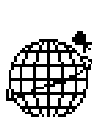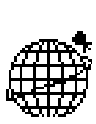# SatTrak© *by Mike Pflueger WD8KPZ*

SatTrak © by Mike Pflueger

About SatTrak

SatTrak is a utility program designed primarily for Amateur Radio operators interested in satellite communications. It also contains a few other functions which may be of more general interest to hams - Great Circle distance and Bearing (for pointing beams for HF communications), Maximum Usable Frequency (MUF) plots, Grid locator identifiers, Radio Horizon for determining the line of sight distance between two antennas, useful for VHF frequencies and above, and wavelength calculations useful for many things such as constructing antennas or matching transformers.

SatTrak comes as a demo version, which means that Save, Copy, and Print are disabled. These functions will be enabled after you pay the shareware fee and get a password from the author. Also this will prevent the "About" screen from popping up every time you open the program.

If you use it, I ask that you please pay the shareware fee as I have put a lot of time and effort into the program. If you haven't paid, don't expect me to support it. Comments, suggestions, and bug reports are welcomed. If you pass the program on, please pass it as a demo version (password never entered) and pass this document with it. Sorry, I don't

distribute the source code.

If you can't download from the network, send a floppy (800K or 1.4M) and a prepaid mailer to the following address and I'll send you the program:

SatTrak
Mike Pflueger
6207 W. Beverly Ln.
Glendale, AZ   85306

Features

- Generate a detailed, customizable plot of when a particular satellite will be visible from a given location, it's position, altitude, and many other items

SatTrak ©

by Mike Pflueger

- Given operation mode data for a satellite, tells you what mode the satellite is operating in

- Generate a list of satellites currently visible from a given location

- Display (on a world map) a satellites position at any point in time

- Display in real time (on a world map) a satellites current location

- Generate beam headings between two locations

- Find grid identifier (Maidenhead grid locator) of any location

- Generate MUF plots between any two locations for any day

- Generate band openings from a selected location to various points around the world

- Find the line-of-sight distance between antennas at two elevations

- Given a frequency, gives the half and quarter wavelengths, and second and third harmonic frequencies - and shows a
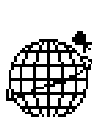
simple dipole antenna design (HF or VHF)

- Convert NASA format element sets to Keplerian format

- Print or save windows to a file, copy text or pictures to other programs

- Saves data for up to 200 satellites, 20 ground locations, and mode data for up to 20 satellites

- Preferences (metric or English, UTC or local, data to output)

- Help panels

- Color pictures. System 7 friendly (sorry, no balloon help yet)

Disclaimers

SatTrak is written with Think Pascal™, so portions are Copyright © Think Technologies, Inc. The rest is Copyright © Mike Pflueger, 1990. This

SatTrak©   by Mike Pflueger

program is shareware: you may distribute it freely so long as it is complete and unaltered, and as long as no fee is charged for the program or distribution thereof (except normal connect fees in the case of BBS's). After 15 days you must pay the requested fee to the author or dispose of the program.
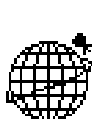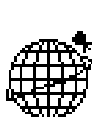
SatTrak ©
by Mike Pflueger

Getting Started

All you really need to get started is the SatTrak program itself. SatTrak uses 4 settings files which it expects to find in the current system folder (or in a folder called "Preferences" inside the system folder) under these *exact* names:

- **SatTrak Config** - contains your preferred general configuration settings for the program - preferences, distance units, and time format

- **SatTrak Sites** - contains your preferred station site(s) on which satellite calculations are based. Each site has a name, location (latitude and longitude), local time difference from UTC (GMT or "Zulu"), site altitude (above sea level), and a minimum satellite visibility angle.

- **SatTrak Elements** - This file contains the orbital elements in Keplerian format for all satellites of interest.

- **SatTrak Satellite Modes** - This file contains operational mode information for up to 20 satellites. Usually used for the OSCAR's.

If you are missing one or more of these files, SatTrak will create a default for each file it doesn't find. Site, Modes, and
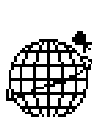
Config files are changed as you change settings (add or delete sites, change output format preferences) from within SatTrak. Elements files are normally "imported" by SatTrak from some other source.

Where do I get orbital elements?

Good question. These are available on many ham packet and telephone modem bulletin board systems, networks such as Compuserve and USENET (posted weekly to sci.space and rec.radio.amateur.misc), and are occasionally found in publications. One such telephone BBS is the Celestial BBS at 513-427-0674 300/1200/2400 8/1/none.

You should try to update the elements you use every few weeks because they *do* get out of date due to various forces acting on the satellites (like orbital correction burns, friction) which can't be precisely anticipated.

SatTrak © by Mike Pflueger

SatTrak expects to import these elements from a plain ASCII text file in one of two particular formats. Keplerian format is SatTraks' preferred format. NASA style format may also be read in and converted to Keplerian by SatTrak. SatTrak is pretty picky about what it gets, so make sure the format is correct (see the Appendices on the two formats). It does, however, try to be specific about what it doesn't like if it comes across bad data so it's easier for you to find and correct.

SatTrak will read in orbital elements for up to 200 satellites. I recommend that you pare your elements file down to something more manageable because this makes for *very* long menus! Also, satellites menus are built in the order they are read in from the elements file. If you want them reorganized or alphabetized, you'll have to do that yourself with a text editor.
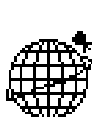
Using SatTrak

Note that SatTrak will work in the time (Local or UTC) and distance (metric or English) formats you specify in the "Preferences" configuration settings. ***It expects all input in the same units used for output.*** So if you want output in UTC, input date and time must also be in UTC. If you want output to be local date and time, input date and time must also be local.

Using the Keyboard

SatTrak was designed to allow you to use keyboard shortcuts in many cases.

As with all Macintosh™ applications, a command key equivalent is listed in the menu as a shortcut for that menu selection. For example, to print, you may

SatTrak ©

press command-P (⌘-P) instead of using the mouse to select the menu option.

In dialog boxes, outlined buttons are the defaults - you may press Enter or Return to select the default. In most dialogs, SatTrak also recognizes the first key of the button name. For example, in the Beam Heading dialog, once you've entered the desired latitude and longitude, you may press "m" to do a MUF plot.
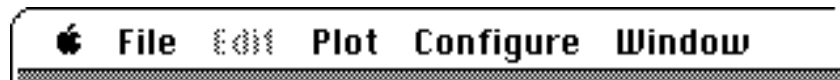
SatTrak ©
by Mike Pflueger

SatTrak also recognizes the help button (for those keyboards with this key) and command-? (⌘-?) to bring up the help panels.

The Menus

SatTrak will only enable menu options which are valid for that point in time. For example, if a window can't be printed (such as the Great Circle window), the Print option on the File menu will be dimmed.
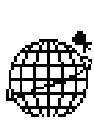
⌘ File Edit Plot Configure Window

About SatTrak… - contains general information on the program and access to help panels for the program.

File

⌘ File Edit Plot
Close ⌘W

Save ⌘S
Save As…

Page Setup…
Print ⌘P

Info ⌘I

Quit ⌘Q
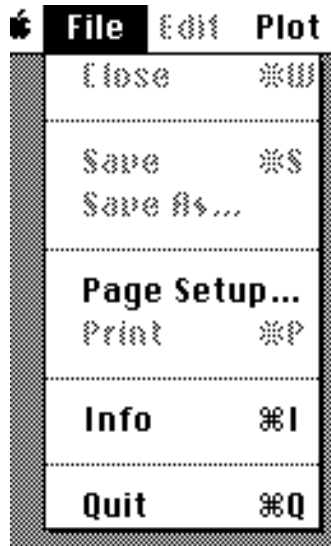
Close - your standard "close window" option. Closes the window and offers
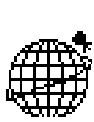
to save the file.

Save, Save As - again the standard options to allow you to save the window as a file. SatTrak files are saved as ASCII text (for text-only windows, such as orbit plots) or PICT (for graphical windows such as MUF and position plots) and can thus be read by other

programs such as word processors, spreadsheets, and graphics programs (MacDraw, MacPaint). In fact, spreadsheets like Excel can come in handy for manipulating orbit plot tables. SatTrak will not reopen or print files that have been previously saved since it does not permit editing of the data. This can be done with any word processor, editor, spreadsheet, or graphics program as applicable. To open a SatTrak document from another program, start that program, then choose its Open option and select the desired SatTrak file.

Save, Print, and Copy are disabled in demo versions of SatTrak. They can be enabled by entering the correct password supplied when you pay the shareware fee.

Page Setup - standard, used to select printer options.
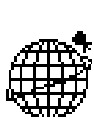
Print - print the currently displayed SatTrak window.

Save, Print, and Copy are disabled in demo versions of SatTrak. They can be enabled by entering the correct password supplied when you pay the shareware fee.

Info - lists some useful information about the current status of SatTrak, such as what configuration, site, and element files are in use, and how many sites and satellites are in those files.

Quit - quit SatTrak. Offers to save any open windows which have not yet been saved.

Edit

Copy - the only edit option which SatTrak will ever allow. Allows you to copy selected text to be pasted in other applications or DA's. If a picture window (MUF plot or position plot) is displayed, choosing copy will copy the
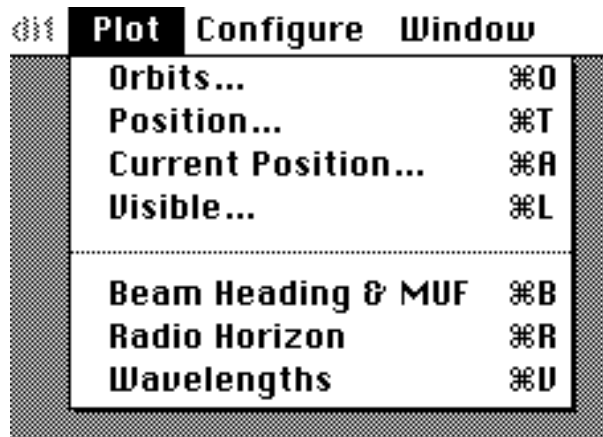
entire picture (PICT format) which can then be pasted in any program that accepts graphics.

Save, Print, and Copy are disabled in demo versions of SatTrak. They can be enabled by entering the correct password supplied when you pay the shareware fee.
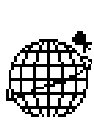
SatTrak © by Mike Pflueger

Plot

A maximum of 5 orbit and position windows may be open. Orbit windows may contain a maximum of 32K of information each. Any orbit plot which attempts to exceed this limit will be terminated with a warning when the limit is reached.
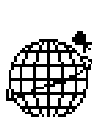
Orbits… - Plots a table containing position of the satellite relative to the site over a period of time. Enter the starting date and hour in UTC or local time as selected under Preferences…, the length of the plot in days, and the step size. Select a satellite and site from the popup menus. When all information is correct, press enter or click on the calculate button to calculate and display the table. For details on the content of the output, see the section on Preferences… below. Due to the intensive nature of the calculations, this process of building the table is slow. You should exercise restraint when choosing a step size and duration. For example, if you select a step size of 1 minute and a duration of 2 days, SatTrak must calculate the position of the satellite 2880 times (the number of minutes in 2 days). If you chose a 10 minute step instead, this is only 288 iterations - however your resolution is more coarse and you may miss the minute the satellite pops above the horizon. It may therefore be more efficient to first

do a plot with a 10 minute step size and a short duration to get a rough idea of where the satellite is, then do a more detailed (1 minute resolution) plot around the time of interest. Orbit plots are saved as ASCII text and can be read by other programs such as word
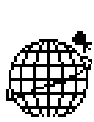
processors and spreadsheets. In fact, spreadsheets like Excel can come in handy for manipulating orbit plot tables. SatTrak will not reopen or print files that have been previously saved. This can be done with any word processor, editor, or spreadsheet.

Position… - Given the date and time, and for a selected satellite, plots the position of the satellite at that moment. This is displayed on a world map and also in text form. The text will state if the satellite is currently eclipsed and if it is visible from the selected site. If the satellite is visible, SatTrak will display azimuth, elevation, doppler, and range information as configured under Preferences.… If the window is saved, only the text is saved for compatibility with all word processors and editors.

Current Position… - Displays the real-time position of a selected satellite. Based on the selected site, azimuth and elevation will be displayed if the satellite is visible.

Visible… - Given the date and time, and for a selected site, lists all of the satellites visible at that moment (as defined by the minimum elevation setting for that site). SatTrak will also display azimuth and elevation for each of these satellites.
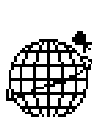
Beam Heading & MUF - Opens a window which will calculate the Great Circle distance and bearing between two locations on the earth. The first site defaults to the latitude and longitude of the most recently used site. It can be changed if desired. You need to fill in the latitude and longitude of the destination site. Latitude and Longitude can be quickly entered from the stored site list by pulling down the Use Site menu for either site 1 or site 2. Pressing enter or clicking on the calculate button will calculate and display the distance between the two locations, the beam heading (or azimuth) from site 1 to site 2, and the Maidenhead Grid Locator for each location. Useful for pointing beam antennas used for HF radio work.

SatTrak © by Mike Pflueger

Once both desired sites have been identified, selecting the MUF option will plot a 24 hour chart of the Maximum Usable Frequency (MUF). This is useful for determining the optimal time of day and frequency for long distance (skip) communications between 2

locations. You are asked to enter either the solar flux or sunspot number (obtainable from WWV on 5, 10,15, or 20 MHz at 18 minutes past the hour) and the date.

Similarly, the Band Openings option lists the MUF from site 1 to 24 selected locations around the world for the selected date and time. This is useful if you want to know, for example, "where is 15 meters open to right now"? The list may be sorted by frequency by selecting the appropriate check box. The 24 sites cannot be changed, but are selected to give representative coverage around the globe.

Radio Horizon - Opens a window which will calculate the maximum line-of-sight distance between to locations. Enter the antenna height for each site, then press enter or click on the calculate button to calculate and display the maximum line-of-sight distance between the two locations. Distance to the horizon can be calculated by setting site 2 elevation to 0. If the elevation above sea level is significantly different at the two sites, this should be added to the antenna height for **both** sites. This is useful for determining expected range on VHF thru optical frequencies. It of course does not take into account the effects of intervening terrain, antenna gain, or any unusual conditions (scattering, reflection or refraction).

Wavelengths - Opens a window which will calculate the basic wavelengths and harmonics for a given frequency. Enter the frequency in megahertz (MHz), then press enter or click on the calculate button to calculate and display the full, half, and quarter wavelengths for that frequency. Also displayed will be the first and second harmonics of the frequency and the frequency whose first harmonic is the entered frequency. The Antennas option is provides instructions on how to build two of the simplest and most basic antennas - the dipole (useful and practical from about 1 to 30 MHz) and the ground plane (useful and practical from about 25 to 800 MHz). The wavelength calculations are useful for determining antenna element
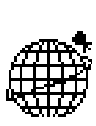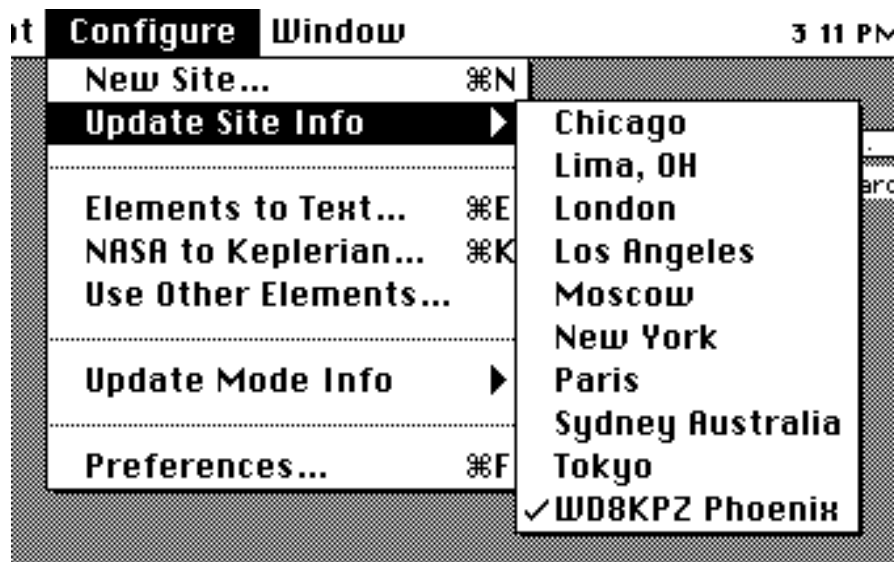
lengths, tuning transformer lengths, and harmonic relationships between frequencies.

Configure

New Site… - allows you to add a new site. You need to specify a name for the site, its position in latitude and longitude (can often be obtained from the blue pages in the phone book, the encyclopedia, maps, or the World Almanac), its elevation above sea level, the number of hours difference from UTC (local time - UTC), and the minimum elevation angle at which the satellite is visible (0° is the horizon, 90° is directly overhead). Normally 0 will be fine for the elevation angle, but if you have surrounding mountains or buildings, you may want to enter another angle. Up to 20 sites are supported.

Edit or Delete Site - Allows you to change any information about a particular site or delete any site. A submenu will appear which you use to select the site you wish to change or delete. You must have at least one site at all times - SatTrak will not allow you to delete the last site.
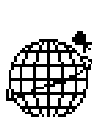
Elements to Text… - Convert a SatTrak Elements file to TEXT. Allows the
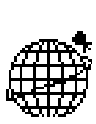
file to be viewed and changed by any word processor or editor. Useful for adding, removing, or updating satellite orbital elements. Follow the formats listed in the Appendices for orbital elements.

NASA to Keplerian… - Convert a text file containing NASA format elements to Keplerian format. Note that this only converts the file, SatTrak does not read the converted elements in. To do this, after converting, you will need to quit SatTrak, move the converted file into the active system folder, and make sure it is named "SatTrak Elements". Now restart SatTrak and the new elements will be read in.

Use Other Elements… - Allows you to switch to an orbital elements other than the default (found in the system folder).

Update Mode Info - Allows you to add, change, or delete information about the operational mode of up to 20 satellites. Some satellites, the OSCAR's for example, switch operating modes as they orbit. These parameters are published by AMSAT and QST. If mode information has been stored for the selected satellite, this information will be calculated and displayed on the appropriate plots.

Preferences… - Sets up your personal preferences for information to be contained in the output and other windows of SatTrak. Checked items will be contained in the resulting orbit plots. The items are:
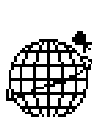
- Azimuth - Azimuth of the selected satellite relative to the selected site. 0° is north, 90° east, 180° south, 270° west. This could also be called the heading or beam heading.

- Elevation - elevation angle of the satellite above the horizon. 0° is on the horizon, 90° is straight up, -90° is straight down.

- Doppler - for the specified frequency, calculate the doppler shift for the satellite. Due to the motion of the satellite relative to the site, the received frequency will be shifted from the transmitter frequency by this amount.
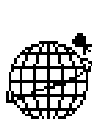
- Range - output range (distance) to the satellite from the site and the height of the satellite.

- Latitude/Longitude - the point on the earth directly under the satellite.
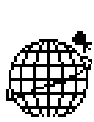
SatTrak © by Mike Pflueger

- Phase - the "phase" of the satellite.

- Eclipsed - the satellite is in the earth's shadow

- Apogee - if the satellite is in a highly elliptical orbit, prints when the satellite reaches apogee.

- Flip - prints the Azimuth and Elevation in inverted format

- Mode - operational mode of the satellite (e.g. OSCAR's).

- Local Δ from UTC - the difference in hours from where the Mac is located and UTC. Negative for west longitudes (the continental US is -5 (EST) to -8 (PST) hours), positive for East longitudes.

- Units (Metric or English) - Selects which types of units will be used for all input and output - metric (meters and kilometers) or English (feet and miles).

- Time (Local or UTC) - Selects which time and date will be used for all input and output - local or UTC (Universal Coordinated Time, also known as GMT or Zulu). The conversion is done based on the UTC conversion you provide for that site (see the New Site… and Edit or Delete Site menus to change this). EST is -5 hours, PST is -8 hours. Satellite orbital elements are in UTC, so if you wish output in local time, this conversion factor *must* be correct.

Windows

Allows you to quickly bring any open window to the front.

Appendix A - NASA Orbital Element Format

NASA data for each satellite consists of three lines in the following format:

AAAAAAAAAAA
1 NNNNNU NNNNNAAA NNNNN.NNNNNNNN +.NNNNNNNN +NNNNN-N +NNNNN-N N NNNNN
2 NNNNN NNN.NNNN NNN.NNNN NNNNNNN NNN.NNNN NNN.NNNN NN.NNNNNNNNNNNNNNN

Each line ends with a carriage return (CR).

Line 1 is a eleven-character satellite name. Lines 2 and 3 are the standard Two-Line Orbital Element Set Format identicalto that used by NASA and NORAD. The format description is:

Line 2
Column   Description
01-01   Line Number of Element Data
03-07   Satellite Number
10-11   International Designator (Last two digits of launch year)
12-14   International Designator (Launch number of the year)
15-17   International Designator (Piece of launch)
19-20   Epoch Year (Last two digits of year)
21-32   Epoch (Julian Day and fractional portion of the day)
34-43   First Time Derivative of the Mean Motion or Ballistic Coefficient (Depending on ephemeris type)
45-52   Second Time Derivative of Mean Motion (decimal point assumed; blank if N/A)
54-61   BSTAR drag term if GP4 general perturbation theory was used. Otherwise, radiation pressure coefficient. (Decimal point assumed)
63-63   Ephemeris type
65-68   Element number
69-69   Check Sum (Modulo 10)
     (Letters, blanks, periods = 0; minus sign = 1; plus sign = 2)

Line 3
Column   Description
01-01   Line Number of Element Data
03-07   Satellite Number
09-16   Inclination [Degrees]
18-25   Right Ascension of the Ascending Node [Degrees]
27-33   Eccentricity (decimal point assumed)
35-42   Argument of Perigee [Degrees]
44-51   Mean Anomaly [Degrees]
53-63   Mean Motion [Revs per day]
64-68   Revolution number at epoch [Revs]
69-69   Check Sum (Modulo 10)

All other columns are blank or fixed.
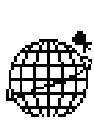
Example:
NOAA 6
1 11416U   86 50.28438588 0.00000140   67960-4 0 5293
2 11416 98.5105 69.3305 0012788 63.2828 296.9658 14.24899292346978

Note that the International Designator fields are usually blank, as issued in the NASA Prediction Bulletins.

SatTrak ©
by Mike Pflueger

Appendix B - Keplerian Orbital Element Format

Satellite: AAAAAAAAAAA
Catalog number: NNNN
Epoch time: NNNNN.NNNNNN
Element set: NNNN
Inclination: NN.NNNNNNdeg
RA of node: NNN.NNNNNNdeg
Eccentricity: N.NNNNNN
Arg of perigee: NNN.NNNNNNdeg
Mean anomaly: NNN.NNNNNNdeg
Mean motion: NN.NNNNNNrev/day
Decay rate: N.NNNNNNe-NN rev/day^2
Epoch rev: NNNN

Satellite: AAAAAAAAAAA
Catalog number: NNNN
Epoch time: NNNNN.NNNNNN
 .
 .
 .

Each line ends with a carriage return (CR).

Each satellite ends with a line with a single carriage return (CR).

Line headers must be exactly as shown above - the text followed immediately by a semicolon and a space, followed by the value.

NOTE: **Some element sets have a alphanumeric (text) string for the Catalog Number or Element Set fields. Per the standard, SatTrak expects numeric (only - no alpha) values in these fields and will generate an error if non-numeric characters are included in these fields.**