Computerland of Colorado Springs
4543 Templeton Gap Road
Colorado Springs, CO 80918

SAT TRAK INTERNATIONAL

Program Description and Operating Manual

(All BASIC Versions)

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Throughout this manual there are references to TRS-80, Apple and SORCERER. TRS-80 is the registered trademark of TANDY Corp. Apple is the registered trademark of Apple, Inc. and SORCERER is the registered trademark of Exidy, Inc.

INTRODUCTION

1. The astrodynamic programs which you have received along with this manual represent state-of-the-art mathematics and computer programming techniques. These programs have been quality control tested prior to shipment and will be replaced at no cost if the cassette or disk is mechanically defective or if it fails to operate properly on the system it is specified for. No other expressed or implied warranty applies. Programs disks or cassettes that have been altered or tampered with in any way will not be replaced.

2. SAT TRAK INTERNATIONAL (STI) is not responsible for any damages or claims resulting from the use of this software. Also, STI cannot be held responsible for overall accuracy since the outputs from the various programs depend upon NASA supplied data (satellite orbital elements*). Information on how to obtain this public information from NASA is supplied on pages 3 and 4.

3. Depending on your order, you may or may not have received all of the astrodynamic programs, TRAK, LOOK and OBS. In any case, a brief description of each program follows. Some minor differences in operator responses and output format will exist for the various computers for which the software is designed. **(SEE APPENDIX D & E FOR LOADING INSTRUCTIONS)**

4. Program Descriptions:

TRAK** - Given either NASA elements* or OBS produced elements, input times of interest and time increment; the program generates an ephemeris* of geodetic latitude*, east longitude, and height in kilometers above mean sea level. For Sorcerer and TRS-80, right ascension* and delination* are also output. Output may also be plotted on a full screen world map display.

LOOK** - Given either NASA elements or OBS produced elements, input times of interest and time increment; latitude, longitude and height in feet above mean sea level for your location; the program generates a series of "look angles*" in the form of azimuth*, elevation*, right ascension and declination which can be used to acquire the satellite. The range* to the satellite in kilometers is also output. Certain constraints on this output may be specified by the operator, e.g., maximum range, visual passes only, minimum elevation, etc.

OBS - Given either NASA elements or OBS produced elements and a culmination* time actually observed by the operator, the program generates an updated and corrected element set* which will have an epoch* at the observed culmination time.

CONTROL - DISC version executive program.

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*See glossary.

**Apple II versions do not output right ascension or declination. If you would prefer this output simply substitute AL for A8 and DC for E8 in lines 3062 and 3064 in program LOOK. The heading should also be changed in line 4240.

WORLD/-GRAF These are unlabled machine language routines used by SORCERER TRAK program to produce the world map. WORLD also includes 2 printer driver routines. With TRAK loaded and operating in the monitor:

SET 0 = 3ECØ, activates the SORCERER serial RS-232 port

SET 0 = 3EEØ, activates the parallel port (cable connected)

5. DATA MANAGEMENT - Another program you have received is UPDAT**(UPDATE in disc version). Both APPLE II and SORCERER cassette versions operate a 30 satellite data base master file array called MD (29,23). Each satellite file consists of 14 satellite elements + 10 spaces for a satellite name. The 10 characters of each satellite name are converted to ASC II code for storage and this allows the alphanumeric strings to be stored numerically on casette tape. Disc versions for TRS-80 and APPLE II operate a MASTER/DTA file of up to 50 satellites and with the exception of disc commands both UPDAT and UPDATE operate much the same. By changing the MD array size your master data file can be expanded to your system limit. UPDAT/UPDATE produce a second numerical data file array called DBASE (9,23), (WKFILE for disc). This file contains any 10 satellites selected from the master file and is the actual data array used for each of the working programs. When new elements are received from NASA or produced by your input to OBS, these numerical values are entered into the master file using UPDAT. Similarily existing values can be deleted or modified as required and a new DB or WKFILE produced. At any time the existing data in the master file can be examined and worked on at random.

6. In case of difficulty or suspected error in any program, simply write STI, including a complete description of the problem and all inputs (including element set) used and all outputs generated. Your inquiry will be handled promptly.

7. In addition, our development staff would be pleased to receive any suggestions for improvement, or new programs which you would like to see offered in future software. Correspondence of this type, including reports on how you are using SAT TRAK software, should be addressed (ATTENTION DEVELOPMENT: MR. W. BARKER.) using the SAT TRAK address on Page 4.

8. Program accuracy is highly time dependent and the older the element set the less accurate the prediction. Similarily, accuracy differences are apparent because of a particular orbit, stage of decay, or drag coefficient due to satellite size, shape, or stability.

9. Program listings or modifications can be obtained anytime by sending $5 to SAT TRAK International c/o the SAT TRAK address on Page 4. Listings will only be supplied to users who return the registration card. Please quote your SAT TRAK registration number located in the upper right corner of the card.

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*See glossary.

**Inputs and prompts for UPDATE (the disc version) are given on page 5. The exact cassette prompts are not given but are generally the same with the notable exception that the cassette program does not use the DATA SORT function. TRS-80 cassette version stores the satellite name with each element set as it is saved. As a result the data arrays are sized at 0 to 13 instead of 0 to 23. (See Appendix E on page 19 for notes on loading and using APPLE and TRS-80 disc versions.

1.1 NASA BULLETIN FORMAT

The numbers which describe a satellites orbit are called "orbital parameters" or "satellite elements". These are calculated for a specific time called an "epoch time" and are a 2 line series of numbers which the National Aeronautics and Space Administration - (NASA) has made available at no cost. NASA will supply these elements to any individual, institution or school who will make practical use of the material and not abuse or overload their capability to supply this data.

If you know which satellites interest you simply write to the "Code 512" address on page 4 and request that you be put on distribution for these satellite elements. You should note the satellite number, and International Designator (ID)* of each element set you request. Note that NASA does not make the entire catalog available and does not publish elements for rocket bodies or debris older than 2 years.

If you do not know the sat number or ID of the satellite you want you may request the SATELLITE SITUATION REPORT from the "Code 202" address for this purpose. (See sample page if included). The SATELLITE SITUATION REPORT is published quarterly and gives a complete listing and information on earth satellites by both satellite number and international designator. From this you can pick satellites of interest to you. If you are interested in visually acquiring satellites without a telescope, you must pick large satellites which are in low orbits (check apogee and perigee height less than 800-1000 km) otherwise you may not see them.

Five satellites of possible interest are:	SAT	ID
1. SEASAT A - a large US Navy test satellite	- #10967	78-064A
2. SALUT 6 - the Soviet Space Station	- #10382	77-097A
3. OSCAR 8 - the Ham Radio Relay Satellite	- #10703	78-026B
4. OSCAR 7 - another earlier HAMSAT	- #7530	74-089B
5. RADIO 1 - the Soviet Ham Satellite	- #11085	78-100B

NASA elements will be mailed to you in the following format:

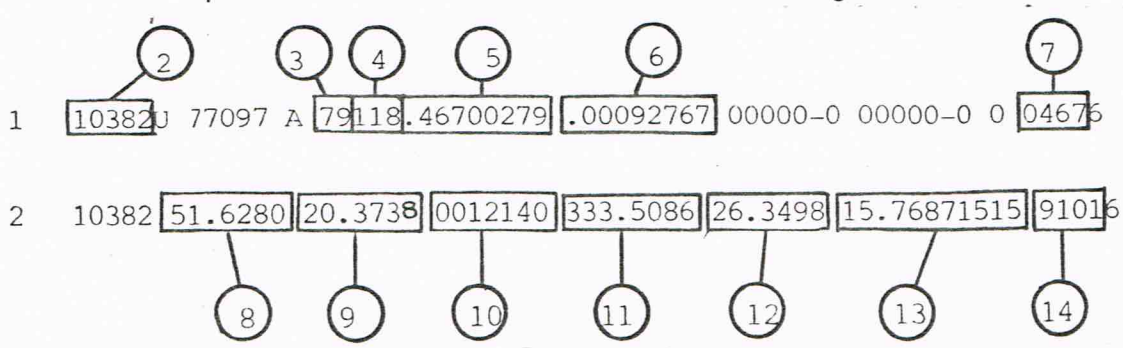
NASA PREDICTION BULLETIN NASA 51004

NASA GODDARD SPACE FLIGHT CENTER, CODE 512, GREENBELT, MD. 20771

ISSUE DATE: April 30, 1979

```
BLTN 467 ELEM 467  OBJ 10382  77097  A          ; IN 3 PARTS, PART I
1 10382U 77097  A 79118.46700279  .00092767  00000-0  00000-0 0 04676
2 10382  51.6280  20.3738 0012140 333.5086  26.3498 15.76871515 91016
```

The satellite orbital elements are contained in the last two lines. Each satellite entry must contain all 14 parameters on two data lines in the following order:



*See glossary.

ENTRY

Data entry:

1 = 1 to N = data base entry number (0 to 9 only for TRS-80 cassette)
2 = 10382 = satellite number
3 = 79 = epoch year
4 = 118 = epoch day
5 = .46700279 = epoch fraction of day
6 = .00092767 = period decay rate* (revs/day squared)
7 = 467 = element set number
8 = 51.628 = inclination* (degrees)
9 = 20.3738 = right ascension of node* (degrees)
10 = .001214 = eccentricity*
11 = 333.5086 = argument of perigee* (degrees)
12 = 26.3498 = mean anomaly* (degrees)
13 = 15.76871515 = mean motion* (revs/day)
14 = 9101 = epoch revolution* (revs)

Notice that in the case of eccentricity, 10, the decimal point is implied at the left in the NASA BULLETIN. This decimal must be entered into the data. Also, the last digit in each line should be ignored (6 in the example).

To order the SATELLITE SITUATION REPORT write to:

NATIONAL SPACE SCIENCE DATA CENTER
CODE 202
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GREENBELT, MD 20771

To request the NASA PREDICTION BULLETIN write to:

OPERATIONS CENTER BRANCH
CODE 512
MISSION OPERATIONS DIVISION
GODDARD SPACE FLT CENTER
GREENBELT, MD 20771

For customer service, or software support write to:

SAT TRAK International
c/o Computerland
4543 Templeton Gap Rd.
Colorado Springs, CO 80918

****
IMPORTANT NOTICE

PLEASE KEEP THE NUMBER OF SATELLITES REQUESTED TO A MINIMUM. ASK FOR ONLY THOSE YOU INTEND ON USING REGULARLY AND YOU MAY REVISE YOUR REQUEST AS REQUIRED.
****

*See glossary.

1.2 UPDATE OPTIONS (DISC, CASSETTE similar)

OPTION	DISPLAY	INSTRUCTION/RESPONSE
1 NEW DATA	**INPUTING FROM DISC**	Hit key "1". Cassette versions will ask only for NEW or ADD data.
	DO YOU WISH TO BUILD A MASTER FILE/ WARNING YES WILL DELETE CURRENT FILE (YES or NO)	ENTER "YES" or "NO" note - warning - "NO" will load the current MASTER/DTA file and display it.
	YOU ARE DESTROYING MASTER FILE. ARE YOU SURE? (YES or NO)	"YES" will produce the response at left. (This is only for starting a completely new data base)
	SATELLITE NAME/	ENTER name (i.e. SKYLAB) less than 8 alphanumerics for Apple. Less than 10 for TRS-80 and SORCERER (because of display limitations).
	DATABASE ENTRY #XX 2. SATELLITE # 3 EPOCH YEAR 4 EPOCH DAY 5 FRACTIONAL DAY 6 PERIOD DECAY RATE 7 ELEMENT SET # 8 INCLINATION 9 RIGHT ASCENSION 10 ECCENTRICITY 11 ARGUMENT OF PERIGEE 12 MEAN ANOMALY 13 MEAN MOTION 14 EPOCH REV	ENTER data from NASA or OBS element set for each prompt (see pages 3 and 4). note: at 14 - STOP - before hitting return, check the data for correctness. Any errors noted can be easily corrected later under option 2 (option 3 on cassette)
	SKYLAB - LAST ENTRY ANOTHER SATELLITE (YES or NO)	"YES" will return the above sequence until the MASTER/DTA file is full. "NO" will cause the current file to be saved and return to the UPDATE option menu.
2 CHANGE DATA	**INPUTING FROM DISC** CURRENT MASTER FILE IS DISPLAYED	Hit key "2"
	RETURN	Hitting return will display the rest of the DATA FILE if it is over 30 satellites. Otherwise, it will give the next prompt.
	SELECT SATELLITE NO FILE TO CHANGE (Ø = EXIT)	Enter the file number of the first satellite file to be modified.

	SELECT SAT FILE TO BE CHANGED OR (D = DELETE E = EXIT) ENTER NEW VALUE FOR #XX	Select number 1 through 14 (RETURN) ENTER the new values (RETURN) and the modified file will be displayed again for another change or EXIT. "E" will cause return to UPDATE MENU
3 SORTS DATA	**INPUTING FROM DISC** MASTER/DTA FILE IS DISPLAYED	Hit key "3". (Not an option for cassette versions) press (RETURN)
	ORDERING AND REPACKING	(no input required)
	OUTPUTING TO DISC	Return to UPDATE MENU is automatic.
4 BUILD WKFILE	**INPUTING FROM DISC**	Hit key "4"
	MASTER FILE IS DISPLAYED (RETURN) SELECT UP TO 10 SAT-ELLITES (E=EXIT)	RETURN displays the rest of the master file or next prompt. ENTER satellite file number and ENTER "E" when done (no more than 10 selections)
	OUTPUTING TO DISC	"E" will output a new WKFILE to disc and return to UPDATE MENU.
5	RETURN TO CONTROL	Hit key "5" (not a cassette option)

2. TRAK

	SEQUENCE	DISPLAY	INSTRUCTION/RESPONSE
1.	Loading	READY	Enter CLOAD TRAK, start tape player and hit RETURN (ENTER for TRS-80)
2.	Data base load	START DATA TAPE AND HIT RETURN	Find the start of a DB data array on tape. Press play on recorder and hit RETURN (use only DB array.) The WK/FILE loads automatically on disc versions.
3.	Satellite selection	SATELLITE DATA BASE SELECT SATELLITE?	Select any number 1 to 10 and hit RETURN (or ENTER for TRS-80)
4.	Date time selection	TIME OF INTEREST - ENTER YY/DDD/HH/DDD/HH	Enter year (last two digits), start day (integer) from beginning of year, start hour or decimal fraction of hour, end day, end hour, e.g., for April 10, 1979 at noon to April 11, 1979 at noon, enter 79,199,12,101,12 and hit RETURN. All times are Greenwich Mean Time** (GMT). If no values are input for start time the Greenwich Mean Time** (GMT). If no values are input for start time the program will default to the satellite epoch time.
5.	Interval selection	OUTPUT INTERVAL-DEFAULT 10 MIN.?	Enter even or decimal fraction of minutes, e.g., 15.5 will output a point every 15 minutes, 30 seconds. If a value is not input the program will default to a 10 minute interval.
6.	Select Map	SELECT WORLD MAP (W) or TABLE (T)	Enter W or T
7.	Lines output selection	LINES PER FRAME	Hitting RETURN or ENTER here will limit the number of output lines (if you do not have a printer) and the program will wait as soon as the screen is full. Entry of any number other than zero will result in continuous output until end time is reached or an interrupt is encountered.

**See glossary.

8.	Output	Header is printed, output continues until end time is reached or screen is full. First output should come in approx. 10 to 15 sec.	This may be interrupted by pressing CTRL C or RUN/STOP key or BREAK KEY. RUN/STOP key will only halt calculation when pressed. CTRL C or BREAK will cause a program break. The satellite data base may be recalled by a direct GO TO 400 in the case of SORCERER. GO TO 600 for TRS-80. GO TO 620 for Apple.
9.	Output	RETURN TO CONTINUE or ENTER TO CONTINUE	Screen is full and end time is not reached. Hit RETURN to continue.
10.	Finished with case	CALCULATION COMPLETE NEW TIME OF INTEREST Y/N	Enter Y for yes Enter N for no
11.	Next Satellite	NEW SATELLITE Y/N	Enter Y for yes Enter N for no
12.	New data base	NEW DATA BASE Y/N	Enter Y for yes Enter N for no
13.	Finished	END OF PROGRAM. BREAK AT 3120 READY	To restart program, enter GO TO 3000 for SORCERER GO TO 1700 for Apple and TRS-80 disc or cassette. Disc versions return automatically to CONTROL Program

Notes on TRAK: (For improved accuracy over screen resolution)

TRAK does not take into account your location or Earth/Sun geometry and therefore outputs much faster than LOOK or OBS. If you have a world map handy, you can plot orbits and times on an acetate overlay to quickly see where the satellite is at any time. By making the orbit trace accurate the first time, you need only to shift the acetate overlay to find the entire ground trace for the next revolution. If desired, you can use the NASA BULLETIN to get ascending node* crossings. In this manner, you can very quickly determine when the satellite will be in your local area. Now you can rerun TRAK with a smaller time of interest and a smaller time increment and produce a very accurate ground trace for your immediate area. This can then be plotted by using an Atlas map of your state or province. (If you have program LOOK, it can be used to find the times, azimuth and elevation, when a satellite will be visible in your area.)

TEST INPUTS - **TEST**

-TIME- 79, 120, 2.4, 125, 2.4
-INTERVAL-1440
-Select T for table
-LINES PER FRAME DEFAULT

```
(()))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))(
( POSITION OF ** TEST ** 0          EPOCH DAY 123 AT 5.78391 HRS(
(                                   START DAY 120 AT 2.4     HRS(
( PERIOD       100.696 MIN.         END   DAY 125 AT 2.4     HRS(
( INCLINATION  108.017 DEG.         OUTPUT INTERVAL  1440    MIN(
(*************************************************************(
*      TIME      "LATITUDE"EAST LONG"   RA    "   DEC  "ALTITUDE"
"YY"DDD"HH"MM"SS "DEGREES " DEGREES " DEGREES" DEGREES"   KM    "
 79 120 2  24 0    33.2916  343.265   236.708  33.1349  796.437
 79 121 2  24 0    36.3286  190.337   84.7652  36.1655  796.004
 79 122 2  24 0   -62.0354  140.128   35.542  -61.8939  814.381
 79 123 2  24 0   -5.38566  .449946   256.85  -5.35379  794.206
 79 124 2  24 0    69.1354  237.786   135.172  69.0214  805.408
 79 125 2  24 0   -26.1797  171.677   78.0485 -26.0446  798.721
CALCULATION COMPLETE
```

3. LOOK

	SEQUENCE	DISPLAY	INSTRUCTION/RESPONSE
1.	Loading	READY	Enter CLOAD LOOK, start tape player, and hit RETURN
2.	Load data BASE	START DATA TAPE AND HIT RETURN	Find a DB array on tape Press play on recorder and hit RETURN (the WK/FILE will load automatically on disc versions)
3.	Input observation site	LATITUDE LONGITUDE ALTITUDE - FT AMSL*	Enter LAT/LONG in degrees or decimal fraction, altitude in feet above mean sea level (AMSL), e.g., when doing TEST use, Colorado Springs, enter N, 38.62, E, 255.431, 6250 and hit RETURN. Longitude may be entered either east or west (E or W, 0^{o} to 360^{o}). Geodetic latitude may be entered north or south (N or S, 0^{o} to 90^{o})
4.	Satellite selection	SATELLITE DATA BASE SELECT SATELLITE?	Select any number 1 to 10 and hit RETURN (ENTER)
5.	Set range limit	SATELLITE - NAME SET MAX RANGE (KM), DEFAULT INFINITY	To default, hit RETURN. You may limit the maximum range for which output will occur. This allows you to reduce the amount of output when you are interested only in near passes. The max range at which satellites are visible is highly variable, therefore, this option should only be exercised after experience has been gained.
6.	Set visible limit	SELECT ALL PASSES DEFAULT VISIBLE PASSES ONLY	Enter ALL for all passes regardless of Sun/Earth shadow geometry. Hit RETURN to output only passes with your position in darkness and satellite in sunlight.
7.	Set minimum elevation	SET MINIMUM PASS ELEVATION DEFAULT TO 10 DEGREES	Hit RETURN to default. If desired, enter number of degrees, e.g., an entry of 20.1 will cause the program to generate only those look angles that have elevations above 20.1 degrees. An entry of .01 degrees will allow passes down to the horizon. Normally, satellites can only be seen visually above 10 degrees elevation. ***

*See glossary.

***Negative values are acceptable, and useful when listening for OSCAR satellites.

8.	Set time of interest	TIME OF INTEREST ENTER YY/DDD/HH/DDD/HH	Enter year (last two digits), start day (integer) from beginning of year, start hour or decimal part of hour, end day, end hour, e.g., for April 10, 1979 at 3:15 p.m. to April 10, 1979 at 3:15 p.m. enter 79,100,15.25,101,15.25 and hit RETURN. All times are Greenwich Mean Time** (GMT). If no values are input for start time the program will start at the satellite element set epoch.
9.	Output time interval	SET OUTPUT INTERVAL MIN ? DEFAULT TO 1 MINUTE	Hit RETURN to default. This interval defines the time between output points within a satellite pass. Inputs larger than 10 minutes will usually cause only one output point to be generated - the culmination or highest elevation point. Very small inputs can produce large amounts of data.
10.	Output	LINES PER FRAME	Hit RETURN to default. This will limit the number of output lines if you do not have a printer and the program will wait as soon as the screen is full. Entry of any number other than zero will result in continuous output until the end time is reached or an interrupt is encountered.
11.	Output	Header is printed and computation begins:	Output will not commence until a suitable pass, if any, is found. If this satellite is <u>never</u> near enough in latitude to your location an immediate prompt, SATELLITE NEVER VISIBLE FROM YOUR LOCATION, results. A time delay begins and the satellite data base display will return after a few seconds for another selection (Go back to 4.) If no pass is suitable, i.e. fails one or more tests, then the prompt, NO SUITABLE PASS FOUND, occurs.
	note:	first output may not begin for from 1 to 3 minutes. A full days looks may take approx. 15 min. to complete.	
12.	Computation for this case complete	NEW PASS LIMITS AND TIME OF INTEREST Y/N?	Enter Y = yes Enter N = no
13.	New satellite	NEW SATELLITE Y/N?	Enter Y = yes Enter N = no

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**See glossary

14.	New observation site	NEW OBSERVATION SITE Y/N?	Enter Y = yes Enter N = no
15.	New data base	NEW DATA BASE Y/N?	Enter Y = yes Enter N = no at this point terminates the program. To restart do a direct GO TO 3000 for SORCERER GO TO 3180 for Apple and TRS-80. Disc versions automatically return to CONTROL program.

Notes on LOOK: (see also notes on Page 13)

Your local geodetic latitude, longitude and height in feet above mean sea level can be approximated from a map or world atlas if more accurate information cannot be obtained.

Look is the slowest running of the programs because of the large number of computations required when considering SUN/EARTH SHADOW geometry. Therefore, do not be alarmed if nothing happens right away after start of execution. (TRS-80 versions use a blinking square, SORCERER says "STAND BY to indicate normal function.).

Sometimes, due to the particular type of orbit of a satellite, visual look angles will not appear for several days. This phasing effect is most noticeable on low altitude and decaying satellites such as SALUT-6 or SKYLAB . If in doubt, execute the same time interval and request "ALL" passes. You should see passes generated but probably at the GMT time of your local day when you are in daylight. If still in doubt, reaccomplish the test sequence given below.

Highly eccentric orbits and synchronous orbits exercise slightly different logic during LOOK computations. Use large (30 min. or greater) output intervals initially to avoid excessive output data until you see which available passes or times are best.

TEST INPUT-**TEST**

SITE-N, 38.62, E, 255.431, 6250
RANGE-default
VISIBILITY-default
ELEVATION-.01
TIME-79,128,0,128,10
OUTPUT-default
LINES/FRAME-default

```
 OBSERVATION SITE N 38.62 E 255.431   ALT 6250 FT AMSL

()))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))))(
( LOOK ANGLES FOR ** TEST ** 0      EPOCH DAY 123 AT 5.78391 HRS(
(                                   START DAY 128 AT 0       HRS(
( PERIOD      100.696 MIN.          END   DAY 128 AT 10      HRS(
( INCLINATION 108.017 DEG.          OUTPUT INTERVAL  1       MIN(
(**************************************************************(
"     TIME      " AZIMUTH "ELEVATION"  RA    "  DEC   " RANGE  "
"YY"DDD"HH"MM"SS " DEGREES " DEGREES "  DEG  "  DEG   "  KM    "
 79 128 6  52 14   69.0962   10.1716   319.049  22.6196  2348.69
 79 128 6  53 14   57.9305   11.8391   325.44   32.2801  2231.19
 79 128 6  54 14   45.8475   12.4328   334.599  41.7472  2192.05
 79 128 6  55 14   33.7856   11.8114   347.333  49.7621  2235.88
 79 128 6  56 14   22.7011   10.1275   3.50537  55.0143  2357.62
 79 128 6  57 14   13.1231   7.7393    20.9034  56.9316  2545.99
 79 128 6  58 14   5.16538   4.99928   36.2619  56.0536  2786.81
 79 128 6  59 14   358.665   2.14764   47.9994  53.5072  3066.96
(;;;;;;;;=
 79 128 8  32 52   352.918   57.2416   237.519  70.8081  926.596
 79 128 8  33 52   343.506   37.9599   161.712  77.0544  1195.36
 79 128 8  34 52   340.238   25.5021   127.314  68.8078  1539.2
 79 128 8  35 52   338.651   17.017    116.752  61.4607  1917.37
 79 128 8  36 52   337.76    10.7638   111.639  55.7938  2310.87
 79 128 8  37 52   337.223   5.79941   108.447  51.2382  2712.85
 79 128 8  38 52   336.894   1.64634   106.16   47.4138  3118.32
```

4. OBS

	SEQUENCE	DISPLAY	INSTRUCTION/RESPONSE
1.	Loading	READY	Enter CLOAD OBS, press play on recorder and hit RETURN.
2.	Load data base	START DATA TAPE AND HIT RETURN	Find DB array on tape. Press play on recorder and hit RETURN. The WK/FILE is automatically loaded on disc versions.
3.	Observation site input	LATITUDE LONGITUDE ALTITUDE - FT AMSL**	Enter latitude and longitude in degrees or decimal fraction, altitude in feet above mean sea level (AMSL), e.g., Colorado Springs, enter N,39,E,255.5,6000 and hit RETURN. Longitude may be east or west (E or W, 0^{o} to 360^{o}). Geodetic latitude may be north or south (N or S, 0^{o} to 90^{o})
4.	Satellite selection	Data base table is displayed SELECT SATELLITE	Select entry number 1 through 10 and hit RETURN (ENTER)
5.	Satellite observation input	OBSERVED CULMINATION** TIME-ENTER YY/DDD/HH/MM/SS	Enter time you observed this satellite at its approximate highest elevation. Last two digits of year, days since beginning of year, integer hours, integer minutes, integer seconds. This input must be in Greenwich Mean Time (GMT). (See Appendix A on page 17 for conversion of local time to GMT and Julian Day). Separate entries by commas and do not use brackets.
6.	Computation	Header is printed	After about 30 to 45 seconds the element comparison output will appear
7.	Accept/reject update	Element comparison display DO YOU WISH TO ACCEPT THIS UPDATE Y/N	Check new parameters against old. Check new epoch to see if it is at the time you observed the satellite. Period decay rate and inclination do not change during the update. Enter Y = yes, Enter N - no. A YES will produce both comments below. A NO will produce only the second line of the comment.
8.	DBASE modified	***UPDATE COMPLETE*** NEW SATELLITE Y/N	

**See glossary.

9.	New site	NEW OBSERVATION SITE Y/N	Enter Y = yes Enter N = no
10.	Save and **	ENTER CSAVE*1 DBASE AND HIT RETURN BREAK AT 3136 READY	Enter as described on display. When save is complete do a direct GO TO 3140 for SORCERER. Disc versions must be updated manually (see footnote)
11.	GO TO 3140	NEW DATA BASE Y/N?	Enter Y = yes, N = no N at this point terminates the program. A direct GO TO 3050 will maintain the current or modified data base and enter the program at 9 (NEW SATELLITE Y/N).

Note on OBS:

The NASA element sets degrade in accuracy with elapsed time from their epoch. This is why you will receive periodic updates from NASA. On low altitude decaying satellites this degradation can be rapid and severe. Assuming the orbit is fairly stable, OBS can improve the accuracy of your predictions, for a reasonable time, as long as you can make observations and without the need for a NASA update. The OBS program can also be used to update and correct NASA elements. This is done in the same way, by observing a satellite (using LOOK) and noting its approximate culmination (max elevation) time. This time must be converted to GMT for input to OBS. Using this input and your location, OBS does a correction on the old elements. If you have observed the wrong satellite or otherwise erred, the comment CULMINATION NOT FOUND is printed. In this case, you must observe the satellite again and run OBS again or use the next NASA update you receive.

Notes on TAKING OBSERVATIONS:

When making observations azimuth is measured clockwise (to the right) from TRUE NORTH (Elevation up to vertical from the horizon). Once you have used a compass to find magnetic north you must add or subtract the local MAGNETIC DEVIATION (MD) to find TRUE NORTH. if you do not know what the deviation is for your locality, ask a weather office or local airport facility. The difference is sometimes small and naked eye observations can then be done using magnetic north. Choose landmarks in your area for NORTH, SOUTH, EAST and WEST and determine where the pass will go across the sky. Begin searching early, up to 10 minutes or more prior to predicted time, and look along the line you have selected, ahead and behind the predicted point and time, until you see it. If you are using satellite elements less than 10 or 15 days old and the satellite is not within a week or so of decay, you should see the satellite moving at very close to the expected time and place (plus or minus a few seconds). SALUT6 or SEASAT-A will appear as a bright star moving quite quickly against the star background and sometimes slowly changing in brightness. OSCAR listeners will start to receive the beacon signal at -5 or -10 degrees. (below the horizon)

**The APPLE II cassette version uses the command STORE DB instead of CSAVE*1 DB. Because of the danger of loosing or unintentionally overwriting existing disc files OBS data is not directly transferrable to the master file. In all disc versions it is preferable to copy these new values down on paper and then enter them into the master file using UPDATE.

TEST

It is recommended upon receipt of your software, that the following tests be accomplished to ensure that each program is working properly. In addition it is recommended that a separate TEST data tape be recorded and kept only for TESTING. You should also keep the original programs this way and make a complete working set for regular use. The output listed below was generated with the 16K Exidy Sorcerer. Comparisons should be exact when using this machine. For other computers, the output will vary only slightly, due to handling of significants.

Using the test satellite, *TEST*, accomplish the following and make the appropriate comparisons. For TEST output on TRAK see page 8, LOOK see page 11, OBS below.

```
DATA ** TEST **
DATA Ø,Ø,79,123,.24Ø99639,.ØØØØ22959,321,1Ø8.Ø171
DATA 255.3915,.ØØØ1809,231.4923, 128.6ØØ4,14.3ØØ51232,4435
```

```
 OBSERVATION SITE N 38.62 E 255.431   ALT 6250 FT AMSL

(((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((((
( CORRECTION FOR ** TEST ** Ø      EPOCH DAY 123 AT 5.78391 HRS(
(                                  NEW EPOCH 128 AT 6.92056 HRS(
( PERIOD      100.696 MIN.                                      (
( INCLINATION 108.017 DEG.                                      (
(*****************************************************************(

PARAMETER NAME      NASA ELS OLD EPOCH    UNITS      NEW EPOCH

DATA BASE NUMBER      -       8           -          8
SATELLITE NUMBER    SATNO     Ø           -          Ø
EPOCH YEAR          EPYR      79          YEARS      79
EPOCH DAY           EPOCH     123         DAYS       128
EPOCH FRACTION DAY  EPOCH     .240996     DEC. DAY   .288357
PERIOD DECAY RATE   NDOT2     2.2959E-05  (R/D)^2    2.2959E-05
ELSET NUMBER        ELNO      321           -        10321
INCLINATION         II        108.017     DEGREES    108.017
RIGHT ASCENSION     NODE      255.392     DEGREES    265.715
ECCENTRICITY        EE        1.809E-04     -        1.70171E-04
ARGUMENT OF PERI.   OMEGA     231.492     DEGREES    222.786
MEAN ANOMALLY       MM        128.6       DEGREES    189.95
MEAN MOTION         NN        14.3005     REVS/DAY   14.3007
REV NUMBER          REVNO     4435        REVS       4507

CHECK NEW PARAMETER AGAINST OLD
DO YOU WISH TO ACCEPT THIS UPDATE Y/N?
```

ERROR AND ADVISORY COMMENTS

PROGRAM	ERROR CONDITION/PROMPT
ALL	Program Data base (DB or MD) will not load

Check cassette connections, volume, tone, etc. or use UPDAT to make a new recording.

ALL — SELECT ONLY 1 THRU 10 SELECT SATELLITE

A number was entered that was not between 1 and 10. Re-enter.

ALL — YEAR(XX)NOT IN ALMANAC

An attempt was made to select a satellite whose epoch* year (XX) was less than 77 or greater than 86. Check data base and correct the epoch year.

ALL — ***NOTICE***
ALMANAC UPDATE REQUIRED IN 60 DAYS

This is an advisory comment to let you know that you are using satellite data epoched within 60 days of the end of 1986. You will soon need to update the almanac. (See Appendix C on page 17).

TRAK/LOOK — ERROR ON INPUT

This comment appears when one of the following input conditions exist: the satellite element epoch year is less than the start year and the end day is less than the start day. The end day must be greater than or equal to the start day. Alphanumeric inputs were entered when the program was expecting numerics only. LOOK will only accept N S E or W for observation site inputs of LAT and LONG.

ALL — Y OR N ONLY NEW SATELLITE Y/N?

The programs will only respond to (Y) yes or (N) no responses.

LOOK/OBS — SATELLITE NEVER VISIBLE FROM LATITUDE XX.X

The inclination of a satellite's orbit determines how far north or south in latitude it will travel, e.g. for an inclination 35^{o} a satellite will travel as far as N, 35^{o} and S, 35^{o} of latitude. If your location happens to be somewhat greater than N, 35^{o} or S, 35^{o} then you may never be able to see this satellite. The program takes into account the altitude of the satellite, it's inclincation, your latitude and prints the comment if appropriate. Your only recourse is to choose another satellite with a greater inclination, or move to a place which is nearer the equator.

OBS — CULMINATION NOT FOUND

The program was unable to find a culmination* (max elevation) point within $\pm$ 30 minutes of the time you input (observed culmination time). You may have observed the wrong satellite or the elements in your data base may be badly out of date. You may try observing the satellite again or wait for the next NASA update.

---

*See glossary.

OBS CULMINATION NOT WELL DEFINED

For very high altitude satellites, the point of highest elevation with respect to a given site is not well defined. For these satellites OBS cannot accomplish a valid correction and therefore terminates.

****

PROGRAM LOOK MODIFICATION
GEO/TOPOCENTRIC RA/DEC

****

Standard output for program LOOK is given in azimuth/elevation/right ascension/declination/and range in kilometers for some time of interest. The output RA/DEC can be either GEOCENTRIC ie., earth centered or TOPOCENTRIC ie., centered at your location on the surface of the earth.

CHECK THESE LINES IN PROGRAM LOOK

********** FOR GEOCENTRIC OUTPUT OF RA/DEC **********

TRS/APPLE LINE #	SORCERER LINE #	*** CODE ***
2950	1750	IF RX=0 THEN RX=1E-6
2960	1760	IF RY=0 THEN RY=1E-6
2970	1770	AL=ATN(RY/RX)
2980	1780	IF(RX>0ANDRY>0) THEN3000 <1810>
2990	1790	AL=AL+PI:IF (RX>0 AND RY<0) THEN AL=AL+PI
3000	1810	>> USE "UZ" IN THE RIGHT SIDE OF THE EQUATION <<

********** FOR TOPOCENTRIC OUTPUT OF RA/DEC **********

2950	1750	IF U1=0 THEN U1=1E-6
2960	1760	IF U3=1 THEN U3=.999999
2970	1770	AL=ATN(U2/U1)
2980	1780	IF (U1>0ANDU2>0) THEN 3000 <1810>
2990	1790	AL=AL+PI:IF (U1>0 AND U2<0) THEN AL=AL+PI
3000	1810	>> USE "U3" IN THE RIGHT SIDE OF THE EQUATION <<

APPENDIX

A. GREENWICH TIME CONVERSION

Since all times output from STI programs are Greenwich Mean Time* (GMT), you will need to make the appropriate conversion to get your local time.

Conversion for the following time zones are provided:

EST = Eastern Standard time
CST = Central Standard Time
MST = Mountain Standard Time
PST = Pacific Standard Time

Time conversions are as follows:

GMT - 5 = EST	or, conversely	EST + 5 = GMT
GMT - 6 = CST		CST + 6 = GMT
GMT - 7 = MST		MST + 7 = GMT
GMT - 8 = PST		PST + 8 = GMT

The first of these reads "Subtract 5 hours from GMT to get EST." All times use the 24 hour clock, i.e., 2:00 p.m. is 1400 hours; 12:00 p.m. is 2400 hours.

NOTE

Don't forget to account for Daylight Savings Time when applicable.

B. DAY OF YEAR CONVERSION

Since all days are referred to the beginning of the year, the following chart is provided for your convenience: At first this may appear to be a difficult way to enter a start time, however if you have a calendar marked with this format you will likely find this method faster and easier than a day/month input.

MONTH	DAY OF YEAR	MONTH	DAY OF YEAR
Jan 0	0	Jul 0	181
Feb 0	31	Aug 0	212
Mar 0	59	Sep 0	243
Apr 0	90	Oct 0	273
May 0	120	Nov 0	304
Jun 0	151	Dec 0	334

In the above chart, Feb 0, is the last day of Jan, etc. To get the day of the year, simply add the day of the month to the number in the right hand column, e.g., Oct 10, 1979 = day 283. The chart is for non leap years. For leap years, (1976, 1980, 1984, etc.), add one day to all months after Feb., e.g., Oct 10, 1980 = day 284.

C. ALMANAC CONSTANTS FOR YEARS 1987-2000

The table on the next page may be used to replace values of the TLC (10,4) table of each program required. The programs supplied contain values for 1977-1986 inclusive and need only be modified when using satellite elements which are epoched outside this time span. A reminder prompt is built into the software and will appear after November 1st, 1986.

---

*See glossary.

1987	1.730112715	4.871805018	-0.062533838
1988	1.725946305	4.867638591	-0.067000161
1989	1.738982683	4.880674968	-0.054264517
1990	1.734816263	4.876508556	-0.058730836
1991	1.730649848	4.872342143	-0.063197158
1992	1.726483435	4.868175732	-0.067663482
1993	1.739519813	4.881212106	-0.054927835
1994	1.735353393	4.877045695	-0.059394159
1995	1.731186984	4.872879272	-0.063860483
1996	1.727020568	4.868712854	-0.068326804
1997	1.740056945	4.881749237	-0.055591159
1998	1.735890528	4.877582823	-0.060057479
1999	1.731724114	4.873416407	-0.064523804

D. CASSETTE OPERATING INSTRUCTIONS

If you have ordered the cassette version STI-900C you must first prepare a data file for use with the main programs (see paragraph 5, page 2). This is done by first running the data management program called UPDATE which should be the first program on the tape. You will need a few feet of blank tape on a separate cassette so you can record the data file you are about to produce. This exercise will also serve to familiarize you with how to add and modify satellite data.

1. Rewind SAT TRAK tape to start.
2. Load program UPDAT, enter CLOAD "U for TRS-80, CLOAD UPDAT for SORCERER or LOAD for Apple, press RETURN and PLAY on the tape recorder.
3. Type RUN and select option 1. BUILD NEW DATE BASE
4. Enter the data in order as shown on page 4, but type "SALYUT-6" for the first entry and just the numerical data for entires 2 to 14. Press RETURN or ENTER after each number.
5. When asked for ANOTHER SATELLITE Y/N, enter "N" for no.
6. You will now be shown the MENU. Select option 3 to see the Master File and verify the existence of "TEST" and "SALYUT-6". Enter"E" to EXIT.
7. Now back with the MENU, SELECT option 4 "BUILD WORK FILE", DBase.
8. Select "TEST" and "SALYUT-6" twice each and "E" to EXIT.
9. New set up your blank tape, press RECORD and SELECT "W" for a new WORKFILE to be recorded.
10. If you wish, you may also record a MASTER FILE at this time.

Now "RESET" your system and LOAD TRAK. When the first prompt is given to "START DATA TAPE and HIT < RETURN>", set up your recorder on playback of the DB WORKFILE only. The MASTER FILE LOADS only with UPDATE. See also page 15 if you have problems loading. Now refer to Pages 7 and 8 for instructions on program TRAK.

E. DISK LOADING INSTRUCTIONS (TRS-80 AND APPLE)

Disc versions of STI-900D software are run by the executive program "CONTROL". Simply bring your system up on DOS (Disc operating System). APPLE users must have floating point BASIC loaded or have Applesoft ROM card. With the supplied disc inserted in a disc drive, enter < RUN " CONTROL > for TRS-80 or < RUN INTRO > for Apple users. You will then be shown a menu of programs to select from. Once you are finished with a program the system will automatically return to "CONTROL" for another request. To break in the middle of a program (not recommended when operating "UPDATE") enter a CTRL C (2 keys at the same time) and RUN CONTROL.

****
* NOTES ON LOADING TRS-80 DISC VERSION *
* STI-900D *
****

GENERAL

THE ENCLOSED CASSETTE CONTAINS THE 3 STANDARD SAT TRAK PROGRAMS TRAK/LOOK/OBS. THREE ADDITIONAL PROGRAMS ON THIS TAPE ARE INIT CONTROL & UPDATE. SINCE RADIO SHACK DOS IS COPYRIGHTED QUALITY SOFTWARE PROVIDES THESE PROGRAMS ON CASSETTE IN DISC FORMAT BUT WITHOUT DOS. THE USER NEED ONLY LOAD EACH OF THESE 6 PROGRAMS FROM CASSETTE & SAVE THEM ON DISC. PROGRAM INIT BELOW (STEP 2) MUST BE USED TO INITIALIZE THE MASTER/DTA FILE THE FIRST TIME ONLY.

STEPS IN MAKING A NEW TRS-80 DISC - STI-900D

1. BRING YOUR SYSTEM UP ON DISC AND ENTER:

```
READY
CMD"T
READY
CLOAD"C
SAVE"CONTROL
```

For each of 6 programs above, CLOAD from tape and save to DISC. List each program fully to be sure of a good CLOAD/SAVE. The order on tape is INIT/CONTROL/UPDATE/ TRAK/LOOK/OBS

2. TO INITIALIZE MASTER/DTA EXECUTE PROGRAM INIT (SIMPLY RUN "INIT)

NOTE: LINES 30, 40 CONTAIN A TEST ELEMENT SET FOR TRAK/LOOK/OBS

3. YOUR DISC SHOULD NOW CONTAIN ALL 6 PROGRAMS+MASTER/DTA WITH ONE SATELLITE (TEST). BEFORE USING ANY OF THE MAIN PROGRAMS YOU MUST CREATE A WORK FILE (WKFILE) WITH THE FOLLOWING:

   A - RUN "UPDATE
   B - SELECT OPTION 4 (BUILD WKFILE)
   C - SELECT SATELLITE "TEST" 3 OR 4 TIMES & "E" FOR EXIT.
   D - SELECT "RETURN TO CONTROL"
   E - SELECT TRAK/LOOK/&OBS IN TURN AND RUN THE TEST FUNCTION
   (SEE PAGE 14)

4. NOW LOAD YOUR OWN SATELLITE ELEMENTS OR TRY THOSE LISTED ON THE SAMPLE NASA DATA SHEET, IF ENCLOSED. YOU CAN DO THIS USING PROGRAM "UPDATE" - OPTION 1

F. GLOSSARY

Apogee - The point in a satellite's orbit farthest from the Earth's center.
AMSL - Above Mean Sea Level.
Argument of Perigee - See orbital elements.
Ascending Node - An equatorial crossing from south to north.
Astrodynamics - a discipline including the parts of Astronomy, Geophysics, Aerodynamics, propulsion theory, electromagnetic theory, and observation theory that bear upon the trajectories of astronomical objects and satellites.
Azimuth - An angle measured in the plane of the horizon from true North clockwise to the vertical plane through the satellite.
Classical orbital elements - See orbital elements.
Culmination - The point at which a satellite reaches its highest position or elevation in the sky relative to an observer.
DBASE - The satellite data base array required for cassette versions of TRAK/LOOK/OBS.
Decay - The tendency of a satellite to lose orbital velocity due to the influence of atmospheric drag and gravitational forces. A decaying object eventually impacts with the surface of the Earth or burns up in the atmosphere.
Declination - The angular distance from the equator to the satellite measured positive north and negative south.
Drag -The force exerted on a satellite by virtue of its passage through the atmosphere of the Earth, acting to oppose its motion.
Eccentricity - See orbital elements.
Elements - See orbital elements.
Element set - See orbital elements.
Elevation - The angular distance of an object above the observers local horizon, measured on a vertical circle.
Ephemeris - A tabulation of a series of points which define the position and motion of a satellite.
Epoch (or epoch time) - A specific time and date which is used as a point of reference; the time at which an element set for a satellite was last validated.
Geodetic latitude - The angle between a perpendicular to the surface of the Earth (plane of the horizon) at a location and the equatorial plane of the earth.
Greenwich Mean Time (GMT) - Local time at zero degrees longitude at the Greenwich Observatory, England. Uses 24 hour clock, i.e., 2:00 P.M. is 1400 hrs.
Inclination - See orbital elements.
International designator - An internationally agreed upon naming convention for satellites. Contains the last two digits of the launch year, the launch number of the year and the piece of the launch, i.e., A, indicates the payload, B, the rocket booster, or second payload etc.
Latitude - See geodetic latitude.
Longitude - The angular distance from the Greenwich (zero degree) meridian, along the equator, east or west, to the meridian which passes through the satellite.
LOOK - STI computer program which produces look angles for satellites.
Look Angle - A set of parameters which determine when and where an observer should look to obtain observations (visual or otherwise) on a satellite, (i.e.: azimuth and elevation).
MD - Master Data File for cassette - called MASTER/DTA in disc version. Both are USED ONLY BY UPDAT/UPDATE.
Mean anomaly - See orbital elements.
Mean motion - See orbital elements.
Meridian - A great circle passing through the north and south poles of the Earth.

NASA elements - Public information supplied by the National Aeronautics and Space Administration which describes the orbit of a satellite. Part I of the NASA Prediction Bulletin which contains the classical orbital elements. See orbital elements.

Node - See orbital elements.

OBS - STI computer program which updates and corrects satellite orbital elements.

OBS elements - Satellite orbital elements which have been updated and corrected by OBS. Element sets produced by OBS have had 10000 added to the original NASA element set number.

Orbital elements - Also called classical elements, satellite elements, element set, etc.

(1) Node or right ascension of the ascending node - the angular distance from the vernal equinox measured eastward in the equatorial plane to the point of intersection of the orbit plane where the satellite crosses from south to north.

(2) Inclination - angle between the orbit plane and the Earth's equatorial plane, measured counter-clockwise.

(3) Argument of perigee - angular distance measured in the orbit plane, in the direction of motion of the satellite, from the point of intersection of the orbit and equatorial planes, to perigee.

(4) Eccentricity - the degree of flattening of the orbit or its departure from a circle.

(5) Mean motion - the number of complete revolutions a satellite makes in a given unit of time, usually measured in revolutions per day.

(6) Mean anomaly - angular distance measured in the orbit plane, in the direction of motion, from perigee to the satellite's mean position.

Perigee - The point in a satellite's orbit nearest the Earth's center.

Period - the time it takes for a satellite to complete one revolution, usually measured in minutes.

Period decay rate - the first time-derivative of mean motion, or rate of change of mean motion. This parameter reflects the amount of atmospheric drag a satellite is encountering. Measured in units of revolutions per day squared.

POSN- STI computer program which produces a satellite ephemeris.

Range - The range (or slant range) of a satellite is the straight line distance between an observer or location and the satellite.

Revolution at epoch - The number of revolutions or ascending node passages that a satellite has completed since it was launched at the time (epoch) of the element set.

Right ascension - Angular distance from the vernal equinox, measured eastward in the equatorial plane, to the meridian which passes through the satellite.

Sensor - an observation site.

TRAK - STI Program identical to POSN which outputs to a WORLD MAP DISPLAY.

UPDATE - STI computer program which is used for satellite data base management. (called UPDAT on cassette)

Visual pass - Normally a satellite is visible by optical means when the observer's location is in darkness (Sun at least 10^{o} below the local horizon) and the satellite is out of Earth shadow (illuminated by the Sun).

Vernal equinox - Also known as the first point of the constellation Aries, being defined by the point where the Sun crosses the Earth's equator going from south to north in the spring. This point in space is essentially fixed and represents the principal axis of a coordinate system used extensively in Astronomy and Astrodynamics.