pSatellite

Documentation For Version 1.3

A. Fischer, June 2002

Content

Introduction

pSatellite (pS) is a satellite tracking application for the Palm OS® environment. It provides visualization of satellite orbit position on a world map (Mercator projection) from any ground location you enter within pS. The core vector propagator within pS uses standard Two Line Elements (TLE's) available on the Internet and works for both low earth orbiting (LEO's) and geo-synchronous (GEO's) satellites.

Installation

Install these three files on your Palm OS® handheld for pS to operate properly:

- psatellite.prc - the application
- satdemo.pdb - a minimal demonstration database containing TLE vectors.
- MathLib.prc - a precision math library written by Rick Huebner for the Palm OS®. If MathLib is already installed on your handheld you don't need to install it again.

If you already have an older version of pS installed on your handheld just export your locations and delete the older version first.

Basic Program Operation

Tap on the application to launch it. The program always starts up with the satellite tracking indicator On and the tracking step interval set per your preference (1 minute default). pS will always remember which satellite and tracking location you last selected, whenever it is launched again, to quickly return to your previous/ last selection. Other operating features are discussed in detail below, and there are built in Help and Tips (I) within the various program windows.

Main Window Features

When you first launch the program you will see the Main display window.
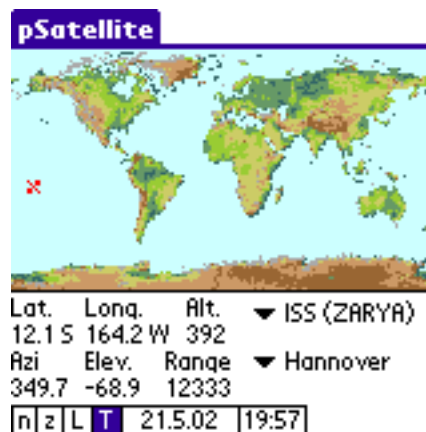
The top half of the Main display has the world map and will show indicators (bitmaps) for the satellite and the (observers) tracking location.

The lower half of the Main display shows the pS computed values and allows various operator selections to me made.

● **Satellite Position/Selection** (first line) - the current satellite position infor-mation is provided showing its Latitude (North or South of the equator), Longitude (West and/or East of the Greenwich 0 degree crossing), and Altitude (height above mean sea level). A pop-up window is provided for selecting a satellite of interest from your currently selected TLE database.

● **Tracker Selection/Observer Information** (second line) - A pop-up window is provided for selecting your desired ground observer location. Relative to this selected ground location, the satellites current Azimuth (Azi) and Elevation (Elev) angular position or bearing (in degrees) is shown along with the computed line of sight Range (Km). A negative Elevation angle would indicate the satellite is not visible from the currently selected location. The third label (shown above as Range) can display other tracking parameters (Velocity, Doppler, Space loss, etc) as selected from the View menu.

● **Date/Time/Tracking Indicator Selections** (third line) - the box button containing the "T" toggles the satellite ground trace On/Off. The box button containing the "L" toggles the observer's location indicator On/Off. The "n"

button (Now) resets the displayed time to current time (useful to quickly reset the time when using the fast time modes). The "z" button (Zoom) zooms the Mail display in and out. The Main display Date and Time can be tapped to bring up the Date and Time selection windows for changing dates and times of tracking interest to observe the satellite position and tracking information.

NOTE: The demo version of pS is crippled in respect to allowing the use of the Date and Time selection feature. The demo pS runs on the current handheld time reference only. You may load other TLE sets into the demo version of pS for evaluating its usefulness/accuracy and all other features of the program. However, selecting other Dates and Time will not be possible (the full registered pS version enables the Date/Time selection feature).

Menu Selections

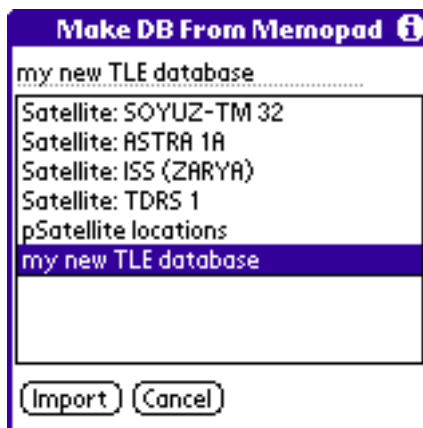There are four menus within pS.

Options Menu Selections

● **Load DB** - Brings up the Database window for selecting the desired TLE set to be loaded into pS for use.
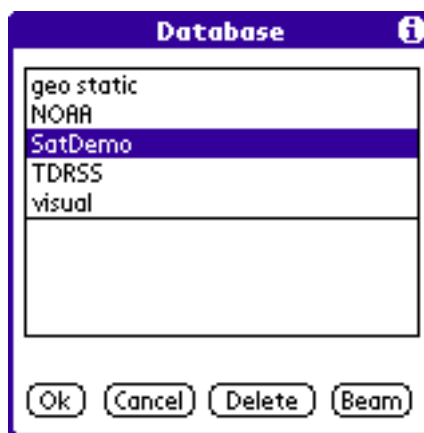
Several TLE sets (each set can contain many satellites) may be installed onto your handheld as desired. You might want to consider having different categories of satellite TLE sets using different file names (i.e., GEO, LEO, NOAA, NASA, etc). This would help minimize the number of satellites selectable at any one time on the pop-up menu within pS. pS has a limitation of reading no more that 300 TLEs within a set. See additional information below on Obtaining TLE Data. You may also select a database for deletion or beaming to another Palm OS® handheld.

NOTE: If you are a PocketSat user the same TLE sets that work with this Palm OS® application can also be shared/used by pS (the file structure/ formats are the same).

● **Make Sat DB** - Brings up a window for selecting a Memo to import TLEs into pS.

```
┌─────────────────────────────────────┐
│ Make DB From Memopad  ⓘ             │
├─────────────────────────────────────┤
│ my new TLE database                 │
│ ┌─────────────────────────────────┐ │
│ │ Satellite: SOYUZ-TM 32          │ │
│ │ Satellite: ASTRA 1A             │ │
│ │ Satellite: ISS (ZARYA)          │ │
│ │ Satellite: TDRS 1               │ │
│ │ pSatellite locations            │ │
│ │ my new TLE database             │ │
│ │                                 │ │
│ │                                 │ │
│ └─────────────────────────────────┘ │
│ (Import) (Cancel)                   │
└─────────────────────────────────────┘
```
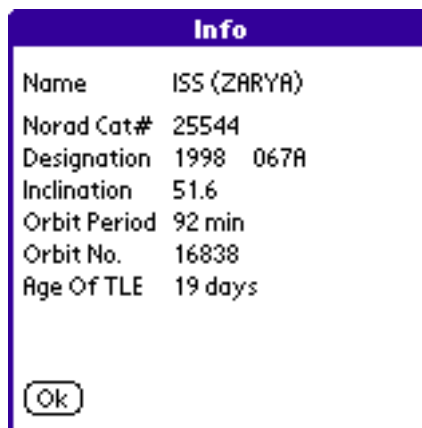
Copy and paste TLE data from various Web pages (see more info at end of this documentation) into your Palm™ Desktop software Memos and then HotSync for easy importing into pS. You may import a single TLE or multiple TLEs within the memo. The standard TLE format is used (Satellite name along with the two lines containing the elements). The imported Memo of TLEs must have a Title line as the first line of data to be importing properly. This Title line will become the suggested new Sat DB name upon import (or you may change its file name as desired). After successfully importing, the new DB will be automatically selected when returning to the Main display. You may also use the Load DB menu option and select any other databases you have imported into pS.
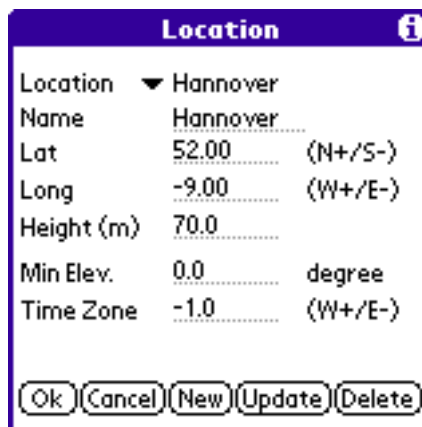
Sample:

```
--------------------------- cut here ----------------------------
my new TLE database
ISS (ZARYA)
1 25544U 98067A   01312.13140046  .00091733  00000-0  11002-2 0  7005
2 25544  51.6395  84.8192 0008428 297.4368  67.6034 15.60112444169543
--------------------------- cut here ----------------------------
```

Please notice: There is one start line and three lines for each TLE and no empty lines after it.

● **Sat Info** - Brings up the Info Window with information on the currently selected satellite.

```
┌─────────────────────────────┐
│            Info             │
├─────────────────────────────┤
│ Name       ISS (ZARYA)      │
│                             │
│ Norad Cat#  25544           │
│ Designation 1998   067A     │
│ Inclination 51.6            │
│ Orbit Period 92 min         │
│ Orbit No.   16838           │
│ Age Of TLE  19 days         │
│                             │
│                             │
│                             │
│ ( Ok )                      │
└─────────────────────────────┘
```

- Name of the satellite contained within the TLE.

- Norad (North American Aerospace Defense Command) Catalog number.

- International Designator - Year of launch and the consecutive object number put into space for that year.

- Inclination - degree of satellite inclination (+/-), or amount of swing above/below the equator.

- Orbit Period - period of time to go around the world (1440 minutes in a day).

- Orbit Number - For LEO's the number of orbits since launch (revolutions to go around the world). For GEO's the number represents complete days in orbit based on Epoch time within the TLE being used.

- Age of the current TLE (State Vector) data based on its Epoch time.

- **Sat Export** - Sends to the Memo pad (undefined category) the detailed Keplerian element information from the currently selected satellite. This information is derived in part from the TLE itself and computations made by the pS propagator.

- **Location** - Brings up the Location Window for entering observer (site) ground locations.

```
┌─────────────────────────────┐
│         Location        🛈  │
├─────────────────────────────┤
│ Location  ▼ Hannover        │
│ Name        Hannover        │
│ Lat         52.00   (N+/S-) │
│ Long        -9.00   (W+/E-) │
│ Height (m)  70.0            │
│                             │
│ Min Elev.   0.0     degree  │
│ Time Zone   -1.0    (W+/E-) │
│                             │
│                             │
│ (Ok)(Cancel)(New)(Update)(Delete) │
└─────────────────────────────┘
```

You may create New observer (site tracking) locations or edit

(Update/Delete) existing locations as desired. pS allows up to 300 locations to be entered. Enter Name (limited character length for pop-up menu size purposes), Latitude, Longitude and Height (not that important if you don't know it exactly). The Min Elev determines your local horizon angle for satellite visibility. This essentially determines when Acquisition of Signal (AOS) and Loss of Signal (LOS) will occur as the satellite passes overhead.
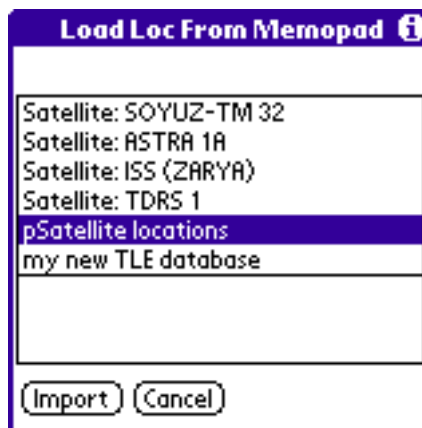
pS Time Management - a few words are needed here to explain how pS manages the Time displayed on the Main display window. The TLE (Epoch) time is always referenced to UTC (Universal Time Coordinated) time, which is essentially the same as Greenwich Mean Time - GMT, or time at O degree Longitude that passes through England. The pS program internally uses UTC as its base time.

The **Time Zone** value (hours), which can be entered within the Location Window, will allow you to offset that particular locations' time (from the base pS UTC time) to show local time in the Main Window Time display. For example, if "5" is entered, this would be for USA Eastern Standard Time (EST), and a "0" entry would indicate UTC for that location. So each location entered within pS can have a different Time Zone offset value to display its local time on the main display.

If that's not confusing enough, there is an option in Preferences to **Show UTC** for all the displayed times, which is what most steely eyed trackers commonly use. When this option is selected, and you have entered your handheld local time offset within the **UTC** Preference, the Main Window Time display will always be in UTC time no matter what observer (site) location you have selected. This Show UTC Preference essentially overrides all local time offsets that you entered within the Location Window Time Zone of each location. If you uncheck the Show UTC Preference, pS will use these Time Zone offset values that you have enter for each of the observer locations.
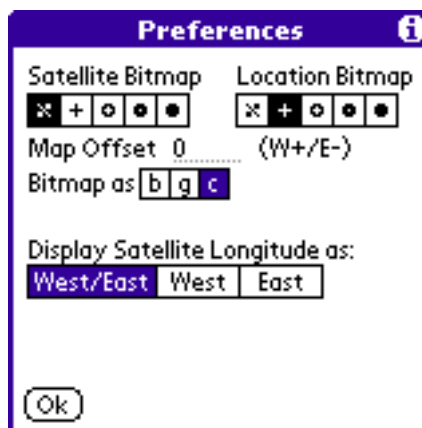
NOTE: pS does not alter your handheld time setting.

- **Location Export** - Sends to the Memo pad (undefined category) all your location information (Name, Latitude, Longitude, Height, Min Elev and Time Zone offset) that you have entered into pS. A Title line 'pSatellite locations' is added as the first line of the exported memo.
- **Location Import** - Brings up a window for selecting a Memo to import additional locations into pS.

Load Loc From Memopad 🛈

Satellite: SOYUZ-TM 32
Satellite: ASTRA 1A
Satellite: ISS (ZARYA)
Satellite: TDRS 1
pSatellite locations
my new TLE database

(Import) (Cancel)

If you have several new observer locations to enter at one time, you may want to consider using this Memo importing capability. Whatever locations you import will be appended to the current location database that pS maintains (duplicate locations are not overwritten). Format of the imported location data (within the memo) is the same as what pS exports to a memo, which includes a Title on the first line. Enter a couple of locations within pS, then Export it to a Memo, and use that Memo as template for the proper formatting of the imported data. The semicolon " ; " character is used as the data field delineator for both importing and exporting of the Location data.

● **Preferences Bitmap** - brings up the Preferences Window for selecting the bitmap options.

Preferences 🛈

Satellite Bitmap   Location Bitmap
⊠ + ○ ◉ ● 　 ⊠ + ○ ◉ ●
Map Offset 0   (W+/E-)
Bitmap as b g c

Display Satellite Longitude as:
West/East | West | East

(Ok)

Bitmaps - You may have different Bitmap symbols for the indicator of the Satellite track and observer Location on the world map.

Map Offset (W+/E-) - The Map Offset allows different views of the world map. Enter any Longitudinal offset within +/-180 degrees to shift the map around. pS by default places the zero degree Longitude (Greenwich) point on the world map at the center of the display. Enter 180 to see what the Pacific view of the world would look like.

Bitmap as - The Map can be displayed in black/white ("b"), gray scale ("g"),

or color ("c") depending on your handheld capability.

Display Satellite Longitude - You may display the Satellites longitude position in different Longitudinal coordinate references. West/East of the Greenwich 0 degree Longitude point (default), or in all West coordinates, or all East coordinates.

● **Preferences View** - brings up the Preferences Window for selecting the view options.
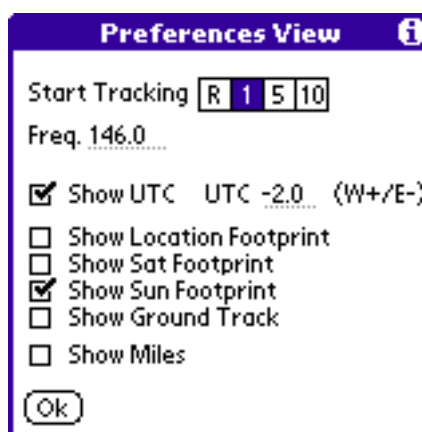
Start Tracking - At pS startup tracking will always be on. This selection allows you to set the default tracking interval (Real time, 1, 5, or 10 minutes) whenever the program starts up.

Freq - You may enter any desired tracking frequency (in MHz). The pS computation of the Doppler frequency is based on this entry.

Audio track Diff. - this is a value used for the antenna view window when audio output is switched on. It tells how wide is the angle (in degrees) before you get an new audio output.

Show UTC - this checkbox enables or disables the local Time Zone offsets that you have entered for your various Locations. When checked shows all times on the main display in UTC no matter what location is selected. (See additional information in pS Time Management above).

UTC (W+/E-) - this preference should have your local handheld time offset from UTC entered. This is very important (mandatory) to have this UTC offset entered in order to anchor (synchronize) the pS program time to your local handheld time (after all pS needs to know where your handheld is in the world). If you do not enter this offset value the pS Time Zone and Show UTC features won't work properly for displaying the time and/or satellite position. If "0" is entered this would indicate your local time is UTC. (See additional information in pS Time Management above).

pS has a new feature for the handling internal time. It works together with the Daylight Savings Time 'DST panel' from Remo Hofer available at http://www.geocities.com/SiliconValley/Cable/5206/. This nice piece of software knows the start and end dates of DST in your local area and can

automatically set the PDA time. pS knows when this program is present and the pS time offset in Preferences doesn't need to be changed when DST occurs. This panel will tell you 'DST is on'. This is not needed when PalmOS® 4 is present.

Show Loc(action) Footprint - pS will draw on the Main display a coverage (visibility) footprint around the currently selected location. This footprint is based on the location minimum elevation angle and the altitude of the currently selected satellite.

Show Sat Footprint - pS will draw on the Main display a coverage (visibility) footprint about the satellite as it moves in its tracking orbit. The footprint is based on satellites altitude above mean sea level. This is redrawn each time the satellite position is updated which has a tendency to slow the program execution/update rate.

Show Sun Footprint - A day and night overlay is shown on the map.

Show Ground Track - A little track forward and backward on the satellite way is shown.

!!! These last three features will cost your pda a lot of power. E.g. moving the map in zoom mode or getting the menu will take a while when all features are selected.

Show Miles - When selected will show all distance values computed by pS in miles vice kilometers.

Track Menu Selections

● **Clear** - this will clear the World Map display of any satellite ground traces.
● **Now** - this resets the time in the Time field on the Main Display to your current Location time (local), or UTC time if that pS preference is selected. The circled "n" button in lower left corner of the display does the same thing as this menu selection.
● **Real Time** - this causes the pS program to be placed into the real time tracking mode. The satellite trace on the map should be noticeably slower and may only show occasional movement since the pS time is running at normal clock increments.
● **1 Min/5 Min/10 Min** - this places the pS program into the fast time mode of 1, 5, or 10 minute increments for updating the satellite position. The satellite trace on the World Map should be noticeably faster with of coarse more gaps. You may also use the handheld hardware Up and Down buttons in increment and decrement the time steps to "walk" the satellite back and forth on the display when using these fast time modes.
● **Next AOS** - this is one of the nicer features of pS. When selected the pS propagator will stop updating the display in its current mode (as indicated by "wait" in lower right corner). PS then starts "looking ahead" in time to determine your next visibility (AOS/LOS times) for the current location. Once the next AOS/LOS times are determined they will be displayed in the lower right corner of the display. After determining these times pS will then resume where it stopped tracking and continue updating the tracking display from

where it left off.

There is a limitation of 12 hours when looking ahead for the next AOS/LOS times. If no visibility occurs within the next 12 hours pS will resume where in previously stopped and continue tracking, however, no times will be displayed in the lower right corner. Because of the 12 hour cutoff time, it is possible that the displayed LOS time could be the correct LOS time or the actual 12 hour cutoff time itself, which ever occurs first. Once the next AOS/ LOS times have went by (expired) you can then reselect Next AOS from the Track menu again to determine the next visibility period. This feature works in both the pS real time and fast time tracking modes.

View Menu Selections

The View menu allows selection of various tracking data information to be displayed on the bottom portion of the screen (second line). The label on the display will identify what is currently selected. This label may also be tapped to rotate through the available data values.

- **Range** - distance in Km (or Miles) between selected location and satellite.
- **Velocity** - orbital speed of satellite relative to ground. The orbital velocity value is provided in Km/sec (or Miles/sec).
- **Doppler** - Doppler frequency in Hz based on the frequency (MHz) specified in the Preferences dialog. Value is only displayed when the site location elevation angle is positive (in view).
- **Space Path Loss** - Space loss (RF signal attenuation) in dB based on the frequency (MHz) specified in the Preferences dialog and current Range between the site location and satellite. Value is only displayed when the site location elevation angle is positive (in view).
- **Show Kilometers/Show Miles** - Selects the displayed distance values, computed by pS, in Kilometers or Miles.
- **Antenna View** - Shows some value for getting in contact with the satellite. A small audio output for azimuth and elevation is added. One works with morse signs and another with audio output. This needs the audio driver from the FocV Project and the audio files to be installed and does not work with all hardware. The delay between audio output is handled in the init dialog as degree of change.
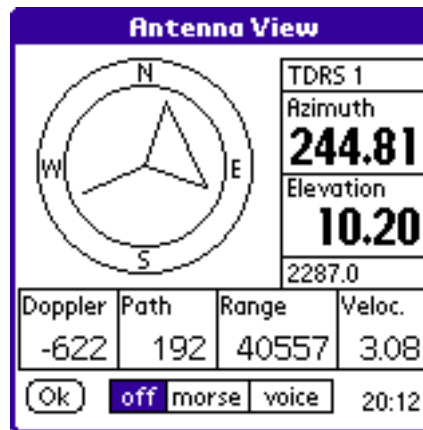
Info Menu

● **Help** - an brief explanation of most the Main Display Window features.
● **SysInfo** - gives you some informations about your system.
● **About** - shows the pS program version number, date, and contact information.

Obtaining TLE Data

As for any State Vector Propagator, to obtain good satellite prediction information, you will need to obtain current TLEs (Epoch time-wise). The pS input format used must be the standard TLE format. You must install the TLE files (sets) into your handheld for pS to use (Options Menu -Load DB). There are several ways to do this (other than mentioned above in Make Sat DB), but will take some extra work to set yourself up to obtain the latest TLE data via the Internet.

- Visit my Web page for online translation of TLE data to the proper file format (pdb) for installing on your handheld. Just copy the text of one or several satellite TLEs into your clipboard from a TLE source and paste it into my Web Page and Save it to your Palm™ Desktop Install Folder, HotSync to your handheld and your ready to track with pS.

- Palm OS® program **GetTLE** download: This Palm OS® based program generates TLE sets with the same format (pdb) that pS uses. If you have internet access directly with your Palm OS® handheld than use this to get the TLE data.

- To translate TLE's into a Palm OS® database (pdb) you can use another PC program called **TLE2PDB**. Get it at www.kh-gps.de. It contains all you need.

- Norad, at www.celestrak.com, will have TLE text files (individual or sets) that can be downloaded.

- More information and links to NASA web pages where TLE's can be obtained are:
  - http://oig1.gsfc.nasa.gov
  - http://earthobservatory.nasa.gov/MissionControl/overpass.html
  - http://dransom.com

- A competitor program that is similar to pS is PocketSat - it gives you prediction of satellite visibility, but displays the data in a different fashion than pS.

Appendix

Revision History

- **Version 1.0** - Initial publication issued in February, 2001.
- **Version 1.1** - Issued in June, 2001.
  - Changed Main Display window features around to better display the tracking position information more accurately for both the low earth orbit (LEO) and the geo-synchronous (GEO) satellites.
  - Added Import and Export to/from Memo pad of the Satellite TLE's and observer (site) Location information, with ability to Delete and Beam the TLE databases as desired to another handheld.
  - Improved the "Next AOS" feature to work with highly inclined GEO satellites.
  - New Preference to provide the ability to shift the World Map view around to any coordinate references you want to display.
  - New Preference to display the Satellite Longitudinal position information in All East, All West, or Both East and West coordinates.
  - Added a new Preference for selecting the tracking interval a program startup.
  - Added several built in Help and Tips windows to better describe the program features.
  - Fixed a Fatal Error bug for Visor owners, which now allows pS program to be run from the Flash Module.
  - Cleaned up some minor display field problems and changed window dialogs and button names around for overall program consistence.
  - Got pS runnig on Palm OS® 2.0. This will run with lower accuracy.

- **Version 1.2** - Issued in October 2001
  - Added a new View menu for additional tracking data information (Range, Velocity, Doppler, Space Loss) and selection of distance values in Kilometers or miles.
  - Added new Map display option for Black/White, Gray scale, and Color selectable within Preferences.
  - Added a new zoom button for zooming the map display in and out.
  - Added Satellite and site Location footprints to better define visibility on the Map display. Selectable within Preferences.
  - Added a new Preference for user to define an RF frequency (MHz) to allow determination and display of Doppler (Hz).
  - Added additional memo information to the exported Satellite information.
  - No longer support for PalmOS® 2.0

- **Version 1.3** - Issued in July 2002
  - Using the new beaming routines for PalmOS® 4.0.
  - Preferences are separated into two dialog boxes.

- If the PalmOS 4.0 is present the value for UTC is preselected at the first start.
- With the PalmOS 4.0 the daylight saving time is used to get the right UTC.
- The sun now is shown with a foot print if selected (see also known problems).
- A little part of the ground track is visible if selected.
- Small audio output for azimuth and elevation (try menu 'Antenna View') . This needs the audio driver from the FocV Project. The delay between audio output is handled in the init dialog.

Known Bugs

- dec 2001 - During installation of pSatellite: After the Hot Sync Clean Up a Fatal Error occurrs. This is reported for the m100 and the Visor Prism. After reset everything is working.
- jun 2002 - On PalmOS 3.3 (german version) I didn't get the sun shadow work in the zoom mode.
  Version 3.0, 3.1 and 3.5 or greater is ok.
- jun 2002 - Some OS versions 3.5 have problems to work with the zoom mode. A message box is shown at the moment.

Acknowledgements

Riley J. Elwood at NASA Goddard Space Flight Center for his beta testing for tracking accuracy, features suggestions, and helping with the documentation.