# GrafTrak II

and

# Silicon Ephemeris

Code Version 4.01

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## Congratulations!

You have just acquired one of the finest integrated satellite display and prediction packages available. Advanced satellite tracking and predicting capabilities, previously available only on large-scale computers, are now available for the smaller personal level machines, complete with real-time color graphics. This software was originally developed in the mid 1980's and has been a benchmark for other satellite-tracking applications for many years. It is provided as a service to those seeking to track satellites as a hobby. No warranties are provided or implied. Although tested for "Y2K" compliance, the programs herein are provided "as is" without cost or obligations, for personal use only.

## A Few Words About This Manual

This manual is arranged in five separate sections. Section I is a general introduction to the over-all system, and briefly describes the programs supplied with this system, as well as the installation and customization procedures. Sections II, III, IV, and V deal with the display, prediction, and editing programs, and the User Station Control Program Interface, respectively.

## Copyright Notice



## Credits

Astronomical algorithms and GT by Richard Allen W5SXD. Satellite algorithms and SEPH by Joseph Bijou WB5CCJ. Our thanks to Gil Carman WA5NOM, Courtney Duncan N5BF, Jan King W3GEY, Dave Beaty K7MNC, Bill McCaa K0RZ, Vern "Rip" Riportella, WA2LQQ and the many other users whose invaluable letters, telephone conversations and suggestions contributed toward the enhancement of this software package. Manual editing for electronic distribution in the year 2000 provided by Andy MacAllister W5ACM.

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# SECTION I - Introduction and Installation

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### 1.1.0 GENERAL DESCRIPTION

This package includes a complete software system for real-time tracking of Earth orbiting satellites, the Moon, and the Sun. The following software program modules are provided:

1. **G**raf**T**rak (**GT**)
2. **S**ilicon **EPH**emeris (**SEPH**)
3. **S**atellite **ED**itor (**SED**)
4. **G**reenwich **M**ean **T**ime (**GMT**)
5. Picture File Animator (**ANIMATE**)
6. Graphics Mode Set (**GR**)
7. Clock Adjuster (**TCL**)
8. **SHOW SAT**ellites (**SHOWSAT**)
9. **UP**date **.SAT** files (**UPSAT**)
10. **M**ost **A**ccurate **C**lock **I**nterface (**MACI**)

These programs operate on the IBM personal computer PC, PC/XT, PC/AT, or true compatibles, equipped as follows:

1. One floppy disk drive and one hard disk drive
2. A Minimum of 512 kbytes of RAM memory, 640 kbytes recommended for all features.
3. An optional but recommended 8087/80287/80387 math co-processor
4. IBM Color Graphics Adapter (**CGA**), IBM Enhanced Graphics Adapter (**EGA**), or true compatible
5. an IBM compatible graphics printer,
   or an Epson FX-80 compatible graphics printer,
   or an Okidata Microline 92 compatible graphics printer,
   or a HP LaserJet Series II compatible graphics printer.
6. MS/PCDOS 2.0 or later

## 1.2.0 BRIEF DESCRIPTION OF PROGRAMS

### 1.2.1 **G**raf**T**rak (**GT**)

**GT** is a graphics oriented program providing a realtime display of the path and coverage area of a selected satellite and information about its relationship to a selected observer. **GT** reads satellite and observer parameters from disk resident database files, created by the **SED** editor program, containing data for up to 16 satellites and 16 observers. You may create as many database files as you wish, limited only by disk storage, and easily switch between them.

In the real-time tracking mode, **GT** displays a Mercator projection world map with a superimposed satellite radio horizon coverage circle. As the satellite position changes, the display is redrawn as often as once per second. Pertinent numeric data such as elevation, azimuth, and Doppler shift corrections are displayed for the selected satellite relative to the selected observer.

Spherical projection map displays may also be produced, showing a view of the Earth as seen from the satellite, complete with Lat/Lon grids, land mass outlines, and major political boundaries.

Any screen display may be routed to the supported graphics printers at any time. Mercator or spherical graphics images may also be saved in standard IBM picture file format for entry into the popular paint programs which support this format. The **ANIMATE** program provided with this package can display and animate the picture files generated by **GT**, as described in section II.

In the astronomical modes, the position of the Moon, Sun, or any user specified star can be displayed to an accuracy of better than one arc-minute. The astronomical modes may be used for any epoch within 2000 years of the current date.

### 1.2.2 **S**ilicon **EPH**emeris (**SEPH**)

The **S**ilicon **EPH**emeris (**SEPH**) is a powerful satellite prediction program providing 15 unique modes of operation which enable the user to accurately predict and display information describing the relationship between the observer(s) and the satellite(s), the Sun, or the Moon. **SEPH** reads satellite and observer parameters from disk resident database files, created by the **SED** editor program, containing data for up to 16 satellites and 16 observers. You may have as many database files as you wish, limited only by disk storage, and easily switch between them. Information can be either displayed in realtime, output to the printer, or output to a disk file for future use.

### 1.2.3 **S**atellite **ED**itor (**SED**)

The **S**atellite **ED**itor (**SED**) program provides the means to easily create and edit data files. The files may contain up to sixteen observers and up to sixteen satellites. The data for each observer includes the name, latitude, longitude, and altitude above sea level. The data for each satellite is the classical Keplerian element set, in a format compatible with data provided regularly by NASA. This data should be updated every two to eight weeks, depending on the satellite, to compensate for factors which influence the predicted orbital positions. The data is available either from NASA on a direct mail basis or from several bulletin board systems, as described in section IV. A virtually unlimited number of database files can be maintained, each containing specific combinations of satellites and observers of interest to the user. Any file generated by **SED** can be selected for processing in the command line of either **GT** or **SEPH**.

1.2.4 **G**reenwich **M**ean **T**ime (**GMT**)

**GT** and **SEPH** operate in Universal Time (UT or GMT). Since **DOS** time on most personal computers is kept in local time, a method is needed to inform **GT** and **SEPH** of the **OFFSET** between **DOS** time and Universal Time. This function is performed by the **GMT** program. When run, **GMT** requests the user to input the offset in hours between Universal Time and **DOS** time. This number is written to a disk file called **OFFSET.GMT**. **GT** and **SEPH** read this file as part of their initialization sequence and algebraically add this number to the **DOS** system time, thereby calculating the correct Universal Time.

1.2.5 Picture File Animator (**ANIMATE**)

**ANIMATE** provides a method for recalling the standard format screen image picture files generated by **GT** for display either individually or as a series of files to animate a display sequence.

1.2.6 Graphics Mode Set (**GR**)

**GR** provides a method to set your IBM compatible **C**olor **G**raphics **A**daptor (**CGA**) or IBM compatible **E**nhanced **G**raphics **A**daptor (**EGA**) to any one of seven modes. The primary use of **GR** is to set the 320X200 graphics mode, which cannot be set using the **DOS MODE** command. These modes are described in the VIDEO_IO section of the BIOS program listing in the IBM Hardware Reference Library Technical Reference Manual.

1.2.7 Clock Adjuster (**TCL**)

**TCL** uses single key strokes to add or subtract 55 ms, 110 ms, 1 second, or 1 minute values to the **DOS** real-time clock. This program, along with a receiver capable of receiving Standard Time Broadcast Stations such as WWV or CHU, makes accurate setting of your **DOS** clock a very easy operation. A sample batch file, **HACK.BAT**, can be used to set a TECMAR battery backed up clock. The call to the program SETTIME, supplied with the TECMAR clock, may be replaced by a call to a similar program supplied with other clocks.

1.2.8 **SHOW SAT**ellites (**SHOWSAT**)

**SHOWSAT** is a program which displays the contents of selected satellite data base files and the age of each element set in units of days. This program provides a quick look at the contents of a **.SAT** file without the need for running **SED**.

1.2.9 **UP**date .**SAT** files (**UPSAT**)

**UPSAT** is a program which updates a **.SAT** file from an element set file downloaded from a bulletin board, such as the WD0GML AMSAT board in St. Louis, Missouri or the Celestial RCP/M board in Fairborn, Ohio. This utility program can reduce the time required to update all 16 objects in a **.SAT** file to under one minute.

1.2.10 **M**ost **A**ccurate **C**lock **I**nterface (**MACI**)

**MACI** is a terminate-and-stay-resident (TSR) program which reads the Heathkit Most Accurate Clock and updates the DOS clock as necessary. This utility program can maintain your local clock within one-half second of WWV or WWVH.

## 1.3.0 INSTALLATION

1.3.1 Create Backups of the Distribution Diskettes

**DO NOT REMOVE THE WRITE PROTECT TABS FROM YOUR DISTRIBUTION DISKETTES.** Before proceeding with the installation, make at least one backup copy of your distribution diskettes. Use the **DISKCOPY** command which is described in the **Disk Operating System** reference manual.

1.3.2 **GT/SEPH** Hard Disk Subdirectory Installation

1. Select drive **C:** as the currently logged disk drive. Ensure that you are in the root directory by entering the following command:

    **CD**

2. Create a subdirectory named **GT** by entering the following command:

    **MD GT**

3. Select the **GT** subdirectory by entering the following command:

    **CD GT**

4. Copy all of the **GT/SEPH** distribution diskettes from your floppy disk drive to the **GT** subdirectory on your hard disk by entering the following command for each diskette:

    **COPY A:*.*/V**

5. Store your distribution diskettes in a safe place.

6. Proceed to Section I.4.0.

1.3.3 **GT** Floppy Diskette Installation

If your application requires that **GT/SEPH** run from a floppy only system, please contact Silicon Solutions for details.

## 1.4.0 CUSTOMIZATION

Customization is a two step process. The first step requires that an **OFFSET.GMT** file be created by using the **G**reenwich **M**ean **T**ime (**GMT**) program. The second step requires that your geographical coordinates be entered into the **DEMO.SAT** data file as observer 1 by using the **S**atellite **ED**itor (**SED**) program.

### 1.4.1 Create **OFFSET.GMT**

Enter the following command:

**GMT**

**GMT** will display the current **DOS** time, and ask for your GMT offset in hours. The quantity that you enter should be the number that you would algebraically add to your **DOS** time to calculate GMT time. For example, if you lived in Houston, Texas and were on **Central Standard Time**, you would **add** six hours to your local time to get GMT. If you were on **Central Daylight Time**, you would **add** five hours to your local time to get GMT.

The rule-of-thumb is that if you are between 0 and 180 degrees west longitude, you will add hours to your local time to get to GMT. If you are between 0 and 180 degrees east longitude, you will subtract hours from your local time to get GMT. If your station location is up to 180 degrees east of Greenwich, the GMT offset number will be negative. **Be certain to update OFFSET.GMT when Daylight Savings Time changes are occur at your station location**.

The offset that you enter will normally be an integer number. If you live in a time zone which is not an integral number of hours from GMT, such as Gander, Newfoundland, you may enter a real number, 4.5.

```
Satellite Database Editor    V3.00    Copyright (C) 1985-1989 Silicon Solutions
file: DEMO                                        edited: 01 May 1989 18:09
title: DEMO - a DEMOnstration file              satellites: 16  observers: 16

  satellite name    AO-13                        command:

element set desc    Obj # 19216, Set #   34                  object:  5
      epoch year    1989
       epoch day    089.37166448                              E   - edit
     inclination     57.2895      degrees                     S   - satellite
      r. a. a. n.   213.9669      degrees                     O   - observer
    eccentricity    .6688587                                  N   - next
  arg of perigee    201.4192      degrees                     P   - previous
    mean anomaly    106.6281      degrees                    .nn  - object 01-16
     mean motion     2.09699506   orbits/day                  C   - clear entry
   decay (ndot2)    -.00000028    orbits/day**2               R   - read entry
     use decay?     1             0=no, 1=yes                 W   - write entry
    orbit number      608                                     G   - get data
      orbit base    0             0=perigee, 1=equator        U   - roll up
 semi-major axis    0             km                          T   - edit title
beacon frequency    145.813       MHz                         X   - exit (update)
  blat or nddot6    2.5           degrees or orbits/day**3    Q   - quit (abort)
    blon or drag    181.1         degrees or bstar            Esc - to this menu
     orbit model    1             0=SSI, 1=Bahn, 2=SGP, 3=SGP4/SDP4
```

Figure 1-1, Typical Satellite Data Fields Display

```
Satellite Database Editor    V3.00    Copyright (C) 1985-1989 Silicon Solutions
file: DEMO                                        edited: 01 May 1989 18:09
title: DEMO - a DEMOnstration file              satellites: 16  observers: 16

   observer name    Houston                      command:

  north latitude    29.674283     degrees (- south)           object:  1
  east longitude    -95.451217    degrees (- west)
          height    8.2           meters                      E   - edit
                                                              S   - satellite
                                                              O   - observer
                                                              N   - next
                                                              P   - previous
                                                             .nn  - object 01-16
                                                              C   - clear entry
                                                              R   - read entry
                                                              W   - write entry
                                                              G   - get data
                                                              U   - roll up
                                                              T   - edit title
                                                              X   - exit (update)
                                                              Q   - quit (abort)
                                                              Esc - to this menu
```

Figure 1-2, Typical Observer Data Fields Display

1.4.3 Add Your Geographical Location to **DEMO.SAT**

Enter the following command line:

**SED DEMO**

**SED** will load and read the **DEMO.SAT** database file. The screen should resemble Figure 1-1, Typical Satellite Data Fields Display. Press the [**O**] key to select the Observer Display mode. The screen should resemble Figure 1-2, Typical Observer Data Fields Display. The blinking cursor should be positioned to the right of the [**command:**] field. **SED** is now in the command mode. Press the [**E]** key to enter the edit mode. The blinking cursor should be positioned at the first character of the [**observer name**] field. Enter up to 16 characters describing your location, followed by pressing the [**ENTER**] key; for example, **Houston**, or **Boston**, or **London**, or **K5GZR**, or **Moscow**, or **W3GEY**, etc. You may press the [**Esc**] key at any time to return to the command mode.

The blinking cursor should now be positioned at the first character of the [**north latitude**] field. Enter your latitude in degrees and decimal degrees preceded by a [ **-** ] minus sign if you are in the southern hemisphere, then press the [ENTER] key; for example, **29.5**, or **-33.375648**, or **34.52748955**.

The blinking cursor should now be positioned at the first character of the [**east longitude**] field. Enter your longitude in degrees and decimal degrees preceded by a [ **-** ] minus sign if you are in the western hemisphere, then press the [**ENTER**] key; for example, **-95.5**, or **37.6**, or **152.5.**

The blinking cursor should now be positioned at the first character of the [**height**] field. Enter your location height in meters preceded by a [ **-** ] minus sign if below sea level, then press the [**ENTER**] key; for example, **15.5**, or **1472.1**, or **-68.7**.

Press the [**Esc**] key to return to the command mode. Press the [**X**] key to select the exit mode. **SED** will display the message [**EXIT(Y/N)?**]. If you respond by pressing the [**Y**] key, **SED** will update the **DEMO.SAT** file and return to the **DOS** prompt. If you respond by pressing the [**N**] key, **SED** will return to the command mode. This completes the Installation and Customization procedures.

## 1.5.0 ADDITIONAL NOTES ON SETTING THE CLOCK

### 1.5.1 Conventional Mode

In the normal mode, **GT** and **SEPH** work in Greenwich Mean Time (GMT), also known as Universal Time (UT). When **GT** or **SEPH** is loaded, it reads the file **OFFSET.GMT**. This file contains a number which is the offset in hours between your **DOS** time and GMT.

### 1.5.2 Astronomical Mode

You may wish to use the many features offered by **GT** in the Astronomical Mode. When **GT** is operating in the astronomical mode, it assumes that the displayed time represents Ephemeris Time (ET or TDT). ET is currently about one minute different from UT. This will cause a real-time error of as much as 1/4 degree in the lunar, solar, and stellar tracking modes. If you require better accuracy than this, you can either set your **DOS** clock to ET or change **OFFSET.GMT** to make the display time read in ET. This offset is determined from year to year by observation and cannot be accurately calculated. The value can be found in the Astronomical Ephemeris.

## THE MOST IMPORTANT USAGE NOTE

There are **many modes of operation** available within the **GT** program. At times, the novice operator can invoke so many features that he/she can literally lose track of the many things going on. It is comforting to note that one **can always back out** of a given point in operation, **and restore fully automatic operation by the following sequence of commands**:

1. If the time cursor is under the **time** indication at the upper right of the screen, **step it fully off the screen to the right using the right arrow on the number pad of the keyboard**.

2. Press the **[T]** key to return to the **TRACK** mode.

3. Press the **[Esc]** key to return to the **real time tracking** mode.

4. Press the **[=]** key to restore operation to the **AUTO-SWITCH** mode.

Although this approach may appear somewhat shotgun, it can prove to be the easiest method to restore fully automatic operation.

Alternatively, fully automatic system operation on dedicated hardware systems with **GT** AUTOEXEC.BAT files can be restored at any time by booting the system. Press **[Ctrl], [Alt] and [Del]** simultaneously.

# <u>SECTION II</u> - GrafTrak II (GT) Tracking and Display Program

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### 2.1.0 BASIC GT OPERATIONS

Although this manual contains a great deal of information, it is not necessary that you absorb all of the information in order to use this system. We suggest that you take your time, use the default parameters supplied, and learn each capability of the system as you go. The experience will be more enjoyable and you will retain the information gained through your hands-on experience longer.

This section deals with operation of the **G**raf**T**rak (**GT**) display program **without invoking either the AC Antenna Control command line token, or the RX Receiver Control command line token**. Operation with **antenna control** is accomplished with minor change to the command line, and adds the real-time antenna position elevation and azimuth to the lower right window of the screen display. Operation with **receiver control** is also accomplished with a minor change to the command line, and adds real-time receiver tuning.

**Operation with real-time antenna positioning control and receiver tuning control is described in section V of this manual**.

### 2.1.1 Load GT Using an Example Batch File

To use the example batch file supplied for loading **GT**, enter the following command line:

**hd** [ENTER]

After **GT** has loaded, the screen will display the control panel shown in Figure 2-1, **GT** Control Panel, along with the **GT** system copyright message, the system serial number, and in some cases, your name and address.


Figure 2-1, **GT** Control Panel

**GT** will then proceed to load the map data. You may need to adjust the intensity and contrast controls for best display clarity. The map loading will take about one minute due to the large amount of data required for each zoom level. **GT** will use observer 1 as its present position and proceed to track and display the first available satellite, complete with ground track, coverage circle, auto-zoom, auto-switch, and Sun line. An example of a map display is provided by Figure 2-2, Typical **GT** Map Display.

2.1.1.1 Example Pass Description

The following series of screens, and the accompanying description of these screens, provides a graphic example of a typical pass by a polar orbiting satellite.

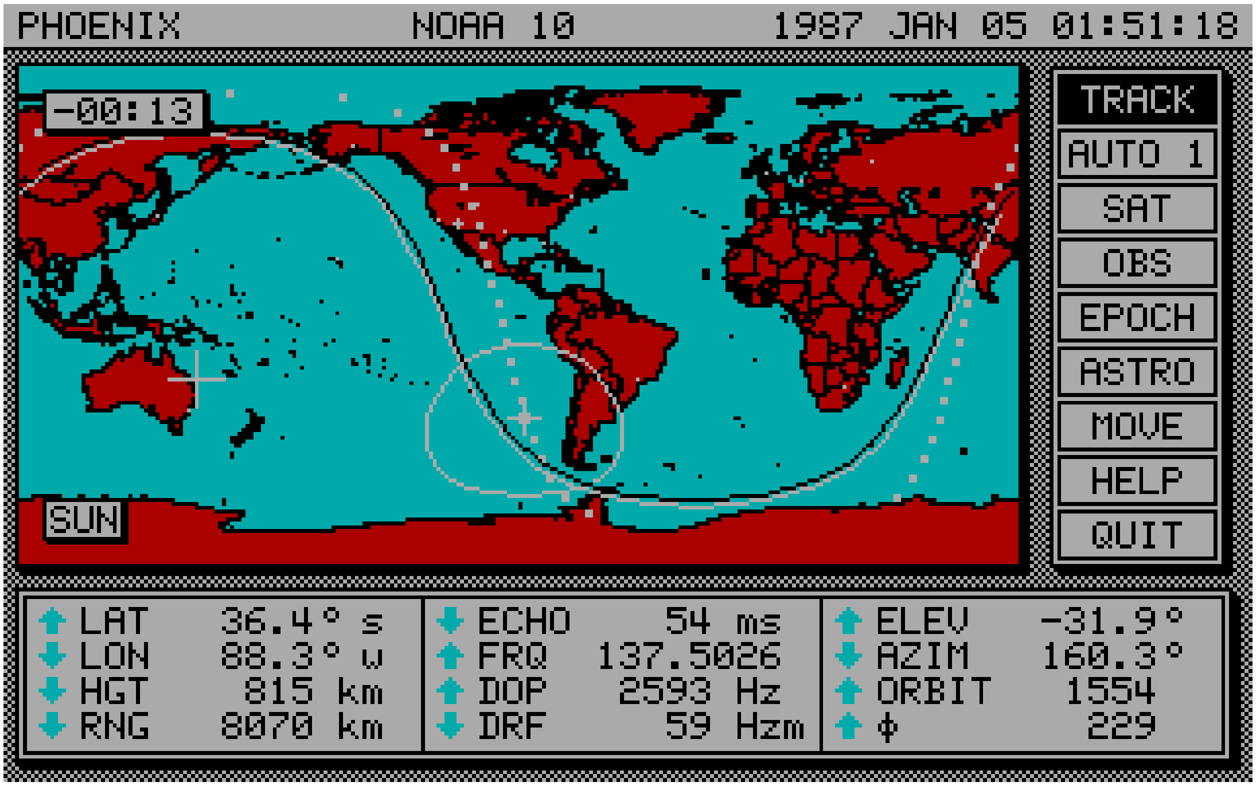



Figure 2-2, Typical **GT** Map Display

2.1.1.1.1 View One

Beginning with Figure 2-3, a display of orbit number 1554 of satellite NOAA-10 is shown. NOAA-10 is one of the two active polar orbiting weather satellites maintained by the National Oceanic and Atmospheric Administration, which transmit continuous weather data and picture information. The picture information, called APT, is transmitted in the 137 MHz satellite down-link band, and is received by many amateur radio operators and research facilities throughout the world.

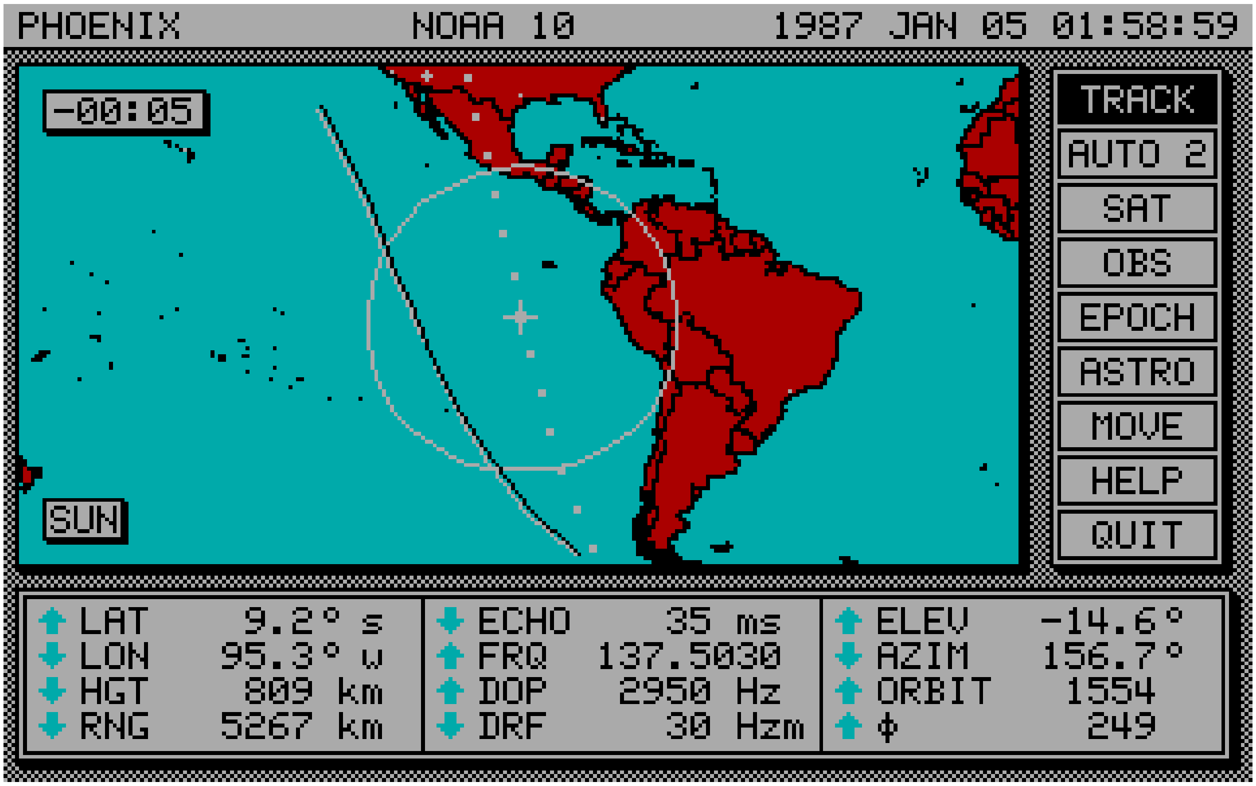



Figure 2-3, Sample S-N Pass, View One

The selected observer is Phoenix, Arizona, shown both in the form of the observer name at the top left corner of the screen, and as a small cross (plus sign) on the map. Secondary observation sites in Texas, California, Florida, and one in South America, are shown as small white dots.

The selected satellite is NOAA-10, as noted at the top center of the screen. The date is 05 JANUARY, 1987, at 01:58:59 hours GMT, noted at the upper right corner of the display.

The auto-switch window, in the upper left corner of the map, indicates that the program is in the auto-switch mode, meaning that it will search for, and automatically display, the next satellite based on the time of arrival at the primary observation site. The countdown time to the start of the next pass, in this case 5 minutes, is displayed in this window, rounded to the nearest minute.

As a point of interest, the program has been instructed to invoke the auto-zoom feature by the command line at system startup, so it will automatically zoom in and out in resolution, as necessary to keep **both** the **selected satellite** and the **selected observer** on the map at all times. At the present time, the second control block from the top on the right side of the display indicates that the program is in [AUTO 2], which means that the display has already been zoomed in 2:1 from the normal viewing mode which is 1:1.

The [SUN] block in the lower left corner of the map indicates that the program is tracking the Sun as well as NOAA-10, providing the light/dark diagonal Sun line which runs through the screen just to the left of center. The left side of the line is white, indicating that the area to the west of the line is illuminated by the Sun at the present time. The black side of the line indicates that the surface of the Earth to the east of the line is in darkness at the present time.

The series of white dots running upward and to the left through the center of the screen is the groundtrack, or path of travel beneath the satellite. Each white dot indicates a two minute change in position of the sub-satellite point, or SSP, beneath the satellite. The program has been told to plot a specific number of two minute steps in the ground track, before and after, the present position of the satellite, by means of the tokens inserted in the command line at system start-up.

The white circle in the center of the screen is the satellite radio horizon coverage circle. Any transmitter within this circle will be able to reach the satellite under normal conditions. Transmitters or ground stations outside this circle will be obscured from a view of the satellite by the horizon due to the curvature of the earth. This circle varies slightly in size during an orbit, and is 6114 km in diameter when the satellite is 810 km above the earth.

The white cross in the center of the screen represents the satellite NOAA-10. The display is designed so that **the satellite will always stay in the horizontal center of the screen**, moving up and down in latitude as appropriate, as the map moves horizontally beneath it.

The display window at the bottom of the screen indicates current statistics appropriate to the system. For example:

The present position of the satellite is 9.2º S [LAT], 95.3º W [LON], at a height [HGT] of 809 km. The up/down trend arrows indicate the direction of change in the number. In this example, the 9.2 degree number is becoming more positive, indicating that the satellite is moving in a northerly direction. The 95.3 degree number is becoming more negative, indicating that the satellite is moving in a westerly direction. The convention used is that negative easterly longitude corresponds to movement to the west.

The downward trend indicator arrow for height [HGT] means that the satellite altitude is decreasing slightly as this portion of the pass progresses. The range [RNG] is indicating 5267 km from Phoenix and is decreasing as shown by the downward direction of the trend arrow, meaning that the satellite is approaching Phoenix.

The center window at the bottom of the screen provides information about Doppler shift. The parameters shown describe the apparent shift in the frequency of the downlink radio signal from the satellite. The true frequency of the signal emanating from NOAA-10 in this example is 137.500 MHz. However, 137.5030 MHz is showing in the frequency [FRQ] window, indicating an upward shift of 2950 Hz due to the Doppler effect. The [DOP] or Doppler window displays a value of 2950 Hz. The shift in frequency is constantly changing as the velocity relative to the primary observer changes. At the present time in the pass, the rate of change, or drift rate [DRF], is shown to be 30 Hz per minute.

The echo [ECHO] window indicates the approximate elapsed time which will be required for a transmitted signal to make the round trip from the earth, to the satellite, and back to the earth. At the indicated range to the satellite, it would take approximately 35 milliseconds plus the internal processing delay of the satellite.

The window at the lower right of the display provides information about the direction of the satellite relative to the observer. If one desired to point an antenna directly toward the satellite at the time shown on the display, it would be necessary to point the antenna 14.6 degrees below the horizon, at an azimuth of 156.7 degrees as shown by the [ELEV] and [AZIM] windows respectively.

The trend arrows indicate that the elevation is becoming more positive, which indicates that the satellite is on the rise with respect to the observation site. The azimuth, as indicated by the trend arrow, is becoming more negative, which indicates northerly movement.

The [ORBIT] window indicates that NOAA-10 is the 1554th revolution since orbital injection. The trend arrow indicates that the number is increasing in value.

The phase [O] window indicates which incremental portion of the orbit the satellite is currently passing through. NOAA-10 is currently shown to be in phase 249 of a possible 256 increments. Knowing this, one can look at the latitude shown, 9.2º S, and see that the 1554th revolution is very nearly complete, terminating in a few minutes as the satellite crosses the equator.

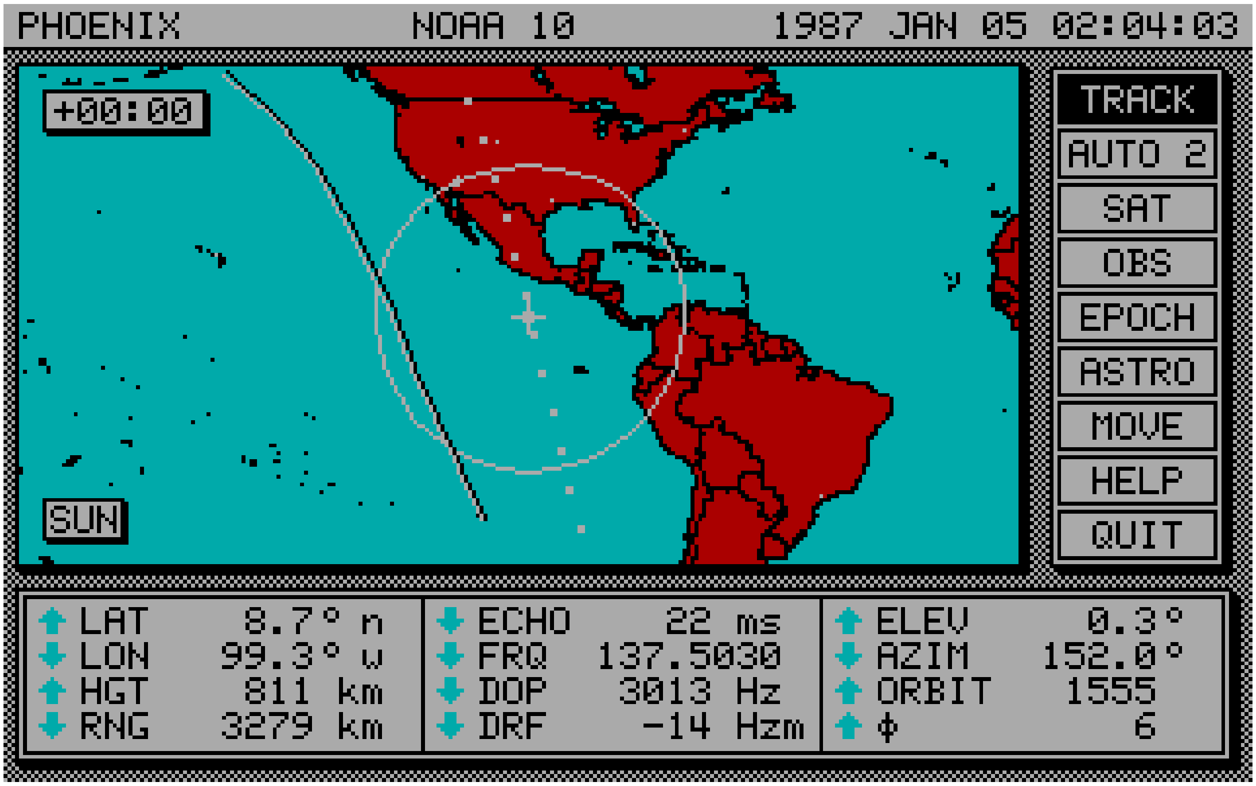



Figure 2-4, Sample S-N Pass, View Two

2.1.1.1.2 View Two

Figure 2-4 shows the position of NOAA-10 at 02:04:03 GMT, about four minutes after view one. Note that the satellite has moved nearly eighteen degrees north in latitude to 8.7º N, and the latitude trend indicator still indicates northerly movement. The range to Phoenix has been reduced to 3279 km, and the elevation of the satellite relative to Phoenix is now 0.3 degrees. Orbit 1555 is 6/256ths complete at this point and the field of view covers all of Central America.

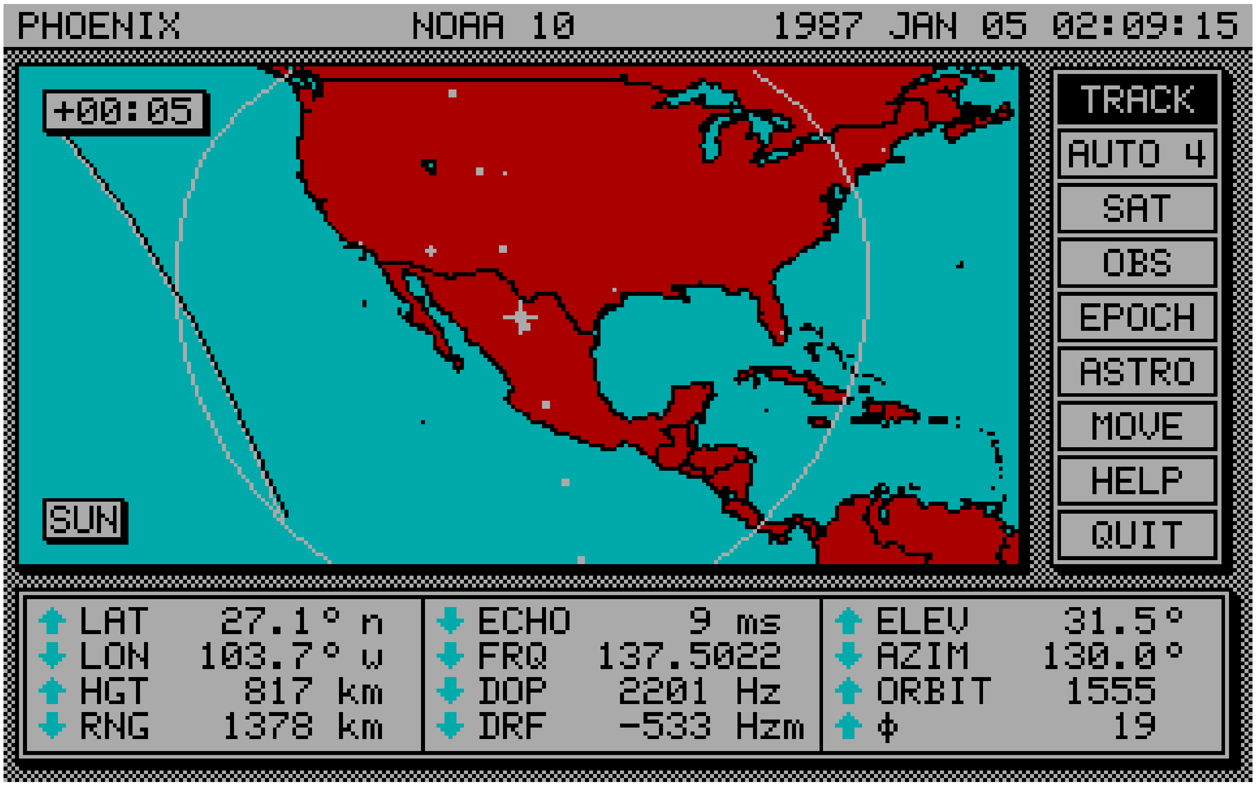



Figure 2-5, Sample S-N Pass, View Three

2.1.1.1.3 View Three

Figure 2-5 was generated approximately five minutes later at 02:09:15 GMT. Virtually all of the United States and most of Central America are in view. Since the previous view, the satellite has moved almost twenty degrees north and is now just slightly below the Texas border. The range to Phoenix has now been reduced to 1378 km, and the satellite is 31.5 degrees above the horizon. The system has automatically changed the zoom factor to [AUTO 4] in order to have maximum resolution of the map while keeping both the selected satellite and observer on screen.

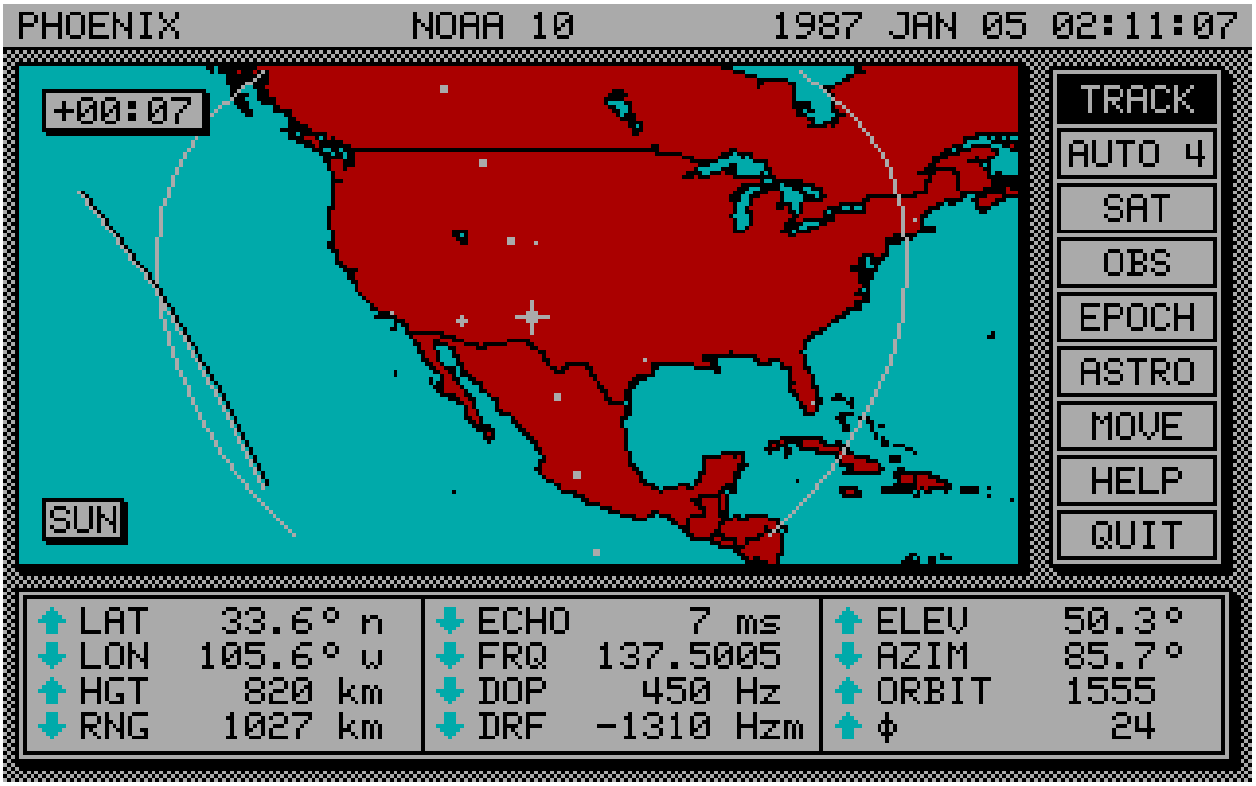



Figure 2-6, Sample S-N Pass, View Four

2.1.1.1.4 View Four

Approximately two minutes later at 02:11:07 GMT, **GT** has calculated that NOAA-10 and Phoenix are sufficiently close together that the highest zoom level can still be used, and automatically maintains zoom level four [AUTO 4] as shown by Figure 2-6. The satellite is now 1027 km from Phoenix, and just slightly north of east, as indicated by the azimuth of 85.7 degrees. The range circle defines the present coverage. At this point all transmitting stations from southern Canada to Central America can be received by the earth station at Phoenix.

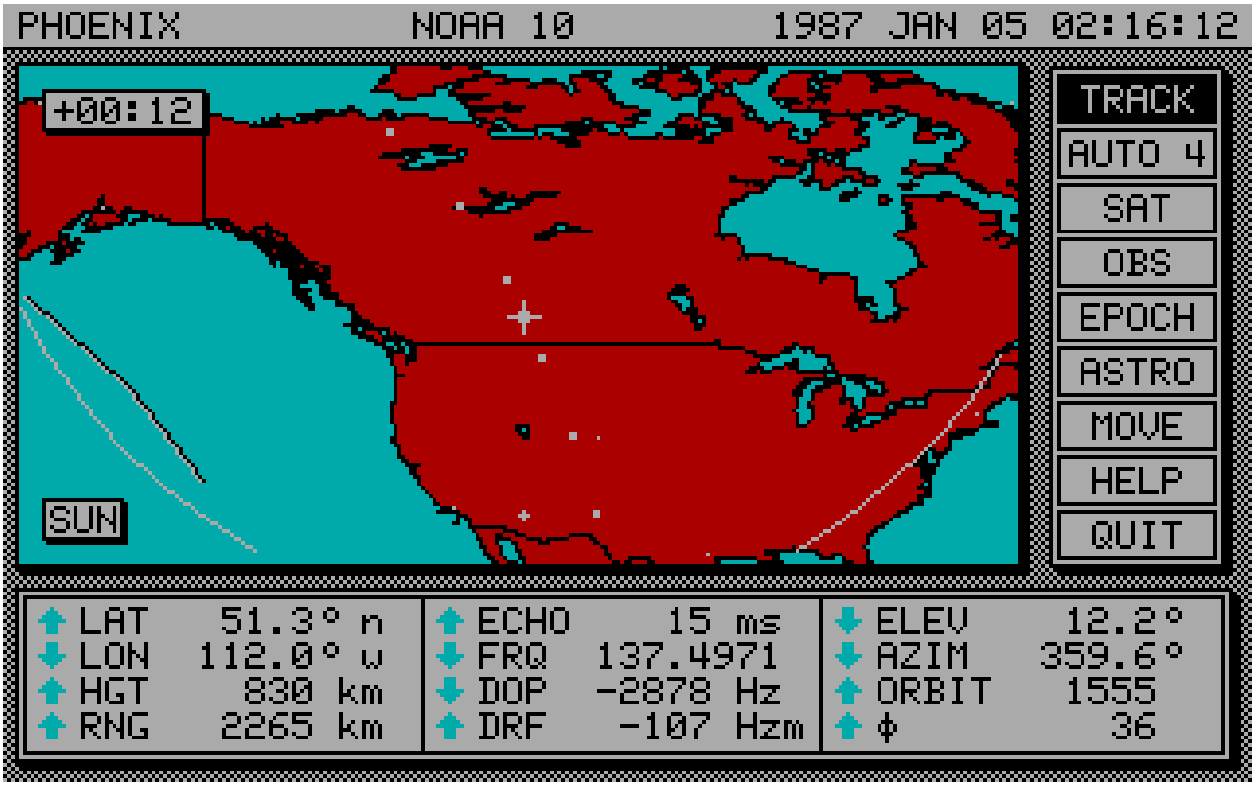



Figure 2-7, Sample S-N Pass, View Five

2.1.1.1.5 View Five

Approximately five minutes later at 02:16:12 GMT, NOAA-10 has moved north to 51.3º N latitude. The map shown in Figure 2-7 is beginning to distort due to the projection. The satellite is just slightly north of the Canadian border, nearly true north from Phoenix at an azimuth of 359.6 degrees. Although the elevation angle of the satellite has decreased to 12.2 degrees, it can see and relay radio signals from a large part of Canada, eastern Alaska, and most of the United States. The Bering and Beaufort Seas are also coming into range of the satellite. Note that the auto-switch window in the upper left corner of the map indicates that approximately 12 minutes have elapsed since the beginning of the pass.

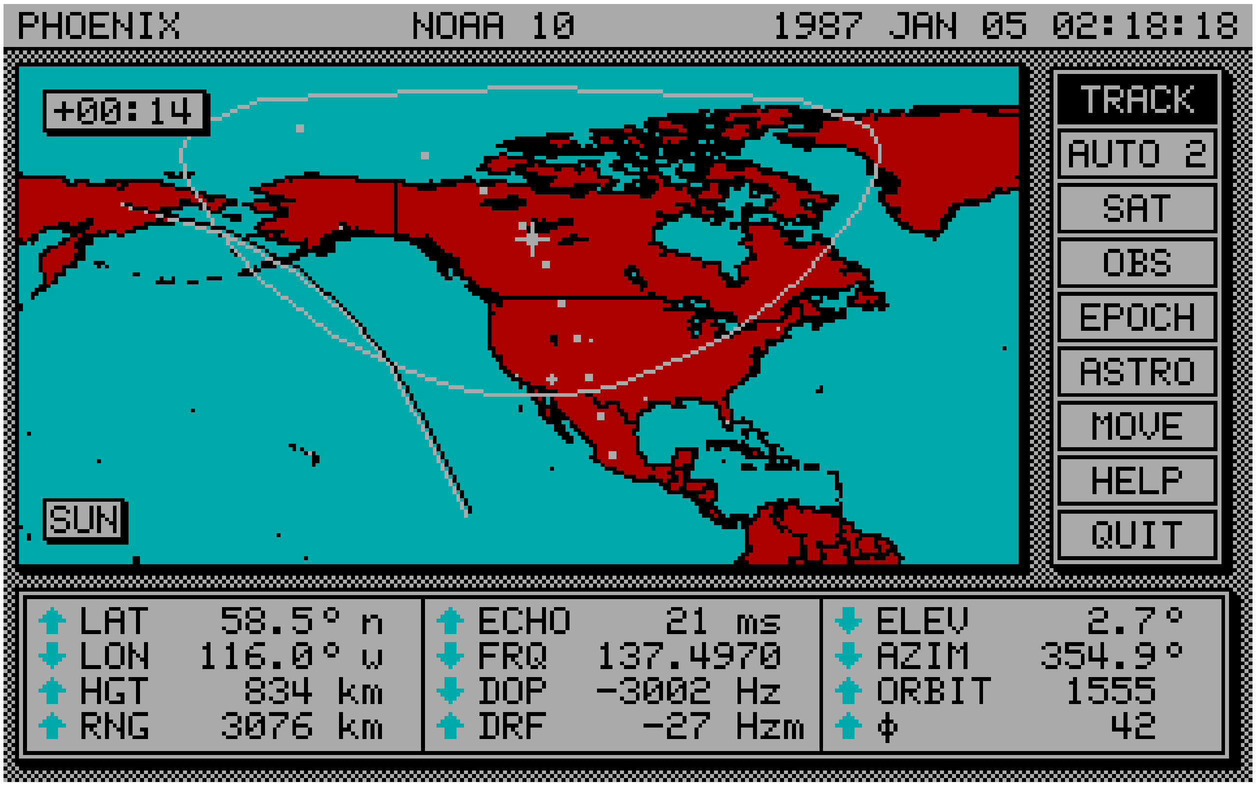



Figure 2-8, Sample S-N Pass, View Six

2.1.1.1.6 View Six

The current map is shown in Figure 2-8. Approximately two minutes after view five, at 02:18:18 GMT, the satellite elevation is only 2.7 degrees and communications may not be reliable at Phoenix due to interfering mountains. At this point, **GT** has computed that zoom level four [AUTO 4] will no longer allow NOAA-10 and Phoenix to be on the screen at the same time, so it has automatically switched to [AUTO 2], zooming back to a 2:1 magnification factor. The Doppler shift of the downlink frequency is now -3002 Hz, indicating that the satellite is moving away from the observer. The two minute marker dots in the ground track preceding the satellite are now beginning to be spaced farther apart due to the map projection distortion. Since the actual time between dots is still two minutes, this distortion will cause the satellite to appear to move more rapidly across the polar regions.

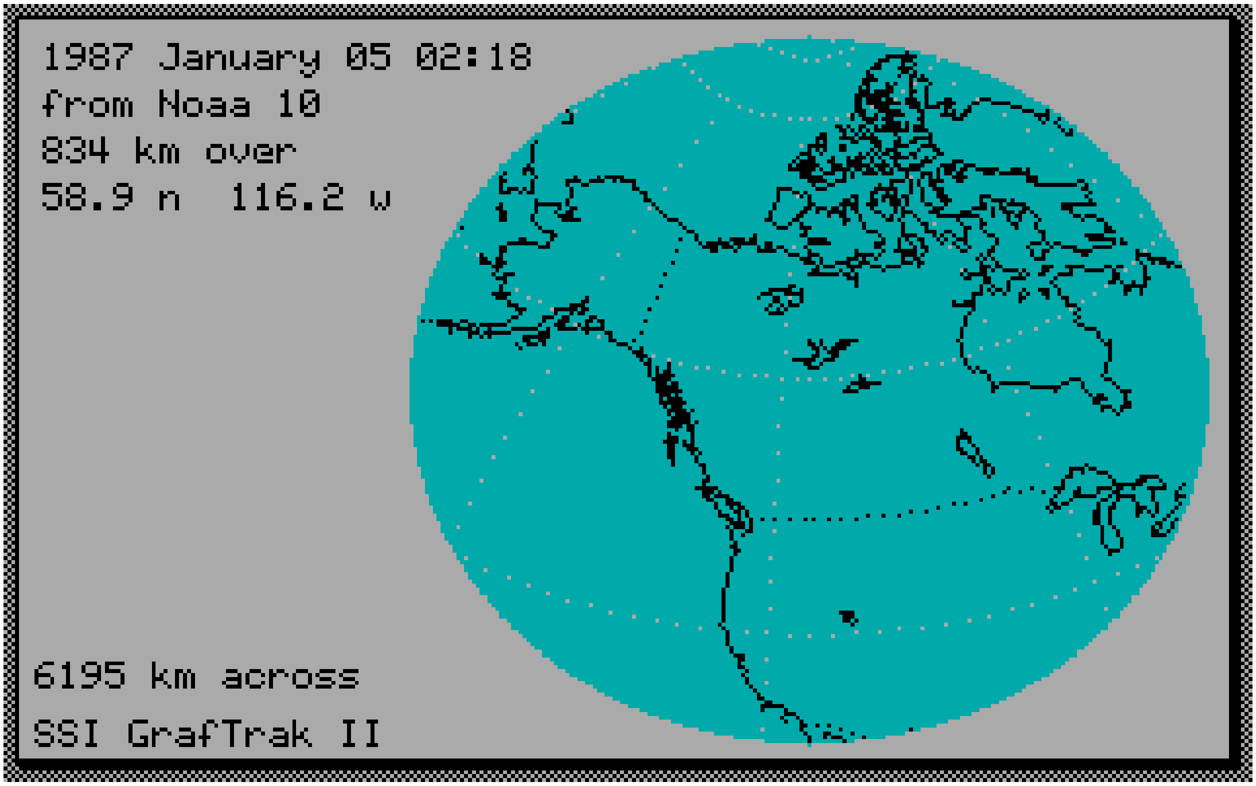



Figure 2-9, Sample S-N Pass, View Seven

2.1.1.1.7 View Seven

Figure 2-9 was generated by pressing [3], the spherical view command key. This view shows the Earth as it would appear looking directly downward from NOAA-10 over 58.9º N latitude by 116.2º W longitude. This view is 6195 km across.

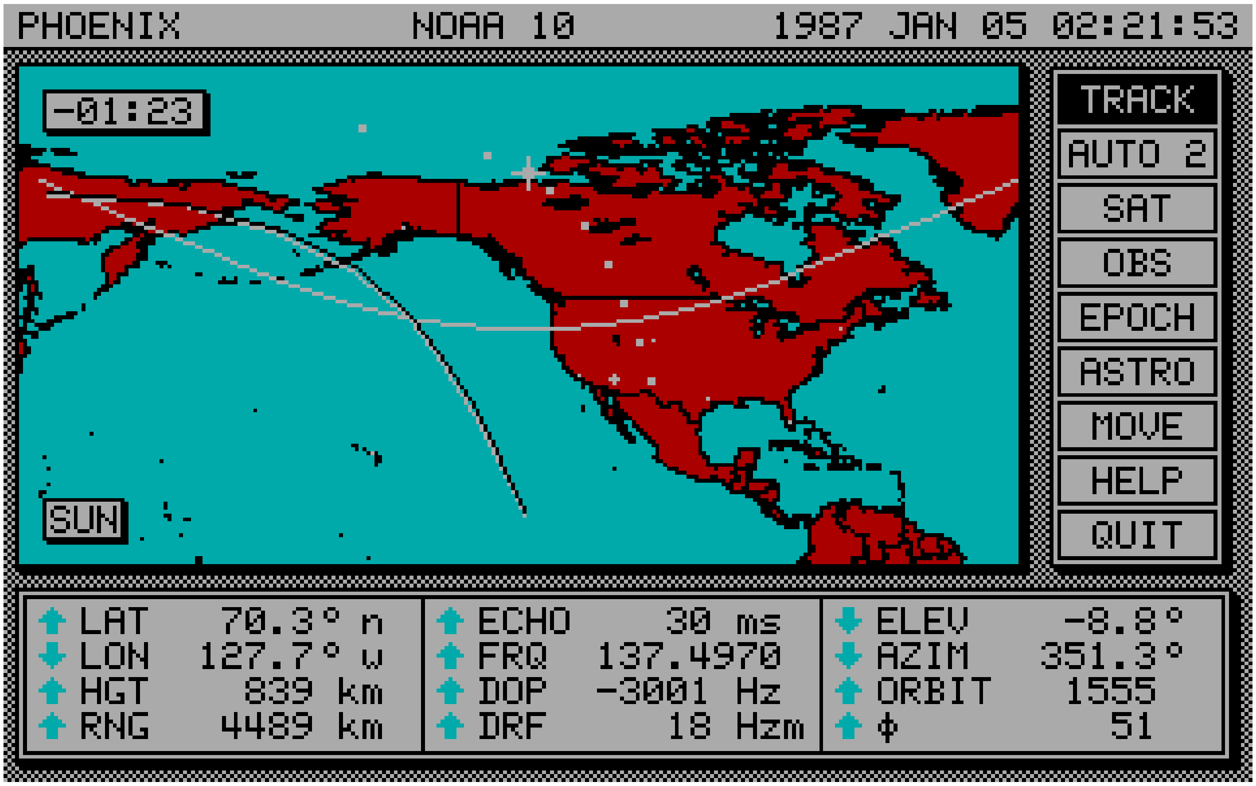



Figure 2-10, Sample S-N Pass, View Eight

2.1.1.1.8 View Eight

Figure 2-10 was generated at 02:21:53 GMT, some four minutes after view seven. Although the satellite has an excellent view of the northern polar regions including the northeastern tip of the Soviet Union, the elevation angle is now -8.8 degrees and signals can no longer be received at Phoenix.

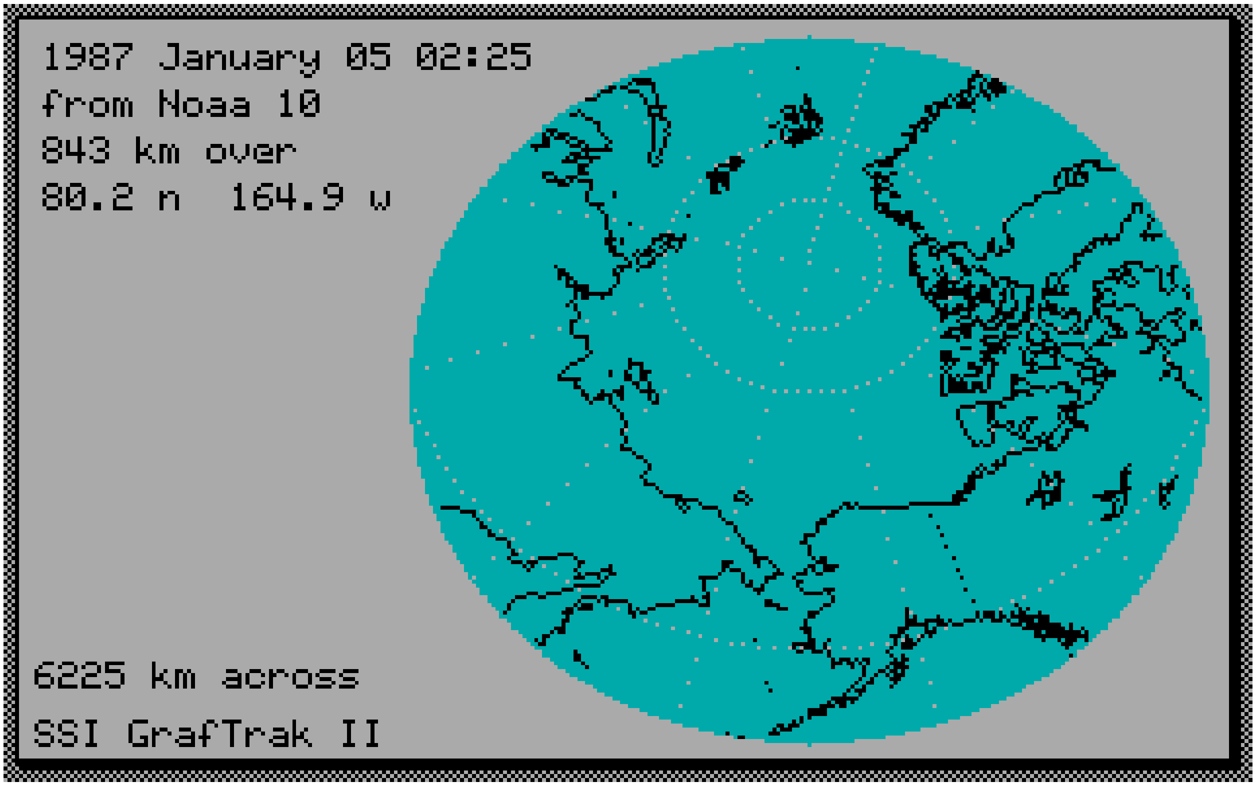



Figure 2-11, Sample S-N Pass, View Nine

### 2.1.1.1.9 View Nine

Figure 2-11, a spherical view at 02:25 GMT, was generated to show coverage of the northern polar regions as the satellite nears the peak point of its ascending node. Notice that the field of view is 6225 km across.

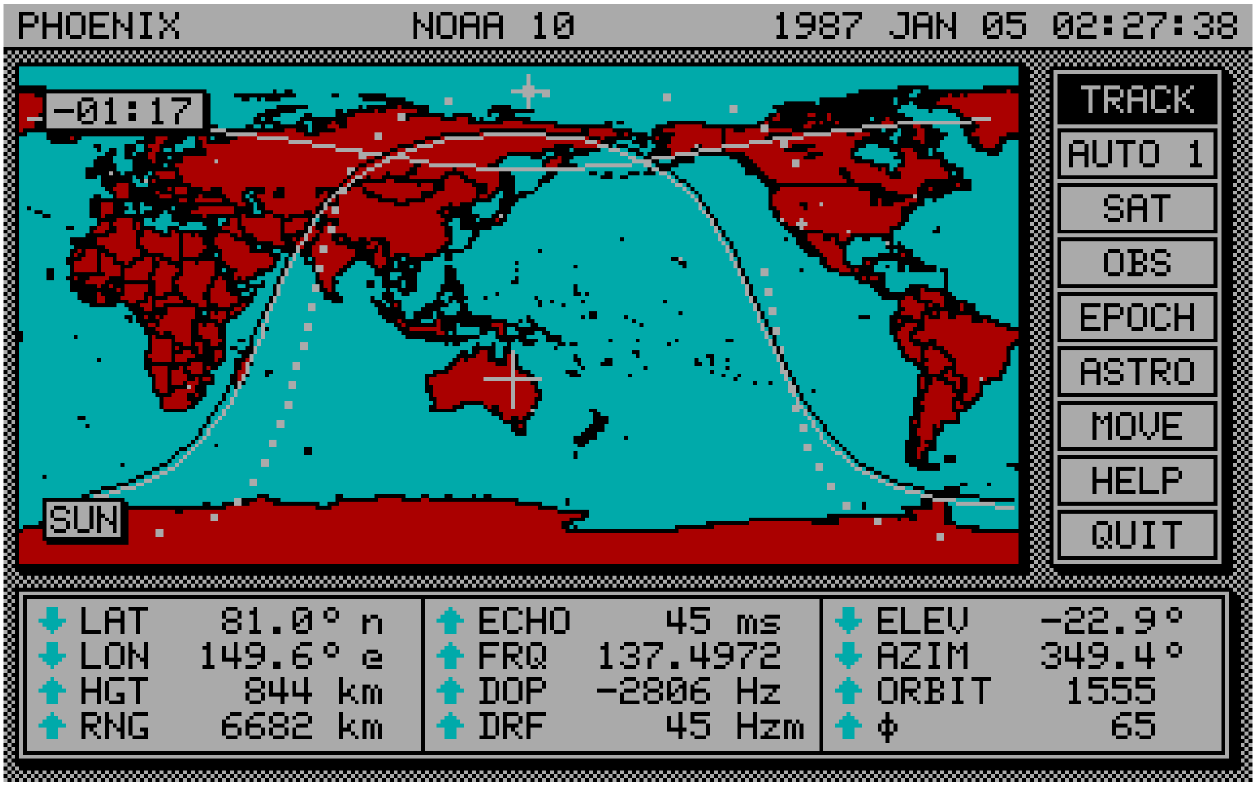



Figure 2-12, Beginning of Descending Node, View Ten

2.1.1.1.10 View Ten

Figure 2-12 is the last view in this series. It shows the start of the descending node of NOAA-10 on this orbit, and shows the leading ground track for the completion of the orbit. The ground track may be seen to exit at the lower left side of the screen, and re-enter at the lower right. The track is continued slightly past the point where the satellite will reach the equator at the end of the present orbit. At this point, **GT** has computed that it must reduce the resolution to the lowest magnification zoom factor in order to keep the satellite and primary observation site on the screen. This is indicated by the [AUTO 1] notation at the upper right of the screen. At this point, the satellite is 6682 km from Phoenix and 22.9 degrees below the horizon.

If you had actually been watching the display during this pass, the screen would have updated smoothly and continuously as the pass progressed. Audible indications would have been heard as the satellite approached Phoenix. First, you would have heard five short beeps which were the "five minute to signal acquisition" warning. Similar warning beeps would have occurred at four, three, two, and one minute points prior to acquisition of signal. At the point where the satellite rose above the observer's horizon, a long warble signal sounded. A similar signal signified the end of the pass. When the currently displayed satellite dropped below the horizon, the auto-switch portion of **GT** checked all satellites in the database file to determine which one will appear next on the horizon, and began to track that satellite. In the case of the sample pass under discussion, **GT** had determined that NOAA-10 is the next satellite which will be seen from Phoenix. NOAA-10 will rise in 1 hour and 17 minutes, as shown by the [-01:17] indication in the auto-switch window at the upper left corner of the map.

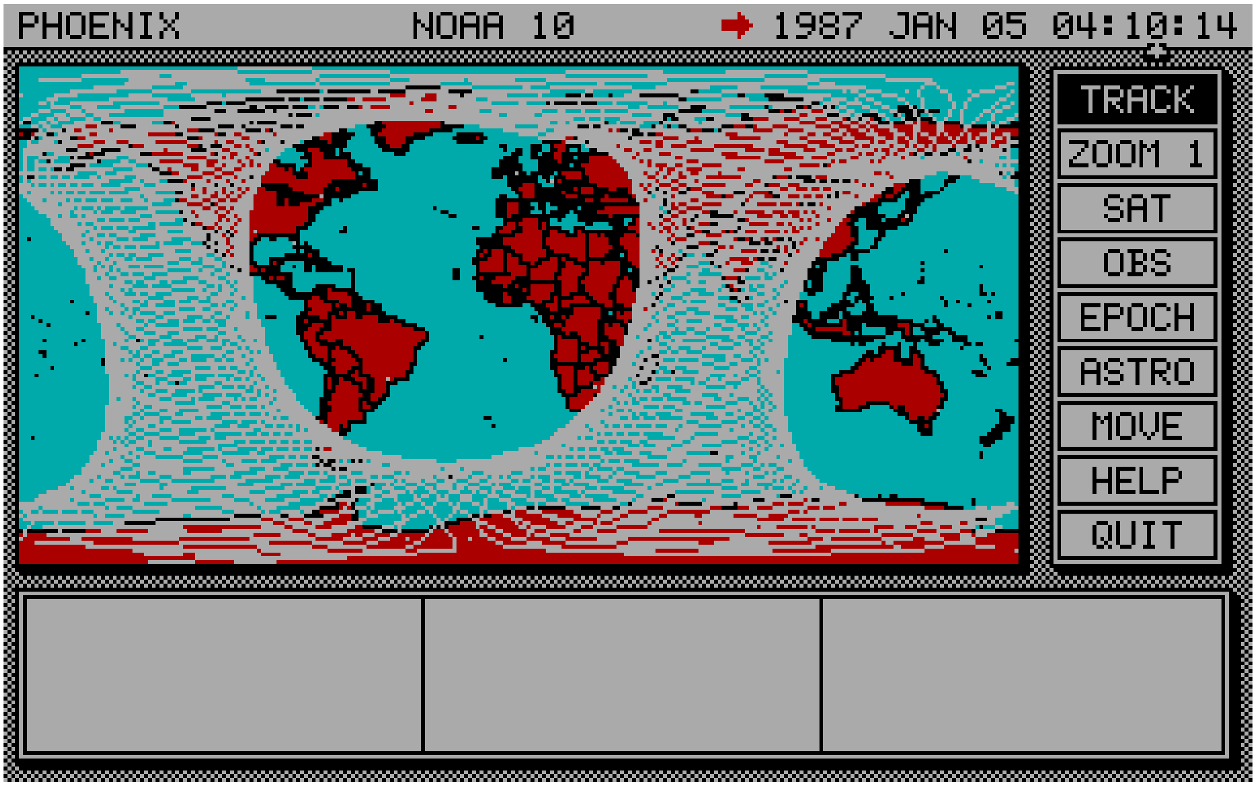



Figure 2-13, Predicted Ground Track Coverage

2.1.1.1.11 Predicted Ground Track Coverage

Figure 2-13 is provided to demonstrate one of the many graphic forecasting capabilities of the system. In this case, it shows the predicted swath of visibility along the ground track of a typical orbit of NOAA-10. The method of display uses moving rings of visibility spaced at even intervals throughout the pass, as determined by placement of the time cursor. The areas of visibility covered during the pass are clearly evident.

### 2.1.2 Display and Signals

This subsection describes the display and audible signaling features of **GT**.

#### 2.1.2.1 Top Line

The top line of the display will show the name of the selected observer on the left, the object being tracked in the middle, and the date and time on the right.

#### 2.1.2.2 Sub-Satellite Point (SSP)

The map display window shows the sub-satellite point directly beneath the satellite as a medium size cross (plus sign). This point will always be in the horizontal center of the display.

#### 2.1.2.3 Visibility Circle

Around the sub-satellite point will be a circle which indicates the horizon or coverage circle of the satellite being tracked. The circle of visibility under the satellite will be distorted as the satellite approaches the poles due to the map projection.

#### 2.1.2.4 Observer Locations

A small cross (plus sign) will appear at the location of the selected observer. Small white dots will indicate the locations of the other fifteen observers.

#### 2.1.2.5 Sun Line

The Sun line indicates the transition from day to night. The white side of the line indicates the illuminated side of the Earth, whereas the black side of the line indicates the dark portion of the Earth. The large cross (plus sign) indicates the point on the Earth where the Sun is directly overhead.

#### 2.1.2.6 Ground Track

The ground track of the satellite currently being tracked is shown by a series of white dots which precede the satellite by ten minutes, and trail the satellite by eighty minutes. These times were chosen to show at a glance where the satellite is going, and where it has recently been. Each dot on this track represents a two minute step in time. The number of minutes chosen to precede and succeed the satellite, and the length of time between dots, were chosen and inserted in the command line at program start-up. You may change these lead and lag times, and the dot spacing, by modifying your .BAT file containing the **GT** command line. Information about configuring the command line follows later in this section.

2.1.2.7 Numeric Display Window

The rectangular window at the bottom of the screen displays various numerical values for the selected satellite and values for the selected observer relative to the selected satellite. Each field contains a trend indicator (up/down arrow), a descriptive token (field name), and a value (number). These fields are updated as often as every second. The trend indicator displays an arrow which points **up** if the value is **increasing** or **down** if the value is **decreasing**.

2.1.2.8 Auto-Zoom Mode Window

When in the auto-zoom mode, **GT** will automatically select the highest zoom factor that will show the observer and the sub-satellite point at the same time on the screen. The word AUTO will appear in the [ZOOM] window at the top right side of the display screen. Pressing the [Ctrl] and [Z] keys together will cause **GT** to switch in and out of the auto-zoom mode. Placing the token **AZM** on the command line will cause **GT** to start in the auto-zoom mode.

2.1.2.9 Auto-Groundtrack Mode

When in the auto-groundtrack mode, **GT** will display the ground track for the currently selected satellite. Up to 400 ground track points can be displayed on the map at a given time. These points are controlled by four parameters which may be entered either on the command line or at any time from the keyboard. The start and end times, specified in minutes, control the length of the ground track on the map. The delta time specifies the number of minutes between each ground track point. The auto-update time specifies how often the ground track is to be recalculated. For example: start time = -10, end time = 80, delta time = 2, update time = 2, will cause a ground track to be displayed from 10 minutes prior to the current time, through 80 minutes after the current time. Each point will be 2 minutes from the previous point and the ground track will be recalculated every 2 minutes. This example will produce 45 points (90 minutes at 2 minute steps). If the specified times produce more than 400 points, **GT** will display an appropriate error message and abort. Too many points will result in excessive screen clutter. If the update time is zero, **GT** will not update the ground track. In this case, a new ground track may be calculated by pressing the [8] key, or the ground track may be disabled and removed by pressing the [9] key. The [0] key may be pressed to cause **GT** to request new values for the ground track. In any case, changes made from the keyboard will remain in effect only until the program is restarted.

2.1.2.10 Horizon

**GT** normally uses a value of zero degrees for the observer's horizon. The horizon value may be changed at the command line level or by pressing the [B] key during program operation. Since this horizon value is used to calculate rise and set times, it is recommended that values between -10 degrees and +30 degrees be entered. Since the radio horizon normally starts at -0.6 degrees, this slightly negative value is used to compensate for refraction of the radio signal close to the horizon. The horizon value chosen will be used whenever **GT** makes reference to the observer's horizon.

2.1.2.11 Auto-Switch Mode

In the auto-switch mode, **GT** will automatically switch between satellites in your database. When the current satellite sets on the horizon, **GT** will switch to the next satellite that will be visible at the selected observer. If any satellites happen to be above the horizon at that time, **GT** will switch to the satellite with the highest elevation angle. Otherwise, GT will calculate the rise time of **all** of the satellites in your data base and switch to the satellite with the earliest rise time.

2.1.2.12 Audible Signals made by **GT**

There are several basic sounds made by **GT**. They signal specific events or warn of specific conditions.

A single beep indicates that **GT** is expecting you to key in a parameter. Two beeps are sounded when **GT** finishes a long map plot or calculation. Five short beeps are sounded when you press a key that **GT** does not understand.

When in the auto-switch mode, other sounds will announce satellite rises and sets. Alarms will sound every minute starting at five minutes before the expected rise of the selected satellite. The five minute alarm will be five long beeps, the four minute alarm will be four beeps, and so forth until the single beep indicating the one minute to rise warning. The rise and set of the selected satellite will be announced by a long warble sound.

A command line token, SILENT, is available to prevent **GT** from making any sounds. However, most users find the signaling and warning indications to be most helpful.

### 2.1.3 Keyboard Commands

Most **GT** functions are controlled by single key entries. The nine fundamental commands are listed on the right side of the screen. Only the first character of a command is used to initiate the command. All of the alphabetic commands may be entered in either upper or lower case. Some of the commands use cursor control keys on the right side of the keyboard. **The keyboard must NOT be in Num Lock to properly execute these commands**.

2.1.3.1 [A] = Astro

The [A] key will switch **GT** back and forth between the satellite mode and the astronomical mode. In the astronomical mode, the [S] key will allow you to switch between the Moon, Sun, and a single star. The coordinates for the star may be entered from the keyboard or from the DOS command line. The object's right ascension and declination may be changed at any time. Of course, the coordinates that you enter need not be for a star. For example, you can enter the coordinates for a comet for the time that you wish to observe it. **GT** will display the altitude (elevation) and azimuth for the object for the current observer.

2.1.3.2 [B] = Set observer's horizon

Pressing the [B] key will cause **GT** to request a new value for the observer's horizon. A value of **-**0.6 degree is suggested. This value corresponds to the generally accepted radio horizon which occurs due to refraction of the radio waves as they pass through the atmosphere.

2.1.3.3 [C] = Change Color Palette

You can change the colors of your **GT** display to suit your taste. Pressing the [C] key will cause a menu window to appear. If you have a **C**olor **G**raphics **A**dapter (**CGA**), the { and } keys will change the background color through the 16 possible selections. The [ and ] keys will change the palette through the 6 possible selections. The current values for the palette (**PAL**) and background (**BACK**) will be displayed at the bottom of the menu.

If you have an **E**nhanced **G**raphics **A**dapter (**EGA**) and you specified the **EGA** token on the command line, the { and } keys will change the color of the water and the [ and ] keys will change the color of the land. The current values for the water (**CW**) and land (**CL**) will be displayed at the bottom of the menu.

When you have made your selection from the available colors, make a note of the numbers and refer to the **PAL**, **BACK**, **EGA**, **CL**, and **CW** tokens description in section II.1.8. Press [**T**] to return to the track mode.

2.1.3.4 [D] = Redisplay last spherical view

The [D] key will cause the most recently generated spherical view map to be displayed. After the map is drawn, the graphics image is saved so that you may recall it instantly without regenerating it.

2.1.3.5 [E] = Epoch

The [E] key will cause instructions for setting specific epochs to be displayed. The left and right cursor keys will cause a time cursor to move right or left underneath the date/time on the top line of the display. When the cursor is positioned beneath a digit, the [+] and [**-**] keys will bump that digit up or down by the appropriate amount. If the cursor is under the month or year fields, the time will be modified as follows:

month +/**-** 30.4375 days
year +/**-** 365.25 days

Time in **GT** is maintained in true Julian dates. The time cursor, in conjunction with the [+] and [**-**] keys, will add or subtract the appropriate amount expressed in days and/or fractions of days. Consequently, if you want to set a specific epoch, you should set the year first, followed by the month and so on, setting the seconds last.

When you enter the Epoch Set mode, the clock will be stopped, and the day of the week will be displayed in the upper left corner of the screen. In addition, the Greenwich Mean Sidereal Time, Local Sidereal Time, and the Julian Date will be displayed at the bottom of the screen. Whenever the date/time is set to something other than real-time, a **red arrow** will appear to the left of the date/time field to remind you that the **displayed time is not real-time**.

2.1.3.6 [F] = Fast mode ON/OFF

The FAST mode allows the user to view screen activity at faster than real-time. The speed of movement on the screen is controlled by placing the time cursor over the unit of time by which you wish to step. The [F] key will toggle the FAST mode ON and OFF. When the FAST mode is ON, the word [FAST] will appear on the top display line as a reminder. During each calculation cycle, the time will be incremented by the selected interval.

2.1.3.7 [G] = GO/STOP clock

The [G] key will cause **GT** to STOP the clock if it is running, or START the clock if it is stopped. While the clock is stopped, the top display line will contain the word [STOP]. If **GT** is in the FAST mode, the [STOP] will not be seen. Refer to the following paragraph regarding the FAST mode.

2.1.3.8 [H] = Help

The [H] key will cause **GT** to display a page of help information. Each press of the [H] key will cause a different help screen to be displayed. Pressing any command key will cause **GT** to exit the help mode.

2.1.3.9 [L] = Enter Map Center Longitude

Pressing the [L] key will cause **GT** to request a value for the longitude to be used as the fixed center of the flat map displays. This option may be toggled with the use of an enable flag as part of the operator dialogue associated with this key.

2.1.3.10 [M] = Move

The [M] key will cause **GT** to enter the Move mode. The move mode indicator box at the right side of the display screen will start to flash and a cross will appear at the map center. While in the move mode, the eight cursor control keys will move the map around under the cross. In [ZOOM 1] you will only be able to move east and west. In [ZOOM 2] you will be limited to between 45N and 45S latitudes. In [ZOOM 4], you will be limited to between 67.5N and 67.5S latitudes. As you move the cross, the current LAT and LON of the cross will be displayed at the bottom of the screen. A spherical map, centered on the cross location, can be displayed at any time by pressing the [3] key. To exit the move mode, enter any command key.

2.1.3.11 [N] = Next satellite

Pressing the [N] key will cause **GT** to step to the next valid satellite in your database. Unused entries in a file will be skipped.

2.1.3.12 [O] = Observer

The [O] key will cause a menu of observers to be displayed. The name of each observer is shown along with its two digit numerical code (01, 02, 03, ..., 16). If a satellite is currently being tracked, each observer number may be surrounded by a red or blue box. If a red box appears around the observer number, the satellite is above the observer's horizon. If the box is blue, the satellite is between the horizon and 5 degrees below the horizon. To select a new observer, enter its two digit number and **GT** will return to the track mode with the newly selected observer. To stay with the current observer, press [T] to return to the track mode.

The "quick selection" capability described in section II.1.3.15 may also be used in the observer menu. The character [O] will be interpreted as a leading zero.

**NOTE**

If you enter a number that is not in the range of one through sixteen, or enter a number for an observer which has not been initialized, **GT** will prompt until you enter a number which is in range and has an observer which has been initialized.

2.1.3.13 [P] = Previous satellite

The [P] key will cause **GT** to step to the previous valid satellite in your database file. Unused entries will be skipped.

2.1.3.14 [Q] = Quit

The [Q] key will cause **GT** to terminate and return to DOS.

2.1.3.15 [S] = Sat

The [S] key will cause a menu of satellites to be displayed. The name of each satellite is shown along with its two digit number (01, 02, 03, ..., 16). If a red box appears around the number, the satellite is currently above the observer's horizon. If the box is blue, the satellite is at a point between the horizon and 5 degrees below the horizon. To select a satellite, enter the two digit number, and **GT** will return to the track mode with the newly selected satellite. If you want to stay with the current satellite, press [**T**] to return to the track mode.

To speed up satellite selection, the following shortcuts may be used:

1. If you enter the satellite code digits before the selection menu is displayed, **GT** will not display the menu and immediately switch to the new satellite.

2. The letter [S] will be interpreted as a zero (0) so that **quick selection** of satellites 1 to 9 may be made by quickly entering [S][S] followed by a single digit.

**NOTE**

If you enter a number that is not in the range of one through sixteen, or enter a number for a satellite which has not been initialized, **GT** will prompt until you enter a number which is in range and has a satellite which has been initialized.

If you are currently tracking the Moon, the Sun, or a star, the [S] key will step you to the next astronomical body. The middle entry of the top line will tell you which object is selected (see Astro mode).

2.1.3.16 [T] = Track

The track mode is the normal mode for **GT**. This mode is entered at start-up and most commands will return to the track mode when they are completed. Pressing the [T] key will normally cause an exit from other modes and a return to the track mode.

2.1.3.17 [W] = Change the database file

Pressing the [W] key will cause **GT** to display the name of the current database file and allow you to change it. To switch to another file, enter its name without the **.SAT** extension and the new file will be loaded.

2.1.3.18 [Z] = Zoom

The [Z] key will cause the map zoom factor to step through each of the zoom maps that you have loaded. The current zoom factor will be displayed in the ZOOM box on the right side of the screen. **GT** cycles serially through the available zoom factors. If you have all three zoom maps loaded and wish to change from [Zoom 4] to [Zoom 2], press [Z] twice. To change from [Zoom 1] to [Zoom 4], press [Z] twice. You will notice a slight delay after each change while the screen graphics are updated. After you press a command, **GT** checks to see if you have pressed another key before returning to the track mode so that the screen update will be postponed until all command keys have been processed.

If you have invoked the Auto-Zoom [AZM] token in the command line, **GT** will automatically select the proper zoom level necessary to keep both the primary observer and the satellite on the screen simultaneously. If you wish to change the zoom factor manually, it will be necessary to toggle Auto-Zoom **OFF** by pressing [**Ctrl**][**Z**].

2.1.3.19 [Alt][F] = Enter Lunar (Moonbounce) Frequency

This command is used to change the carrier frequency used in moonbounce Doppler calculations. The frequency may be entered in units of megahertz.

2.1.3.20 [Alt][G] = Enter Graze Parameters

This command is used to alter the characteristics of the range circle of a selected satellite by specifying the minimum elevation angle as seen by the observer on the ground. For example, if a GRAZE angle of five degrees is specified, the displayed range circle will represent the five degree elevation angle contour line.

2.1.3.21 [Alt][H] = Enter Off-Nadir Parameters

This command is used to alter the characteristics of the range circle of a selected satellite by specifying the half-cone angle between the sub-satellite point and the edge of the range circle.

2.1.3.22 [Alt][N] = Next observer

Pressing the [Alt] and [N] keys together will cause **GT** to step to the next valid observer in your database file. Unused entries will be skipped.

2.1.3.23 [Alt][P] = Previous observer

Pressing the [Alt] and [P] keys together will cause **GT** to step to the previous valid observer in your database file. Unused entries will be skipped.

2.1.3.24 [Alt][S] = Select Additional Satellite

This command is used to enable the display of the range circle of satellites other than the prime satellite. Enter [Alt][S] and a list of the satellites will be displayed on the screen. To enable additional range circles, enter the two digit number of each satellite to be displayed. A black bordered box will be drawn around the satellites selected for display. To disable a previously selected range circle, enter the two digit number for that satellite and observe that the black bordered box is removed from that satellite. Enter a [T] to return to the track mode.

2.1.3.25 [Alt][W] = Enter Swath Parameters

This command is primarily of interest to Weather and Earth Resources satellite users. It is used to enable the display of a line, normal to the ground track of the selected satellite, representing the beam width of the scanner devices carried in the satellite.

2.1.3.26 [Ctrl][D] = Execute DOS commands

Pressing [Ctrl] and [D] together will cause **GT** to load another copy of the DOS command line processor. You may then execute any DOS command that will run in the amount of memory that is not used by **GT**. If you press [**ENTER**] on a blank command line, **GT** will regain control. If you do not have enough memory to perform the requested DOS command, **GT** will display an error message. This is a very powerful capability, as you can issue DOS commands then return to the resident copy of **GT**, saving the time that would otherwise be required to reload **GT**.

2.1.3.27 [Ctrl][E] = Edit the database file

If your PC is equipped with at least 512 kbytes of memory, you can press the [**Ctrl**] key and the [**E**] key together to cause **GT** to load and transfer to the **S**atellite **ED**itor (**SED**). This is much faster than quitting **GT**, loading **SED**, and then reloading **GT**. After you press [**Ctrl**][**E**], **GT** will display the name of the current database file and wait for a response. If you press [**ENTER**] without entering a file name, **SED** will operate on the current database file. When you return to **GT**, the edited file will be loaded as the current database file. If you want to switch to another file, enter its name without the **.SAT** extension. When you press [**ENTER**], **SED** will operate on the new database file. When you return to **GT**, the new file will be loaded as the current database file. If you do not have enough memory to load **SED**, **GT** will display an error message. Press return to go back to **GT**.

2.1.3.28 [Ctrl][F] = Issue form feed to printer

Pressing the [Ctrl] key and the [F] key together will issue a form feed command to the printer.

2.1.3.29 [Ctrl][Z] = Auto-Zoom ON/OFF

Pressing the [Ctrl] and [Z] keys together will cause **GT** to toggle the auto-zoom mode ON and OFF. The status of this mode is indicated on the right side of the screen. If the auto-zoom mode is OFF, the word ZOOM will be displayed in the ZOOM indicator box to the left of the current zoom factor (i.e., [ZOOM 4]). If the auto-zoom mode is ON, the word AUTO will be displayed in the ZOOM indicator box.

2.1.3.30 [0] = Set ground track parameters

Pressing the [0] key will cause **GT** to request new values for the ground track parameters.

2.1.3.31 [1] = Plot ground track

The [1] key will cause **GT** to enter the plot ground track mode. To plot a ground track, select the desired satellite and move the time cursor to the desired time interval between plot points. [ZOOM 1] works best, although you may plot at any zoom factor. When the plotting starts, the map will be moved so that the center is at latitude 0 and longitude 0. Time will be stepped at the selected interval. A time step of one minute will work nicely for low orbit satellites such as the Advanced TIROS series used by NOAA, and for some amateur satellites. You may wish to change the ground track step time when tracking other satellites. Pressing any command key will terminate the ground track plot.

2.1.3.32 [2] = Plot ground track with range circle

The [2] key will cause the ground track to be plotted in the same manner as the [1] key described previously, except that the range or coverage circle will also be plotted. This is a very handy function for investigating the width of the coverage swath. It is also valuable to visualize pass overlap.

2.1.3.33 [3] = Plot spherical projection view from current object

The [3] key will cause a spherical projection map to be plotted showing the view from the current object. The track mode screen will be replaced by the new display. A blue disk will appear indicating the horizon of the object. The prime meridian will be drawn first, then the parallel at 80N will be drawn. Depending on the view from the object, you may not see the grid lines being drawn. Parallels will then be drawn every 20 degrees starting with 80S and ending with 80N. Meridians will be drawn next, placed every 30 degrees in a westerly direction. The prime meridian, equator, and far north and south parallels will be drawn with dots at one degree spacing. All other meridians and parallels have two degree dot spacing. After the grids are drawn, coastlines will be drawn, followed by the political boundaries. The drawing may be terminated at any time by pressing a command key. When the map is completed, **GT** will stop, sound a beep, and wait for any command key to be pressed.

The left side of the map will contain the date/time of the plot, the object name, height, and location. The lower left corner will show the distance across the map. This distance is the map **surface distance** (the length of a string stretched from one edge to the other). The map plotting time is typically less than one minute.

2.1.3.34 [4] = Plot a specific view

The [4] key will allow you to plot a spherical projection map from any point above the surface of the Earth. After pressing the [4] key, **GT** will prompt you to enter the latitude, longitude, and height of the vantage point and the amount that you want the map tilted. At each prompt, a value will be displayed inside curly brackets { }. If you press [ENTER], that value will be used. Otherwise, you may enter the desired number and press [ENTER].

The values for latitude, longitude, and height are updated when you are in the track mode, whereas, only the values for latitude and longitude are updated when you are in the Move mode. The tilt parameter will rotate the map by the angle entered so that you can display the Earth as it would appear from the plane of the ecliptic. If you press [4] after the map has been drawn, the default parameters will be the same as the map just completed. This allows you to re-adjust the parameters until you get the map exactly the way you want it.

2.1.3.35 [5] = Enter star coordinates

The [5] key causes **GT** to request new coordinates for the star track mode. When **GT** is started you may place stellar coordinates in your command line. If you do not, **GT** will set the coordinates to the location of the star Antares, in Scorpio at 1985.5. If you use the star mode to track planets, you should update the desired coordinates as often as necessary to maintain accuracy. Sky and Telescope magazine publishes these coordinates monthly.

2.1.3.36 [6] = Make picture file

The [6] key will allow you to write a standard format picture file to disk. You will be asked to enter a file name, and the screen image will be written to disk. **GT** will then return to the track mode.

2.1.3.37 [7] = Display Sun line

The Sun line mode provides an aid to satellite eclipse planning. This mode also aids in forecasting passes which will be visible to the naked eye. The [7] key toggles this mode **ON** and **OFF**. When the Sun line mode is ON, **GT** will plot the night/day terminator in addition to the satellite coverage circle. The black curve is the actual terminator and the white curve indicates the day side. A large cross indicates the sub-solar point. When the Sun line mode is ON, the word SUN will appear in the lower left corner of the map. The map will remain centered on the selected satellite. If the entire satellite coverage circle is contained in the night side of the Sun line, the satellite is in eclipse.

Solar eclipses may be seen by using the Sun line mode in conjunction with the Lunar display. An annular eclipse of the Sun occurred at about 16h to 17h UT, 30 May 1984, and was visible from the southeastern United States.

2.1.3.38 [8] = Calculate new ground track

Pressing the [8] key will cause **GT** to calculate and display a new ground track for the current satellite according to the current ground track parameters.

2.1.3.39 [9] = Disable ground track

Pressing the [9] key will disable the satellite ground track display. The auto-update time will be set to zero.

2.1.3.40 [Esc] = Return to Real-Time

Pressing the [Esc] key will cause **GT** to return to the real-time tracking mode. If the FAST mode was active, it will be toggled off.

**If there is a RIGHT ARROW and/or the word FAST showing to the left of the time, you are not in the real-time mode.**

2.1.3.41 [*] = Print Screen

The [*] key will cause **GT** to print the screen to the graphics printer. If your printer is not fully IBM compatible, you must specify the printer in the **GT** command line as discussed in section II.1.8 of this manual.

2.1.3.42 [+] key = Increment time

The [+] key will cause the time to increment by one unit of the type indicated by the time cursor.

2.1.3.43 [-] key = Decrement time

The [-] key will cause the time to decrement by one unit of the type indicated by the time cursor.

2.1.3.44 [/] = Set Auto-Switch mode for selected satellite

Pressing the [/] key will cause **GT** to enter the auto-switch mode for a selected satellite. If the satellite is above the horizon, [AUTOSW] will appear in the upper left corner of the map. If the satellite is not above the horizon, **GT** will compute the rise time and will display the time until rise in hours and minutes in the [AUTOSW] box in the upper left corner of the map. The time until rise is similar to NASA Mission Elapsed Time: negative prior to rise and positive after rise. The auto-switch mode will be disabled when any other key is pressed. It can be turned on again, after any keyboard action, by pressing the [/] key.

2.1.3.45 [;] = Show satellite status

Pressing the [;] key will cause **GT** to display the status of all of the satellites. If the satellite is above the horizon, the current elevation angle will be displayed. If the satellite is below the horizon, **GT** will calculate and display the time of the next rise of the satellite. If a rise will not occur within 24 hours, the search for the next rise will terminate and **RISE?** will be displayed instead of a time.

2.1.3.46 [=] = Set Auto-Switch mode for all satellites

Pressing the [=] key will cause **GT** to enter the auto-switch mode. If any satellites are above the horizon, the display will be switched to the satellite with the highest elevation angle and [AUTOSW] will appear in the upper left corner of the map. If no satellites are above the horizon, **GT** will compute the rise times of all satellites and switch to the satellite that will be the first to rise. The time until rise in hours and minutes will appear in the [AUTOSW] box in the upper left corner of the map. The time until rise is similar to NASA Mission Elapsed Time: negative prior to rise and positive after rise. The auto-switch mode will be disabled when any other key is pressed. It can be turned on again after any keyboard action by pressing the [=] key.

2.1.3.47 [PgUp] key = Move ahead one orbit

The [PgUp] key will cause the time to be moved ahead by an amount equal to the period of the selected satellite.

2.1.3.48 [PgDn] key = Move back one orbit

The [PgDn] key will cause the time to be moved back by an amount equal to the period of the selected satellite.

2.1.3.49 [up] and [down] cursor keys = Next/Previous rise/set

The [up] or [down] cursor keys will cause **GT** to search for the next or previous rise or set for the selected satellite. The elevation of the satellite at each iteration of the search will be displayed at the bottom of the screen. Pressing any command key will terminate the search. If you search for an event that will never occur, **GT** will continue to search forever. The initial search increment is one hour for astronomical objects, and 1/20 of the period for satellites.

2.1.3.50 [left] and [right] cursor keys = Time Cursor Left/Right

The [left] and [right] cursor keys will move the time cursor left and right. When **GT** is loaded, the time cursor will be to the right of the seconds field and not visible. Each left cursor press will move the cursor further left to the next valid location. Similarly, the right cursor key will move the time cursor to the right.

### 2.1.4 Satellite Display Fields Description

2.1.4.1 AZIM

AZIM is the bearing of the satellite relative to true north. A value of 90 degrees indicates east, 180 degrees is south, 270 degrees is west, and 0 degrees is north.

2.1.4.2 DOP

DOP is the calculated Doppler shift of the beacon frequency.

2.1.4.3 DRF

DRF is the rate of change of the apparent frequency of the satellite beacon expressed in Hertz per minute.

2.1.4.4 ECHO

ECHO is the time required for a radio signal to travel from the observer to the satellite and back. The value displayed does not include any delay in the satellite transponder. The transponder delay is normally less than a millisecond.

2.1.4.5 ELEV

ELEV is the elevation of the satellite above the observer's horizon. An upward pointing trend indicator means the satellite is rising. The calculated elevation is not corrected for refraction. Therefore, when the calculated elevation is close to zero, the apparent elevation may be as much as ½ degree above the horizon. If your satellite data is good, you should be able to hear the beacon as much as ½ degree below the horizon.

2.1.4.6 FRQ

FRQ is the satellite beacon frequency corrected for Doppler shift.

2.1.4.7 HGT

HGT is the height of the satellite above the sub-satellite point.

2.1.4.8 LAT

LAT is the sub-satellite latitude for the satellite currently being displayed. The trend indicator will point **down** when the satellite is moving **south**.

2.1.4.9 LON

LON is the sub-satellite longitude for the satellite currently being displayed. The trend indicator will point **down** when the satellite is moving **west**.

2.1.4.10 ORBIT

ORBIT is the current orbit or revolution number.

2.1.4.11 PHI

PHI is the satellite mean anomaly expressed as a number between 0 and 255 in accordance with the de-facto standard created for the Amateur Radio Satellite Oscar 10. If the orbit counter is perigee based, a value of 0 will indicate perigee and a value of 128 will indicate apogee. If the orbit counter is equator based, a value of 0 will indicate the ascending equator crossing and a value of 128 will indicate the descending equator crossing. This parameter is used primarily for scheduling of Phase III type Amateur Radio satellites.

2.1.4.12 RNG

RNG is the distance from the observer to the satellite in kilometers. The trend indicator will point **down** when the satellite is moving **toward** the observer.

2.1.4.13 SQUINT

SQUINT is the angle between the observer and the satellite spin axis as seen from the satellite. This parameter is used primarily with Phase III type Amateur Radio Satellites.

### 2.1.5 Lunar Display Fields Description

2.1.5.1 ALT

ALT is the altitude (elevation) of the Moon above the observer's horizon. It is not corrected for refraction but is corrected for parallax.

2.1.5.2 AZIM

AZIM is the azimuth from the observer to the Moon.

2.1.5.3 DEC

Dec is the Lunar apparent declination expressed in degrees and minutes.

2.1.5.4 DISG

DISG is the distance from the center of the Moon to the center of the Earth. (It is not the distance from the observer).

2.1.5.5 ECHO

ECHO is the light travel time from the observer to the center of the Moon and back.

2.1.5.6 FRQ

FRQ is the echo frequency in megahertz corrected for Doppler shift. The transmitted frequency may be set with the command line parameter FRQ or during run time with the keyboard command [Alt][F].

2.1.5.7 GHA

GHA is the Lunar Greenwich hour angle expressed in degrees and minutes.

2.1.5.8 HP

HP is the horizontal parallax expressed in minutes and seconds of arc. This angle is the angle subtended by the Earth's radius as viewed from the Moon.

2.1.5.9 ILLUM

ILLUM is the percentage of the Lunar disk which is illuminated.

2.1.5.10 RA

RA is Lunar apparent right ascension expressed in hours and minutes.

2.1.5.11 SD

SD is the apparent semi-diameter of the Moon expressed in minutes and seconds of arc. This angle is one half of the diameter of the Moon as viewed from the center of the Earth.

2.1.5.12 SUN

SUN is the apparent angle between the Sun and the Moon at the observer's location in degrees of arc. This value is corrected for parallax and thus may be used to observe topocentric eclipse phenomena. If a minus sign is present, the Sun is below the horizon. A plus sign indicates that the Sun is above the horizon. If the angle is greater than one degree, it will be displayed with one digit to the right of the decimal point. If the angle is less than one degree, it will be displayed with four digits to the right of the decimal point.

### 2.1.6 Solar Display Fields Description

#### 2.1.6.1 ALT

ALT is the altitude (elevation) of the Sun above the observer's horizon. It is not corrected for refraction.

#### 2.1.6.2 AZIM

AZIM is the azimuth from the observer to the Sun.

#### 2.1.6.3 DEC

DEC is the Solar apparent declination expressed in degrees and minutes.

#### 2.1.6.4 DIAM

DIAM is the apparent diameter of the Sun expressed in minutes and seconds of arc.

#### 2.1.6.5 DIST

DIST is the distance from the center of the Sun to the center of the Earth. It is not the distance from the observer.

#### 2.1.6.6 ECL

ECL is the apparent ecliptic longitude of the Sun expressed in degrees and minutes.

#### 2.1.6.7 GHA

GHA is the Solar Greenwich hour angle expressed in degrees and minutes.

#### 2.1.6.8 GMST

GMST is the current Greenwich mean sidereal time expressed in hours, minutes, and seconds. The number at the top of the center group is the current epoch expressed in Julian days and fraction.

#### 2.1.6.9 RA

RA is the Solar apparent right ascension expressed in hours and minutes.

2.1.6.10 SD

SD is the apparent semi-diameter of the Sun expressed in minutes and seconds of arc.

### 2.1.7 Stellar Display Fields Description

2.1.7.1 ALT

ALT is the altitude (elevation) of the object above the observer's horizon. It is not corrected for refraction or parallax.

2.1.7.2 AZIM

AZIM is the azimuth from the observer to the object.

2.1.7.3 DEC

DEC is the user entered declination angle of the object expressed in degrees and minutes.

2.1.7.4 ELONG

ELONG is the angular distance between the object and the Sun.

2.1.7.5 GHA

GHA is the current Greenwich hour angle of the object expressed in degrees and minutes.

2.1.7.6 GMST

GMST is the current Greenwich mean sidereal time expressed in hours, minutes, and seconds. The number at the top of the center group is the current epoch expressed as Julian days and fraction.

2.1.7.7 RA

RA is the user entered right ascension of the object expressed in hours and minutes.

### 2.1.8 Command Line Syntax

The general format of the command line used to invoke **GT** is as follows:

**GT** satfile [token] [token] ...

where **satfile** is the name of the desired database file with no extension, and **token** is any combination of the command abbreviations listed in this section.

#### 2.1.8.1 AC c

This token and number causes the antenna control routines within **GT** to output antenna pointing information to an external ARRL compatible rotator control unit through async COM port c, where c is 1, 2, 3 or 4.

#### 2.1.8.2 ASAT n

This token causes **GT** to always display the range circle for satellite n. The position of the range circle will be updated whenever the position of the prime satellite is updated. This option can be modified while **GT** is running with the [Alt][S] keyboard command.

#### 2.1.8.3 ASW

This token will cause **GT** to start operation in the auto-switch mode. This option can be modified while **GT** is running with the [=] keyboard command.

#### 2.1.8.4 ASW1

This token will cause **GT** to start operation in the auto-switch mode. Only the satellite specified on the command line using the **SAT** token will be used. If a **SAT** token is not specified, **GT** will auto-switch satellite one. This option can be modified while **GT** is running with the [/] keyboard command.

#### 2.1.8.5 AZM

This token will cause **GT** to start operation in the auto-zoom mode. This option can be modified while **GT** is running with the [Ctrl][Z] keyboard command.

#### 2.1.8.6 BACK n

This token and number will cause **GT** to set the **CGA** background color to n. The value of n must be between 1 and 16. This option can be modified while **GT** is running with the [C] keyboard command.

2.1.8.7 CL n

This token and number will cause **GT** to set the **EGA** land color to n. The value of n must be between 0 and 63. This option can be modified while **GT** is running with the [C] keyboard command.

2.1.8.8 CML x

This token causes **GT** to fix the center of the flat map display to a longitude of x degrees. This option can be modified while **GT** is running with the [L] keyboard command.

2.1.8.9 CW n

This token and number will cause **GT** to set the **EGA** water color to n. The value of n must be between 0 and 63. This option can be modified while **GT** is running with the [C] keyboard command.

2.1.8.10 DAZ x

This token must be followed by a number which specifies the number of degrees per step in the coverage circles. If DAZ x is not used, a step size of 20 degrees will be used. If DAZ x specifies a value smaller than 20 then the screen update rate will not always be once per second but the curves of the coverage circles will be smoother.

2.1.8.11 DECL d

This token and number will set the star declination to d degrees. This option can be modified while **GT** is running with the [5] keyboard command.

2.1.8.12 EGA

This token will cause **GT** to select the **E**nhanced **G**raphics **A**dapter (**EGA**) instead of the default **C**olor **G**raphics **A**dapter (**CGA**) as the display device.

2.1.8.13 EPSON

This token will cause **GT** to make graphic screen dumps to an Epson FX-80 compatible printer whenever the [*] command key is pressed.

2.1.8.14 FLIP

This token informs **GT** that the elevation rotator is capable of 180 degrees of motion. This feature eliminates the "swing-around" problem encountered with 90 degree elevation rotator motion. **This token should be used only with an elevation rotator capable of full 180 degree motion that has been properly installed**.

2.1.8.15 FREQ f

This token must be followed by f, the desired frequency in megahertz used for the Lunar Doppler shift calculation. This option can be modified while **GT** is running with the [Alt][F] keyboard command.

2.1.8.16 GRAZE n d

This token causes **GT** to display a modified range circle. Instead of the normal zero degree elevation contour, a contour line of d degrees will be displayed for satellite n. This option can be modified while **GT** is running with the [Alt][G] keyboard command.

2.1.8.17 GTA n

This token and number will cause **GT** to set the ground track auto update time in minutes. This option can be modified while **GT** is running with the [0] keyboard command.

2.1.8.18 GTR s e d

This token and three numbers will cause **GT** to set the groundtrack **s**tart, **e**nd, and **d**elta times in minutes, respectively. This option can be modified while **GT** is running with the [0] keyboard command.

2.1.8.19 HRZ d

This token and number will cause **GT** to set the logical horizon to d degrees. Since the refraction of a radio signal is approximately 0.6 degree at the physical horizon, this token is usually set to -.6 degrees. If this token is not specified, the logical horizon is set equal to the physical horizon (0.0 degrees). This option can be modified while **GT** is running with the [B] keyboard command.

2.1.8.20 ISCP n

This token defines the interrupt vector number of the first of two consecutive interrupt vectors used by **GT**'s interface to the **S**tation **C**ontrol **P**rogram (**SCP**). The default values of 103d and 104d (67h and 68h) can be changed to another vector pair if the default values are found to interfere with other functions within your PC. We recommend 100d (64h) if another vector pair is needed.

2.1.8.21 LAG d

This token causes **GT** to overlay the flat maps with latitude grid lines having an interval of d degrees starting at the equator. If a value of zero is specified for the interval only the equator will be displayed.

2.1.8.22 LJ2

This token will cause **GT** to make graphic screen dumps to an HP LaserJet Series II compatible printer whenever the [*] command key is pressed.

2.1.8.23 LOG d

This token causes **GT** to overlay the flat maps with longitude grid lines having an interval of d degrees starting at Prime Meridian (Greenwich Meridian). If a value of zero is specified for the interval only the Prime Meridian will be displayed.

2.1.8.24 MONO

This token will cause **GT** to change certain colors to provide better contrast on a composite monochrome monitor. This monitor must be attached to the composite video output (RCA jack) of the IBM **C**olor **G**raphics **A**dapter (**CGA**).

2.1.8.25 MOON

This token will cause **GT** to start tracking the Moon at startup.

2.1.8.26 NAD n d

This token causes **GT** to display a modified range circle. Instead of the normal zero degree elevation contour, the edge of a cone whose half angle is d degrees off nadir will be displayed for satellite n. This option can be modified while **GT** is running with the [Alt][H] keyboard command.

2.1.8.27 NZ2

This token will cause **GT** to NOT load the [zoom 2] map file.

2.1.8.28 NZ4

This token will cause **GT** to NOT load the [zoom 4] map file.

2.1.8.29 OBS n

This token and number will cause **GT** to start tracking using observer n. The default is observer 1. This option can be modified while **GT** is running with the [O], [Alt][P], or [Alt][N] keyboard command.

2.1.8.30 OKI

This token will cause **GT** to make graphic screen dumps to an Okidata uL-92 compatible printer whenever the [*] command key is pressed.

2.1.8.31 PAL n

This token and number will cause **GT** to set the **CGA** color palette to n. The value of n must be between 1 and 6. This option can be modified while **GT** is running with the [C] keyboard command.

2.1.8.32 PARK n

This token and number will cause **GT** to drive the elevation rotator to the 90 degree position if the next satellite to rise will not be visible within n minutes. This feature is useful in reducing wind load on dish antennas.

2.1.8.33 PATH p

This token must be followed by the desired path name for **GT** to use to load the map files. On a dual-floppy disk system, for example, you should specify PATH B: to cause **GT** to read the map data files from the B drive. This path name is not used for the **.SAT** files or the **OFFSET.GMT** file. They must be in the same path as the **.EXE** files.

2.1.8.34 PIC

This token will cause **GT** to make a picture file of the screen before exiting. The file generated will be named GT.PIC. An existing file of the same name will be replaced by the new file.

2.1.8.35 RTASC h

This token and number will set the star right ascension to h hours. This option can be modified while **GT** is running with the [3] keyboard command.

2.1.8.36 RX c

This token and number causes the receiver frequency control routines within **GT** to output frequency control information to an external FRG-9600 compatible receiver through async COM port c, where c is 1, 2, 3 or 4.

2.1.8.37 SAT n

This token and number will cause **GT** to start tracking satellite n. The default is satellite 1. This option can be modified while **GT** is running with the [S], [P], or [N] keyboard command.

2.1.8.38 SILENT

This token will cause **GT** to run with no audible signals.

2.1.8.39 STAR

This token will cause **GT** to start tracking the specified star.

2.1.8.40 SUN

This token will cause **GT** to start tracking the Sun at startup. This option can be modified while **GT** is running with the [7] keyboard command.

2.1.8.41 SUNL

This token will cause **GT** to start operation with the sun line activated. This option can be modified while **GT** is running with the [7] keyboard command.

2.1.8.42 SWATH n d

This token causes **GT** to display a line normal to the ground track of satellite n with a width of d degrees. This token would be used primarily with weather or Earth resources type satellites to show the actual scanner coverage. The swath will be displayed only when the satellite is the currently tracked object. This option can be modified while **GT** is running with the [Alt][W] keyboard command.

2.1.8.43 TILT d

This token must be followed by d, the desired tilt angle for the spherical projection maps. A value of 23.5 will make the Earth appear as if it were being viewed from the plane of the ecliptic. This option can be modified while **GT** is running with the [3] keyboard command.

2.1.8.44 TRA

This token, **TR**ack **A**lways, causes **GT** to output antenna control information at all times. If this token is not present, **GT** will only output when the clock is in the real-time mode and the selected satellite is above the logical horizon.

2.1.8.45 TS790

This token replaces the default internal Yaesu FRG-9600 receiver interface with an alternative internal Kenwood TS-790 receiver interface.

### 2.1.9 Typical GT Command Lines

Startup commands or tokens can be specified by either of two methods; on the command line or from a disk file. An example of a **GT** command line would be:

**gt demo ac 1 rx 2 lj2 sunl hrz -.6 asw azm gtr -10 80 2 gta 2**

Due to the large number of command line tokens available in **GT**, it is possible to exceed the maximum command line length of 128 characters. Under these circumstances, it is preferable to construct a **command** file on disk which can be read by **GT**. An example invocation of **GT** using a **command** file would be:

**gt @CommandFileName**

The **@** character preceding the **CommandFileName** informs **GT** that what follows is a **command** file and should be used for startup parameter input. The following is an example of a typical **command** file:

**demo**<br>**ac 1**<br>**rx 2**<br>**lj2**<br>**sunl**<br>**hrz -.6**<br>**asw**<br>**azm**<br>**gtr -10 80 2**<br>**gta 2**<br>**asat 2**<br>**flip**<br>**swath 2 57**<br>**lag 30**<br>**log 30**

where

**gt** is the executable program;

**demo** is the name of the database file **GT** will use and must always be the first token on the command line;

**ac 1** invokes the **a**ntenna **c**ontrol portion of **GT** and communicates through COM1;

**rx 2** invokes the receiver control portion of **GT** and communicates through COM2;

**lj2** specifies that an HP LaserJet Series II compatible printer will be used for the screen dump output device;

**sunl** tells the program to display the sun line;

**hrz -.6** specifies the observer's **logical** horizon to be placed at 0.6 degrees **below** the **physical** horizon;

**asw** tells the program to start in the auto-switch mode;

**azm** indicates that we want to start in the auto-zoom mode;

**gtr -10 80 2** specifies that we want to display the ground track for the primary satellite, with the track line extending **10** minutes **behind** the satellite, **80** minutes **ahead** of the satellite, and dots placed **along** the ground track at **2** minute intervals;

**gta 2** tells the program to recalculate the ground track at two minute intervals;

**asat 2** specifies that the range circle for satellite number 2 will be continuously displayed;

**flip** will cause the rotator control logic to drive the rotator through 180 degrees of elevation to eliminate the "swing-around" problem encountered with a 90 degree elevation rotator motion restriction (**this token should be used <u>only</u> with an elevation rotator capable of full 180 degree motion that has been <u>properly</u> installed**);

**swath 2 57** specifies that a swath line of 57 degrees width will be displayed when satellite number 2 is the prime object;

**lag 30** will cause a latitude grid starting at the equator and spaced every 30 degrees to be displayed on the flat maps;

**log 30** will cause a longitude grid starting at the prime meridian (Greenwich) and spaced every 30 degrees to be displayed on the flat maps.

## 2.2.0 UTILITY PROGRAMS SUPPLIED WITH GT

### 2.2.1 **TCL -** Clock Adjuster

**TCL** is a clock adjustment program which uses single key functions to add or subtract 55 ms, 110 ms, 1 second, or 1 minute to the DOS real-time clock. A sample batch file, **HACK.BAT**, may be used to set both the DOS clock and a TECMAR battery backed-up clock. **HACK.BAT** calls **TCL** and the **DOSTIME** program which is supplied with the TECMAR board. The call to **DOSTIME** may be replaced by a call to similar clock set programs for clocks made by other manufacturers.

### 2.2.2 **GR -** Graphics Mode Set

**GR** is used to set the color adapter into any of the seven modes available on the IBM and compatible computers. To use the program, you must enter **gr n**, where n is the desired mode, from either the DOS prompt, or as a command in a batch file. The option **gr 4** sets the 320x200 graphics mode which is required in conjunction with the **ANIMATE** display program. This is the mode in which **GT** normally operates. However, once you have **Q**uit **GT**, you must select the 320x200 graphics mode before running **ANIMATE**. The display cannot be set to this mode with the DOS MODE command.

### 2.2.3 **ANIMATE -** Picture File Animator

#### 2.2.3.1 Using **ANIMATE** with ONLY a Color Adapter

The picture file display program, **ANIMATE**, will allow one or more standard picture files to be displayed on your color monitor. **ANIMATE** assumes that the graphics controller is in the 320x200 mode. Since this mode cannot be set by the DOS MODE command, use the supplied program **GR** to set the 320x200 mode. The picture file name must have the extension **.PIC** when saved to disk. However, the **.PIC** extension is omitted when calling picture files from the command line. Retrieval and display of picture files is accomplished as follows. Assuming that a picture was saved in a disk file named s5.pic, the command line

**animate s5**

would load the **ANIMATE** program and cause the picture file s5.pic to be displayed on the color monitor. After the file has been displayed briefly, the **ANIMATE** program will return to DOS.

If your primary terminal is the color adapter, you may keep a single display, such as our example file s5.pic, on the screen indefinitely, by entering the file name twice on the command line. **ANIMATE** will then swap between the two equal images. The picture then will appear to be permanently fixed on the display, as the swapping will not be visible to the eye. On a standard PC or PC/XT the animation rate is about 15 frames per second.

The command line

**animate s6 s7**

will cause picture files s6.pic, and s7.pic, to be loaded into memory and then rapidly swapped. In a 640k system, as many as 30 pictures may be animated if you keep the filenames short. The DOS command line can contain a maximum of 128 characters including spaces. Assuming that 12 characters are used for the program name and delay time factor plus one trailing space, i.e., ANIMATE -30 , a total of 116 characters and spaces can contain picture names. Approximately thirty (30) picture names could be inserted in the command line.

If a large number of pictures are to be displayed, it is generally desirable to place a slight delay time between each picture change, in much the same manner as a slide show. You can slow the display rate by placing the token **-**n on the **ANIMATE** command line. This will cause a delay of n frames of 1/60 sec each to be inserted between each picture. For example, the command line

**animate -60 s14 s15**

will flip between picture files s14.pic, and s15.pic, every second. The delay time has been specified as 60 delays, each delay being 1/60th of a second long, for a total delay of one second.

You can use **GT** key [6] to produce a Solar view for every hour of the day, and then use **ANIMATE** to display the rotating globe. Remember to keep the **.PIC** file names short. Use s0, s1, ..., s23, or similar short names.

A separate task to animate a series of pictures may be defined by combining the necessary command and program calls in a batch file which includes the names of the pictures to be displayed. A user may have a library of many such batch files, as long as they all have a separate batch file name, and as long as there is room on disk to hold all the picture files. Multiple disks may be used if the drive name, etc., is included as a part of the file name, i.e:

**a:s12 a:s13 b:s15 ...**

The series of pictures in this example would include pictures s12.pic and s13.pic from drive A:, and picture s15.pic from drive B:.

A complete batch file required to run a slide show of the Earth rotating with a 1/4 second delay between each frame of the animation could take the following form:

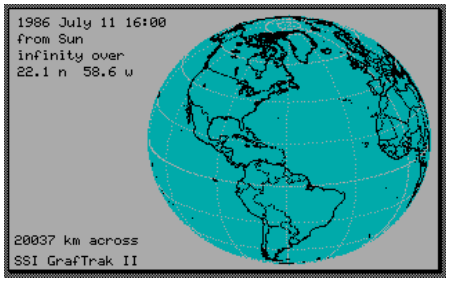
```
gr 4
animate -15 s00 s01 s02 s03 s04 s05 s06 s07 s08 s09 s10 s11 s12 s13 s14 s15 s16 s17 s18 s19 s20 s21 s22 s23
```

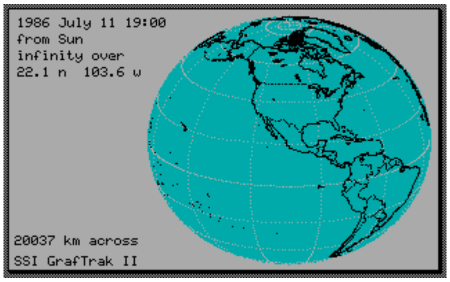
In this case, a snapshot of the Earth was taken by stopping the clock on each hour of a 24 hour period and displaying the spherical view of the Earth as seen from the Sun. The file names shown above are coded for convenience, with an **s** indicating Sun view, and two numbers representing the respective hour of the day for which the picture was snapped.

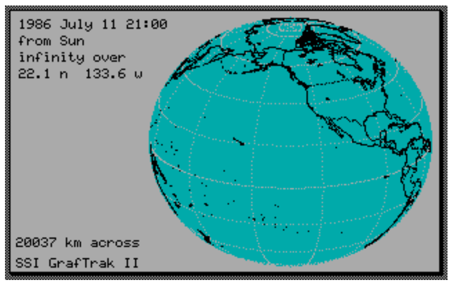
The picture files were created by stopping the clock in the EPOCH mode. The time was then set to 00:00:00 hours, and stepped in one hour increments using the time cursor controls. The [3] key was then used to display a spherical view of the Earth as viewed from the Sun for each time increment. The [6] key was then used to save each picture to a disk file.

A portion of an animation sequence comprised of the **.PIC** files described in Section II.2.3.1 is shown in Figure 2-15. The four pictures shown were selected from the command line sequence s00 s01 s02 s03 ...... and so on. The specific pictures shown are s16, s19, s21, and s23, corresponding to GMT hours 16:00, 19:00, 21:00, and 23:00 respectively. The intervals chosen were intentionally spaced more than one hour apart in order to illustrate greater movement between frames than shown by one hour intervals.

By coupling this method of animation with the editing capabilities of the various paint programs, the possibilities for graphic demonstration displays are, quite literally, limited only by the user's imagination.



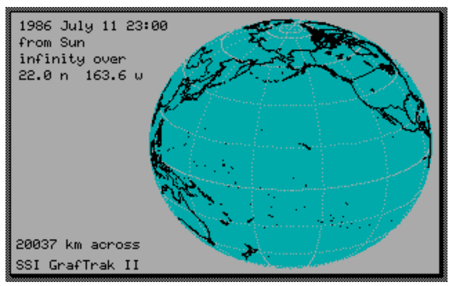




Figure 2-14, Partial Animation Sequence

2.2.3.2 Using **ANIMATE** with BOTH Monochrome and Color Adapters

If your system is equipped with BOTH a monochrome and a color adapter, you can use the **ANIMATE** program to display a picture file on your color monitor while using your monochrome monitor for other functions.

To use your system in this manner, use **mode co80** to switch to your color monitor then use **gr 4** to set the color adapter to the 320x200 graphics mode. You can then enter **mode mono** to return the console output to the monochrome adapter. In this manner, the color adapter memory can still be used for picture displays. To prepare your system for **ANIMATE** displays, the command sequence may be combined into a batch file as follows:

**mode co80**
**gr 4**
**mode mono**
**animate filename [filename ...]**

The following is a command sequence to run **GT** on a system with both color and monochrome adapters. Enter your normal single monitor command line as the first line of a batch file. Then add the lines shown to your batch file:

**gr 4**
**mode mono**
**animate gt**

2.2.4 **SHOWSAT -** Display Contents of .SAT File

**SHOWSAT** is used to display the names and last edit date of **.SAT** files, the contents and age of each satellite element set within a **.SAT** file, or the names and contents of all **.SAT** files in your current directory. **SHOWSAT** is invoked with the following command line:

**showsat filespec [*]**

where

**filespec** is a .sat file name with no extension. Wildcards may be used in the filespec but directory paths may not.

and

***** is an optional token to cause the listing of filenames and edit dates only.

| | |
|---|---|
| showsat * * | to list names and last edit dates of all **.sat** files |
| showsat * | to list the contents of all **.sat** files |
| showsat z* | to list the contents of all **.sat** files that start with z |
| showsat demo | to list the contents of **demo.sat** file |

2.2.5 **UPSAT -** Update a .SAT file to a Bulletin Board Element Set File

**UPSAT** is used to automatically update the contents of **.SAT** files to an element set file in either the **AMSAT** or **NORAD** bulletin board format. The **NORAD** format is sometimes referred to as the **Kelso** format. The run time options are:

1. analyze a BBS file to determine which satellites it contains
2. update one or more **.SAT** files to the BBS file

**UPSAT** is invoked with the following command line:

**upsat ElementSetType BBSFileName SatFileName**

where

**ElementSetType** is

| | |
|---|---|
| **amsat** | for an **AMSAT** formatted element set BBS file. |
| **norad** | for a **NORAD** formatted element set BBS file. |

| | |
|---|---|
| **BBSFileName** | is the name of the BBS file that contains the new element sets. |
| **SatFileName** | is an optional list of one or more **.SAT** files to be updated. If no **.SAT** file names are listed, the BBS file will be analyzed to determine which satellites it contains and list them to the console. |

In order for the **UPSAT** program to be able to match element sets in the BBS file with element sets in the **.SAT** file, a unique datum element common to all three file formats is required; the NASA catalog number fulfills that requirement. In the **.SAT** file, the first eleven characters on the **element set desc** line for each satellite **MUST** be as follows:

**Obj # nnnnn**

that is, the ASCII string **Obj** followed by a **space**, followed by a **#**, followed by another **space**, followed by a **five digit** NASA Catalog Number.

See Section IV, Satellite Editor Program, for additional information regarding the **.SAT** file format.

2.2.6 **MACI -** Most Accurate Clock Interface

**MACI** is a terminate-and-stay-resident (TSR) program which provides an interface between a Heathkit Most Accurate Clock and the DOS clock. **MACI** is capable of maintaining the DOS time to within ½ second of the National Bureau of Standards time as transmitted by **WWV** or **WWVH**. **MACI** may be invoked with the following command line:

**maci CommPortMonitor**

where

**CommPort** is

1 for COM1
2 for COM2
3 for COM3
4 for COM4

**Monitor** is an optional token for Heathkit/DOS clock status display

**m** for display on the top line of a monochrome monitor
**c** for display on the top line of a color monitor

and there is no space between the **CommPort** and **Monitor** tokens.

The Most Accurate Clock should be set up for 2400 baud continuous output. The **CommPort** should be initialized using the DOS Mode command. A typical initialization and load would be as follows:

**mode com1:2400,n,8,1**
**maci 1**

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# <u>SECTION III</u>
# Silicon EPHemeris (SEPH) Tracking and Prediction Program

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### 3.1.0 SEPH GENERAL DESCRIPTION

The **S**ilicon **EPH**emeris (**SEPH**) is a Satellite/EME orbital prediction software package designed to produce tabular style numeric data output for satellite tracking and moonbounce operations. Fifteen modes of operation provide flexibility in the selection and display of observers and objects.

### 3.2.0 SEPH RESPONSES

Each mode requires input of certain information in order to properly set up the program to perform the requested operations. Pressing **ONLY** the **ENTER** key in response to any request for input will result in the use of **DEFAULT** values. In SEPH, default values are enclosed between left and right curly brackets { }. The default values at initial program load are as follows:

mode : 1
primary observer number : 1
alternate observer number : 2
object number : 1
1 to set time, 0 for real time : 0

Gregorian date
day : system clock day
month : system clock month
year : system clock year
hours : system clock hours
minutes : 0
seconds : 0.0
delta T
hours : 0.0
minutes : 15.0
seconds : 0.0
step size
minutes : 8.0
minimum elevation : -1.0
page heading : { blank }
list device (1, 2, or 3) : 1 (console)
epoch : 1 (equator and equinox of date)
maximum elevation of Sun : -18.0

Once a default value has been changed, the new value will remain in effect until a response other than [**ENTER**] is input. All characters of an incorrect response can be deleted with a [**Ctrl**] [**X**]. The rightmost character of a response can be deleted with a **BACKSPACE**. You can return to the MODE menu at any time by entering an [**Esc**].

### 3.2.1 Mode

This is always the first response required when SEPH is loaded. SEPH will display a menu of available modes followed by a prompt for MODE. All other requests for input are based on the response to this question. Modes 1 through 9 and 18 are satellite specific while modes 10 through 13 and 15 are Sun/Moon specific. A response of zero will result in an orderly termination of the program and a return to DOS.

### 3.2.2 Primary Observer Number

Modes requiring primary observer (Earth station site location) information will display a list of up to 16 observers, showing observer name, latitude, longitude, and height. The program expects a 1 or 2 digit observer number from the displayed list of observers.

### 3.2.3 Alternate Observer Number

Modes requiring alternate observer (Earth station site location) information will display a list of up to 16 observers, showing observer name, latitude, longitude, and height. The program expects a 1 or 2 digit observer number from the displayed list of observers.

### 3.2.4 Object Number

Modes requiring specific object (satellite) information will display a list of up to 16 objects, showing object name and description. The program expects a 1 or 2 digit object number from the displayed list of objects.

### 3.2.5 1 to Set Time, 0 for Real Time

This prompt provides a choice of either automatic (**REAL-TIME**) or manual (**NON-REAL-TIME**) timekeeping. If a zero (0) is entered to select automatic timekeeping, the time is read from the system clock and the time increment is computed from system clock deltas. If a one (1) is entered to select manual timekeeping, both the time and time increment are prompted for, and entered through, the keyboard. Modes 1, 2, 7, 8, 10, and 11, are intrinsically **REAL-TIME** and therefore would usually require a zero (0) response. If, however, you are attempting to search for an event or verify an event at some known epoch, a one (1) response would be necessary to initiate the manual time selection sequence.

### 3.2.6 Gregorian Date

This sequence of prompts and responses are the result of selecting mode 3, 4, 5, 9, 12, 13, 15, or 18, or electing to set the time manually from keyboard input, rather than to set the time automatically from the system clock. Three prompts are issued for integer DAY, MONTH, and YEAR, followed by three more prompts for integer HOURS, MINUTES, and real SECONDS. The provision for input of real SECONDS is provided for the special cases where it is desirable to start processing at an epoch which is known to a high degree of resolution. For example, you might wish to start processing Oscar 10 from a reference perigee of 01 September 1984 at 23:20:22.143 UTC.

### 3.2.7 Delta T

This sequence of prompts and responses are the result of selecting mode 3, 4, 5, 9, 12, 13, 15, or 18, or electing to set the time manually from keyboard input, rather than to set the time automatically from the system clock. Three prompts are issued for real HOURS, MINUTES, and SECONDS. Real input is provided for those special cases where the delta T is known to a high degree of resolution. For example, you might wish to start processing Oscar 10 from a reference perigee of 01 September 1984 at 23:20:22.143 UTC, and increment by a DELTA T of one orbital period, or 699.538196 minutes. It is much easier to enter 0 HOURS, 699.538196 MINUTES, and 0 SECONDS than it is to convert 699.538196 to integer HOURS, MINUTES, and real SECONDS.

### 3.2.8 Step Size

This response is required only for mode 5. This parameter is the coarse step size in minutes input to a brute force implementation of a visibility search algorithm, whereby the object is stepped along its orbital path at some coarse STEP SIZE unit of time, followed by a test for visibility. Once visibility has been determined, the algorithm switches to a finer resolution to determine the actual rise and set times. The coarse value must be selected empirically, based on your knowledge of the type of object being processed. For example, predictions for the NOAA Advanced TIROS-N spacecraft (NOAA-9, 10, ... series) are adequately defined with a four (4) minute step value. **If you are processing an object such as AMSAT-OSCAR 10, 8 minutes would be a good value; if you are processing an object such as the Space Shuttle, 2 MINUTES would be more appropriate.**

### 3.2.9 Minimum Elevation

This response is required for all modes which either suppress data output until a visibility criteria is satisfied or highlight the display when the visibility criteria is satisfied. For example, assuming you have selected mode 3 and only want output when the object is above -2.0 degrees elevation, a response of -2.0 would be entered.

### 3.2.10 Page Heading

This request is specific to modes which are capable of producing hard copy output. This feature provides for special notes or comments to be included in the title heading of each page. The maximum number of characters allowed for input is 70.

### 3.2.11 Number of Days to Process

This request is specific to modes which are capable of producing hard copy output. The specified number of days will be processed and the program will then return to the menu.

### 3.2.12 Select List Device

This request is specific to modes which are capable of producing hard copy output:

Device **1** is the **system console**
Device **2** is the **printer**
Device **3** is a **disk file**

If device 3 is selected, **SEPH** will prompt for input of the desired filename. The default filename is **SAT.LST**.

3.2.13 Select Epoch

Three reference epochs are available for modes 7, 8, and 9. The satellite positions will be precessed to the appropriate epoch for plotting against a star map background. One of the following references may be selected:

epoch **1** is equator and equinox of **1950.0**
epoch **2** is equator and equinox of **2000.0**
epoch **3** is equator and equinox of **date**

3.2.14 Maximum Elevation of the Sun

This request is specific to mode 18, Sun/Satellite Visibility. It specifies the maximum elevation of the Sun that will be used in conjunction with the selected satellite to determine whether the satellite should be optically visible. i.e, not eclipsed by the Earth.

### 3.3.0 RUNNING SEPH

**SEPH** is the program that actually performs the satellite, Solar, and Lunar calculations. For the following example, **DEMO.SAT** is the database file which contains the satellite and observer data.

Enter the following command line at the DOS prompt:

**SEPH DEMO [ENTER]**

The program loads, then reads in the file **DEMO.SAT** and the file **OFFSET.GMT**. You then have the option of selecting one of the fifteen available modes of operation.

3.3.1 Mode 1 **-** one observer to all satellites

```
responses:
                primary observer number
                minimum elevation
                1 to set time, 0 for real time
    if 1
                Gregorian date
                    day of month
                    month
                    year
                    hours
                    minutes
                    seconds
                delta T
                    hours
                    minutes
                    seconds
    endif
```

3.3.2 Mode 2 - all observers to one satellite

responses:

object number
minimum elevation
1 to set time, 0 for real time

if 1

Gregorian date
day of month
month
year
hours
minutes
seconds
delta T
hours
minutes
seconds

endif

3.3.3 Mode 3 - schedule for one observer to one satellite

responses:

primary observer number
object number
minimum elevation
page heading
Gregorian date
day of month
month
year
hours
minutes
seconds
delta T
hours
minutes
seconds
number of days to process
list device

3.3.4 Mode 4 **-** window between two observers and one satellite

responses:

- primary observer number
- alternate observer number
- object number
- minimum elevation
- page heading
- Gregorian date
  - day of month
  - month
  - year
  - hours
  - minutes
  - seconds
- delta T
  - hours
  - minutes
  - seconds
- number of days to process
- list device

3.3.5 Mode 5 **-** rise and set times for one satellite

responses:

- primary observer number
- object number
- minimum elevation
- page heading
- Gregorian date
  - day of month
  - month
  - year
  - hours
  - minutes
  - seconds
- step size
  - minutes
- number of days to process
- list device

3.3.6 Mode 6 **-** time ordered alerts for all satellites

responses:

primary observer number
page heading
1 to set time, 0 for real time

if 1

Gregorian date
- day of month
- month
- year

endif

number of days to process
list device

3.3.7 Mode 7 **-** one observer to all satellites (astro)

responses:

primary observer number
minimum elevation
1 to set time, 0 for real time

if 1

Gregorian date
- day of month
- month
- year
- hours
- minutes
- seconds

delta T
- hours
- minutes
- seconds

endif

select epoch

3.3.8 Mode 8 **-** all observers to one satellite (astro)

responses:

object number
minimum elevation
1 to set time, 0 for real time

if 1

Gregorian date
day of month
month
year
hours
minutes
seconds
delta T
hours
minutes
seconds

endif

select epoch

3.3.9 Mode 9 **-** schedule for one observer to one satellite (astro)

responses:

primary observer number
object number
minimum elevation
page heading
Gregorian date
day of month
month
year
hours
minutes
seconds
delta T
hours
minutes
seconds
number of days to process
list device
select epoch

3.3.10 Mode 10 - almanac for Sun and Moon

responses:
- 1 to set time, 0 for real time
- if 1
  - Gregorian date
    - day of month
    - month
    - year
    - hours
    - minutes
    - seconds
  - delta T
    - hours
    - minutes
    - seconds
- endif

3.3.11 Mode 11 - all observers to the Sun and Moon

responses:
- 1 to set time, 0 for real time
- if 1
  - Gregorian date
    - day of month
    - month
    - year
    - hours
    - minutes
    - seconds
  - delta T
    - hours
    - minutes
    - seconds
- endif

3.3.12 Mode 12 - schedule for one observer and the Moon

responses:

- primary observer number
- minimum elevation
- page heading
- Gregorian date
  - day of month
  - month
  - year
  - hours
  - minutes
  - seconds
- delta T
  - hours
  - minutes
  - seconds
- number of days to process
- list device

3.3.13 Mode 13 - window between two observers and the Moon

responses:

- primary observer number
- alternate observer number
- minimum elevation
- page heading
- Gregorian date
  - day of month
  - month
  - year
  - hours
  - minutes
  - seconds
- delta T
  - hours
  - minutes
  - seconds
- number of days to process
- list device

3.3.14 Mode 15 - schedule for one observer and the Sun

responses:

primary observer number
minimum elevation
page heading
Gregorian date
- day of month
- month
- year
- hours
- minutes
- seconds

delta T
- hours
- minutes
- seconds

number of days to process
list device

3.3.15 Mode 18 - Sun/satellite visibility

responses:

primary observer number
object number
minimum elevation
page heading
Gregorian date
- day of month
- month
- year
- hours
- minutes
- seconds

delta T
- hours
- minutes
- seconds

number of days to process
list device
maximum elevation of the Sun

### 3.4.0 SEPH FIELD DESCRIPTIONS

#### 3.4.1 Satellite Display Fields Description

3.4.1.1 AZIM

AZIM is the azimuth from the observer to the satellite relative to true north.

3.4.1.2 BEACON

BEACON is the satellite beacon frequency in megahertz corrected for Doppler shift.

3.4.1.3 DEC

DEC is the satellite declination in degrees, minutes, and seconds.

3.4.1.4 ECHO

ECHO is the time in milliseconds for a radio signal to travel from the observer to the satellite and back. The value displayed does not include any delay in the satellite transponder. The transponder delay is normally quite small (less than 1 millisecond).

3.4.1.5 ELEV

ELEV is the elevation of the satellite above the observer's horizon. An upward pointing trend indicator means the satellite is rising. The elevation value is not corrected for refraction. When the elevation value is close to zero (the horizon), the apparent location may be as much as ½ degree above the horizon. If your satellite data is good, you should be able to hear the beacon as much as ½ degree below the horizon.

3.4.1.6 HEIGHT

HEIGHT is the height in kilometers of the satellite above the sub-satellite point.

3.4.1.7 KHZ

KHZ is the calculated Doppler shift in kilohertz of the satellite beacon.

3.4.1.8 HZ/MIN

HZ/MIN is the apparent rate of change of frequency of the satellite beacon.

3.4.1.9 LAT

LAT is the latitude of the sub-satellite point.

3.4.1.10 LENGTH

LENGTH is the length of the pass in hours, minutes, and optionally, seconds.

3.4.1.11 LON

LON is the longitude of the sub-satellite point.

3.4.1.12 MAX

MAX is the maximum angular separation in degrees between the Sun and the satellite selected for visual observation.

3.4.1.13 OR/SQ

This field may contain either of two descriptors:

1. if the selected object has been initialized with Bahn Coordinates, this field represents the **SQ**int angle between the spin axis of the satellite and the observer as viewed from the satellite, and is expressed as a real number

2. otherwise, this field represents the current **OR**bit or revolution and is expressed as an integer number.

3.4.1.14 PHASE

PHASE is the satellite mean anomaly expressed as a number between 0 and 255 in accordance with the de-facto standard created for the Amateur Radio Satellite Oscar 10. If the orbit counter is perigee based, a value of 0 will indicate perigee and a value of 128 will indicate apogee. If the orbit counter is equator based, a value of 0 will indicate the south to north equator crossing and a value of 128 will indicate the north to south equator crossing. This parameter is used primarily for scheduling of Phase III type Amateur Radio satellites.

3.4.1.15 RA

RA is the satellite right ascension in hours, minutes, and seconds.

3.4.1.16 RANGE

RANGE is the distance in kilometers from the observer to the satellite.

3.4.1.17 RATE

RATE is the velocity in kilometers per second of the object relative to the observer.

3.4.1.18 RISE

RISE is the time of rise of the object in hours, minutes, and optionally, seconds.

3.4.1.19 SEP

SEP is the current angular separation in degrees between the Sun and the satellite selected for visual observation.

3.4.1.20 SET

SET is the time of set of the object in hours, minutes, and optionally, seconds.

3.4.1.21 TCA

TCA is the time of closest approach of the object in hours, minutes, and optionally, seconds.

### 3.4.2 Lunar Display Fields Description

3.4.2.1 AZIM

AZIM is the azimuth in degrees from the observer to the Moon.

3.4.2.2 DEC

DEC is the Lunar apparent declination in degrees and minutes.

3.4.2.3 ELEV

ELEV is the altitude (elevation) in degrees of the Moon above the observer's horizon. It is not corrected for refraction but is corrected for parallax.

3.4.2.4 FRAC

FRAC is the fractional part of the Lunar disk which is illuminated.

3.4.2.5 GHA

GHA is the Lunar Greenwich Hour Angle in degrees and minutes.

3.4.2.6 RA

RA is the Lunar apparent right ascension in hours and minutes.

3.4.2.7 RANGE

RANGE is the distance in kilometers from the center of the Moon to the center of the Earth. **It is not the distance from the observer**.

### 3.4.3 Solar Display Fields Description

3.4.3.1 AZIM

AZIM is the azimuth in degrees from the observer to the Sun.

3.4.3.2 DEC

DEC is the Solar apparent declination in degrees and minutes.

3.4.3.3 ELEV

ELEV is the altitude (elevation) in degrees of the Sun above the observer's horizon. It is not corrected for refraction or parallax.

3.4.3.4 GHA

GHA is the Solar Greenwich Hour Angle in degrees and minutes.

3.4.3.5 RA

RA is the Solar apparent right ascension in hours and minutes.

## 3.5.0 SEPH SPECIAL NOTES

### 3.5.1 Mode 6

Mode 6 uses a closed form solution to calculate the time of rise. The result is a much faster calculation but certain restrictions must apply due to the interesting nature of some types of orbits:

1. Satellites with a mean motion of less than 1.5 orbits per day will not be processed.

2. Satellites with an eccentricity greater than 0.1 will not be processed.

3. Satellites whose reference epoch is more than 360 days old will not be processed.

Mode 6 results are generally compatible with the SSI propagation model.

### 3.5.2 Mode 5

Mode 5 is recommended for satellites such as Molniya and AMSAT Phase III, which do not qualify for use with Mode 6.

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# SECTION IV - Satellite EDitor (SED) Program

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## 4.1.0 SED GENERAL DESCRIPTION

The **S**atellite **ED**itor **(SED)** is a program which provides a simple and convenient method of creating and editing database files, containing satellite and observer information, which are used by the **G**raf**T**rak (**GT**) and **S**ilicon **EPH**emeris (**SEPH**) programs. The user may create as many database files as needed, then select the desired file by inserting its name into the command line of either **GT** or **SEPH**.

## 4.2.0 OPERATION AND USAGE

The following paragraphs explain various methods of using the **SED** program, and provide suggestions to expedite operation and avoid confusion. An explanation of keyboard commands is also provided.

### 4.2.1 How to Create and Edit Database Files

**SED** can be called either from the DOS command prompt, or from within the **GT** program by using the [**CONTROL**][**E**] "Edit File" command function.

It is possible to create a new database file and tag it with a comment title through the execution of a single command line. The following is an example of a command line to load **SED** and create a **new** database file named NOAA.SAT, with the title "Weather Satellites":

**SED NOAA Weather Satellites**

The following is an example of a command line to load **SED** and edit an **existing** database file named GPS.SAT:

**SED GPS**

The main difference between the two previous command line examples are:

a. When creating a new database file, you may include a title after the filename ("Weather Satellites" in the example), whereas;

b. When editing an existing database file, no title is necessary.

After entering the proper command line and pressing the [**ENTER**] key, **SED** will be loaded, and the **.SAT** file specified in the command line will be opened and read. If the file has just been created, all data fields displayed on the screen will be blank as shown in Figure 4-1, Blank Location Data Fields Display, and Figure 4-2, Blank Satellite Data Fields Display.

If the file existed previously, the data fields displayed on the screen will reflect the information contained within the file, as shown in Figure 4-3, Typical Location Data Fields Display, and Figure 4-4, Typical Satellite Data Fields Display.

```
Satellite Database Editor    V3.00    Copyright (C) 1985-1989 Silicon Solutions
file: DEMO                                       edited: 01 May 1989 18:09
title: DEMO - a DEMOnstration file           satellites: 16  observers: 16

   observer name                              command:

  north latitude                 degrees (- south)         object:  1
  east longitude                 degrees (- west)
          height                 meters                    E   - edit
                                                           S   - satellite
                                                           O   - observer
                                                           N   - next
                                                           P   - previous
                                                          .nn  - object 01-16
                                                           C   - clear entry
                                                           R   - read entry
                                                           W   - write entry
                                                           G   - get data
                                                           U   - roll up
                                                           T   - edit title
                                                           X   - exit (update)
                                                           Q   - quit (abort)
                                                           Esc - to this menu
```

Figure 4-1, Blank Location Data Fields Display

```
Satellite Database Editor    V3.00    Copyright (C) 1985-1989 Silicon Solutions
file: DEMO                                       edited: 01 May 1989 18:09
title: DEMO - a DEMOnstration file           satellites: 16  observers: 16

  satellite name                              command:

element set desc                                           object:  1
      epoch year
       epoch day                                           E   - edit
     inclination                 degrees                   S   - satellite
     r. a. a. n.                 degrees                   O   - observer
    eccentricity                                           N   - next
  arg of perigee                 degrees                   P   - previous
    mean anomaly                 degrees                  .nn  - object 01-16
     mean motion                 orbits/day                C   - clear entry
   decay (ndot2)                 orbits/day**2             R   - read entry
      use decay?                 0=no, 1=yes               W   - write entry
    orbit number                                           G   - get data
      orbit base                 0=perigee, 1=equator      U   - roll up
 semi-major axis                 km                        T   - edit title
beacon frequency                 MHz                       X   - exit (update)
  blat or nddot6                 degrees or orbits/day**3  Q   - quit (abort)
    blon or drag                 degrees or bstar          Esc - to this menu
     orbit model                 0=SSI, 1=Bahn, 2=SGP, 3=SGP4/SDP4
```

Figure 4-2, Blank Satellite Data Fields Display

```
Satellite Database Editor    V3.00    Copyright (C) 1985-1989 Silicon Solutions
file: DEMO                                      edited: 01 May 1989 18:09
title: DEMO - a DEMOnstration file               satellites: 16  observers: 16

   observer name    Houston                    command:

  north latitude    29.674283     degrees (- south)         object:  1
  east longitude    -95.451217    degrees (- west)
          height    8.2           meters                    E   - edit
                                                            S   - satellite
                                                            O   - observer
                                                            N   - next
                                                            P   - previous
                                                           .nn  - object 01-16
                                                            C   - clear entry
                                                            R   - read entry
                                                            W   - write entry
                                                            G   - get data
                                                            U   - roll up
                                                            T   - edit title
                                                            X   - exit (update)
                                                            Q   - quit (abort)
                                                            Esc - to this menu
```

Figure 4-3, Typical Location Data Fields Display

```
Satellite Database Editor    V3.00    Copyright (C) 1985-1989 Silicon Solutions
file: DEMO                                      edited: 01 May 1989 18:09
title: DEMO - a DEMOnstration file               satellites: 16  observers: 16

  satellite name    UO-9                       command:

element set desc    Obj # 12888, Set #  522                 object:  1
      epoch year    1989
       epoch day    106.60042392                            E   - edit
     inclination     97.5630      degrees                   S   - satellite
     r. a. a. n.    156.6223      degrees                   O   - observer
    eccentricity    .0002010                                N   - next
  arg of perigee    193.4152      degrees                   P   - previous
    mean anomaly    166.7158      degrees                  .nn  - object 01-16
     mean motion    15.51928771   orbits/day                C   - clear entry
   decay (ndot2)    0.00074227    orbits/day**2             R   - read entry
      use decay?    1             0=no, 1=yes               W   - write entry
    orbit number    41941                                   G   - get data
      orbit base    1             0=perigee, 1=equator      U   - roll up
 semi-major axis    0.0           km                        T   - edit title
beacon frequency    145.8250      MHz                       X   - exit (update)
  blat or nddot6    0.0           degrees or orbits/day**3  Q   - quit (abort)
    blon or drag    0.12288e-2    degrees or bstar          Esc - to this menu
     orbit model    0             0=SSI, 1=Bahn, 2=SGP, 3=SGP4/SDP4
```

Figure 4-4, Typical Satellite Data Fields Display

Subsequent to loading, **SED** will be in the command mode. The blinking cursor will be positioned at the command entry line. The right side of the screen will contain a menu of the commands that may be entered. **SED** is expecting a single letter command to be entered.

To edit or modify an **existing** satellite or observer entry, use either the [**N**] (Next) or [**P**] (Previous) key to select the satellite or observer to be edited, then press the [**E**] key to enter the **EDIT** mode. The cursor will move to the first character of the first line of the display. In the edit mode, the cursor may be moved around using the arrow keys on the right side of the keyboard. Any data entered will replace the data currently pointed to by the cursor.

If you wish to replace the entire value in a field, enter the new value and press the [**ENTER**] key. The remainder of the field will be cleared and the cursor will move to the next field.

If you wish to change a single digit but leave the remainder of the field, move the cursor to the digit to be replaced, enter the new digit, and then move the cursor to the next digit to be changed without pressing the enter key.

If you are **creating** a new database file, enter the desired data using the directional arrows and the [**ENTER**] key to move between fields.

**For a satellite or observer to be recognized by GT or SEPH, the name field must not be blank**. A field can be skipped by simply pressing [**ENTER**] while the cursor is at the first character position of the field. A field can be cleared by entering a [**SPACE**] in the first character position followed by pressing the [**ENTER**] key.

**When all changes have been made, press the Esc key to return to the command mode**.

It is suggested that you experiment with an existing data file, using a backup diskette in order to become familiar with the format required in the various fields. Making a screen dump of the display prior to experimenting can be very helpful and can often reduce confusion after many changes have been made.

After all desired changes/entries have been made, and you have **returned to the command mode by pressing the Esc key**, you may either save the changes, thereby updating the data file, or you may leave the data file without modifying the existing data, thereby restoring the data to the values prior your changes.

The [**X**] key will cause **SED** to update the entire data file, write a new disk file, and exit to DOS. The original file will be saved with the extension **.BAK**, and the new file will have the extension **.SAT**.

The [**Q**] key will cause **SED** to **QUIT** and return to the DOS prompt without incorporating any of the changes made in the editing session.

### 4.2.2 Keyboard Commands

#### 4.2.2.1 [C] = Clear Entry

The [**C**] command is used to **CLEAR** all of the data for the currently selected object, in effect "zeroing out" the selected satellite or observer.

4.2.2.2 [E] = Edit

The [**E**] command causes **SED** to enter the **EDIT** mode for the selected satellite number or observer number. The cursor will be positioned at the first character of the first data field. For a satellite, this field will be the **SATELLITE** name. For an observer, this field will be the **OBSERVER** name.

4.2.2.3 [G] = Get Data

The [**G**] command is used to **EXCHANGE** the contents of two satellites or two observers. The contents of the currently displayed object number will be exchanged with the contents of the object number entered with this command. For example, if the currently displayed object is 11, and the command

**G 15**

is entered, the data for object 15 will be swapped with the data for object 11.

4.2.2.4 [N] = Next

The [**N**] command causes the **NEXT** object in the file, satellite or observer, to be displayed. The display for both satellites and observers are designed to "wrap-around". For example, if the current object is satellite 16, the next object displayed will be satellite 1. If the current object is observer 16, the next object displayed will be observer 1. The right arrow key will perform the same function as the [**N**] key.

4.2.2.5 [O] = Observer

The [**O**] command causes **SED** to display the data for a selected **OBSERVER** (The term "observer" refers to the specific latitude, longitude, and height of an observation site on the surface of the earth). The number of the selected observer, 1 through 16, appears on the screen next to the heading "object". The number of the observer being displayed may be changed by using the [**N**], [**P**], or [**.**NN] commands.

4.2.2.6 [P] = Previous

The [**P**] command causes the **PREVIOUS** item in the file, satellite or observer, to be displayed. The "wrap-around" feature is also applicable in this mode. If the current object is satellite 1, the previous object will be satellite 16. If the current object is observer 1, the previous object will be observer 16. The left arrow key will perform the same function as the [**P**] key.

4.2.2.7 [Q] = Quit (Abort)

The [**Q**] command is used to **ABORT** the edit session. **SED** is terminated by executing the [**Q**] command, and the edit file is left unchanged.

4.2.2.8 [R] = Read Entry

The [**R**] command is used to **READ** a disk file containing either satellite or observer data into the currently displayed satellite or observer number. This command, along with the [**W**] command, provides an easy method of moving and copying satellite and observer data within and between files.

Three file formats are supported by the [**R**] command:

1. Observer files written by **SED** using the [**W**] command.

2. Satellite files written by **SED** using the [**W**] command.

3. Satellite files created by the operator using his favorite text editor and following the well defined **NASA TWO LINE ORBITAL ELEMENT** format as described in section IV.3.0 of this manual.

Files written by **SED** will have an extension of **.SSI**. Files produced by any other text editor must have an extension of **.TLE**. No other file name extensions will be recognized by **SED**.

Upon entry, the [**R**] command will determine whether you are attempting to read an observer or satellite file. If a satellite file read request is detected, **SED** will request selection of the file format description, **.SSI** or **.TLE**. **SED** will then proceed to read the file. If a **.TLE** file was specified, the check character at the end of each line will be verified and if an error occurred the data will not be read into the selected object. Otherwise, the data will be read and **SED** will then return to the main menu.

**The [R] command should only be used to read files generated by the [W] command or files which obey the format specification for NASA TWO LINE ORBITAL ELEMENT (.TLE) files**.

4.2.2.9 [S] = Satellite

The [**S**] command causes **SED** to display the data for a selected **SATELLITE**. The number of the selected satellite, 1 through 16, appears on the screen next to the heading "object". The number of the satellite being displayed may be changed by using the [**N**], [**P**], or [**.**NN] commands.

4.2.2.10 [T] = Edit file Title

The [**T**] command is used to change the **TITLE** of the file being edited. This command is handy in the event that you copy an entire file to a new file name, edit the new file, and desire to change the title of the new file. This command can also be used if you have created a new file using **SED** but forgot to put the file title on the command line. When the [**T**] command key is pressed, the screen will be cleared and you will be prompted to enter the new title. After the new title has been typed, the [**ENTER**] key will return **SED** to the main display.

4.2.2.11 [U] = Roll Up

The [**U**] command is used to roll **UP** the observer or satellite list by one number. For example, 3 to 2, 2 to 1, 1 to 16, 16 to 15, etc. This capability is handy for adding a new observer or satellite to the bottom of the list.

4.2.2.12 [W] = Write Entry

The [**W**] command is used to **WRITE** the currently displayed satellite or observer data to a special disk file with an extension of **.SSI**. You have the option of either entering a file name or letting **SED** produce a default file name based on the object type (**SAT**ellite or **OBS**erver) and object number (**1** through **16**). This command, along with the [**R**] command, provides an easy method of moving and copying satellite and observer data within and between files.

4.2.2.13 [X] = Exit (Update)

The [**X**] command is used to **END** the edit session and **SAVE** the new data to a disk file.

Reasonability tests are performed on the data when the [**X**] command is executed. If any errors are detected, **SED** will enter the edit mode and place the cursor at the line that contains the error. You are given the opportunity to correct the error. When the data passes the reasonability tests, the calculations necessary to convert the data to computational units are automatically performed and the data is written to disk.

4.2.2.14 [.NN] = Object

The [**.**NN] command provides for the command line entry of a two digit object number in the range of 01 to 16 to select an observer or satellite. The command must always start with a period (**.**) and be followed by two digits. Examples of correct commands are: .01 .09 .10 .16

4.2.2.15 [Esc] = Escape to Main Menu

The [**Esc**] command is used to end the current operation and return to the main menu for selection of a new command.

## 4.3.0 Satellite Fields Description

Most of the satellite fields correspond directly to the NASA elements and require no explanation with the possible exception of the fields dealing with propagation model selection.

4.3.1 Orbit Model

This field specifies to **GT**/**SEPH** which of the four available propagation models to use in calculating the satellite position.

4.3.1.1 SSI

This is the simplest and fastest propagation model and can be used reliably for nearly all satellites in stable orbits. This model is selected by entering a zero (0) for the orbit model.

4.3.1.2 Bahn

This model is identical to the SSI model with the additional capability of calculating the squint angle and should be used **ONLY** with Amateur Radio Satellites of the Phase III type for which there is a valid set of Bahn Coordinates entered as Bahn Latitude (**blat**) and Bahn Longitude (**blon**). This model is selected by entering a one (1) for the orbit model.

4.3.1.3 SGP

This is the simplest of the three NORAD propagation models supported by **GT**/**SEPH** and probably the best choice for Chicken Little (the sky is falling) applications. The **Second Derivative of Mean Motion** should be entered for **nddot6**. This model is selected by entering a two (2) for the orbit model.

4.3.1.4 SGP4/SDP4

These are the more complex of the three NORAD propagation models supported by **GT**/**SEPH** and, if chosen, will be automatically switched based on whether the satellite is Near-Earth (SGP4) or Deep Space (SDP4). The **Second Derivative of Mean Motion** should be entered for **nddot6** and **BSTAR** (the drag term) should be entered for **drag**. These models are selected by entering a three (3) for the orbit model.

4.3.2 blat or nddot6

This field can contain either of two parameters. Blat is part of the Bahn Coordinate system used to describe the orientation of the satellite in its orbit and should be used when orbit model one (Bahn) is selected. Nddot6 is the second derivative of Mean Motion and should be used whenever orbit model two (SGP) is selected. This field may be zero when orbit model zero (SSI) or orbit model three (SGP4/SDP4) is selected.

4.3.3 blon or drag

This field can contain either of two parameters. Blon is part of the Bahn Coordinate system used to describe the orientation of the satellite in its orbit and should be used when orbit model one (Bahn) is selected. Drag is the drag term and should be used whenever orbit model three (SGP4/SDP4) is selected. This field may be zero when orbit model zero (SSI) or orbit model two (SGP) is selected.

### 4.4.0 Updating Ephemeris Data

Current ephemeris data can be obtained either from the NASA Two Line Orbital Element data sets or from the NASA Prediction Bulletin. The NASA Prediction Bulletin is suggested. These data sets are issued regularly by NASA and are available free of charge. A written request that you be placed on the NASA mailing list should be addressed to:

NASA/Goddard Space Flight Center
Project Operations Branch, Code 513
Greenbelt, MD 20771

A special composite mailing list called the Weather Satellites Mailing List has recently been introduced by NASA. This list will normally include all satellites of interest for remote sensing and imaging systems. Other special interest lists may also be made available from NASA in the near future.

The NASA Prediction Bulletin provides all data necessary for the **GT**, **SEPH**, and **SED** programs within the first two (2) lines of Part I, at the top of the page as shown in figure 4-5. The remaining information in parts II and III is used in conjunction with other tracking applications and is not required by these programs.

Figure 4-5 is an example of the NASA PREDICTION BULLETIN. Figure 4-6 describes the format of the TWO LINE ELEMENT part of the bulletin.

Additional information regarding amateur satellites may be obtained from the following Bulletin Boards:

1. WD0GML AMSAT BBS Service (314) 447-3003
2. Celestial RCP/M BBS Service (513) 427-0674

# NASA PREDICTION BULLETIN

NASA 51004

**NASA GODDARD SPACE FLIGHT CENTER, CODE 513.2, GREENBELT, MD. 20771**

**ISSUE DATE:** December 28, 1981

BLTN 753 ELEM 753 OBJ 01328 1965 032 A ; IN 3 PARTS PART 1

1 01328U 65032 A 81361.75324961 0.00000070 20661-3 0 7532
2 01328 41.1873 263.1704 0245364 221.6817 136.4995 13.36210358813588

THIS PREDICTION SHOULD NOT BE USED FOR PRECISE SCIENTIFIC ANALYSIS.

PART II S-N EQUATOR CROSSINGS.

| REV | TIME Z | LONG W | REV | TIME Z | LONG W | REV | TIME Z | LONG W |
|---|---|---|---|---|---|---|---|---|
| 30 DEC 81 | | | | | | | | |
| 81392 | 704.70 | 312.47 | 81393 | 852.35 | 339.78 | 81394 | 1040.00 | 7.08 |
| 81395 | 1227.65 | 34.38 | 81396 | 1415.30 | 61.69 | 81397 | 1602.94 | 88.99 |
| 81398 | 1750.59 | 116.30 | 81399 | 1938.24 | 143.60 | 81400 | 2125.89 | 170.91 |
| 81401 | 2313.54 | 198.21 | | | | | | |
| 31 DEC 81 | | | | | | | | |
| 81402 | 101.19 | 225.51 | 81403 | 248.84 | 252.82 | 81404 | 436.48 | 280.12 |
| 81405 | 624.13 | 307.43 | 81406 | 811.78 | 334.73 | 81407 | 959.43 | 2.04 |
| 81408 | 1147.08 | 29.34 | 81409 | 1334.73 | 56.64 | 81410 | 1522.38 | 83.95 |
| 81411 | 1710.03 | 111.25 | 81412 | 1857.67 | 138.56 | 81413 | 2045.32 | 165.86 |
| 81414 | 2232.97 | 193.17 | | | | | | |
| 1 JAN 82 | | | | | | | | |
| 81415 | 20.62 | 220.47 | 81416 | 208.27 | 247.77 | 81417 | 355.92 | 275.08 |
| 81418 | 543.57 | 302.38 | 81419 | 731.22 | 329.69 | 81420 | 918.87 | 356.99 |
| 81421 | 1106.52 | 24.30 | 81422 | 1254.17 | 51.60 | 81423 | 1441.81 | 78.91 |
| 81424 | 1629.46 | 106.21 | 81425 | 1817.11 | 133.51 | 81426 | 2004.76 | 160.82 |
| 81427 | 2152.41 | 188.12 | 81428 | 2340.06 | 215.43 | | | |
| 2 JAN 82 | | | | | | | | |
| 81429 | 127.71 | 242.73 | 81430 | 315.36 | 270.04 | 81431 | 503.01 | 297.34 |
| 81432 | 650.66 | 324.65 | 81433 | 838.31 | 351.95 | 81434 | 1025.96 | 19.25 |
| 81435 | 1213.61 | 46.56 | 81436 | 1401.26 | 73.86 | 81437 | 1548.91 | 101.17 |
| 81438 | 1736.56 | 128.47 | 81439 | 1924.21 | 155.78 | 81440 | 2111.86 | 183.08 |
| 81441 | 2259.51 | 210.39 | | | | | | |
| 3 JAN 82 | | | | | | | | |
| 81442 | 47.16 | 237.69 | 81443 | 234.81 | 265.00 | 81444 | 422.46 | 292.30 |
| 81445 | 610.11 | 319.60 | 81446 | 757.76 | 346.91 | 81447 | 945.41 | 14.21 |
| 81448 | 1133.06 | 41.52 | 81449 | 1320.71 | 68.82 | 81450 | 1508.36 | 96.13 |
| 81451 | 1656.01 | 123.43 | 81452 | 1843.66 | 150.74 | 81453 | 2031.31 | 178.04 |
| 81454 | 2218.96 | 205.35 | | | | | | |
| 4 JAN 82 | | | | | | | | |
| 81455 | 6.61 | 232.65 | 81456 | 154.26 | 259.96 | 81457 | 341.91 | 287.26 |
| 81458 | 529.56 | 314.57 | 81459 | 717.21 | 341.87 | 81460 | 904.86 | 9.17 |

PART III. REDUCTION TO OTHER LATITUDES AND HEIGHTS FOR REV 81425

| LAT N | MINUTES PLUS | L CORR | HT KILOM | LAT S | MINUTES PLUS | L CORR | HT KILOM |
|---|---|---|---|---|---|---|---|
| SN 0 | 0. | 0. | 1188.3I | NS 0 | 55.34 | 166.73 | 1050.0 |
| SN 5 | 2.31 | 354.88 | 1210.0I | NS 5 | 57.55 | 161.59 | 1029.4 |
| SN 10 | 4.65 | 349.62 | 1230.8I | NS 10 | 59.77 | 156.30 | 1010.6 |
| SN 15 | 7.06 | 344.07 | 1250.3I | NS 15 | 62.03 | 150.71 | 993.7 |
| SN 20 | 9.57 | 338.00 | 1268.2I | NS 20 | 64.36 | 144.60 | 978.8 |
| SN 25 | 12.24 | 303.82 | 1284.7I | NS 25 | 66.83 | 137.66 | 966.3 |
| SN 30 | 15.18 | 295.57 | 1297.9I | NS 30 | 69.52 | 129.35 | 956.7 |
| SN 35 | 18.64 | 284.76 | 1307.2I | NS 35 | 72.67 | 118.46 | 950.9 |
| SN 40 | 23.77 | 266.44 | 1307.6I | NS 40 | 77.33 | 100.02 | 953.3I |
| N PT | 28.00 | 249.81 | 1295.8I | S PT | 81.19 | 83.30 | 964.8I |
| NS 40 | 32.21 | 233.15 | 1273.6I | SN 40 | 85.07 | 66.56 | 984.3I |
| NS 35 | 37.27 | 214.81 | 1235.1I | SN 35 | 89.79 | 48.13 | 1017.2I |
| NS 30 | 40.65 | 203.98 | 1203.5I | SN 30 | 93.01 | 37.26 | 1044.3I |
| NS 25 | 43.51 | 195.72 | 1174.4I | SN 25 | 95.77 | 28.37 | 1069.8I |
| NS 20 | 46.10 | 188.81 | 1146.9I | SN 20 | 98.31 | 22.05 | 1094.5I |
| NS 15 | 48.53 | 182.73 | 1120.6 | SN 15 | 100.72 | 15.96 | 1118.7I |
| NS 10 | 50.85 | 177.15 | 1095.7 | SN 10 | 103.05 | 10.39 | 1142.5I |
| NS 5 | 53.12 | 171.87 | 1072.1 | SN 5 | 105.36 | 5.12 | 1165.7I |
| NS 0 | 55.34 | 166.73 | 1050.0 | SN 0 | 107.65 | 360.00 | 1188.3I |

Figure 4-5, Example NASA Prediction Bulletin

**Line 1**

| Column | Description |
|---|---|
| 01 | line number of element set |
| 02 | blank |
| 03-07 | satellite number |
| 08 | not applicable |
| 09 | blank |
| 10-11 | last two digits of launch year |
| 12-14 | launch number of the year |
| 15-17 | piece of launch |
| 18 | blank |
| 19-20 | last two digits of epoch year |
| 21-32 | day and fractional day of epoch year |
| 33 | blank |
| 34-43 | ndot2 - first time derivative of mean motion |
| 44 | blank |
| 45-52 | nddot6 - second time derivative of mean motion |
| 53 | blank |
| 54-61 | bstar - drag term |
| 62 | blank |
| 63 | ephemeris type |
| 64 | blank |
| 65-68 | element set number |
| 69 | check sum Modulo 10; letters, blanks, periods = 0; minus sign (-) = 1; plus sign (+) = 2 |

**Line 2**

| Column | Description |
|---|---|
| 01 | line number of element data |
| 02 | blank |
| 03-07 | satellite number |
| 08 | blank |
| 09-16 | inclination |
| 17 | blank |
| 18-25 | right ascension of ascending node |
| 26 | blank |
| 27-33 | eccentricity (leading decimal point assumed) |
| 34 | blank |
| 35-42 | argument of perigee |
| 43 | blank |
| 44-51 | mean anomaly |
| 52 | blank |
| 53-63 | mean motion |
| 64-68 | revolution number at epoch |
| 69 | check sum Modulo 10; letters, blanks, periods = 0; minus sign (-) = 1; plus sign (+) = 2 |

Figure 4-6, NASA Two Line Orbital Element Format

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# SECTION V - Station Control Program (SCP)

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### 5.1.0 SCP GENERAL DESCRIPTION

**GT** has two methods for station control. The first method is built-in to the **GT** program and will output control data to communications ports in a format compatible with the ARRL antenna controller and Yaesu FRG-9600 receiver. The second method will output data to a user-written control program through a software interrupt. The two methods are normally mutually exclusive but **GT** can do them both simultaneously.

When **GT** is performing antenna control, the antenna controller will normally return current position information. If this information is received by **GT**, it will be displayed on the screen as shown in figure 5-1.

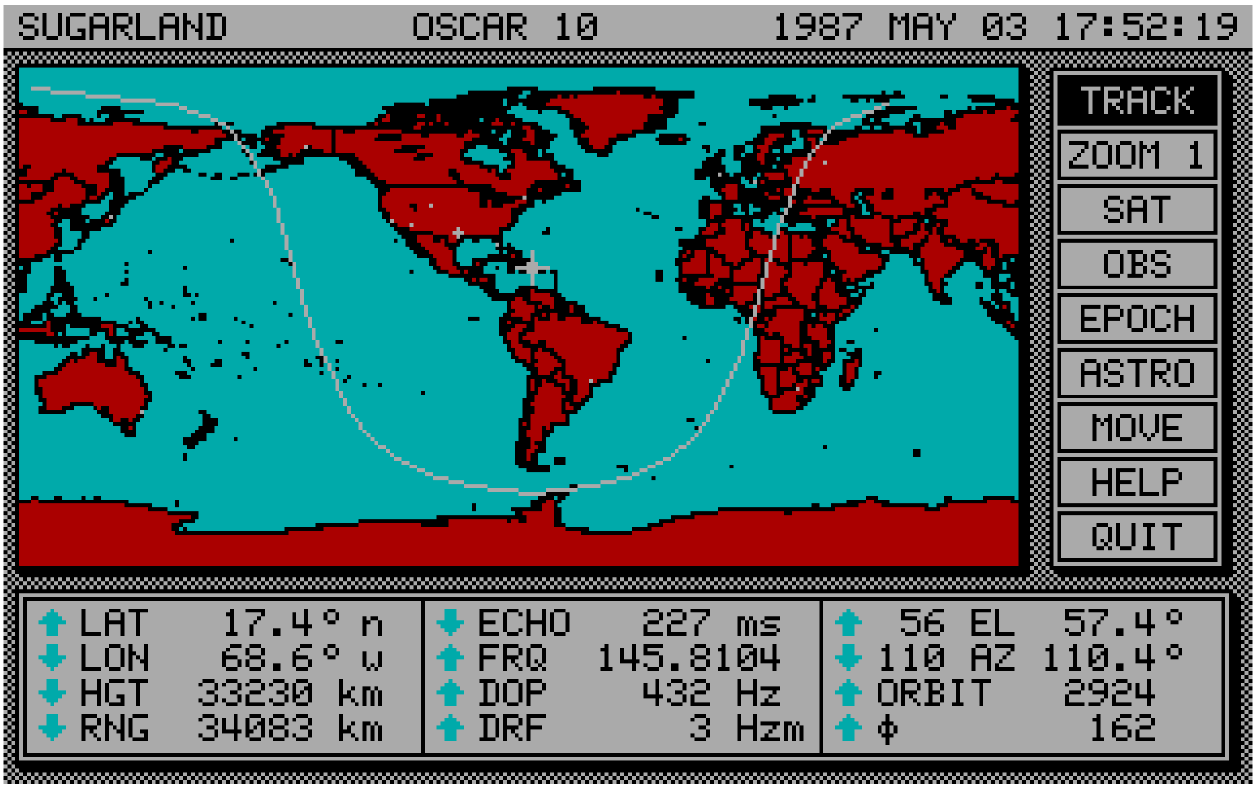


Figure 5-1, Typical **GT** Antenna Position Display

### 5.1.1 Built-in Method

To use the built-in method, place the token **AC** and/or **RX** in the command line followed by the communications port number. If the clock is in the real-time mode and the object elevation is greater than zero then every display update cycle **GT** will output the current elevation and azimuth and read back the current antenna position. The token **TRA** (**TR**ack **A**lways) may be added to the **GT** command line to cause the control output to occur even if the clock is not in real-time or the elevation is negative. **TRA** mode is handy for tests and demonstrations but of course will cause the rotators to be updated continuously. In any event, negative elevations will be output as zero. If the **RX** token and associated communications port number have been specified, **GT** will output receiver tuning information every display update cycle.

### 5.1.2 User Written Interrupt Method

To use the interrupt method, the user must load a resident control program before loading **GT**. **GT** will invoke the control program every cycle by calling it through a software interrupt. This interface is described in detail in a following section. A working example of a user control program is supplied with the **GT** package along with instructions on how to assemble it.

### 5.1.3 ARRL Antenna Control Protocol

**GT** uses a subset of the ARRL antenna controller command protocol. Only those commands that are used will be described here. A full description of the protocol may be found in the August, 1986 issue of QST magazine.

| | |
|---|---|
| PA xxx<CR> | set elevation to xxx degrees. |
| PB yyy<CR> | set azimuth to yyy degrees. |
| P<CR> | report position in the format<br>xxx yyy<CR><LF><br>where xxx is the current elevation<br>and yyy is the current azimuth. |

The controller must send position data only when requested by **GT**. **GT** expects exactly nine characters in response to the [**P**] command.

5.1.4 Yaesu FRG-9600 Receiver Frequency Control Protocol

**GT** uses a subset of the Yaesu FRG-9600 **CAT System** command protocol. Only the frequency set command is used. A full description of the protocol may be found in the FRG-9600 OPERATING MANUAL. Each cycle, **GT** will send out five bytes of data as shown in the following example:

| Byte | Contents | Description |
|---|---|---|
| 1 | 0AH | frequency set command |
| 2 | 43H | hundreds and tens of MHz |
| 3 | 57H | units of MHz, hundreds of kHz |
| 4 | 97H | tens and units of kHz |
| 5 | 20H | hundreds of Hz |

In this example, the frequency of the FRG-9600 will be set to 435.7972 MHz.

### 5.2.0 THE USER INTERRUPT INTERFACE

The interrupt interface is designed for use with a user written station control program. It may be used by itself or in conjunction with the built-in interface. A sample program is included in source format that the user may modify to suit his specific needs.

The user program must be a "terminate and stay resident" type program which is loaded prior to loading **GT**, and is implemented using a pair of the 8088/8086 software interrupt vectors. The first vector (103d) is loaded with a specific code to identify the presence of the user program. The second vector (104d) is used for the actual software interrupt. **GT** checks for the presence of the code word in vector 103 and if it is present issues a software interrupt 104 to the user program. Various parameters including elevation, azimuth, and Doppler corrected beacon frequency are sent to the user program in the CPU registers. The user program must then return current antenna position in the specified registers.

The code word is in the offset portion of interrupt vector 103 as shown here:

| seg:off | value |
|---|---|
| 0000:019C | AF |
| 0000:019D | DE |

The default interrupt vector pair can be changed to another vector pair if they are found to interfere with other functions within your PC. See the description of the **ISCP** command line token in Section II.1.8 of this manual.

There are three functions issued by **GT** through the software interrupt. The AL register contains the function number which is either 0, 1 or 2.

5.2.1 Description of Function 0

Function 0 is the normal data command. The register contents are described as follows:

| | | |
|---|---|---|
| AL | = | 0, defines function 0, data command |
| BX | = | azimuth in degrees |
| CH | = | observer number (1-16) |
| CL | = | object code 1-16 = satellite |
| | | 90 = sun |
| | | 91 = moon |
| | | 92 = star |
| DX | = | elevation in degrees (0 if negative) |
| ES | = | beacon freq MHz part |
| SI:DI | = | beacon freq Hz part |

The user program must return the current antenna location as follows:

| | | |
|---|---|---|
| BX | = | current azimuth in degrees (0xFFFF if none) |
| DX | = | current elevation in degrees (0xFFFF if none) |

The other registers may contain any value as they are not used on the return to **GT**.

The following example shows the register contents of a typical user program invocation from **GT**. The satellite elevation is 10 degrees, azimuth is 340 degrees, and the apparent beacon frequency is 435.797123 MHz.

| reg | hex | decimal | description |
|---|---|---|---|
| AL | 00h | 0 | data command |
| BX | 0154h | 340 | azimuth in degrees |
| CH | 01h | 1 | observer number 1 |
| CL | 01h | 1 | satellite number 1 |
| DX | 000Ah | 10 | elevation in degrees |
| ES | 01B3h | 435 | MHz part of beacon freq |
| SI:DI | 000C29C3h | 797123 | Hz part of beacon freq |
| SI | 000Ch | | most significant half of Hz |
| DI | 29C3h | | least significant half of Hz |

5.2.2 Description of Function 1

Function 1 will be invoked when the **GT** operator presses the [**R**] key. **GT** will save the graphics screen and pass control the user program with the AL register set to one (1). This mode is intended to allow the user program to communicate with the operator using the screen for whatever it needs. When the user program is done, it will return to **GT**. **GT** will then restore the graphics screen and continue.

5.2.3 Description of Function 2

Function 2 will be invoked when **GT** desires only to read the current position of the antenna control rotators. **GT** will pass control to the user program with the AL register set to two (2). The contents of the other registers are not significant.

The user program must return the current antenna location as follows:

BX = current azimuth in degrees (0xFFFF if none)
DX = current elevation in degrees (0xFFFF if none)

The other registers may contain any value as they are ignored on return to **GT**.

## 5.3.0 THE EXAMPLE USER CONTROL PROGRAM

This section describes the procedure for assembling, linking, and loading the user **Station Control Program (SCP)** as supplied with **GT**.

5.3.1 How to Assemble and Link the User Control Program

The file SCP.ASM contains the complete source code for a working user control program. As supplied, it will perform in the same manner as the built-in ARRL interface. The following set of commands will assemble the program and create an executable module called SCP.COM.

```
masm scp,,,;
link scp,,,;
exe2bin scp.exe scp.com
del scp.exe
```

The first line causes the file SCP.ASM to be assembled producing the file SCP.OBJ. The second line causes the file SCP.OBJ to be converted to the file SCP.EXE. It is normal for this step to produce the warning message:

```
Warning: no stack segment
```

The third line converts the file SCP.EXE into an executable file called SCP.COM and the fourth and last line will delete the file SCP.EXE which is no longer needed. After these four steps have been performed, **SCP** is ready to be used.

5.3.2 Startup of the User Station Control Program

**SCP** requires two command line tokens. The first token specifies the communications port to be used for the antenna rotator control interface. The second token specifies the communications port to be used for the receiver frequency control interface. **SCP** will normally output ARRL format rotator controller data through communications port 1, and Yaesu FRG-9600 format receiver frequency control data through communications port 2.

The following is a list of the valid combinations of command line tokens that will be accepted by **SCP**:

scp **a** 0 ; antenna controller on COM **a**, no receiver
scp 0 **r** ; no antenna controller, receiver on COM **r**
scp **a** **r** ; antenna controller on COM **a**, receiver on COM **r**

where

**a** = 1, 2, 3 or 4
**r** = 1, 2, 3 or 4

and

**a** and **r** are mutually exclusive.

The communications port baud rate and mode must be set by using the DOS MODE command prior to loading **SCP**. The following example shows a typical command line sequence for **SCP** startup:

```
mode com1:2400,n,8,2
mode com2:4800,n,8,2
scp 1   2
gt ...
```

The first line sets the COM1 port to 2400 baud, no-parity, eight data bits, and two stop bits. The second line sets the COM2 port to 4800 baud, no-parity, eight data bits, and two stop bits. The third line causes SCP.COM to be loaded and told to use the COM1 port for the rotator control interface and the COM2 port for the receiver frequency control interface. The fourth line is the normal **GT** invocation.

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