	______	______

_____No external oscillator used

10/88

Page ____ of ____

GPS FIELD LOG

Station No. (DMA)________________
Date (UT) ________________
Day Number________________
Session No. ________________
No. of Cassettes________________
Data File Name________________

Project ID________________________

Navigation Processor Software

Name________________________ Version________________

Measurement Interval

Measurement Recording Interval ____________ Real-time Solution Interval ______________

TRACKING SCENARIOS

Scenario	Start Time (UT) Scheduled	Start Time (UT) Actual	Satellites Tracked PRN Nos.				
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

WEATHER DATA

Time (UT)	Temperature (^{o}C) Wet Bulb	Temperature (^{o}C) Dry Bulb	Pressure (Mb)	Relative Humidity (%)

Page ____ of ____

GPS FIELD LOG

Station No. (DMA)________________
Date (UT) ________________
Day Number________________
Session No. ________________
No. of Cassettes________________
Data File Name________________

Project ID________________________

REAL-TIME RECEIVER POSITION & CLOCK SOLUTIONS

Time (UT)	Latitude (deg,min,sec)	Longitude (deg,min,sec)	Height (m)	Clk Bias (sec)	Clk Drift (sec/sec)

CHRONOLOGY OF EVENTS LOG

Time (UT)	Comments

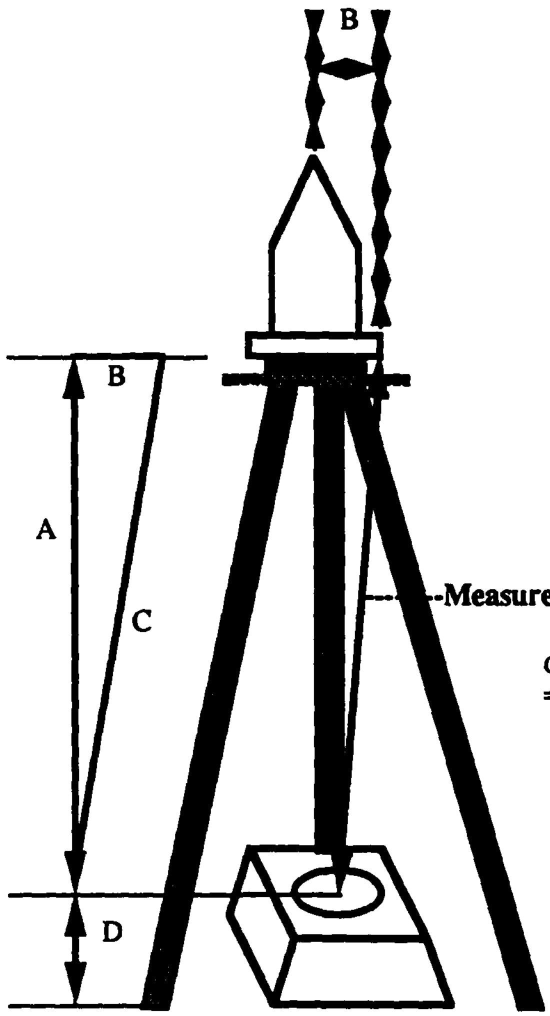
Station No. (DMA)________________
Date (UT) ________________
Day Number ________________
Session No. ________________
No. of Cassettes________________
Data File Name________________

GPS ANTENNA HEIGHT WORKSHEET

Orientation to North

Antenna	B
TI 4100	0.084 m

BASE OF PREAMP



Computed Antenna Height---

A = ______meters
______inches

$A = (C^2 - B^2)^{1/2}$

--Measured Slant Height

C = ______meters
= ______inches

Ht. of Mark above Ground

D = ______meters
______inches

Page ____ of ____

DMA GPS GEODETIC POINT POSITIONING FILE MANAGEMENT

STATION	DISK/TAPE SOURCE	MASS STORAGE FILE NAME	NOTES	PRN #S	SPAN	PRECISE EPHEMERIS	PRECISE CLOCKS	POINT FILE	GASP RESULTS	NOTES

Appendix B. Sample STARPREP Output

The selected pages of STARPREP output reproduced here represent the typical output from a normal program execution. The entire output has not been included since much of it is simply repeated for each satellite which was processed. The complete output from which these samples were extracted was 97 pages.

```
GSGT*MALYS(1).NEWSTAR/RUNPALL(0)
        @SUSPEND
        @HDG,F **UNCLASSIFIED** STARPREP   PLATTVILLE   DAY 223 1989
        @PRT,S    GSGT*MALYS.NEWSTAR/RUNPALL
        @XQT GPS*FICASTARPREP.PTSTARPREP/PCLOCK
        ASGFILES    4    GEOSTAR*STATIONLOC.
        ASGFILES    7    GEOSTAR*GA5PLAA9223.
        ASGFILES   10    GEOSTAR*PTPLA9223P.
        ASGFILES   11    GEOSTAR*0385PLA9223T.
        ASGFILES   12    GEOSTAR*0685PLA9223T.
        ASGFILES   13    GEOSTAR*0985PLA9223T.
        ASGFILES   14    GEOSTAR*1185PLA9223T.
        ASGFILES   15    GEOSTAR*1285PLA9223T.
        ASGFILES   16    GEOSTAR*1385PLA9223T.
        ASGFILES   21    GPS*EF0389218.
        ASGFILES   22    GPS*EF0689218.
        ASGFILES   23    GPS*EF0989218.
        ASGFILES   24    GPS*EF1189218.
        ASGFILES   25    GPS*EF1289218.
        ASGFILES   26    GPS*EF1389218.
        ASGFILES   31    GEOSTAR*MT85PLA9223P.
        ASGFILES   32    GEOSTAR*RC85PLA9223P.
        ASGFILES   33    GEOSTAR*SV85PLA9223P.
        ASGFILES   34    GEOSTAR*ST85PLA9223P.
        ASGFILES   40    GPS*PC89218.
        ASGFILES   41    GEOSTAR*MMET.
        ASGFILES   42    GEOSTAR*MRCV.
        ASGFILES   43    GEOSTAR*MSAT.
        ASGFILES   44    GEOSTAR*MSTA.
        ASGFILES   51    GEOSTAR*PT03223LOUT.
        ASGFILES   52    GEOSTAR*PT06223LOUT.
        ASGFILES   53    GEOSTAR*PT09223LOUT.
        ASGFILES   54    GEOSTAR*PT11223LOUT.
        ASGFILES   55    GEOSTAR*PT12223LOUT.
        ASGFILES   56    GEOSTAR*PT13223LOUT.
        FPROCSEL    EDIT   TTAGCOR   DATACOR
        CMPUTCOR    ID   IR   ER   TC   SC   GR   SA   TH
        APPLYCOR    ID   IR   ER   TH   SC   GR   SA
        PLOTCORR    ID   IR   ER   TH   SC   GR   SA
        EPHEMRIS    P
        EDCNTRCL    RCVOPT   TOLOPT
        DEBUGSCN    QBUG
        LOGICALS    SETERM
        SELECTSV    3   6   9  11  12  13
        ENDINPUT
        @RESUME,EG
        L SOURCE
        F 22

@XQT GPS*FICASTARPREP.PTSTARPREP/PCLOCK
```

STARPREP

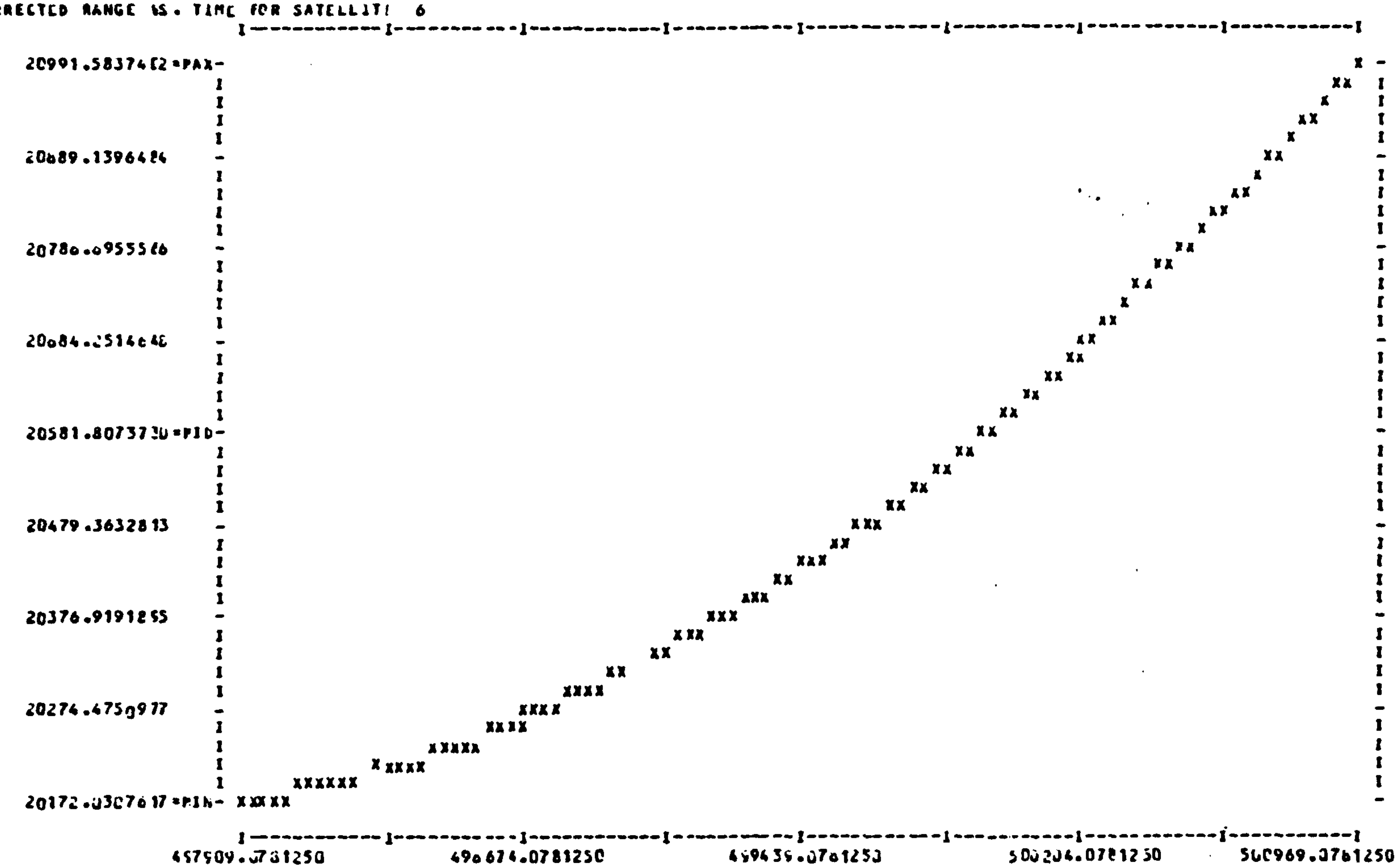
GEOSTAR PREPROCESSOR

CURRENT RANGE MEASUREMENTS FOR SATELLITE 6
NUMBER OF RECORDS FILLED = 100

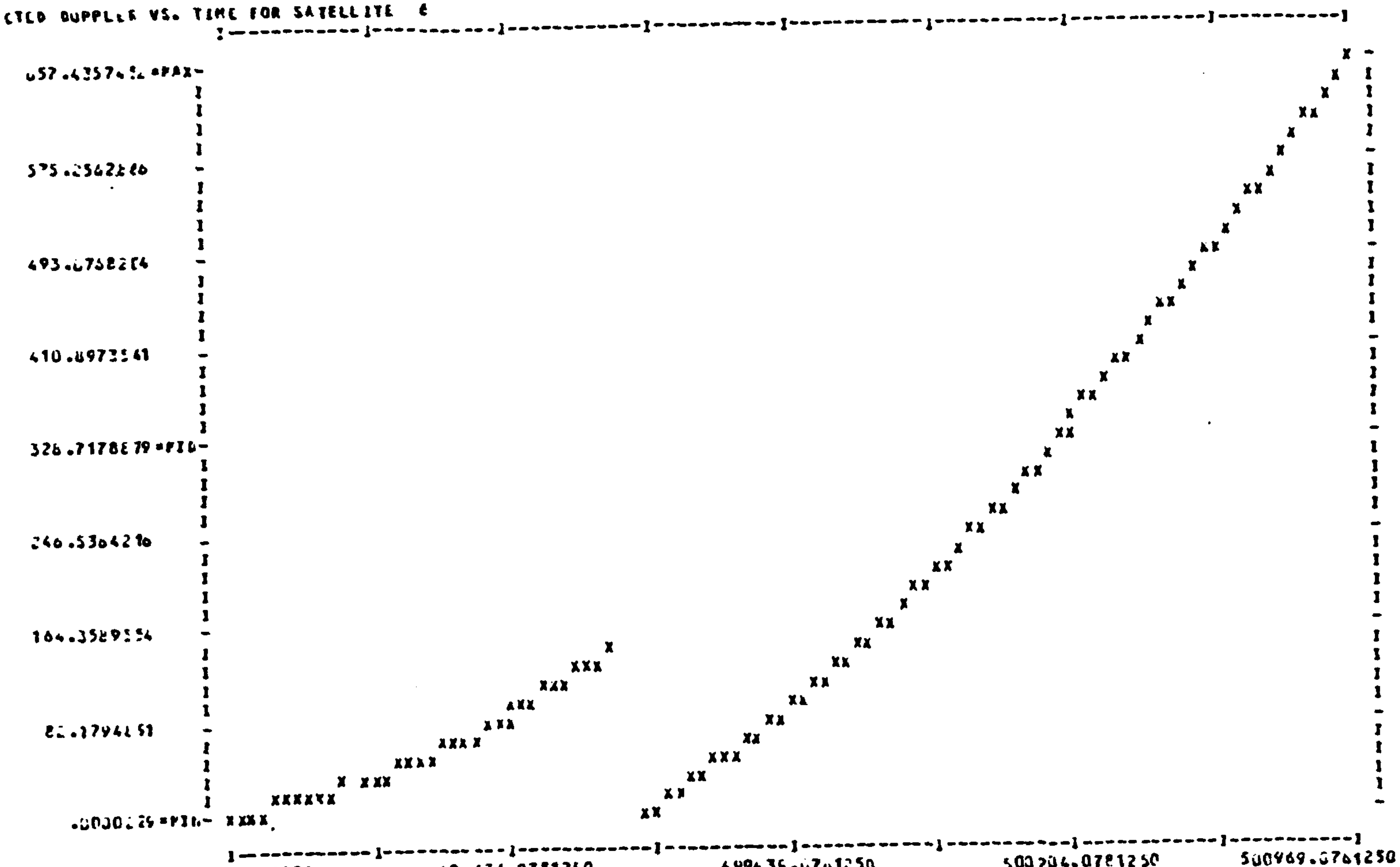
REC#	CHN	TIME	RANGE	IONO CORR	REC#	CHN	TIME	RANGE	IONO CORR
1	1	.497909080000+006	.201720309164+005	-.24680-002	51	1	.499499080000+006	.204455645899+005	-.56622-002
2	1	.497939080000+006	.201740990601+005	-.44437-002	52	1	.499529080000+006	.204539645246+005	-.52662-002
3	1	.497969080000+006	.201762352109+005	-.37898-002	53	1	.499559080000+006	.204624610536+005	-.61032-002
4	1	.497999080000+006	.201785893866+005	-.43911-002	54	1	.499589080000+006	.204710760133+005	-.68566-002
5	1	.498029080000+006	.201810111266+005	-.54708-002	55	1	.499619080000+006	.204798095858+005	-.43566-002
6	1	.498059080000+006	.201835525876+005	-.22954-002	56	1	.499649080000+006	.204886606768+005	-.51526-002
7	1	.498089080000+006	.201862100266+005	-.46904-002	57	1	.499679080000+006	.204976287071+005	-.51535-002
8	1	.498119080000+006	.201889845763+005	-.56159-002	58	1	.499709080000+006	.205067148004+005	-.34069-002
9	1	.498149080000+006	.201918788856+005	-.55212-002	59	1	.499739080000+006	.205159156247+005	-.61716-002
10	1	.498179080000+006	.201948939766+005	-.35444-002	60	1	.499769080000+006	.205252370181+005	-.64585-002
11	1	.498209080000+006	.201980362452+005	-.19740-002	61	1	.499799080000+006	.205346745023+005	-.66448-002
12	1	.498269080000+006	.202046447948+005	-.53464-002	62	1	.499829080000+006	.205442283631+005	-.30737-002
13	1	.498299080000+006	.202081336620+005	-.47934-002	63	1	.499859080000+006	.205538986152+005	-.29645-002
14	1	.498329080000+006	.202117413233+005	-.37317-002	64	1	.499889080000+006	.205636843844+005	-.52646-002
15	1	.498359080000+006	.202154673225+005	-.44172-002	65	1	.499919080000+006	.205735656459+005	-.70992-002
16	1	.498389080000+006	.202193126368+005	-.63417-002	66	1	.499949080000+006	.205836064422+005	-.53083-002
17	1	.498419080000+006	.202232757901+005	-.72713-002	67	1	.499979080000+006	.205937409986+005	-.39591-002
18	1	.498449080000+006	.202273612929+005	-.55069-002	68	1	.500009080000+006	.206039906876+005	-.43352-002
19	1	.498479080000+006	.202315644169+005	-.32451-002	69	1	.500039080000+006	.206143558503+005	-.56844-002
20	1	.498509080000+006	.202358669088+005	-.36433-002	70	1	.500069080000+006	.206248377619+005	-.53316-002
21	1	.498539080000+006	.202403289393+005	-.65407-002	71	1	.500099080000+006	.206354340049+005	-.38707-002
22	1	.498569080000+006	.202448908525+005	-.50146-002	72	1	.500129080000+006	.206461435043+005	-.46890-002
23	1	.498599080000+006	.202495725335+005	-.42626-002	73	1	.500159080000+006	.206569683796+005	-.56180-002
24	1	.498629080000+006	.202543716934+005	-.58993-002	74	1	.500189080000+006	.206679080995+005	-.56622-002
25	1	.498659080000+006	.202592922804+005	-.47920-002	75	1	.500219080000+006	.206789609484+005	-.65470-002
26	1	.498689080000+006	.202643327767+005	-.35972-002	76	1	.500249080000+006	.206901297161+005	-.43580-002
27	1	.498719080000+006	.202694923065+005	-.61205-002	77	1	.500279080000+006	.207014095516+005	-.57058-002
28	1	.498749080000+006	.202747711614+005	-.50586-002	78	1	.500309080000+006	.207128037459+005	-.68359-002
29	1	.498779080000+006	.202801596762+005	-.51694-002	79	1	.500339080000+006	.207243112274+005	-.35617-002
30	1	.498809080000+006	.202856892168+005	-.45515-002	80	1	.500369080000+006	.207359312921+005	-.60376-002
31	1	.498839080000+006	.202913280974+005	-.53242-002	81	1	.500399080000+006	.207476645860+005	-.59270-002
32	1	.498869080000+006	.202970853141+005	-.53242-002	82	1	.500429080000+006	.207595087900+005	-.54417-002
33	1	.498899080000+006	.203029036157+005	-.45950-002	83	1	.500459080000+006	.207714064520+005	-.34732-002
34	1	.498929080000+006	.203089603461+005	-.68497-002	84	1	.500489080000+006	.207835351963+005	-.43123-002
35	1	.498959080000+006	.203150774335+005	-.46386-002	85	1	.500519080000+006	.207957147796+005	-.46227-002
36	1	.499049080000+006	.203341441259+005	-.43356-002	86	1	.500549080000+006	.208080263041+005	-.39799-002
37	1	.499079080000+006	.203407424046+005	-.28325-002	87	1	.500579080000+006	.208204086525+005	-.48660-002
38	1	.499109080000+006	.203474564262+005	-.39384-002	88	1	.500609080000+006	.208329213104+005	-.36346-002
39	1	.499139080000+006	.203542891740+005	-.68124-002	89	1	.500639080000+006	.208455442363+005	-.56615-002
40	1	.499169080000+006	.203612437123+005	-.56844-002	90	1	.500669080000+006	.208582773555+005	-.54853-002
41	1	.499199080000+006	.203683155564+005	-.56622-002	91	1	.500699080000+006	.208711189965+005	-.74759-002
42	1	.499229080000+006	.203755068280+005	-.76307-002	92	1	.500729080000+006	.208840709756+005	-.74536-002
43	1	.499259080000+006	.203828200693+005	-.29645-002	93	1	.500759080000+006	.208971325351+005	-.30523-002
44	1	.499289080000+006	.203902489153+005	-.65020-002	94	1	.500789080000+006	.209103006138+005	-.74103-002
45	1	.499319080000+006	.203977974311+005	-.23236-002	95	1	.500819080000+006	.209235791977+005	-.60816-002
46	1	.499349080000+006	.204054665829+005	-.40476-002	96	1	.500849080000+006	.209369664625+005	-.54417-002
47	1	.499379080000+006	.204132525569+005	-.52427-002	97	1	.500879080000+006	.209504586137+005	-.90899-002
48	1	.499409080000+006	.204211576414+005	-.51984-002	98	1	.500909080000+006	.209640614178+005	-.60825-002
49	1	.499439080000+006	.204291612054+005	-.69672-002	99	1	.500939080000+006	.209777690078+005	-.58841-002
50	1	.499469080000+006	.204373240369+005	-.72112-002	100	1	.500969080000+006	.209915356026+005	-.65255-002

```
*** TIME TAG OFFSET UPDATE OCCURRED AT  497969.07999999999     SECS (GPS TIME)
*****FILE 12 OPENED FOR SATELLITE  6
     COLUMN INDEX KEY FOR THIS SATELLITE IS  2
*****FILE 13 OPENED FOR SATELLITE  9
     COLUMN INDEX KEY FOR THIS SATELLITE IS  3
*****FILE 14 OPENED FOR SATELLITE 11
     COLUMN INDEX KEY FOR THIS SATELLITE IS  4
*****FILE 16 OPENED FOR SATELLITE 13
     COLUMN INDEX KEY FOR THIS SATELLITE IS  6
 ***** CK4JMP: TIME GAP FOR SV PRN          6   TIME GAP=  60.000000000000000      SEC
 ***** CK4JMP: TIME GAP FOR SV PRN          6   TIME GAP=  60.000000000000000      SEC
 GVECTOR: LOSS OF LOCK       TRACKER 1 AT TIME  .49901908000000+006    L1QVC=    9  L2QVC=   1
*****FILE 15 OPENED FOR SATELLITE 12
     COLUMN INDEX KEY FOR THIS SATELLITE IS  5
 ***** CK4JMP: TIME GAP FOR SV PRN          6   TIME GAP=  90.000000000000000      SEC
 BUGS>>> DIONO,TC,TCYLS -18000.1325508316171      1140.0000000000000000      .00000000000000000
 .000000000000000000      .000000000000000000      .000000000000000000      .000000000000000000
 .000000000000000000
>> THE DOPPLER IONC CORRECTION INDICATES THAT A CYCLE SLIP OCCURED FOR PRN #  6 TTAG =    499049.0
 ***** CK4JMP: TIME GAP FOR SV PRN          6   TIME GAP=  90.000000000000000      SEC
```

UNCORRECTED RANGE VS. TIME FOR SATELLITE 6



UNCORRECTED DOPPLER VS. TIME FOR SATELLITE 6

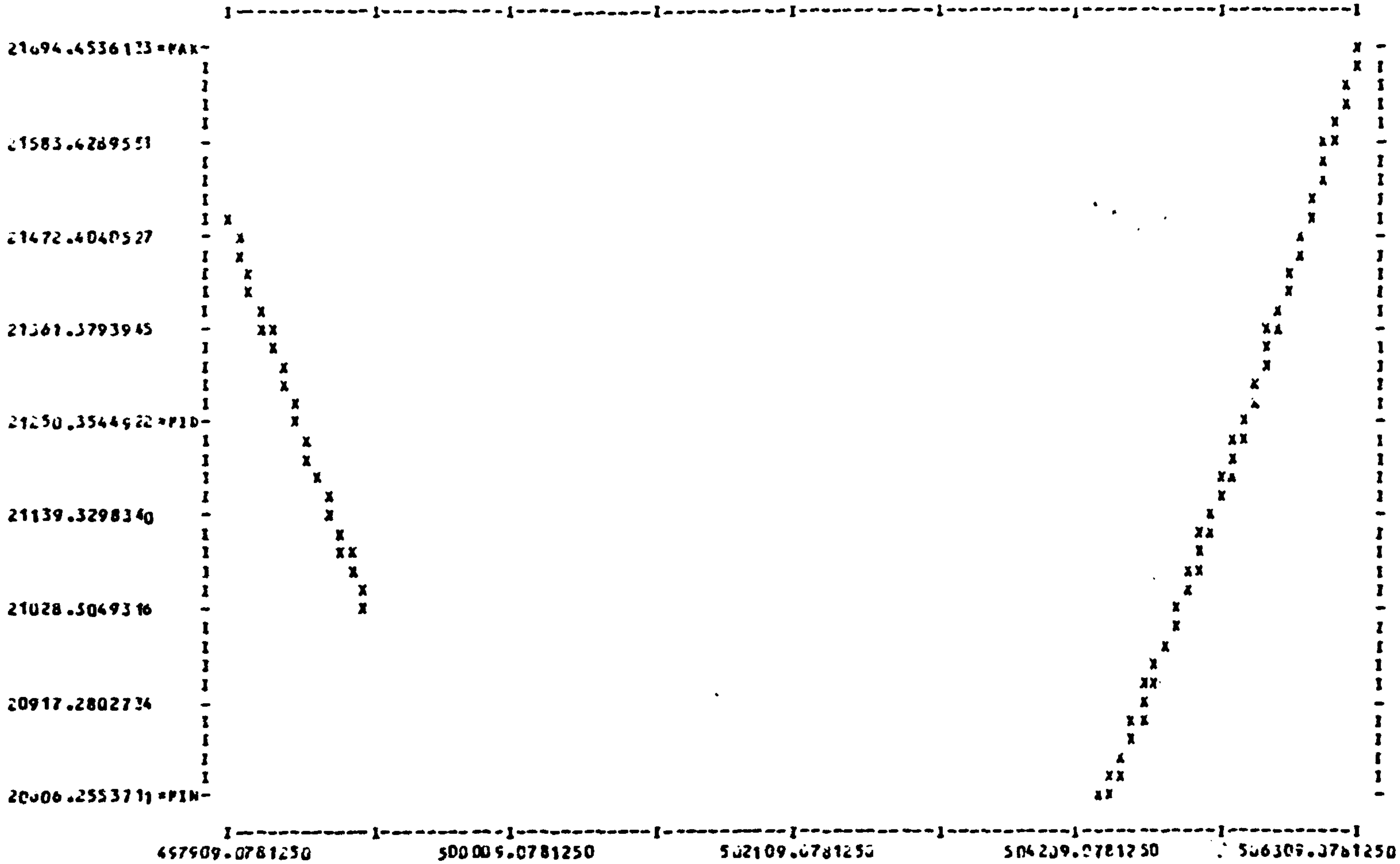



```
GVECTOR: LOSS OF SIGNAL     TRACKER 4 AT TIME  .501479080000000+006     L1QVC=    0   L2QVC=  145
GVECTOR: LOSS OF SIGNAL     TRACKER 3 AT TIME  .501509080000000+006     L1QVC=   25   L2QVC=  128
GVECTOR: LOSS OF SIGNAL     TRACKER 4 AT TIME  .501509080000000+006     L1QVC=    0   L2QVC=   17
GVECTOR: LOSS OF SIGNAL     TRACKER 3 AT TIME  .501539080000000+006     L1QVC=    0   L2QVC=   17
***** CK4JMP: TIME GAP FOR SV PRN          13   TIME GAP=  90.0000000000000000       SEC
LOGS>>> D10AU,TC,TCYCS -63.7346603617996664       3630.0000000000000000       .0000000000000000000        1140.0000000000000000
.000000000000000000         .00000000000000000000       .0000000000000000000       3630.0000000000000000       .00000000000000000000
.000000000000000000
>> THE DOPPLER IONO CORRECTION INDICATES THAT A CYCLE SLIP OCCURED FOR PRN # 13 TTAG =    501539.03
***** CK4JMP: TIME GAP FOR SV PRN          13   TIME GAP=  90.0000000000000000       SEC
```

CURRENT ACCUMULATED DOPPLER MEASUREMENTS FOR SATELLITE 9
NUMBER OF RECORDS FILLED = 100

REC#	CHN	TIME	DOPPLER	IONO CORR	REC#	CHN	TIME	DOPPLER	IONO CORR
1	2	.497909080000+006	.128144100899-003	.21479-003	51	4	.504839080000+006	.158994546901+003	.70529-003
2	2	.497939080000+006	-.149981122609+002	.19818-003	52	4	.504869080000+006	.171246791776+003	.71595-003
3	2	.497969080000+006	-.299203561105+002	.17993-003	53	4	.504899080000+006	.183616052244+003	.72696-003
4	2	.497999080000+006	-.447600084292+002	.16536-003	54	4	.504929080000+006	.196102034698+003	.74357-003
5	2	.498029080000+006	-.595344537043+002	.15349-003	55	4	.504959080000+006	.208734235217+003	.75906-003
6	2	.498059080000+006	-.742251380638+002	.13976-003	56	4	.504989080000+006	.221422191631+003	.77345-003
7	2	.498089080000+006	-.883375079910+002	.12446-003	57	4	.505019080000+006	.234255050208+003	.78673-003
8	2	.498119080000+006	-.103370924154+003	.11118-003	58	4	.505049080000+006	.247206050621+003	.80049-003
9	2	.498149080000+006	-.117824856449+003	.10091-003	59	4	.505079080000+006	.260256087753+003	.81747-003
10	2	.498179080000+006	-.132198680009+003	.82233-004	60	4	.505109080000+006	.273443836734+003	.83128-003
11	2	.498209080000+006	-.146491621525+003	.66796-004	61	4	.505139080000+006	.286734202163+003	.85117-003
12	2	.498239080000+006	-.160703767786+003	.55082-004	62	4	.505169080000+006	.300137072717+003	.86145-003
13	2	.498269080000+006	-.174833789639+003	.42263-004	63	4	.505199080000+006	.313653643471+003	.87773-003
14	2	.498299080000+006	-.188881376567+003	.36006-004	64	4	.505229080000+006	.327251030966+003	.89443-003
15	2	.498329080000+006	-.202846101211+003	.20464-004	65	4	.505259080000+006	.341021680555+003	.90696-003
16	2	.498359080000+006	-.216727068946+003	.69136-005	66	4	.505289080000+006	.354872046891+003	.92246-003
17	2	.498389080000+006	-.230524095977+003	-.43305-005	67	4	.505319080000+006	.368834349629+003	.93474-003
18	2	.498419080000+006	-.244236404001+003	-.15218-004	68	4	.505349080000+006	.382906123315+003	.94923-003
19	2	.498449080000+006	-.257863444287+003	-.20209-004	69	4	.505379080000+006	.397067421911+003	.96742-003
20	2	.498479080000+006	-.271404562246+003	-.29448-004	70	4	.505409080000+006	.411377975130+003	.98251-003
21	2	.498509080000+006	-.284859337309+003	-.43835-004	71	4	.505439080000+006	.425777166860+003	.10003-002
22	2	.498539080000+006	-.298226905531+003	-.53438-004	72	4	.505469080000+006	.440284672128+003	.10209-002
23	2	.498569080000+006	-.311507180726+003	-.66127-004	73	4	.505499080000+006	.454899568948+003	.10349-002
24	2	.498599080000+006	-.324699069653+003	-.74113-004	74	4	.505529080000+006	.469621571365+003	.10537-002
25	2	.498629080000+006	-.337802374285+003	-.85033-004	75	4	.505559080000+006	.484450149527+003	.10684-002
26	2	.498659080000+006	-.350816392017+003	-.95025-004	76	4	.505589080000+006	.499384758441+003	.10696-002
27	2	.498689080000+006	-.363740411549+003	-.11229-003	77	4	.505619080000+006	.514424030320+003	.11079-002
28	2	.498719080000+006	-.376574110796+003	-.12606-003	78	4	.505649080000+006	.529569322810+003	.11214-002
29	2	.498749080000+006	-.389316746176+003	-.12892-003	79	4	.505679080000+006	.544819496343+003	.11390-002
30	2	.498779080000+006	-.401967935925+003	-.14413-003	80	4	.505709080000+006	.560172685506+003	.11578-002
31	2	.498809080000+006	-.414527070332+003	-.15550-003	81	4	.505739080000+006	.575629224490+003	.11723-002
32	2	.498839080000+006	-.426993431799+003	-.16298-003	82	4	.505769080000+006	.591189343143+003	.11699-002
33	2	.498869080000+006	-.439366546928+003	-.17486-003	83	4	.505799080000+006	.606851206945+003	.12056-002
34	2	.498899080000+006	-.451645989512+003	-.18553-003	84	4	.505829080000+006	.622614099844+003	.12202-002
35	2	.498929080000+006	-.463831174331+003	-.19621-003	85	4	.505859080000+006	.638479361522+003	.12407-002
36	2	.498959080000+006	-.475921440366+003	-.20224-003	86	4	.505889080000+006	.654444553278+003	.12572-002
37	4	.504419080000+006	.160869920335-003	.52672-003	87	4	.505919080000+006	.670509743428+003	.12737-002
38	4	.504449080000+006	.105689469360+002	.54530-003	88	4	.505949080000+006	.686674398723+003	.12880-002
39	4	.504479080000+006	.212604018303+002	.55270-003	89	4	.505979080000+006	.702937394914+003	.13020-002
40	4	.504509080000+006	.320743332627+002	.56330-003	90	4	.506009080000+006	.719299819109+003	.13235-002
41	4	.504539080000+006	.430103042644+002	.57789-003	91	4	.506039080000+006	.735759343933+003	.13420-002
42	4	.504569080000+006	.540679021017+002	.58903-003	92	4	.506069080000+006	.752316024659+003	.13606-002
43	4	.504599080000+006	.652460798267+002	.59814-003	93	4	.506099080000+006	.768969028232+003	.13754-002
44	4	.504629080000+006	.765465330172+002	.61036-003	94	4	.506129080000+006	.785719515474+003	.13951-002
45	4	.504659080000+006	.879607200265+002	.62081-003	95	4	.506159080000+006	.802567150827+003	.14184-002
46	4	.504689080000+006	.995069246105+002	.63706-003	96	4	.506189080000+006	.819502560609+003	.14344-002
47	4	.504719080000+006	.111166347109+003	.64991-003	97	4	.506219080000+006	.836536164737+003	.14500-002
48	4	.504749080000+006	.122945984859+003	.66100-003	98	4	.506249080000+006	.853663424562+003	.14777-002
49	4	.504779080000+006	.134843854912+003	.67662-003	99	4	.506279080000+006	.870883660204+003	.14996-002
50	4	.504809080000+006	.146860325260+003	.68942-003	100	4	.506309080000+006	.888196321267+003	.15244-002

UNCORRECTED RANGE VS. TIME FOR SATELLITE 9



SUMMARY INFORMATION FROM INPUT DATA FILE GEOSTAR*GPSPLAA9223. PAGE 1

CAMPAIGN:

	WEEK	YEAR	DAY
DATES: BEGIN:	500	1989	223
END:	500	1989	223

IDENTIFIER: 1 LABEL: GPS TESTIN
COMMENT: GPS NAIL GARRISON NETWORK
DO NOT FORGET TO WRITE MESSAGES

STATION:
IDENTIFIER: 5. PLATTEVILLE
LOCATION: PHI: 40.000000 LAMBDA: 255.300000(EAST) HEIGHT: 1.505176(KM)
DATUM: WGS84
ANTENNA:
LOCATION FROM PARK(M): NORTH: .000000 EAST: .000000 UP: .001507
ELEV. ANGLE CUTOFFS: .0 .0 .C .0 .C .0 .0 .0 .0 .0 .0 .0 .0 .0 .0 .0
COMMENT: ANY TRACKING STATION

SATELLITE SUMMARY:

PRN NO.	NO. BROADCAST MESSAGES: EPHEM	NO. BROADCAST MESSAGES: CLOCK	NO. RANGE OBSERVATIONS: ON TAPE	NO. RANGE OBSERVATIONS: REJ. FOR IONO.	NO. RANGE OBSERVATIONS: EDITED OUTPUT	NO. DOPPLER OBSERVATIONS: ON TAPE	NO. DOPPLER OBSERVATIONS: REJ. FOR IONO.	NO. DOPPLER OBSERVATIONS: EDITED OUTPUT
3	3	3	299	0	297	299	0	297
6	4	4	216	0	213	216	1	213
9	3	3	255	0	254	255	1	254
11	5	5	516	0	512	516	1	512
12	5	5	472	0	468	472	2	468
13	5	5	295	0	293	295	2	293

NO ADDITIONAL SATELLITES ON TAPE

RECEIVER SUMMARY:
REQUESTED INTERVALS(SEC): MEASUREMENT: 30.000 SOLUTION: 990.000 CALIBRATION: 0.
NO. TIMES QUALITY VECTOR BAD:

	TRACKER 1	TRACKER 2	TRACKER 3	TRACKER 4
LOSS OF SIGNAL:	0	4	2	2
LOSS OF LOCK:	1	0	0	0
OTHER PROBLEMS:	0	0	0	0

NO. WEATHER MEASUREMENTS: 1 RECORDED: MANUAL
NO. TIME TAG UPDATES: 1

```
SUMMARY INFORMATION FROM INPUT DATA FILE GEOSTAR*GASPLAA9223.            PAGE 2
-------------------------------------------------------------------------------

RECEIVER NO. 1:
   SERIAL NO.:        00001
      TYPE:            4100   TEXAS INSTR. 268211-5 (TI-4100 85112G1400 78)

     ANTENNA(S):
        SERIAL NO.: 00001
           TYPE:         1    TEXAS INSTRUMENT 2780226-1 (TI-4100)

     TIME STANDARD:
        SERIAL NO.: 00001
           TYPE:         0    EFRATOM RUBIDIUM FRK-H

     WEATHER STATION:
        SERIAL NO.: 00000
           TYPE:         0     NONE

     AUXILIARY EQUIPMENT:
        NOT PRESENT ON INPUT TAPE

     SOFTWARE:
        IDENTITY:          0
        REVISION/MOD. NO.:      1

  CONVERSION PROGRAM (CASSETTE TO 9-TRACK):
     IDENTITY:               1   DMA/HTC FICA CONVERSION PROGRAM
     REVISION/MOD. NO.:      1    LAST UPDATED 30 JUN 1988
     NO. RECEIVERS:          1

  PROCESSING AT DMA:
     DATE PROCESSED AT DMA (MMDDYY):    102589

     ARCHIVE TAPE NO.:

     OUTPUT EDITED MEASUREMENT FILES:
        PRN NO.:  3      FILE NO.: 11     FILE NAME: GEOSTAR*0385PLA9223T.
                  6                12                GEOSTAR*0685PLA9223T.
                  9                13                GEOSTAR*0985PLA9223T.
                 11                14                GEOSTAR*1185PLA9223T.
                 12                15                GEOSTAR*1285PLA9223T.
                 13                16                GEOSTAR*1385PLA9223T.
```

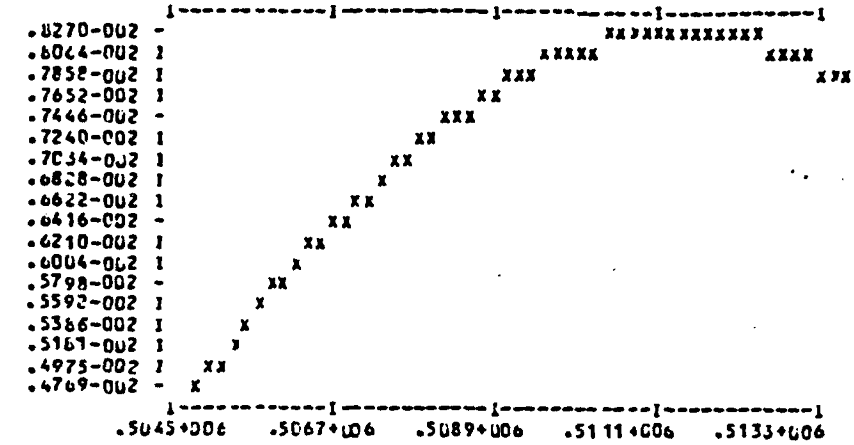
TIME TAG SUMMARY

PRN NO.	FILE NO.	FILE NAME
3	11	GEOSTAR*0385PLA9223T.
6	12	GEOSTAR*0685PLA9223T.
9	13	GEOSTAR*0985PLA9223T.
11	14	GEOSTAR*1185PLA9223T.
12	15	GEOSTAR*1285PLA9223T.
13	16	GEOSTAR*1385PLA9223T.

PRN NO.	NO. OBS.	TIMES OF RECEPTION FROM WEEK	TIME	THRU WEEK	TIME	TIMES OF TRANSMISSION FROM WEEK	TIME	THRU WEEK	TIME
3	297	500	504419.080000000	500	513359.080000000	500	504416.997317337	500	513359.009378755
6	213	500	497909.080000000	500	504359.080000000	500	497909.013066126	500	504359.003204602
9	254	500	497909.080000000	500	510959.080000000	500	497909.006692691	500	510958.996704535
11	512	500	497909.080000000	500	513359.080000000	500	497909.009997475	500	513358.996558724
12	468	500	479019.080000000	500	513359.080000000	500	459018.997670697	500	513359.000220601
13	293	500	497909.080000000	500	513359.080000000	500	497908.999454654	500	513359.006772430

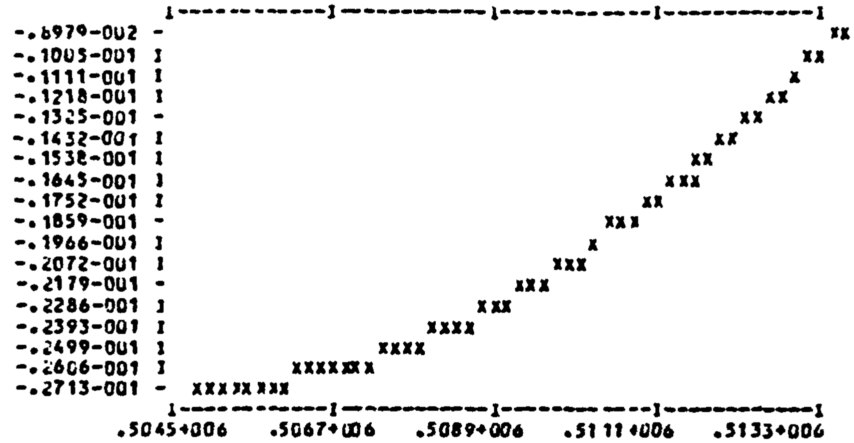
UNCLASSIFIED STARFRLP PLATTVILLE DAY 223 1989 DATE 102589 PAGE 50

SATELLITE 3 RELATIVITY VS TIME



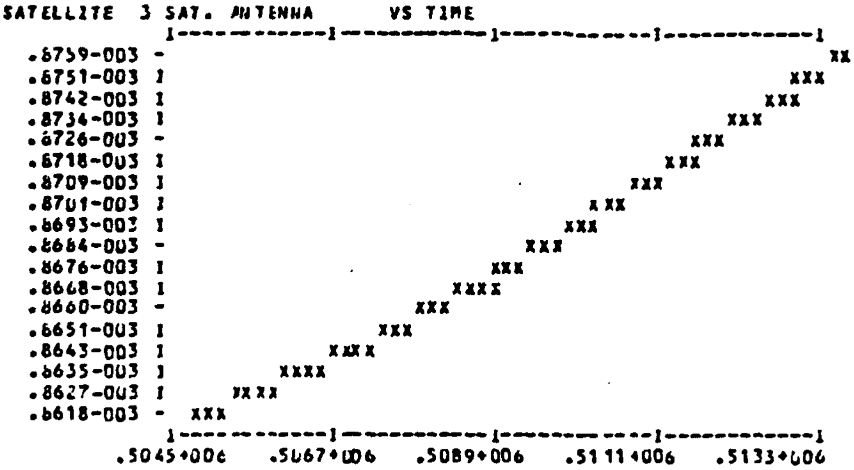
UNCLASSIFIED STARFREP PLATTVILLE DAY 223 1989

SATELLITE 3 EARTH ROTATE VS TIME

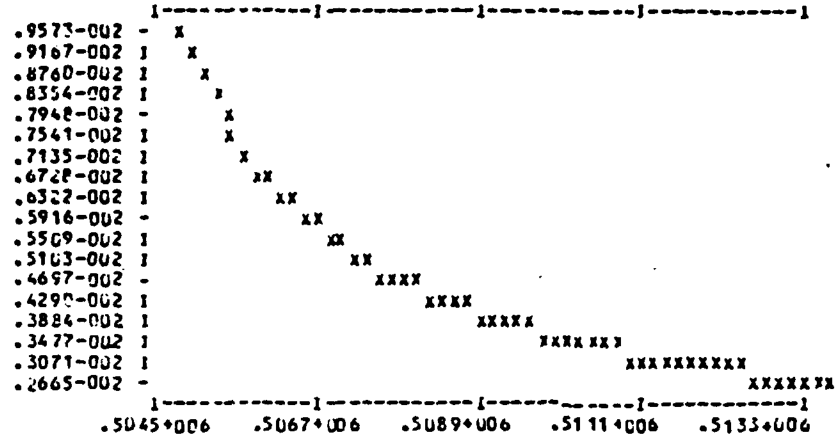


UNCLASSIFIED STARFREP PLATTVILLE DAY 223 1989

SATELLITE 3 SAT. ANTENNA VS TIME



SATELLITE 3 HOPPLE TROPO VS TIME



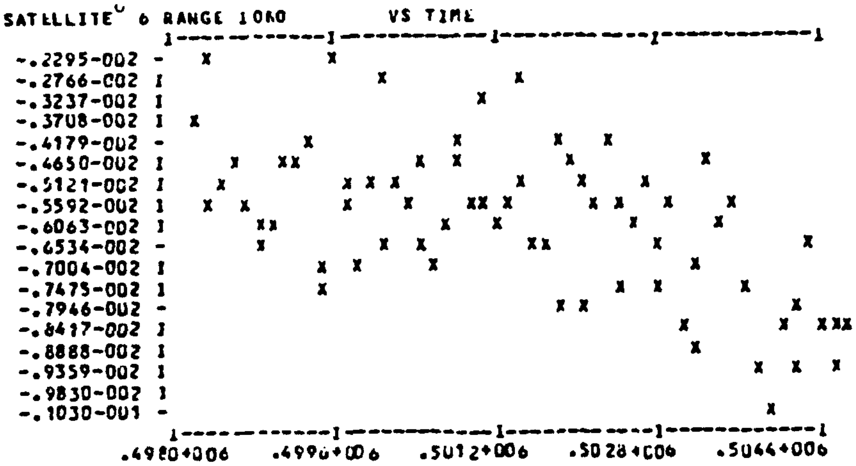
SATELLITE 6 HAS NC PET TIME WITHIN THE TOLERANCE FOR 100 MEASUREMENTS
BETWEEN WEEK 500 TIME 497909.013066126 AND WEEK 500 TIME 500969.010332442

SATELLITE 6 HAS NC PET TIME WITHIN THE TOLERANCE FOR 100 MEASUREMENTS
BETWEEN WEEK 500 TIME 500999.010286009 AND WEEK 500 TIME 503969.004180421

SATELLITE 6 HAS NC PET TIME WITHIN THE TOLERANCE FOR 13 MEASUREMENTS
BETWEEN WEEK 500 TIME 503999.004106407 AND WEEK 500 TIME 504359.003204602

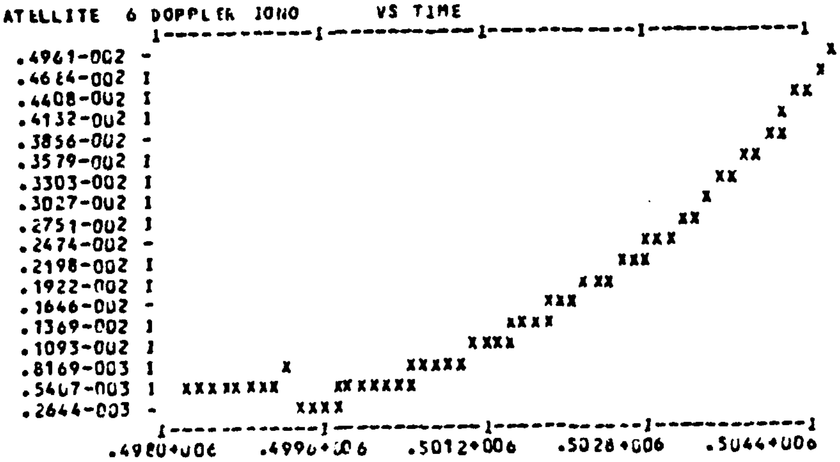
UNCLASSIFIED STARFRLP PLATTVILLE DAY 223 1989

SATELLITE 6 RANGE IONO VS TIME

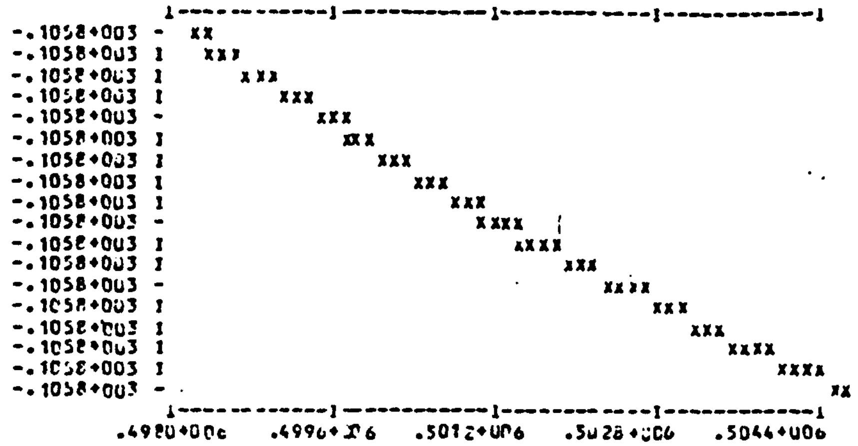


UNCLASSIFIED STARFREP PLATTVILLE DAY 223 1989

SATELLITE 6 DOPPLER IONO VS TIME

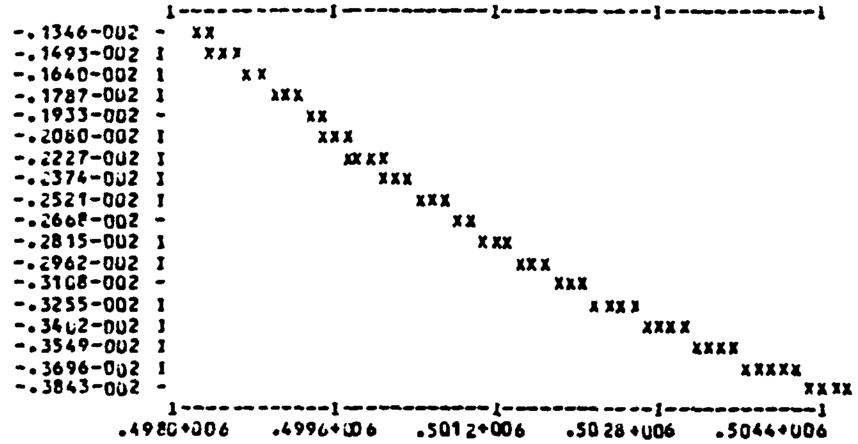


SATELLITE 6 SAT. CLOCK VS TIME



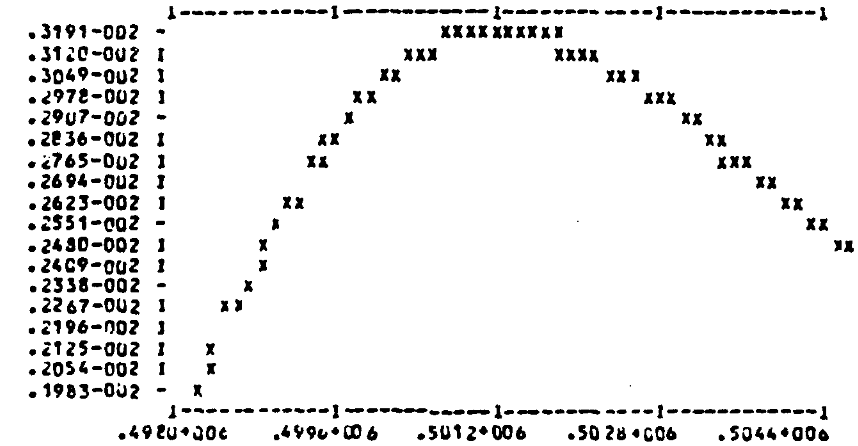
UNCLASSIFIED STARFRCP PLATTVILLE DAY 223 1989

SATELLITE 6 RELATIVITY VS TIME



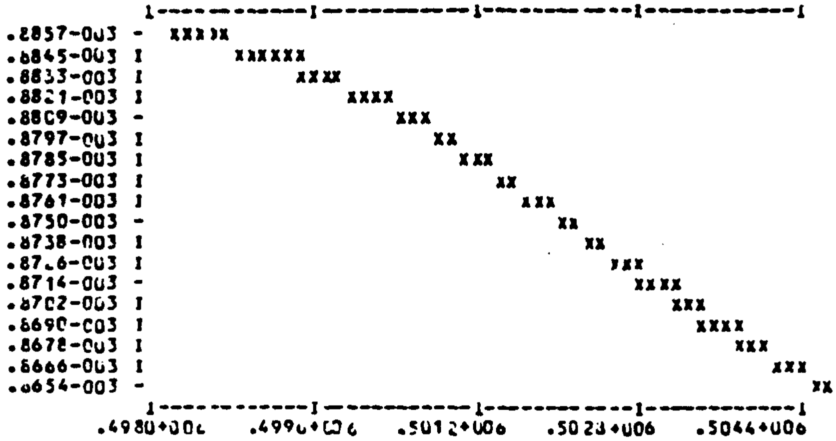
UNCLASSIFIED STARFRCP PLATTVILLE DAY 223 1989

SATELLITE 6 EARTH ROTATE VS TIME



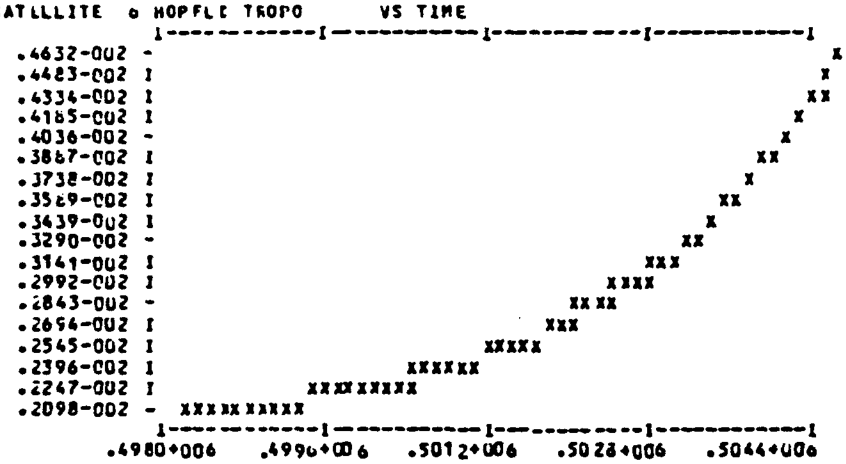
UNCLASSIFIED STAFFREP PLATTVILLE DAY 223 1989

SATELLITE 6 SAT. ANTENNA VS TIME



UNCLASSIFIED STAFFREP PLATTVILLE DAY 223 1989

SATELLITE 6 HOPFLD TROPO VS TIME



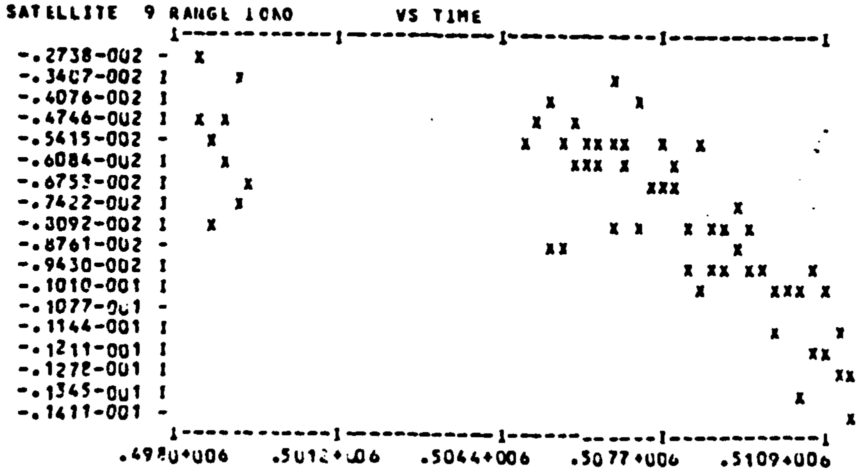
SATELLITE 9 HAS NO PET TIME WITHIN THE TOLERANCE FOR 100 MEASUREMENTS
BETWEEN WEEK 500 TIME 497909.008692891 AND WEEK 500 TIME 506309.008059484

SATELLITE 9 HAS NO PET TIME WITHIN THE TOLERANCE FOR 100 MEASUREMENTS
BETWEEN WEEK 500 TIME 506339.008001427 AND WEEK 500 TIME 509339.001020872

SATELLITE 9 HAS NO PET TIME WITHIN THE TOLERANCE FOR 54 MEASUREMENTS
BETWEEN WEEK 500 TIME 509369.000943164 AND WEEK 500 TIME 510958.996764535

UNCLASSIFIED STAFFREP PLATTVILLE DAY 223 1989

SATELLITE 9 RANGE IONO VS TIME



DATA CORRECTIONS SUMMARY

PRN NO.	NO. OBS.	INPUT FILE NO.	INPUT FILE NAME
3	247	11	GEOSTAR*0385PLA9223T.
6	163	12	GEOSTAR*0685PLA9223T.
9	204	13	GEOSTAR*0985PLA9223T.
11	462	14	GEOSTAR*1185PLA9223T.
12	418	15	GEOSTAR*1285PLA9223T.
13	243	16	GEOSTAR*1385PLA9223T.

EPHEMERIS SOURCE: REFERENCE

PRN NO.	EPHEM. FILE NO.	EPHEM. FILE NAME
3	21	GPS*EF0389218.
6	22	GPS*EF0689218.
9	23	GPS*EF0989218.
11	24	GPS*EF1189218.
12	25	GPS*EF1289218.
13	26	GPS*EF1389218.

CORRECTIONS:	COMPUTED	APPLIED
	RANGE IONO	RANGE IONO
	DOPPLER IONO	DOPPLER IONO
	SAT. CLOCK	SAT. CLOCK
	RELATIVITY	RELATIVITY
	EARTH ROTATE	EARTH ROTATE
	SAT. ANTENNA	SAT. ANTENNA
	CFAC TROPO	
	HOPFLD TROPO	HOPFLD TROPO

OUTPUT FILE NO.: 1C

OUTPUT FILE NAME: GEOSTAR*PTPLA9223P.

FILE SUMMARY

THE FOLLOWING FILES WERE ACCESSED DURING THIS RUN:

FILE NO.	FILE NAME	NO. TIMES OPENED	PURPOSE
4	GEOSTAR*STATIONLOG.	1	
7	GEOSTAR*GASPLAA9223.	1	FICA-FORMATTED INPUT DATA
10	GEOSTAR*PTFLA9223P.	1	POINT FILE (CORRECTED MEASUREMENTS)
11	GEOSTAR*U03ESPLA9223T.	3	EDIT/TTAG MEASUREMENTS, SATELLITE NO. 3
12	GEOSTAR*U06ESPLA9223T.	3	EDIT/TTAG MEASUREMENTS, SATELLITE NO. 6
13	GEOSTAR*U09ESPLA9223T.	3	EDIT/TTAG MEASUREMENTS, SATELLITE NO. 9
14	GEOSTAR*U11ESPLA9223T.	3	EDIT/TTAG MEASUREMENTS, SATELLITE NO. 11
15	GEOSTAR*U12ESPLA9223T.	3	EDIT/TTAG MEASUREMENTS, SATELLITE NO. 12
16	GEOSTAR*U13ESPLA9223T.	3	EDIT/TTAG MEASUREMENTS, SATELLITE NO. 13
21	GPS*EF03E9218.	1	REFERENCE EPHEMERIS, SATELLITE NO. 3
22	GPS*EF06E9218.	1	REFERENCE EPHEMERIS, SATELLITE NO. 6
23	GPS*EF09E9218.	1	REFERENCE EPHEMERIS, SATELLITE NO. 9
24	GPS*EF11E9218.	1	REFERENCE EPHEMERIS, SATELLITE NO. 11
25	GPS*EF12E9218.	1	REFERENCE EPHEMERIS, SATELLITE NO. 12
26	GPS*EF13E9218.	1	REFERENCE EPHEMERIS, SATELLITE NO. 13
31	GEOSTAR*WTESPLA9223P.	1	TRANSACTION WEATHER DATA
32	GEOSTAR*RCESPLA9223P.	1	TRANSACTION RECEIVER DATA
33	GEOSTAR*SVESPLA9223P.	1	TRANSACTION SATELLITE DATA
34	GEOSTAR*STESPLA9223P.	1	TRANSACTION STATION DATA
40	GPS*PC89218.	1	
51	GEOSTAR*PT03223LOUT.	1	
52	GEOSTAR*PT06223LOUT.	1	
53	GEOSTAR*PT09223LOUT.	1	
54	GEOSTAR*PT11223LOUT.	1	
55	GEOSTAR*PT12223LOUT.	1	

UNCLASSIFIED STARFREP PLATTVILLE DAY 223 1989 DAT

UNCLASSIFIED STARFREP PLATTVILLE DAY 223 1989 DAT

56	GEOSTAR*PT13223LOUT.	1	

Appendix C. Sample GASP Output

```
UNCLASSIFIED          GASP PLATTEVILLE     DAY 223   ---PRECISE EPHM---                    DATE 102489


UNCLASSIFIED          GASP PLATTEVILLE     DAY 223   ---PRECISE EPHM---                    DATE 102489

GSGT*MALYS(1).RUNSTD(C)
        @SUSPEND
        @HDG UNCLASSIFIED          GASP PLATTEVILLE     DAY 223   ---PRECISE EPHM---
        @PRT,S GSCT*MALYS.RUNSTD
        @ASG,T 35.
        @ERS 35.
        @XQT GPS*GASP.GASP
        GLOSTAR*FIPLA9223P.
        A               (CHOOSE STANDARD OPTIONS)
        GLOSTAR*S185PLA9223P.
        @LDM,G GSCT*GASPRESULTS.FALCON/PLATT
        LAS
        ADD 35.
        E
        @FREE GSGT*LASPRESULTS.
        @RESUME,QL
        L,2 SUMMARY
        C 15
        L,4 COVARIANCE
        F 30
        L SOLUTION
        F 40

@ASG,T 35.
I:002333 ASG complete.

@ERS 35.
FURPUR  30R1/HTC      (890921 1821:14) 1989 Oct 24 Tue 1058:32
END ERS.

@XQT GPS*GASP.GASP

        ************************************
        **                                **
        **      G     A     S     P       **
        **                                **
        **  GEODETIC ABSOLUTE SEQUENTIAL  **
        **      POSITIONING PROGRAM       **
        **                                **
        ************************************

THIS PROGRAM USES THE POINT FILE GENERATED BY THE PREPROCESSOR
PROGRAM STARPREP TO PRODUCE A POINT POSITION FROM DIFFERENCED
GPS CARRIER BEAT PHASE DATA (COLLECTED WITH A TI4100 RECEIVER)

THE WGS-84 ELLIPSOID WILL BE USED FOR ALL CONVERSIONS BETWEEN
CARTESIAN AND GEODETIC FORMS:
A =   6378.137 KM , INVERSE FLATTENING =  298.2572235630

ENTER POINT FILE NAME, (A22)
ENTER PROCESSING OPTIONS CHOICE:
  A) USE STANDARD OPTIONS
  B) CHOOSE OPTIONS
```

```
UNCLASSIFIED          GASP PLATTEVILLE     DAY 223    ---PRECISE EPHM---                          DATE 102489

THE STANDARD OPTIONS THAT WILL BE USED ARE:
 ELEVATION ANGLE CUTOFF                          : 10.00 DEG
 RMS MULTIPLIER                                  :  3.00
 PSEUDORANGE EDIT CHECK                          :  5.00 M
 MIN # SVS/EPOCH PAIR                            :  2
 STANDARD DEVIATION/GASP OBSERVABLE              : 20.00 CM
 STANDARD DEVIATION/STATION POSITION             :   .50 KM

 THE REFERENCE SATELLITE WILL BE SELECTED SEQUENTIALLY

 THESE STANDARD OPTIONS WILL BE USED TO PERFORM 3 ITERATIONS OF BATCH LEAST SQUARES ESTIMATION
 THEN 1 CYCLE THROUGH THE SEQUENTIAL ESTIMATION ALGORITHM
 THE STANDARD DEVIATIONS SHOWN ABOVE WILL BE UPDATED BETWEEN PROCESSING MODES


ENTER THE STATION FILE (I.E. GEOSTAR*ST65KMM8169P.

EPHEMERIS TYPE ::::: F :::::

ECHO OF STATION FILE (UNIT 34):GEOSTAR*ST85PLA9223P.

      5.       01                                         .402000000+002 .255300000+003 .15031760+001
      5.       0.   .000000 .000000 .00150769223  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0

DISTANCE FROM GROUND MARK TO BASE OF TI4100 ANTENNA =     1.50700 METERS (ASSUMED NORMAL TO ELLIPSOID)
BASE TO MEAN ELECTRICAL CENTER CONSTANT =                  .22733 METERS
ANTENNA HEIGHT =                                          1.73433 METERS


SUMMARY OF REFERENCE SATELLITE SELECTIONS:  PRN #     NO. OF TIMES USED

                                               3          35
                                               6          25
                                               9          30
                                              11          68
                                              12          61
                                              13          39

   APRIORI ANTENNA COORDINATES
  GEODETIC          LAST(0-360)       ELLIPSOID
  LATITUDE          LONGITUDE         HEIGHT (KM)              X(KM)           Y(KM)           Z(KM)
  40.1999999993   255.2999999970     1.503176           -1236.2249526   -4719.8327881   4095.9426473
 040 11 60.0000   255 17 60.0000     1.503176

---------------------------------------
ESTIMATION METHOD: BATCH LEAST SQUARES
---------------------------------------


THE MEAN O-C FOR  757 GASP OBSERVABLES IS:  -13.075 CM
THE SUM OF SQUARES OF ALL RESIDUALS IS      ******* CM

******************************************** BEGIN ITERATION # 01 ********************************************
```

MEAN OF DELTA PSEUDORANGE - DELTA CARRIER BEAT PHASE FOR EACH SATELLITE IN THIS DATA SET

PRN #	NO. OF REMAINING EPOCH PAIRS	BIAS (M)
3	214	.174107
6	154	.279777
9	185	-.129062
11	364	.023436
12	342	.180969
13	221	.035756

OF THE 753 GASP OBSERVABLES ORIGINALLY FORMED,
753 ARE BEING PROCESSED IN THIS ITERATION
THE AMOUNT OF DATA REJECTED SO FAR IS : .00%

THE TOLERANCE BEING USED FOR PSEUDORANGE VS.CARRIER BEAT PHASE DATA EDITING IS: 5.00 METERS

PSR EDIT>	25, 26	13 11	498149.00	498179.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	6.40 M	.57 M
PSR EDIT>	27, 28	13 9	498149.00	498179.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	6.40 M	.58 M
PSR EDIT>	29, 30	13 6	498149.00	498179.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	6.40 M	3.54 M
PSR EDIT>	109, 110	13 12	499049.00	499079.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	6.30 M	.13 M
PSR EDIT>	111, 112	13 11	499049.00	499079.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	6.30 M	.21 M
PSR EDIT>	113, 114	13 6	499049.00	499079.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	6.30 M	2.34 M
PSR EDIT>	125, 126	6 11	499169.01	499199.01	DELTA PSEUDORANGE - DELTA BEAT PHASE =	.45 M	5.30 M
PSR EDIT>	131, 132	12 6	499229.00	499259.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	1.28 M	6.46 M
PSR EDIT>	137, 138	13 6	499289.00	499319.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	.62 M	5.27 M
PSR EDIT>	293, 294	11 6	500849.01	500879.01	DELTA PSEUDORANGE - DELTA BEAT PHASE =	2.38 M	5.02 M
PSR EDIT>	317, 318	11 6	501089.01	501119.01	DELTA PSEUDORANGE - DELTA BEAT PHASE =	3.54 M	5.83 M
PSR EDIT>	331, 332	6 13	501269.01	501299.01	DELTA PSEUDORANGE - DELTA BEAT PHASE =	2.70 M	7.54 M
PSR EDIT>	371, 372	12 13	501749.00	501779.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	1.95 M	5.00 M
PSR EDIT>	521, 522	12 13	503249.01	503279.01	DELTA PSEUDORANGE - DELTA BEAT PHASE =	.94 M	5.29 M
PSR EDIT>	671, 672	11 3	504749.01	504779.01	DELTA PSEUDORANGE - DELTA BEAT PHASE =	1.22 M	7.89 M
PSR EDIT>	679, 680	3 12	504869.00	504899.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	7.85 M	.48 M
PSR EDIT>	681, 682	3 11	504869.00	504899.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	7.85 M	.17 M
PSR EDIT>	683, 684	3 9	504869.00	504899.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	7.85 M	.24 M
PSR EDIT>	693, 694	11 9	504989.01	505019.01	DELTA PSEUDORANGE - DELTA BEAT PHASE =	.99 M	6.07 M
PSR EDIT>	729, 730	3 11	505349.00	505379.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	.60 M	5.07 M
PSR EDIT>	813, 814	11 9	506249.01	506279.01	DELTA PSEUDORANGE - DELTA BEAT PHASE =	5.70 M	2.51 M
PSR EDIT>	815, 816	11 3	506249.01	506279.01	DELTA PSEUDORANGE - DELTA BEAT PHASE =	5.70 M	.35 M
PSR EDIT>	895, 896	11 12	507149.01	507179.01	DELTA PSEUDORANGE - DELTA BEAT PHASE =	5.46 M	.02 M
PSR EDIT>	897, 898	11 9	507149.01	507179.01	DELTA PSEUDORANGE - DELTA BEAT PHASE =	5.46 M	2.55 M
PSR EDIT>	899, 900	11 3	507149.01	507179.01	DELTA PSEUDORANGE - DELTA BEAT PHASE =	5.46 M	3.61 M
PSR EDIT>	979, 980	3 12	507989.00	508019.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	5.26 M	.07 M
PSR EDIT>	981, 982	3 11	507989.00	508019.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	5.26 M	1.06 M
PSR EDIT>	983, 984	3 9	507989.00	508019.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	5.26 M	.31 M
PSR EDIT>	1037,1038	3 9	508529.00	508559.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	1.71 M	6.49 M
PSR EDIT>	1053,1054	9 11	508709.00	508739.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	.42 M	5.41 M
PSR EDIT>	1131,1132	12 11	509609.01	509639.01	DELTA PSEUDORANGE - DELTA BEAT PHASE =	.30 M	5.03 M
PSR EDIT>	1145,1146	11 9	509729.00	509759.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	2.31 M	5.76 M
PSR EDIT>	1253,1254	3 11	510809.01	510839.01	DELTA PSEUDORANGE - DELTA BEAT PHASE =	.06 M	6.14 M
PSR EDIT>	1399,1400	11 13	512309.00	512339.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	7.82 M	3.15 M
PSR EDIT>	1401,1402	11 12	512309.00	512339.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	7.62 M	3.88 M
PSR EDIT>	1403,1404	11 3	512309.00	512339.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	7.62 M	.16 M
PSR EDIT>	1467,1468	13 11	512969.01	512999.01	DELTA PSEUDORANGE - DELTA BEAT PHASE =	.60 M	5.39 M
PSR EDIT>	1471,1472	11 13	513029.00	513059.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	7.64 M	.03 M
PSR EDIT>	1473,1474	11 12	513029.00	513059.00	DELTA PSEUDORANGE - DELTA BEAT PHASE =	7.64 M	.00 M

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UNCLASSIFIED          GASP PLATTEVILLE      DAY 225   ---PRECISE EPHM---                          DATE 102489

PSR EDIT> 1475,1476    11  3   513029.00    513059.00   DELTA PSEUDORANGE - DELTA BEAT PHASE =    7.64 M   1.51 M

THE MEAN O-C FOR  713 GASP OBSERVABLES IS:       .329 CM
THE SUM OF SQUARES OF ALL RESIDUALS IS           .150 CM

 A-POSTERIORI VARIANCE OF UNIT WEIGHT =    .0502


THE RESIDUALS INDICATE THAT THE REMAINING GASP OBSERVABLES IN THIS DATA SET HAVE A STANDARD DEVIATION OF     4.44
THIS VALUE WILL BE USED FOR FURTHER PROCESSING


VARIANCE-COVARIANCE MATRIX OF CARTESIAN ESTIMATED POSITION (M**2)

       X          Y          Z

    .6083     -.2560     -.1002
   -.2560      .5041     -.0051
   -.1002     -.0051      .1267

CORRELATION MATRIX OF CARTESIAN ESTIMATED POSITION
       X          Y          Z

   1.0000     -.4533     -.3609
   -.4533     1.0000     -.0199
   -.3609     -.0199     1.0000

ESTIMATED STANDARD DEVIATIONS ON X, Y, Z (M)

    .7799      .7040      .3560

 END ITERATION: 01        PREVIOUS RMS OF (MEAN(O-C)-(O-C))=      1262.13 CM
                            CURRENT RMS OF (MEAN(O-C)-(O-C))=        4.44 CM       RMS DIFFERENCE:1257.69 CM
NUMBER OF GASP OBSERVABLES USED: 0713                NUMBER OF OBSERVABLES EDITED IN THIS ITERATION: 0040
THE NUMBER OF GASP OBSERVABLES REJECTED BECAUSE OF THE PSEUDORANGE VS. CARRIER BEAT PHASE CHECK IS:   40

***************************************** BEGIN ITERATION # 02 *****************************************

MEAN OF DELTA PSEUDORANGE - DELTA CARRIER BEAT PHASE FOR EACH SATELLITE IN THIS DATA SET

PRN #    NO. OF REMAINING EPOCH PAIRS              BIAS (M)

  3                    200                        .237758
  6                    146                        .403520
  9                    176                      -.159607
 11                    258                        .137245
 12                    338                        .183927
 13                    208                      -.166974

 OF THE   753 GASP OBSERVABLES ORIGINALLY FORMED,
          713 ARE BEING PROCESSED IN THIS ITERATION
               THE AMOUNT OF DATA REJECTED SO FAR IS :   5.31%

THE TOLERANCE BEING USED FOR PSEUDORANGE VS.CARRIER BEAT PHASE DATA EDITING IS:  5.00 METERS
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UNCLASSIFIED           GASP PLATTEVILLE     DAY 223   ---PRECISE EPHM---                              DATE 102489

RMS EDIT>  177, 178    12 11    499709.00   499739.00 O-C=  14.99 CM        RMS SCREEN =    13.32 CM
RMS EDIT>  179, 180    12  6    499709.00   499739.00 O-C=  14.67 CM        RMS SCREEN =    13.32 CM
RMS EDIT>  255, 256    13 11    500489.00   500519.00 O-C=  13.56 CM        RMS SCREEN =    13.32 CM
RMS EDIT>  481, 482    13 11    502829.01   502859.01 O-C= -15.52 CM        RMS SCREEN =    13.32 CM
RMS EDIT> 1021,1022    12 11    508409.01   508439.01 O-C=  17.51 CM        RMS SCREEN =    13.32 CM
RMS EDIT> 1179,1180    12 11    510089.01   510119.01 O-C= -17.30 CM        RMS SCREEN =    13.32 CM

THE MEAN O-C FOR  707 GASP OBSERVABLES IS:      .288 CM
THE SUM OF SQUARES OF ALL RESIDUALS IS          .137 CM

 A-POSTERIORI VARIANCE OF UNIT WEIGHT =   .9781

THE RESIDUALS INDICATE THAT THE REMAINING GASP OBSERVABLES IN THIS DATA SET HAVE A STANDARD DEVIATION OF    4.24
THIS VALUE WILL BE USED FOR FURTHER PROCESSING

VARIANCE-COVARIANCE MATRIX OF CARTESIAN ESTIMATED POSITION (M**2)

       X          Y          Z

     .5904     -.2420     -.0976
    -.2468      .5065     -.0052
    -.0976     -.0052      .1225

CORRELATION MATRIX OF CARTESIAN ESTIMATED POSITION
       X          Y          Z

    1.0000     -.4514     -.3629
    -.4514     1.0000     -.0210
    -.3629     -.0210     1.0000

ESTIMATED STANDARD DEVIATIONS ON X, Y, Z (M)

     .7684      .7117      .3500

 END ITERATION: 02      PREVIOUS RMS OF (MEAN(O-C)-(O-C))=      4.44 CM
                         CURRENT RMS OF (MEAN(O-C)-(O-C))=      4.24 CM     RMS DIFFERENCE:    .20 CM
NUMBER OF GASP OBSERVABLES USED: 0707           NUMBER OF OBSERVABLES EDITED IN THIS ITERATION: 0006
THE NUMBER OF GASP OBSERVABLES REJECTED BECAUSE OF THE PSEUDORANGE VS. CARRIER BEAT PHASE CHECK IS:    0

***************************************** BEGIN ITERATION # 03 *****************************************

MEAN OF DELTA PSEUDORANGE - DELTA CARRIER BEAT PHASE FOR EACH SATELLITE IN THIS DATA SET

PRN #    NO. OF REMAINING EPOCH PAIRS          BIAS (M)

  3                 200                       .237758
  6                 145                       .375368
  9                 170                     -.159637
 11                 153                       .124131
 12                 134                       .182793
 13                 200                     -.180476

 OF THE  753 GASP OBSERVABLES ORIGINALLY FORMED,
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.CLASSIFIED          GASP PLATTEVILLE     DAY 223   ---PRECISE EPHM---                         DATE 102489

       707 ARE BEING PROCESSED IN THIS ITERATION
           THE AMOUNT OF DATA REJECTED SO FAR IS :   6.11%

.E TOLERANCE BEING USED FOR PSEUDORANGE VS.CARRIER BEAT PHASE DATA EDITING IS:  5.00 METERS

.S EDIT> 619, 620     12 11   504209.01   504239.01 O-C=  12.99 CM        RMS SCREEN =    12.71 CM
.S EDIT> 1023,1024    12  9   508409.01   508439.01 O-C=  12.99 CM        RMS SCREEN =    12.71 CM

.E MEAN O-C FOR  705 GASP OBSERVABLES IS:       .252 CM
.E SUM OF SQUARES OF ALL RESIDUALS IS           .133 CM

.-POSTERIORI VARIANCE OF UNIT WEIGHT =  1.0563


.E RESIDUALS INDICATE THAT THE REMAINING GASP OBSERVABLES IN THIS DATA SET HAVE A STANDARD DEVIATION OF     4.19 C
.IS VALUE WILL BE USED FOR FURTHER PROCESSING


.RIANCE-COVARIANCE MATRIX OF CARTESIAN ESTIMATED POSITION (M**2)

      X           Y          Z

    .5622      -.2415     -.0963
   -.2415       .4554     -.0055
   -.0963      -.0055      .1205

ORRELATION MATRIX OF CARTESIAN ESTIMATED POSITION
      X           Y          Z

   1.0000      -.4479     -.3635
   -.4479      1.0000     -.0222
   -.3635      -.0222     1.0000

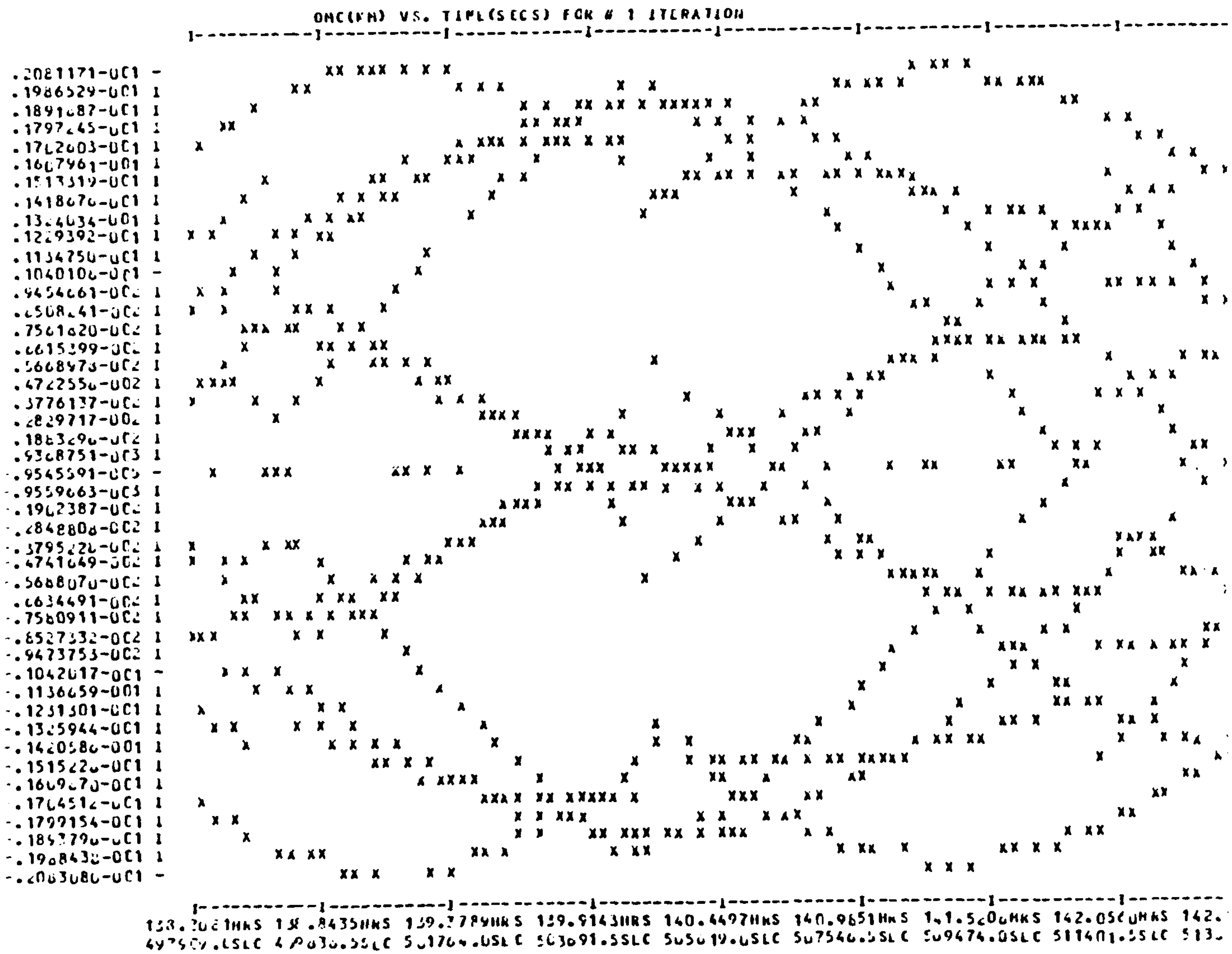
.STIMATED STANDARD DEVIATIONS ON X, Y, Z (M)

    .7630       .7047      .3472

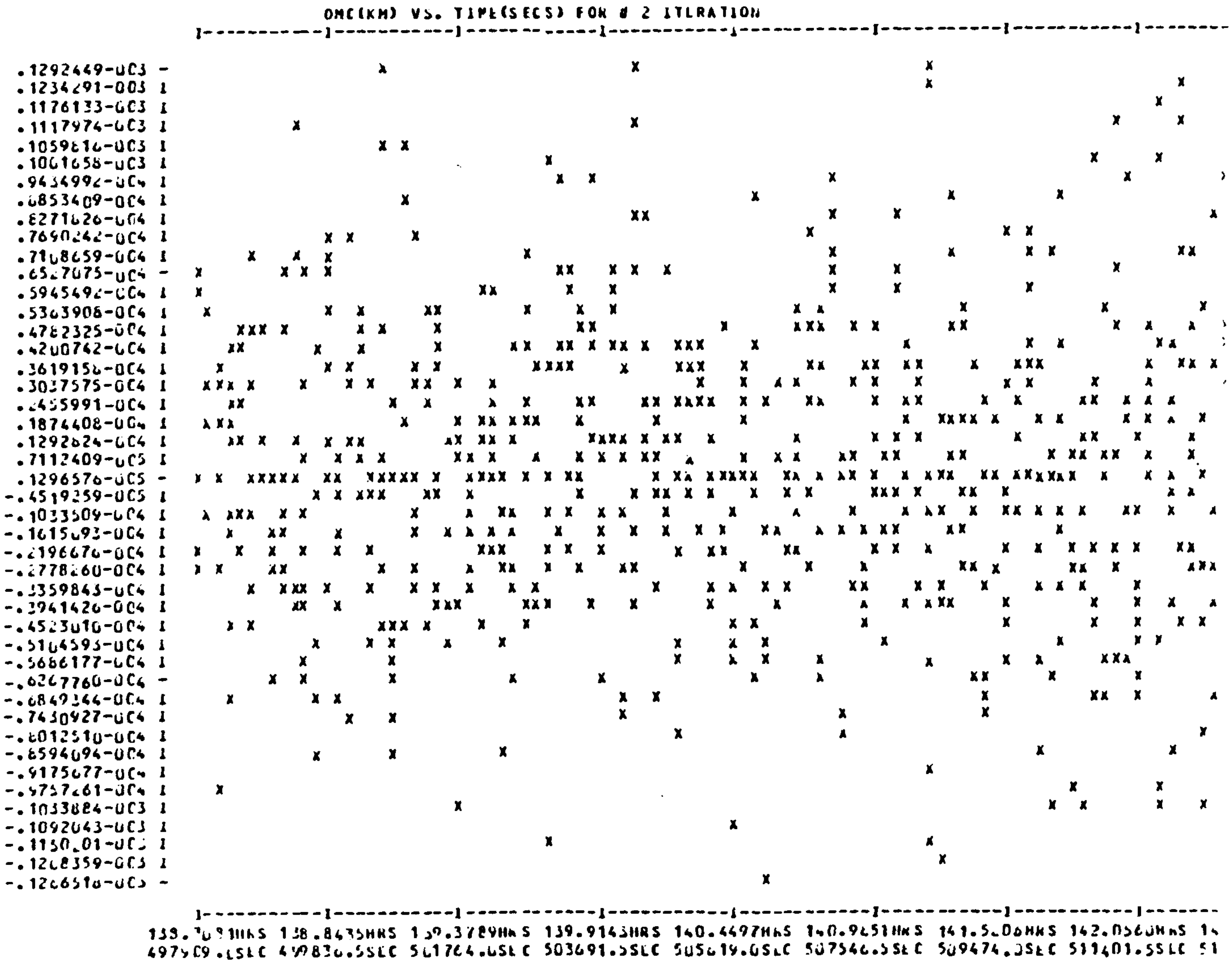
END ITERATION: 03        PREVIOUS RMS OF (MEAN(O-C)-(O-C))=        4.24 CM
                           CURRENT RMS OF (MEAN(O-C)-(O-C))=       4.19 CM       RMS DIFFERENCE:     .05 CM
.UMBER OF GASP OBSERVABLES USED: 0705              NUMBER OF OBSERVABLES EDITED IN THIS ITERATION: 0002
.E NUMBER OF GASP OBSERVABLES REJECTED BECAUSE OF THE PSEUDORANGE VS. CARRIER BEAT PHASE CHECK IS:     0

>> SO FAR,   6.37% OF THE DATA HAS BEEN REJECTED >>>
```

CLASSIFIED GASP PLATTEVILLE DAY 223 ---PRECISE EPHM--- DATE 102489

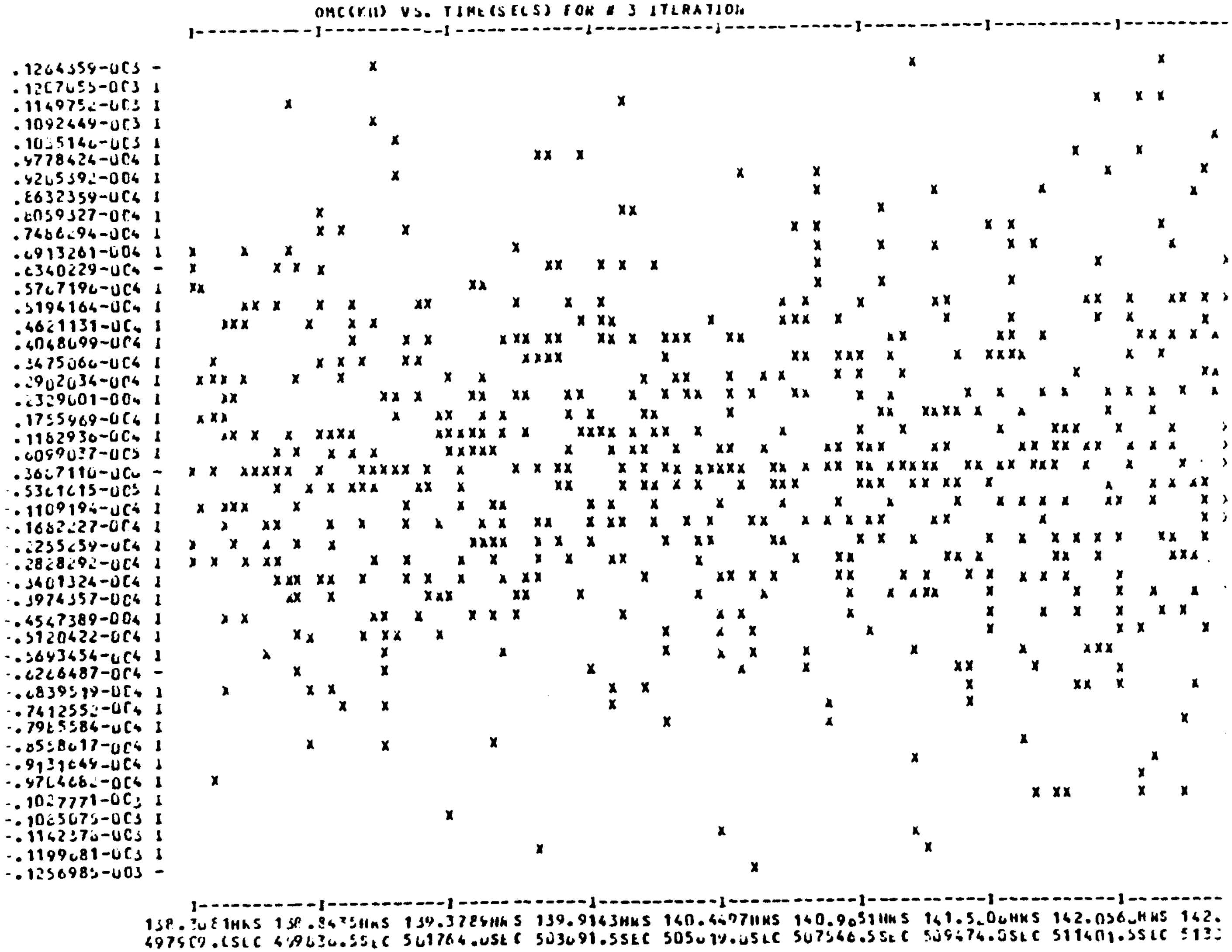


UNCLASSIFIED GASP PLATTEVILLE DAY 223 ---PRECISE EPHM--- DATE 102489



CLASSIFIED GASP PLATTEVILLE DAY 223 ---PRECISE EPHM--- DATE 102489

OMC(KM) VS. TIME(SECS) FOR # 3 ITERATION



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UNCLASSIFIED          GASP PLATTEVILLE     DAY 223   ---PRECISE EPHM---                         DATE 102489

**************************************************************************************
**   SOLUTION FOR FILE: GLOSTAR*PTPLA9223P.
**************************************************************************************

NUMBER OF ITERATIONS: 03
RMS OF MEAN(O-C)-(C-C):      4.186(CM)                   NUMBER OF OBSERVABLES EDITED:   48 ( 6.4%)

    FINAL  ANTENNA  COORDINATES

   GEODETIC         EAST(0-360)       ELLIPSOID
   LATITUDE         LONGITUDE         HEIGHT (KM)                X(KM)          Y(KM)          Z(KM)
   40.1827953160    255.2736589749    1.503023               -1240.7061441  -4720.4555514   4094.4828789
  040 10 58.0631    255 16 25.1723    1.503023

    APRIORI ANTENNA COORDINATES

   GEODETIC         EAST(0-360)       ELLIPSOID
   LATITUDE         LONGITUDE         HEIGHT (KM)                X(KM)          Y(KM)          Z(KM)
   40.1999999993    255.2999999970    1.503176               -1240.2229526  -4719.8327861   4095.9426473
  040 11 60.0000    255 17 60.0000    1.503176

    (INITIAL - FINAL) STATION DIFFERENCES

   GEODETIC         EAST(0-360)       ELLIPSOID
   LATITUDE         LONGITUDE         HEIGHT (KM)                X(KM)          Y(KM)          Z(KM)
     .0172046832       .0263410222    .000153                    .4831915       .6227653      1.4597684
  000 01  1.9369    000 01 34.8277    .000153

GPS/GASP-REALIZED ECEF COORDINATES OF THE GROUND MARK ARE:

   GEODETIC         EAST(0-360)       ELLIPSOID
   LATITUDE         LONGITUDE         HEIGHT (KM)                X(KM)          Y(KM)          Z(KM)
   40.1827953160    255.2736589749    1.501269               -1240.7078073  -4720.4542699   4094.4817599
  040 10 58.0631    255 16 25.1723    1.501269

GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!G.
                                    > A PROCESSING MODE HAS BEEN COMPLETED <
GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!C.

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ESTIMATION METHOD: SEQUENTIAL (KALMAN FILTER)
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THE MEAN O-C FOR  705 GASP OBSERVABLES IS:      .252 CM
THE SUM OF SQUARES OF ALL RESIDUALS IS          .153 CM

****************************************** BEGIN ITERATION # 01 ******************************************

MEAN OF DELTA PSEUDORANGE - DELTA CARRIER BEAT PHASE FOR EACH SATELLITE IN THIS DATA SET

PRN #     NO. OF REMAINING EPOCH PAIRS          BIAS (M)
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UNCLASSIFIED          GASP PLATTEVILLE     DAY 223    ---PRECISE EPHM---                        DATE 102489

 3          200                .237758
 6          145                .375368
 9          175               -.133244
11          252                .130859
12          332                .161503
13          206               -.186476

OF THE  753 GASP OBSERVABLES ORIGINALLY FORMED,
        705 ARE BEING PROCESSED IN THIS ITERATION
            THE AMOUNT OF DATA REJECTED SO FAR IS :   6.37%

THE TOLERANCE BEING USED FOR PSEUDORANGE VS.CARRIER BEAT PHASE DATA EDITING IS:  5.00 METERS

RMS EDIT>   19, 20     6 13   493089.01   496119.01 O-C=  13.36 CM      RMS SCREEN =   12.56 CM
RMS EDIT>  787, 788   12 11   505949.01   505979.01 O-C= -13.10 CM      RMS SCREEN =   12.56 CM

VARIANCE-COVARIANCE MATRIX OF CARTESIAN ESTIMATED POSITION (M**2)

      X          Y          Z

   .5577     -.2042     -.0759
  -.2042      .5456      .0406
  -.0759      .0406      .1383

CORRELATION MATRIX OF CARTESIAN ESTIMATED POSITION
      X          Y          Z

  1.0000     -.3701     -.2733
  -.3701     1.0000      .1477
  -.2733      .1477     1.0000

ESTIMATED STANDARD DEVIATIONS ON X, Y, Z (M)

   .7468      .7386      .3719

END ITERATION: 01      PREVIOUS RMS OF (MEAN(O-C)-(O-C))=      4.19 CM
                        CURRENT RMS OF (MEAN(O-C)-(O-C))=      4.25 CM      RMS DIFFERENCE:   -.06 CM
NUMBER OF GASP OBSERVABLES USED: 0703             NUMBER OF OBSERVABLES EDITED IN THIS ITERATION: 0002
THE NUMBER OF GASP OBSERVABLES REJECTED BECAUSE OF THE PSEUDORANGE VS. CARRIER BEAT PHASE CHECK IS:    0

>>> SO FAR,   6.64% OF THE DATA HAS BEEN REJECTED >>>
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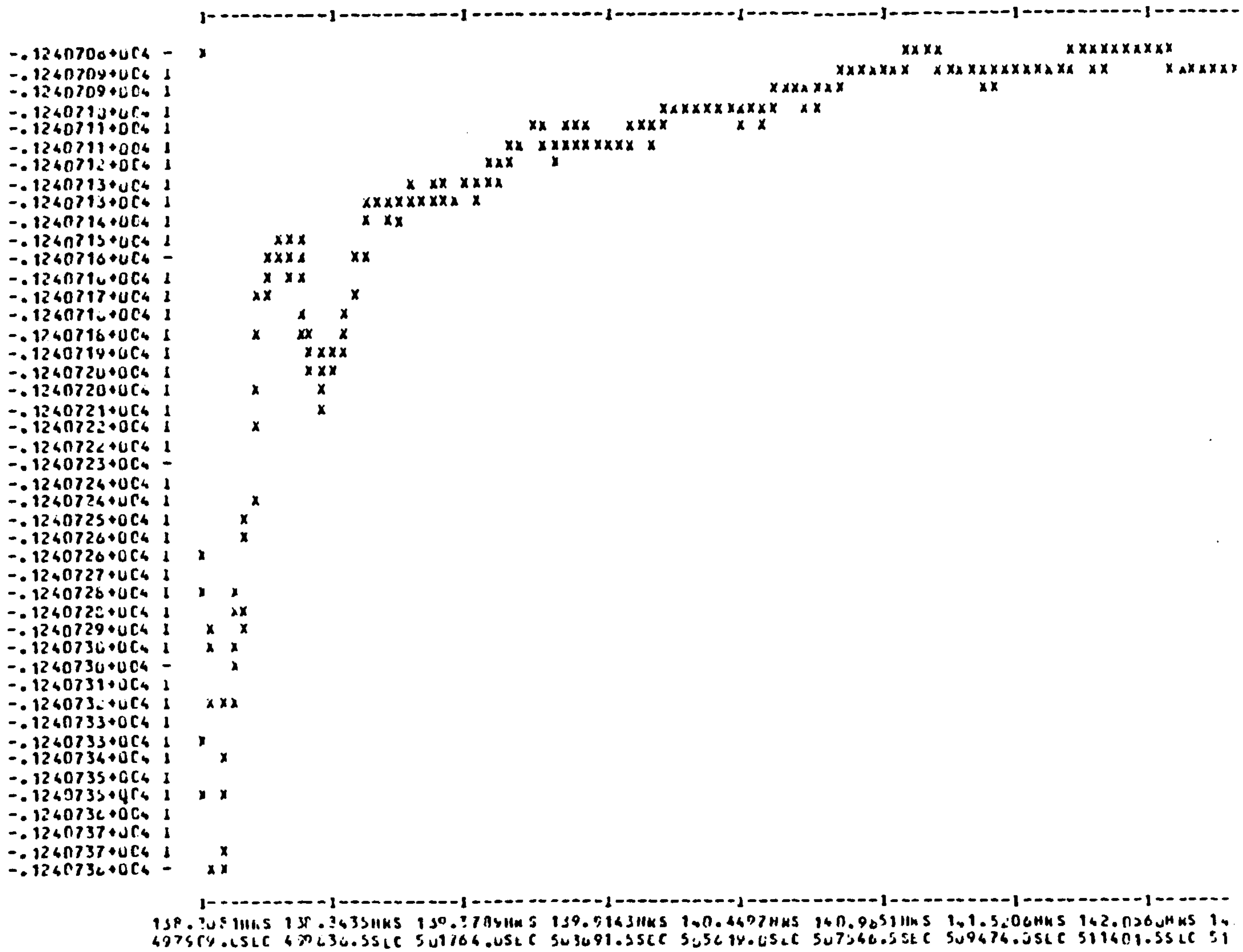
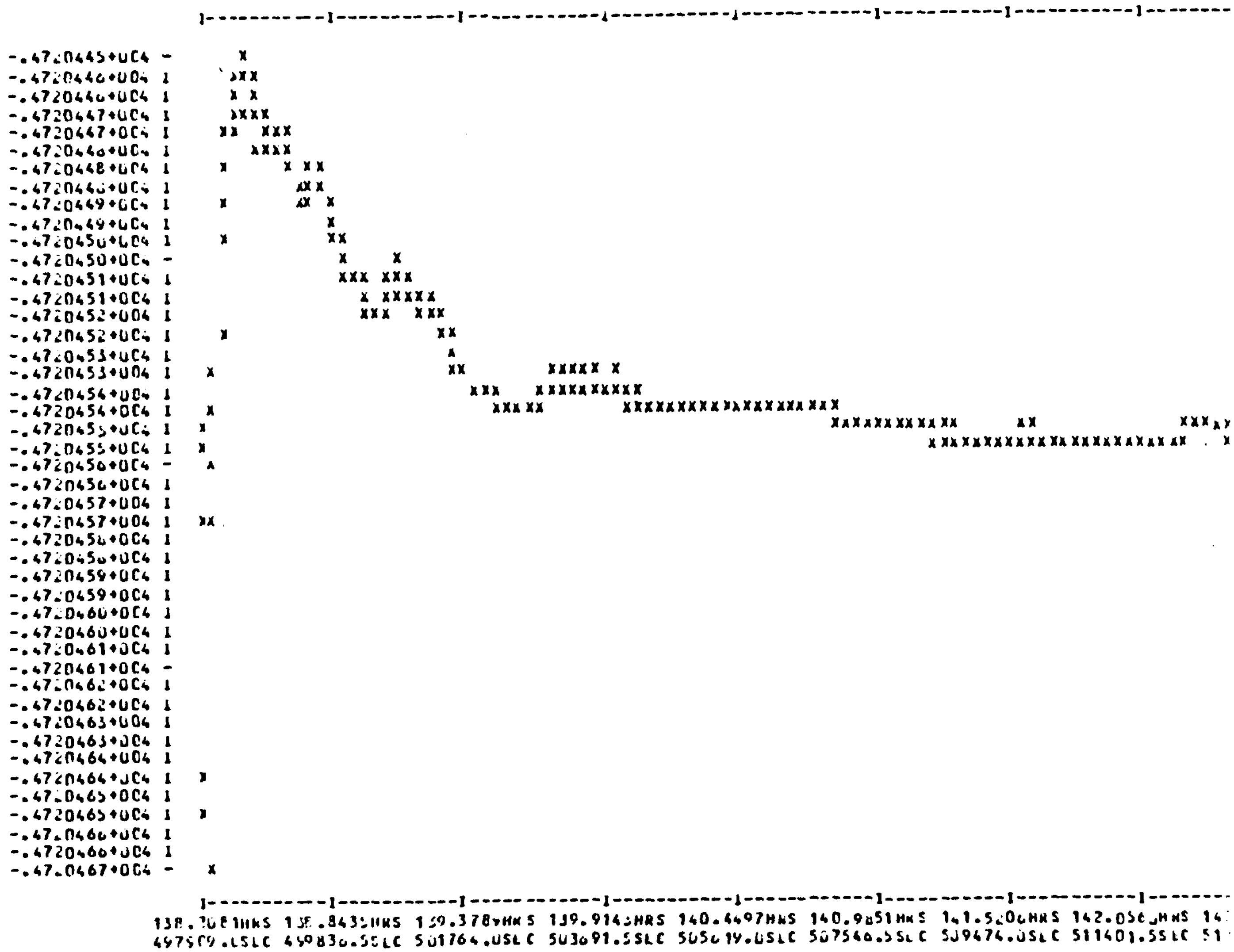
UNCLASSIFIED GASP PLATTEVILLE DAY 223 ---PRECISE EPHM--- DATE 102489

X COORDINATE(KM) VS TIME(SECS)



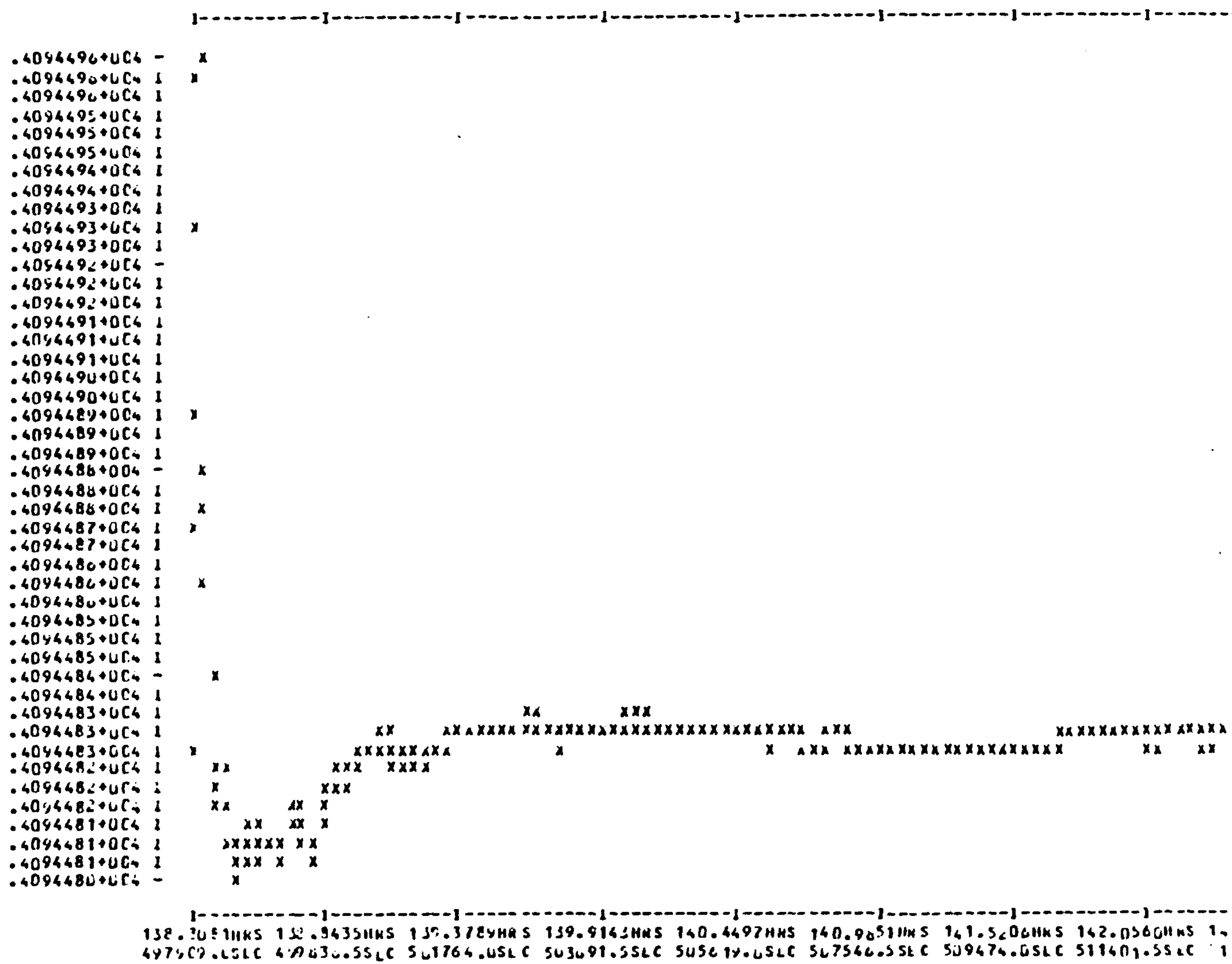
UNCLASSIFIED GASP PLATTEVILLE DAY 223 ---PRECISE EPHM--- DATE 102479

Y COORDINATE(KM) VS TIME(SECS)



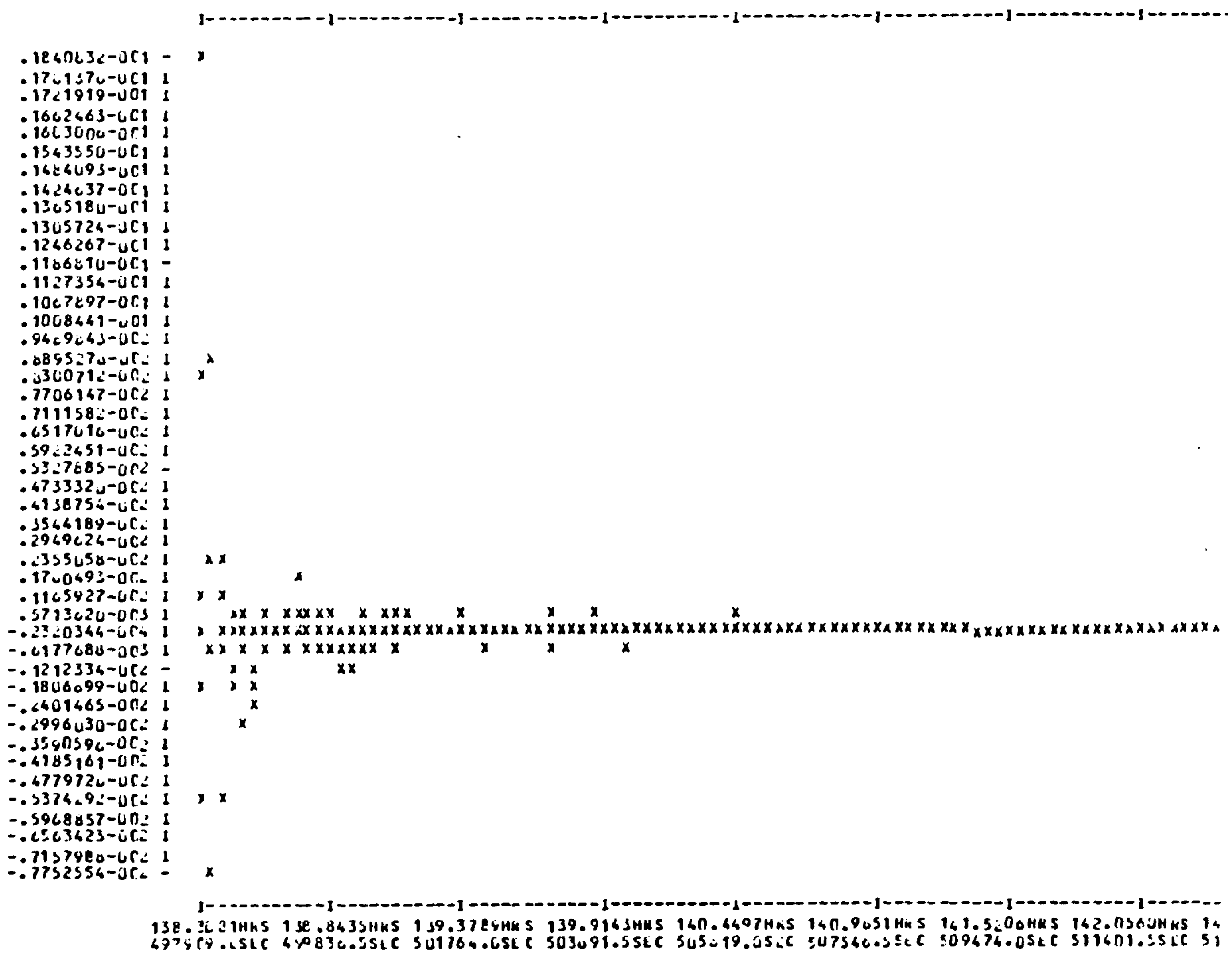
UNCLASSIFIED GASP PLATTEVILLE DAY 223 ---PRECISE EPHM--- DATE 102489

Z COORDINATE(KM) VS TIME(SECS)



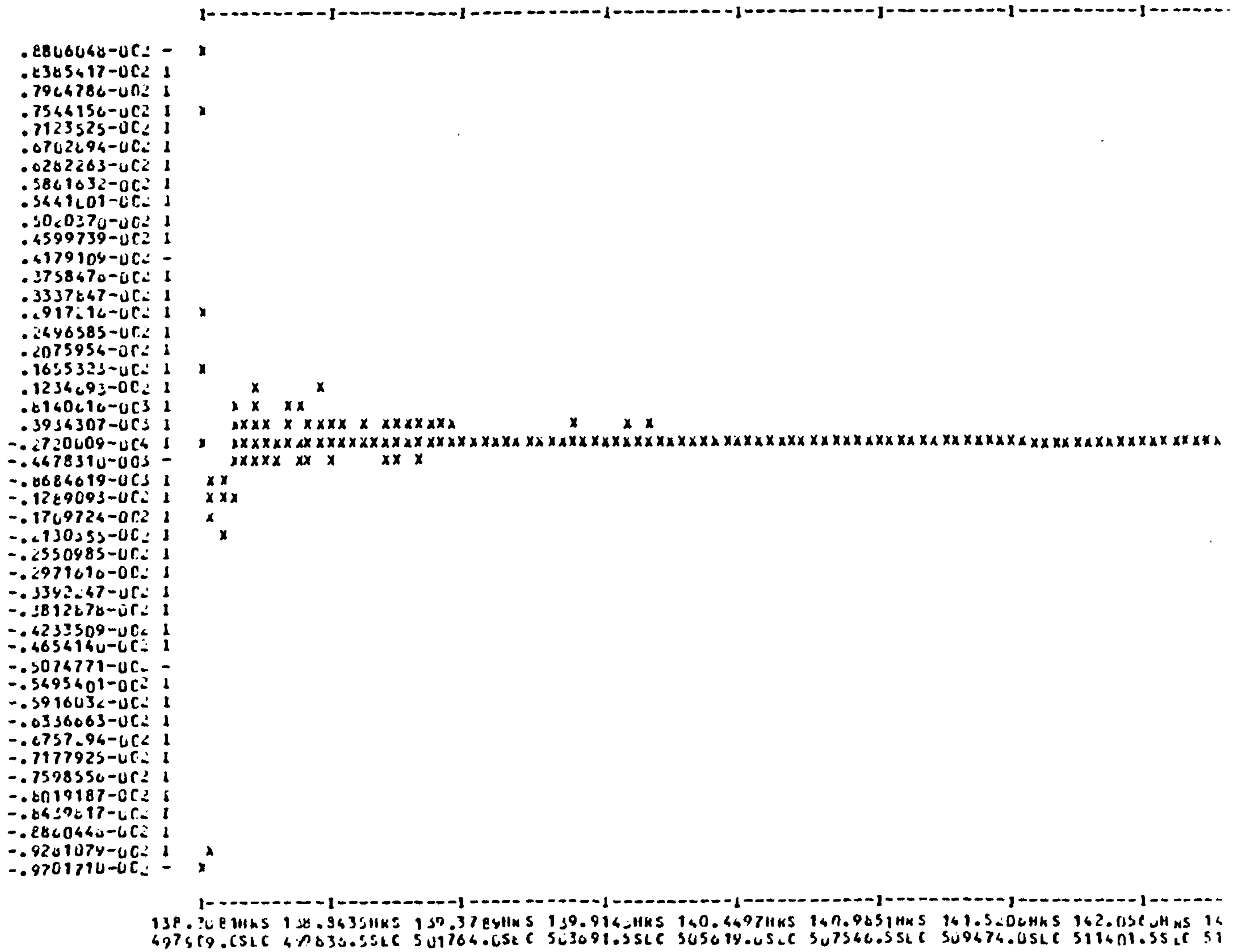
UNCLASSIFIED GASP PLATTEVILLE DAY 223 ---PRECISE EPHM--- DATE 102489

DELTA X (KM) VS TIME(SECS)



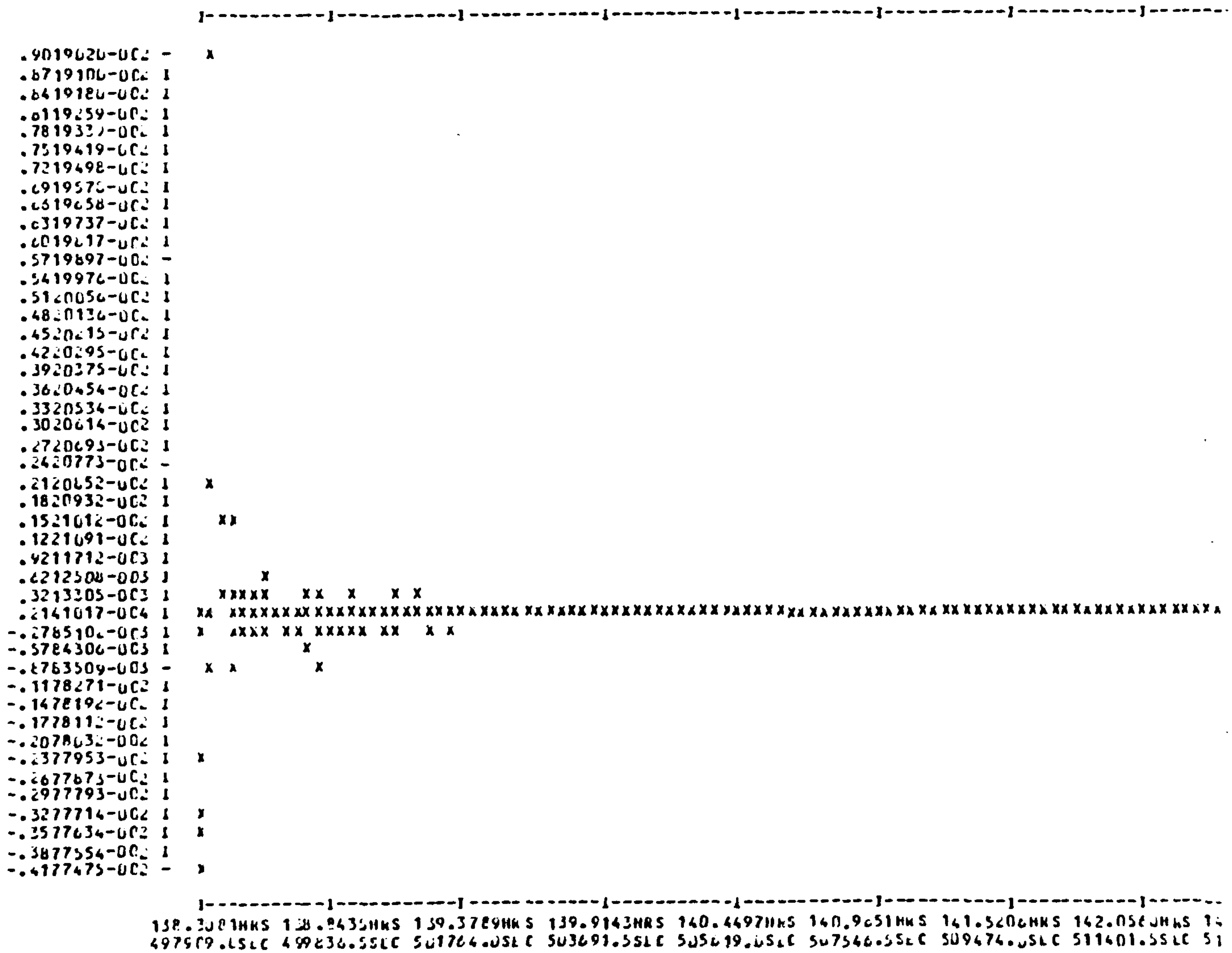
UNCLASSIFIED GASP PLATTEVILLE DAY 223 ---PRECISE EPHM--- DATE 102489

DELTA Y (KM) VS TIME(SECS)



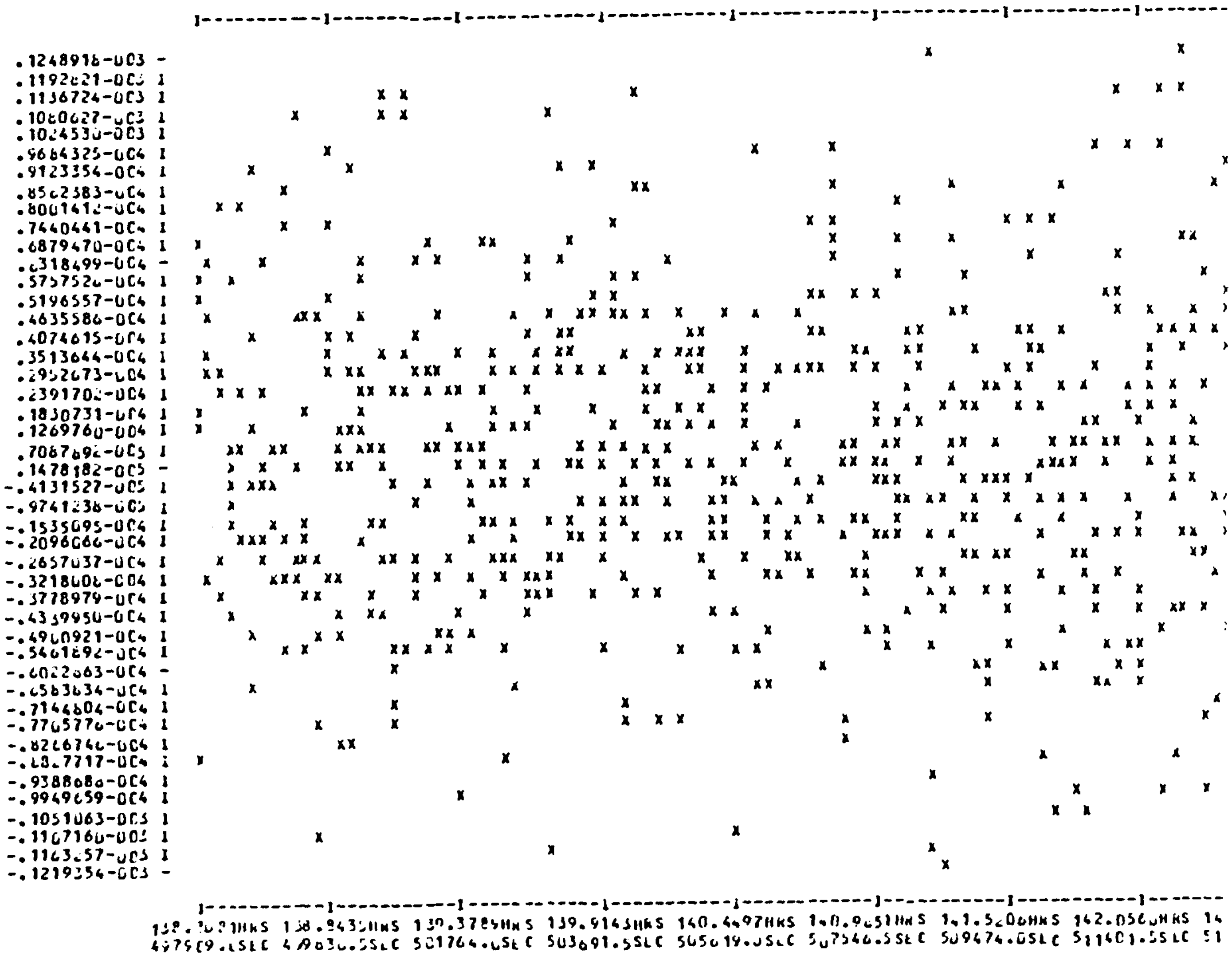
UNCLASSIFIED GASP PLATTEVILLE DAY 223 ---PRECISE EPHM--- DATE 102489

DELTA Z (KM) VS TIME(SECS)



UNCLASSIFIED   GASP PLATTEVILLE   DAY 223   ---PRECISE EPHM---   DATE 102489

OMC(KM) VS TIME(SECS)



COV X (KM) VS TIME(SECS)

```
                    I-----------I-----------I-----------I-----------.-----------I-----------I-----------I--------
.5822389-002 -      X
.5690075-002 I
.5557761-002 I
.5425446-002 I
.5293132-002 I
.5160818-002 I
.5028503-002 I
.4896189-002 I
.4763875-002 I
.4631560-002 I
.4499246-002 I
.4366932-002 -
.4234617-002 I
.4102303-002 I
.3969989-002 I
.3837674-002 I
.3705360-002 I
.3573046-002 I
.3440731-002 I
.3308417-002 I      X
.3176103-002 I
.3043789-002 I
.2911474-002 -
.2779160-002 I
.2646846-002 I
.2514531-002 I
.2382217-002 I
.2249903-002 I
.2117588-002 I
.1985274-002 I
.1852960-002 I
.1720645-002 I
.1588331-002 I
.1456017-002 -
.1323702-002 I
.1191388-002 I
.1059074-002 I
.9267594-003 I
.7944451-003 I
.6621308-003 I
.5298165-003 I
.3975022-003 I      X
.2651879-003 I      X
.1328735-003 I      XXX
.5591518-006 -        XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

                    I-----------I-----------I-----------I-----------I-----------I-----------I-----------I--------
              138.3081HRS 138.8435HRS 139.3789HRS 139.9143HRS 140.4497HRS 140.9851HRS 141.5206HRS 142.0560HRS 14
              497909.0SEC 499836.5SEC 501764.0SEC 503691.5SEC 505619.0SEC 507546.5SEC 509474.0SEC 511401.5SEC 51
```

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COV Y (KM) VS TIME(SECS)

```
                   I-----------I-----------I-------------I-----------I-------------I-----------I-----------I------
.4993985-002 -     X
.4860496-002 I
.4767011-002 I
.4653524-002 I
.4540036-002 I
.4426549-002 I     X
.4313062-002 I
.4199575-002 I
.4086087-002 I
.3972600-002 I
.3859113-002 I
.3745626-002 -
.3632139-002 I
.3518651-002 I
.3405164-002 I
.3291677-002 I
.3178190-002 I
.3064702-002 I
.2951215-002 I
.2837728-002 I
.2724241-002 I
.2610754-002 I
.2497266-002 -
.2383779-002 I
.2270292-002 I
.2156805-002 I
.2043317-002 I
.1929830-002 I
.1816343-002 I
.1702856-002 I
.1589369-002 I
.1475881-002 I
.1362394-002 I
.1248907-002 -
.1135420-002 I
.1021932-002 I
.9084453-003 I
.7949580-003 I
.6814706-003 I     X
.5679830-003 I
.4544964-003 I
.3410092-003 I
.2275219-003 I     X
.1140347-003 I     X
.5474503-006 -     XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                   I-----------I-----------I-------------I-----------I-------------I-----------I-----------I------
                 138.3063HRS 138.8435HRS 139.3789HRS 139.9143HRS 140.4497HRS 140.9851HRS 141.5206HRS 142.0560HRS 1
                 497909.1SEC 499836.5SEC 501764.0SEC 503691.5SEC 505619.0SEC 507546.5SEC 509474.0SEC 511401.5SEC 5
```

UNCLASSIFIED GASP PLATTEVILLE DAY 223 ---PRECISE EPHM--- DATE 102489

COV Z (KM) VS TIME (SECS)

```
                  I-----------I-----------I------------I-----------I------------I-----------I-----------I--------
.1205252-002 -    X
.1177863-002 I
.1150474-002 I
.1123085-002 I
.1095696-002 I
.1068307-002 I    X
.1040918-002 I
.1013529-002 I
.9861404-003 I
.9587514-003 I
.9313624-003 I
.9039735-003 -
.8765845-003 I
.8491955-003 I    X
.8218066-003 I
.7944176-003 I
.7670286-003 I
.7396396-003 I
.7122507-003 I
.6848617-003 I
.6574727-003 I
.6300838-003 I
.6026948-003 -
.5753058-003 I
.5479168-003 I
.5205279-003 I
.4931389-003 I
.4657499-003 I
.4383610-003 I
.4109720-003 I
.3835830-003 I
.3561941-003 I
.3288051-003 I
.3014161-003 -
.2740271-003 I
.2466382-003 I
.2192492-003 I
.1918602-003 I
.1644712-003 I
.1370823-003 I
.1096933-003 I
.8230434-004 I    X
.5491536-004 I
.2752640-004 I     XX
.1374.00-006 -       XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

                  I-----------I-----------I------------I-----------I------------I-----------I-----------I-------
              138.7081HRS 138.8435HRS 139.3789HRS 139.9143HRS 140.4497HRS 140.9851HRS 141.5206HRS 142.0560HRS 14
              497909.0SEC 499836.5SEC 501764.0SEC 503691.5SEC 505619.0SEC 507546.5SEC 509474.0SEC 511401.5SEC 51
```

```
.CLASSIFIED          GASP PLATTEVILLE     DAY 223    ---PRECISE EPHM---                         DATE 102489

*******************************************************************************
*   SOLUTION FOR FILE: GLOSTAR*PTPLA9223P.
*******************************************************************************

UMBER OF ITERATIONS: 01
.S OF MEAN(O-C)-(C-C):      4.249(CM)                NUMBER OF OBSERVABLES EDITED:    50 ( 6.6%)

   FINAL  ANTENNA  COORDINATES

  GEODETIC            EAST(0-360)        ELLIPSOID
  LATITUDE            LONGITUDE          HEIGHT (KM)              X(KM)          Y(KM)          Z(KM)
  40.1627959086      255.2736557077     1.503064          -1240.7064142  -4720.4554844  4094.4829683
 040 10 58.0653      255 16 25.1605     1.503064

   APRIORI ANTENNA COORDINATES

  GEODETIC            EAST(0-360)        ELLIPSOID
  LATITUDE            LONGITUDE          HEIGHT (KM)              X(KM)          Y(KM)          Z(KM)
  40.1627957160      255.2736559749     1.503023          -1240.7061441  -4720.4555514  4094.4828789
 040 10 58.0631      255 16 25.1723     1.503023

   (INITIAL - FINAL) STATION DIFFERENCES

  GEODETIC            EAST(0-360)        ELLIPSOID
  LATITUDE            LONGITUDE          HEIGHT (KM)              X(KM)          Y(KM)          Z(KM)
   -.0000005926        .0000002672      -.000041             .0002702       -.0000670      -.0000894
-000 00   .0021      000 00   .0118      -.000041

PS/GASP-REALIZED ECEF COORDINATES OF THE GROUND MARK ARE:

  GEODETIC            EAST(0-360)        ELLIPSOID
  LATITUDE            LONGITUDE          HEIGHT (KM)              X(KM)          Y(KM)          Z(KM)
  40.1627959086      255.2736557077     1.501349          -1240.7060774  -4720.4542029  4094.4918493
 040 10 58.0653      255 16 25.1605     1.501349

ASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GAS
                                       > A PROCESSING NODE HAS BEEN COMPLETED <
ASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GASP!GAS


EDM,Q GSGT*GASPRESULTS.FALCON/PLATT
E 29E 10/24/89 10:59 FALCON/PLATT(U):A
EIT
4.17  450  25   1 3.CO SEQ  ============
ND EDIT 94 LINES OUTPUT

FREE GSGT*GASPRESULTS.
:120433 filename not known to this run.

RESUME,QL
```

Appendix D. Troubleshooting

The chart provided below is intended to help new STARPREP/GASP users diagnose and solve processing problems which may occur during familiarization and training phases.

Symptom	Possible Problem	Solution
STARPREP defaults to broadcast ephemerides	One or more precise ephemeris files missing or Tracking span is to large (requiring over 100 ephemeris points)	Include all required ephemeris files in runstream Shorten Tracking span or eliminate large data gap
Point file contains meaningless interpolated ephemerides or GASP message: no data in point file	Data spans week crossover, but standard (full week) ephemerides were assigned in the STARPREP runstream	Use 'half-week' ephemeris / clock files or Edit FICA file to remove week crossover
Non specific error message: when running STARPREP on UNISYS: Guard mode	Wrong Precise clock file assigned	Assign correct clock file
GASP position plots do not converge or High correlation coefficients High standard deviations	Data set is too short (or too much rejected) or Very poor geometry	Use different data set or Determine why too much data was rejected and resolve
GASP residual plots do not appear random at last iteration or Large percentage (>30%) of data rejected or Most data rejected in GASP by RMS screening	A priori station coordinates are too gross or Data set contains an erratic satellite (check delta pseudorange - delta carrier beat phase biases, and rejected data by satellite)	Rerun STARPREP and GASP with improved a priori station coordinates (obtained from initial GASP result if some data was processed) or Eliminate erratic satellite
GASP position plots do not converge or High RMS of Residuals	Missing or empty clock file	Assign correct clock file