
Home Planet
by John Walker

Overview

Home Planet is a Microsoft Windows application which calculates the position of the Earth, Sun, Moon, planets, asteroids, comets, and Earth satellites with high accuracy and provides the following capabilities:

Map of the Earth
- Day and night regions
- Current location of the Moon
- Correct phase of the Moon
- Current position of an Earth satellite
- Can copy to clipboard
- Multiple display formats
- Earth map images can be customised

Sun/Moon information panel
- Local time, Universal time, and Julian date
- Moon's age, phase, distance from Earth, and angular size
- Sun's distance from the Earth and angular size
- Date and time of last and next new, quarter, and half Moons
- Lunation number
- Picture of Moon in current phase

Planetary position panel
- Right ascension, declination, distance from Earth, azimuth, and altitude above the horizon at the observer's location for solar system objects, including selected asteroid or comet
- Indicates Up, Set, Rising, Setting, and Transit

Sky map
- Shows stars, planets, satellite, and optionally constellations
- Track selected asteroid or comet
- Choose fast or high-quality star display
- Optional display of star colours
- Optionally display coordinates: poles, celestial equator, ecliptic
- Optionally display star names, Bayer letters, Flamsteed numbers
- Optionally display deep sky objects (galaxies, star clusters, nebulæ) from user-extensible deep sky database
- Choose star catalogue: Yale Bright Star Catalogue (BSC5) or Smithsonian Astronomical Observatory Catalogue (SAO)
- Click on object in sky map to view through telescope
- Animate to watch Earth rotate and orbit, planets move, Earth precess, stars drift over millenia
- Displays precession at any epoch
- Calculates proper motion of stars

Telescope display
- Shows stars, planets, satellites, and asteroids/comets
- Pan and zoom aim point with scroll bars, mouse click to aim, or enter right ascension and declination in control panel
- Aim by selecting in Object catalogue
- Point computer-controlled telescope via DDE
- Right click on object to display description from Object catalogue
- Variable limiting magnitude for stars
- Variable magnification power

- Optionally displays constellations, star names, magnitudes, and codes, deep sky objects, North or South up
- Uses same star catalogue, precession, and proper motion calculation as the Sky map

Horizon view

- Shows stars, planets, satellites, and asteroids/comets
- Select viewing direction by scroll bar, cardinal points, or azimuth
- Optional fractal-generated terrain and user-extensible scenery at horizon
- Click on object to view through telescope
- Right click on object to display description from Object catalogue
- Variable limiting magnitude for stars
- Variable field of view
- Optionally displays constellations, star names and codes, deep sky objects
- Uses same star catalogue, precession, and proper motion calculation as the Sky map

Orrery

- View solar system from any viewpoint
- Planet positions and orbits calculated precisely
- View entire solar system or just inner planets
- Shows orbit of asteroid or comet being tracked
- Scale factors: Real, Log distance, or equally-spaced orbits

Satellite tracking panel

- Name of satellite being tracked
- Year of launch, launch number, and piece code
- Inclination of orbit
- Revolutions per day
- Current latitude, longitude, and altitude
- Orbit number
- Whether satellite is eclipsed (in Earth shadow)

View Earth from... panel

- Horizon-to-horizon view of Earth as seen from Sun, Moon, satellite, above observatory, or night hemisphere
- Vector map or texture-mapped image rendering
- Current latitude, longitude, and altitude

Satellite icon selection

- Choose any of 10 icons for the satellite

Object catalogue

- General-purpose multimedia database system
- Includes databases of asteroids, periodic comets, Messier objects, deep-sky favourites, constellations, navigation stars, solar system objects, star names, meteor showers, spacecraft, radio sources, and chart numbers in various sky atlases
- Aim telescope at selected objects
- Retrieve objects by right clicking on them in telescope or Horizon view
- User-extensible: add your own images, sounds, objects, and entire new catalogues
- Extract asteroid and comet orbital elements from IAU Circulars
- Add objects, lines, and text to sky maps with user-defined chart catalogues

Satellite database selection

- Choose satellite elements database
- Uses standard NASA/NORAD two-line elements
- Drag and drop orbital elements files

DDE server implementation

- Comprehensive information with real-time updates available to DDE clients
- Provides real-time aiming information to computer-controlled telescopes

Cuckoo clock

- Uses wave audio output device
- Yes, you can turn it off

Set observing site

- Specify observing site anywhere on Earth
- Database of more than 1300 cities and towns
- Pick location graphically on map or enter latitude and longitude
- Add new locations to site database

Set Universal time or Julian date

- Calculates for specified date and time
- Julian day calculator
- Permits historical research: "was the Moon full when..."
- Accurate from 4713 B.C. into the distant future

Animation

- Speed, direction, and time step selectable
- Demonstrate seasonal changes, Moon phases, satellite orbits, precession, proper motion
- Animate Earth map, sky map, orrery, Horizonand telescope views

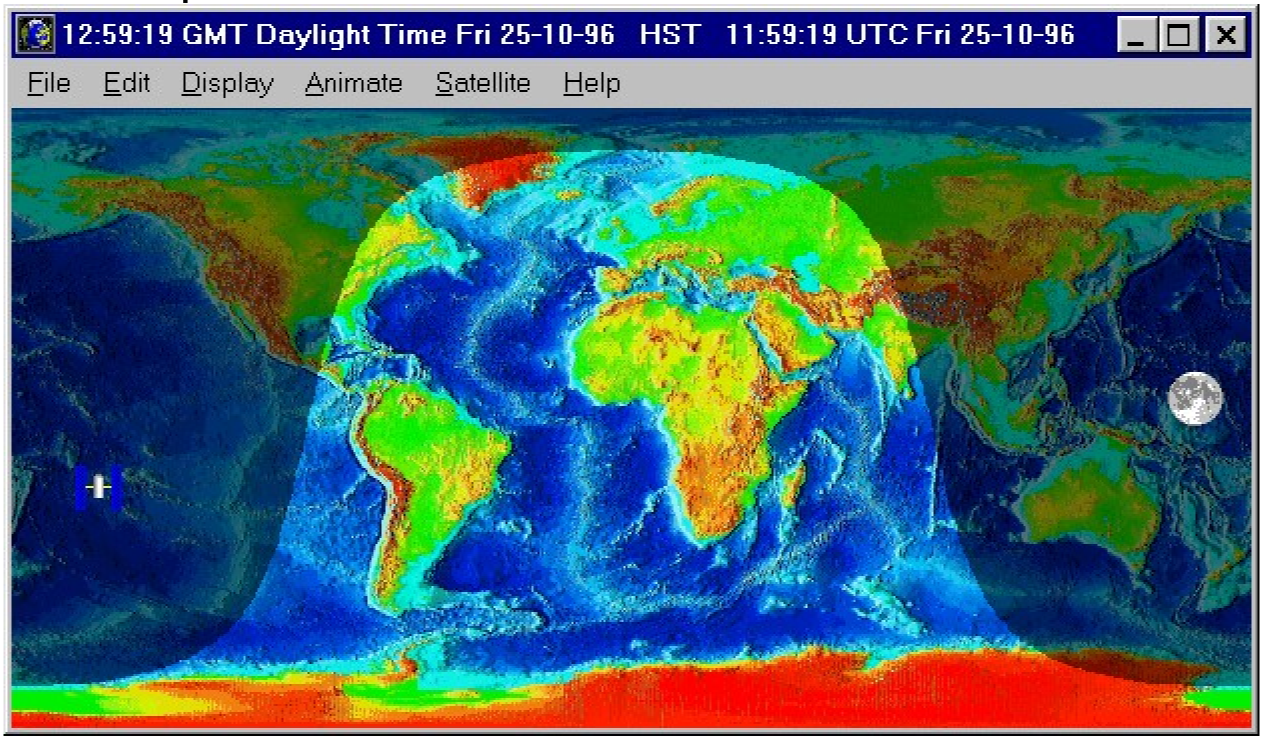
Icon display

- Local date and time
- Universal time during animations

User preferences

- May be saved for subsequent sessions
- Can reset to defaults

The Map Window



The Map window appears when you start Home Planet.   It provides at-a-glance information about the Sun, Moon, Earth, and a selected Earth satellite.   Let's examine the map window to understand all the data packed into it.

The title bar at the top gives the current local time, including the time zone, and the corresponding Universal time (UTC or Greenwich mean time) taking into effect the number of hours your time zone differs from UTC and whether Daylight Saving Time is in effect.   If a satellite is being tracked, its name appears after the application name "Home Planet:" in the centre of the title bar.

The map window shows a map of the Earth in the Mercator projection.   The image used depends on your display hardware and the image you've selected with the Display/Map window menu item.   The portion of the Earth illuminated by the Sun is highlighted and the night side of the Earth is drawn in subdued tones.   Advanced users can customise the supplied Earth maps and/or replace them with new maps of their own.

If Show Moon is checked in the Display menu, an image of the Moon in the correct phase is shown on the map at the location on the Earth where the Moon is currently at the zenith. Double clicking on the Moon icon displays the Sun/moon information panel (unless it's already active).

If you've selected a satellite to be tracked, an icon representing it (which you can choose with the Satellite/Change satellite icon menu item) is drawn at the point above which the satellite is currently passing.   Double clicking on the satellite icon displays the Satellite tracking control panel (unless it's already on screen, in which case a panel appears showing the Earth as seen from the satellite).

You can resize the Map window from its default size of 620 by 310 pixels.   If you have a high resolution display and expand the Map window to much larger than its original size, the image may look coarse. To avoid this problem, when using large Map windows switch the Map window display to 16 Colour or Monochrome mode. These maps are generated from a vector database which can be rescaled to any size without artifacts.

Customising map window images

The following is an advanced topic which assumes you're familiar with editing resources in a Windows DLL file and/or developing DLL's from scratch, and that you have the software tools such tasks require. Most Home Planet users won't need to concern themselves with such details. The information is presented here to provide those interested in such extensive customisation the means to accomplish it.

The Map window allows you to select a bitmap image of the Earth from a variety of available images. The map images are defined in a file, **MAPBITS.DLL**, supplied with Home Planet, and accessed using interface functions. You can customise the Earth map images either by directly editing the resources in the DLL with a tool such as Microsoft's App Studio, or by creating your own **MAPBITS.DLL** which implements the same interface functions.

Editing MAPBITS.DLL resources

The easiest way to modify and extend the Earth map bitmap library is to edit the supplied version of with a resource editor. When you display the resources in this file, you'll see the following string resource:

1 "2 ; Number of bitmaps in DLL"

If you're adding a bitmap, increase the number in this string resource. Only the number is relevant; the comment is for documentation only.

For each bitmap in **MAPBITS.DLL**, there is a string resource, numbered from 100, which provides a description of the bitmap that appears in the Display/Map image menu item and a bitmap reource bearing the same number which contains the actual bitmap. To add a new bitmap to **MAPBITS.DLL**, edit string resource 1 to increase the number of bitmaps in the file, then add the description string resource and the bitmap resource to the file.

Map window bitmaps have a special format upon which the Map window display code counts--if you develop new bitmaps for the map window, you must be sure they conform to its expectations. All map window bitmaps contain at most 117 unique colours. The palette in the bitmap consists of up to 117 "subdued" colours starting at palette index 0, used to paint night regions of the Earth, a filler of the size required, then starting at palette index 128, up to 117 "day" colours used in the portion of the Earth illuminated by the Sun. Pixels in the bitmap are assumed to have the 0x80 bit set, selecting the day portion of the palette.

Replacing MAPBITS.DLL

To replace **MAPBITS.DLL** with a compatible library, you need to implement the following functions:

extern int FAR PASCAL _export mapbitsCount(void);

Returns the number of bitmaps defined within the DLL. Returns 0 in case of error.

```
extern void FAR PASCAL _export mapbitsGetBitMap(
        WORD bitmapNumber,      // Bitmap number to get
        HANDLE FAR *hBitmap);   // Handle to bitmap or NULL = error
```

Returns a handle to the bitmap, as obtained by **LoadResource()**. Note that this is *not* the result of **LoadBitmap**! Home Planet needs to manipulate the original Device Independent Bitmap, and thus must look directly at an in-memory copy of the bitmap resulting from direct access to the resource.

```
extern void FAR PASCAL _export mapbitsGetDesc(
        WORD bitmapNumber,              // Bitmap description to get
        LPSTR sbuf, UINT buflen);       // Buffer and length
```

Returns, for the bitmap with the given *bitmapNumber*, the description from its corresponding string resource, stored into string *sbuf*, with a maximum length of *buflen*. If an error occurs, *sbuf* will be set to the null string. The description will appear in the Display/Map image submenu.

Icon display

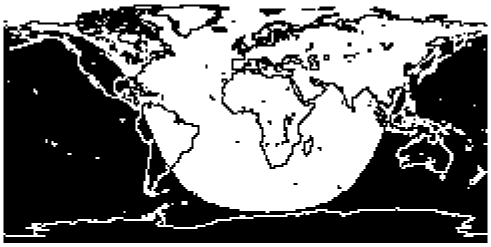
When you minimise the Map Window to an icon, the icon title gives the current local time and date unless you minimised Home Planet whilst running an animation.   In that case the icon displays the current Universal time of the animation in the format:

23:35Z 11/9

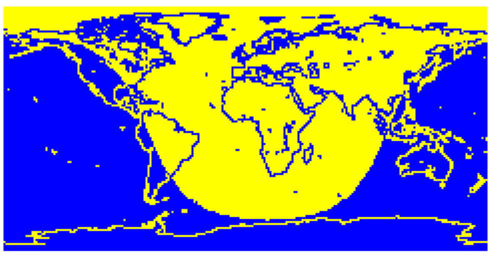
The "Z" (for "Zulu time", one of the many synonyms for Universal time) reminds you that the image doesn't show the real-time illumination of the Earth.

Map window display modes

The Display/Map window menu item allows you to select the representation of the Earth map in the Map window. The choices, presented on a cascading sub-menu are:

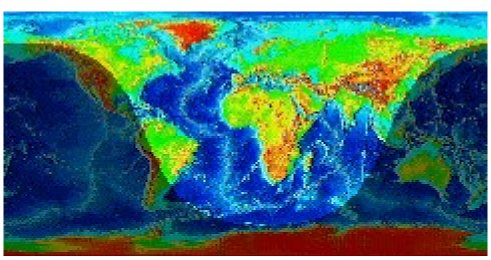


Monochrome: Black and white map generated from vector map database. This choice is best for monochrome screens. You can resize this map to any scale without loss of resolution.



16 Colour: Blue and yellow colour display from vector map database. This is the best choice for machines with 16 colour displays. You can resize the map to any size and shape without loss of resolution.

Grey scale: Grey scale rendition of full colour bitmap image of the Earth. This is the same image as the "Full colour" option shown below, but rendered in grey tones. This option looks best on 256 colour displays.

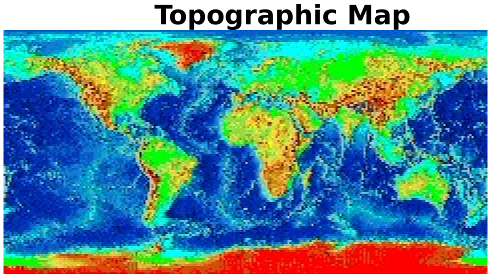


Full colour: Full colour bitmap image of Earth. This option requires a 256 colour display for proper results; choosing it on a 16 colour display results in a cartoon-like image which is generally unusable.

Home Planet chooses the default mode for displaying the Map window based on the display hardware available in your computer. You need at least a 256 colour display board to fully appreciate the Grey scale and Full colour display modes. The 16 Colour mode works well on most RGB display boards, and Monochrome is a good choice for laptops without grey scale capability.

In Grey scale and Full colour display modes, the Map window initially displays a topographic map of the Earth with the oceans removed. If this subdued image is too restrained for your taste, choose the Display/Map image/Gaudy map menu item. You can make the gaudy map the default image when Home Planet starts by selecting it and then using the File/Save settings menu item. Other map images may be available from customised versions of the Earth map database **MAPBITS.DLL**; if so they will appear as options in the Display/Map image menu.

Topographic Map **Gaudy Map**



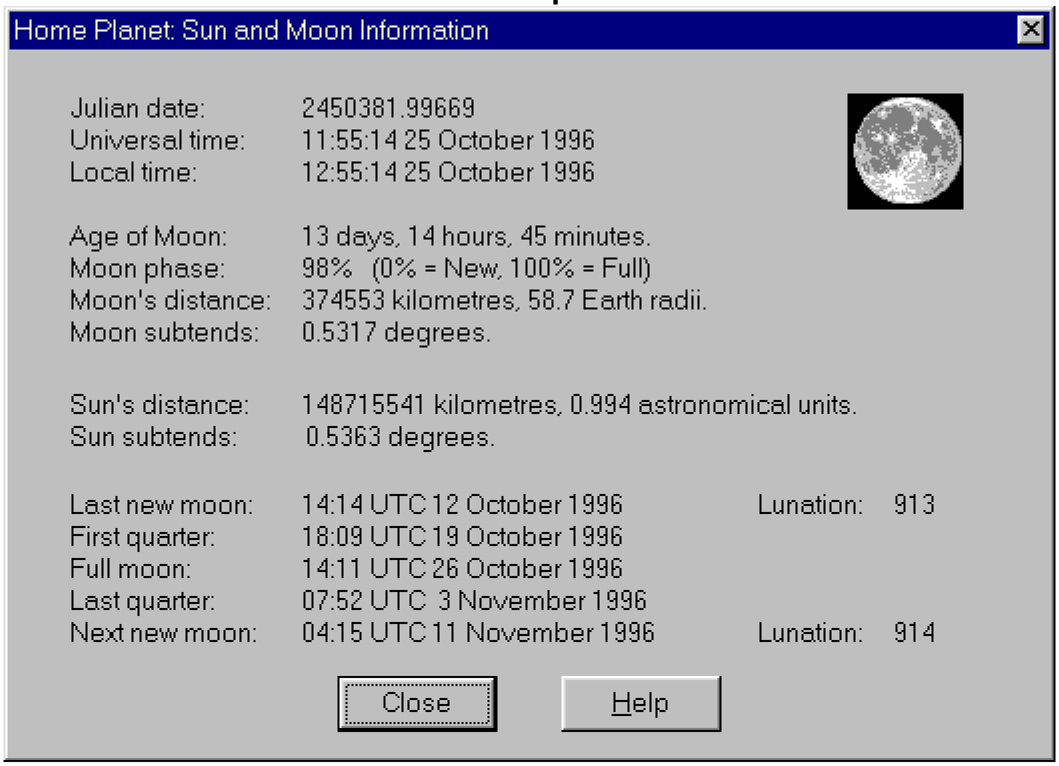
The global topographic map was developed by the Marine Geology and Geophysics Division of the National Geophysical Data Center operated by the United States Department of Commerce, National Oceanic and Atmospheric Administration. The colour resolution in the original image has been reduced to allow rapid generation of day and night hemispheres. For more information, visit the NOAA-MGG site on the World-Wide Web: **http://www.ngdc.noaa.gov/mgg/**.

Show Moon?

The Display/Show Moon menu item lets you toggle whether the current position and phase of the Moon are shown in the Map window.   You might want to turn off the Moon whilst running an animation of satellite motion since eliminating the need to calculate and draw the Moon at each step will make the animation run faster and more smoothly.

The setting of Show Moon? does not affect visibility or updating of the Sun/Moon information panel.   It is controlled by the Display/Sun/moon Info... menu item.

Sun/Moon information panel



You can activate the Sun and Moon information panel by selecting the Display/Sun/moon info... menu item or by double clicking the image of the Moon in the Map window. The panel continues to be displayed and updated until you close it with its Close button or with the Control menu box. The information displayed in the panel reflects either the current time and date or the most recent time step in an animation. If an animation is in progress the Local time is not displayed.

Items displayed in the information panel are as follows:

Julian date This is the current Julian date with the time represented as a fraction of a day. Be careful, when interpreting the day fraction, to recall that Julian dates start noon, not midnight.

Universal time This field specifies the current Coordinated Universal Time (UCT), also known as Greenwich Mean Time (GMT). This is the time at the Prime Meridian, not adjusted for Daylight (Summer) time. This time is computed from the local time supplied by your computer's clock by applying a time zone correction. Every other number in Home Planet is calculated based on this Universal time, so if it's incorrect, you'll have to adjust your time zone setting to yield the accurate Universal time.

Local time The current local time and date supplied by your computer's clock.

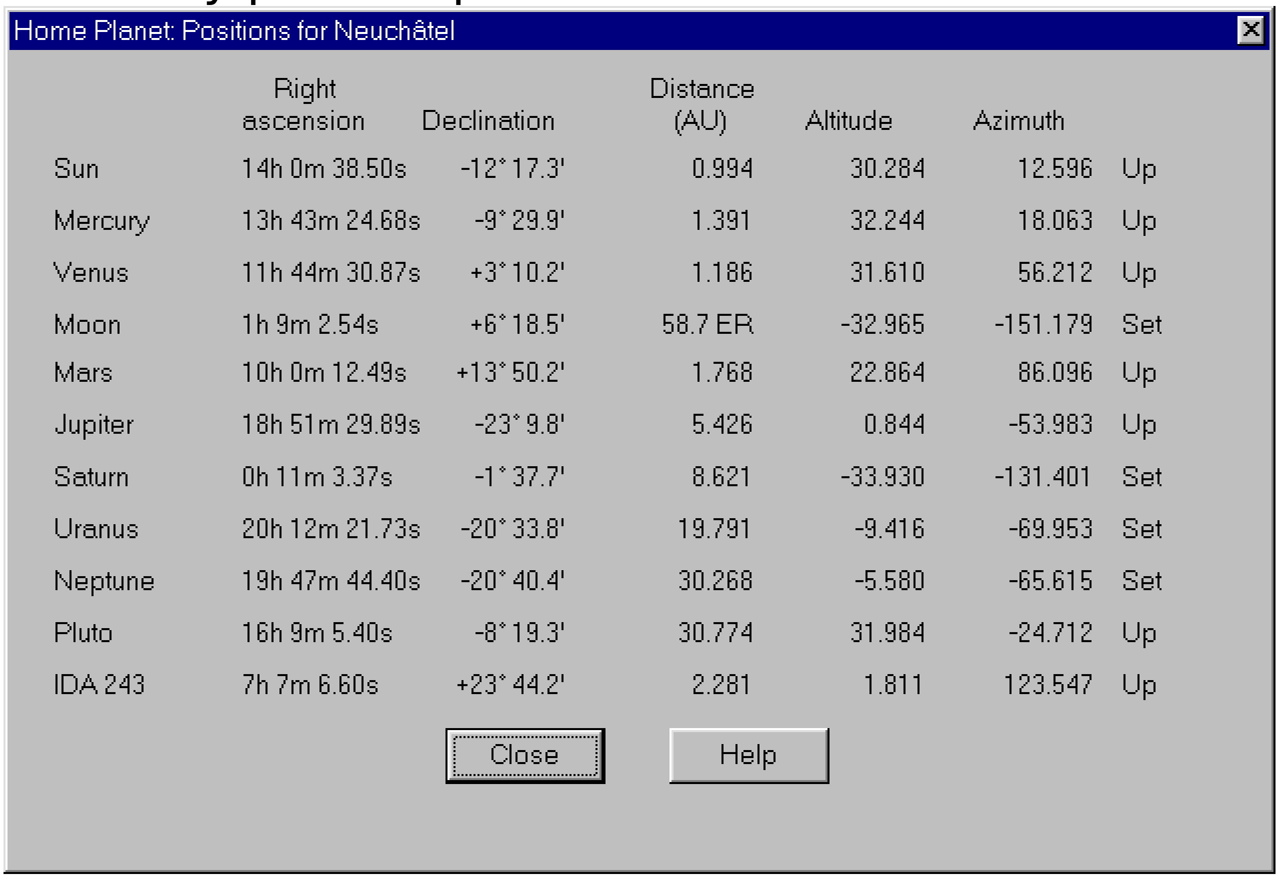
Age of Moon The time, expressed as days, hours, and minutes, since the last New Moon.

Moon phase Moon's phase (percent of the lunar disc illuminated, as seen from Earth).

Moon's distance Distance of the centre of the Moon from the centre of the Earth, given both in kilometres and Earth radii (approximately 6378.14 kilometres, neglecting equatorial flattening of the globe).

Moon subtends	Angle subtended by the Moon in the sky. A solar eclipse will be total if the angle subtended by the Moon equals or exceeds that subtended by the Sun; otherwise the eclipse will be annular.
Sun's distance	The distance of the Earth from the Sun in kilometres and mean astronomical units (149,597,870 km).
Sun subtends	Angle subtended by the Sun in the sky. A solar eclipse will be total if the angle subtended by the Sun is less than that subtended by the Moon; otherwise the eclipse will be annular.
Last new moon **First quarter** **Full moon** **Last quarter** **Next new moon**	Time and date of phases of the current lunation. These times are accurate to about two minutes.
Lunation	Number of the current and next lunation (interval between New Moons) in E. W. Brown's numbered series of lunations starting on 1923 January 16.

Planetary position panel



Home Planet: Positions for Neuchâtel

	Right ascension	Declination	Distance (AU)	Altitude	Azimuth	
Sun	14h 0m 38.50s	-12° 17.3'	0.994	30.284	12.596	Up
Mercury	13h 43m 24.68s	-9° 29.9'	1.391	32.244	18.063	Up
Venus	11h 44m 30.87s	+3° 10.2'	1.186	31.610	56.212	Up
Moon	1h 9m 2.54s	+6° 18.5'	58.7 ER	-32.965	-151.179	Set
Mars	10h 0m 12.49s	+13° 50.2'	1.768	22.864	86.096	Up
Jupiter	18h 51m 29.89s	-23° 9.8'	5.426	0.844	-53.983	Up
Saturn	0h 11m 3.37s	-1° 37.7'	8.621	-33.930	-131.401	Set
Uranus	20h 12m 21.73s	-20° 33.8'	19.791	-9.416	-69.953	Set
Neptune	19h 47m 44.40s	-20° 40.4'	30.268	-5.580	-65.615	Set
Pluto	16h 9m 5.40s	-8° 19.3'	30.774	31.984	-24.712	Up
IDA 243	7h 7m 6.60s	+23° 44.2'	2.281	1.811	123.547	Up

Close Help

This panel shows you the current (or simulated, if you've set a specific date and time or are running an animation) positions of the principal bodies in the Solar System, both in celestial coordinates and as seen from your observing site. If you're tracking an asteroid or comet, chosen from the Object catalogue, its position is given at the foot of the table. For each solar system body the following data are displayed:

Right ascension: Hour angle at Greenwich.

Declination: Declination with regard to the equator.

Distance (AU): Distance from the Earth in astronomical units (the Moon's distance is given in units of the Earth's radius).

Altitude: Altitude of the body above the horizon, in degrees at the observing site. If negative, the body is below the horizon ("set") and hence invisible.

Azimuth: Local compass point at the observing site above which the object appears. Astronomers measure azimuth from the South (consistent with the convention for hour angle), with positive angles toward the West and negative angles toward the East.

Visibility: This column interprets the Altitude and Azimuth to describe what you can expect to *see*. Objects below the apparent horizon (taking account of the refraction of the atmosphere and the finite angular size of the Sun and Moon but not altitude of the observer) are shown as "Set" while objects clearly visible in the sky (or visible if the Sun weren't also up) are shown as "Up". Objects that are just appearing or disappearing on the horizon are shown as "Rising" or "Setting", and objects at culmination (crossing the local meridian) are shown as being in "Transit". Transit times are quite accurate, but rising and setting times can be given only approximately because the altitude of the observer, the local topography along the horizon, and the effects of atmospheric refraction (which, in turn, vary based upon temperature and barometric pressure) have a major influence upon when you will actually see an object appear or disappear at the horizon.

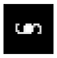
The Planetary position panel shows the gory details that underlie the Sky and Orrery displays and provides the serious observer the information needed to plan sessions at the telescope far in advance.

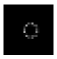
Solar system object symbols

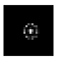
Sun
Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
Pluto
Asteroid
Comet

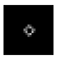
Deep sky object symbols

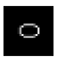
 **Elliptical galaxy**

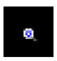
 **Spiral galaxy**

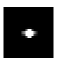
 **Open star cluster**

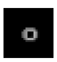
 **Globular star cluster**

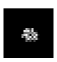
 **Diffuse (gaseous) nebula**

 **Planetary nebula**

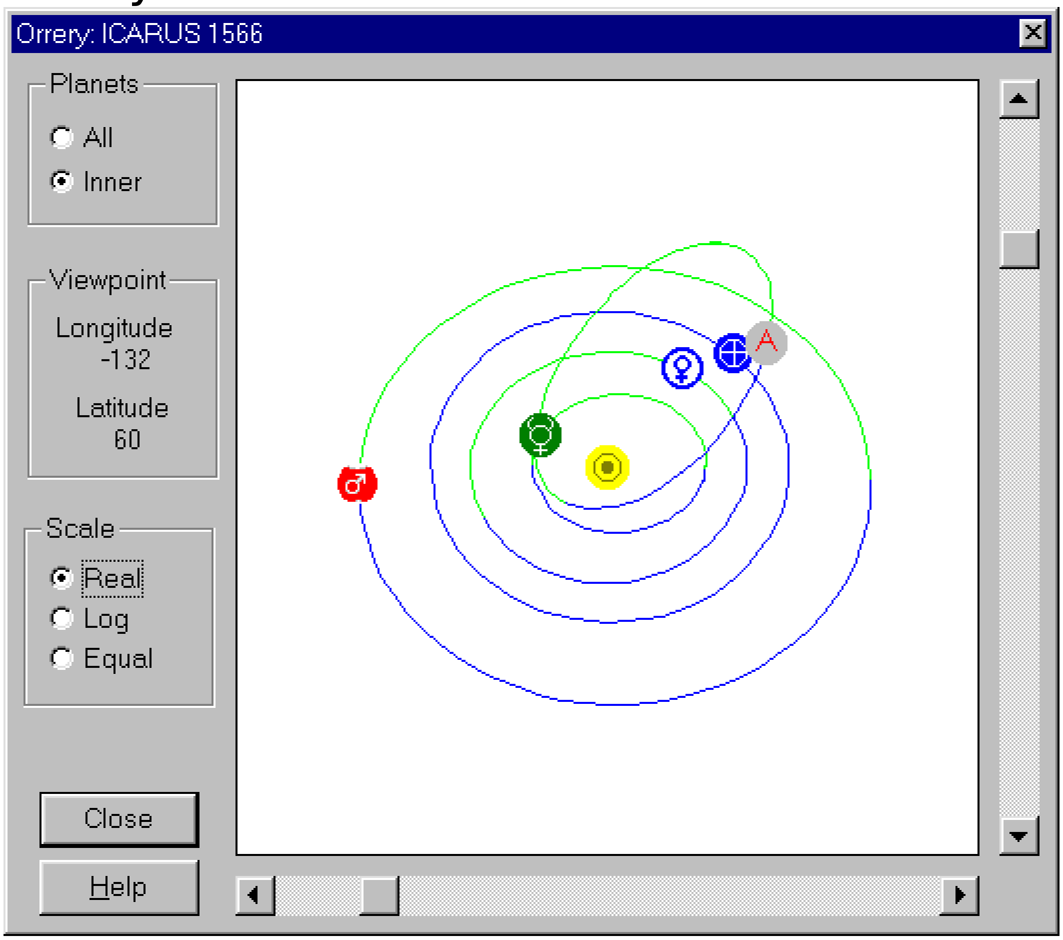
 **Quasar**

 **Double star**

 **Dark nebula**

 **Irregular galaxy**

Orrery



The orrery provides a view of the Solar System, showing the planets (or just the inner planets, if you wish) at their instantaneous positions along their respective orbits. Orbits are plotted based on the actual orbital paths of the planets, taking into account eccentricity, inclination to the ecliptic, perturbations, and perihelion advance. Each planet is represented by its conventional astronomical symbol. If you've selected an asteroid or comet to be tracked from the Object Catalogue, the body's orbit and current position will also be shown. The Sun always appears in the centre of the orrery.

The orbits of the planets are not coplanar, and many comets and asteroids have highly inclined orbits. The plane of the Earth's orbit is defined as the *ecliptic*. With respect to that plane, the other orbits are inclined and thus, in the course of each revolution the planets rise above and fall below the plane of the ecliptic. The portion of the orbit above the plane of the ecliptic is drawn in blue, the portion below in green. Most planets' orbits are only slightly inclined with regard to the ecliptic; notable exceptions are Mercury, 7 degrees and Pluto, a whopping 17.2°.

You can view the solar system from any three-dimensional vantage point to better see the orbital inclinations. Initially, the orrery shows a "plan view" of the solar system--the view from directly above the Sun's North pole (heliocentric latitude 90° North, as astronomers phrase it). The vertical scroll bar adjusts the latitude, allowing increasingly oblique views of the orbits or views from southern heliocentric latitudes. As you adjust the latitude, the latitude display on the left of the window reads out the current latitude and a schematic image of the inclination of the ecliptic is shown in the display window. The horizontal scroll bar adjusts the heliocentric longitude. Adjusting this scroll bar rotates the solar system with respect to your viewpoint--you can, for example, put the Earth in the front of an oblique display to see which planets are in conjunction and opposition more easily. As you drag the horizontal scroll bar the longitude read-out changes and the resulting position of Earth in its orbit is shown.

Given the scale of the solar system, the size of the Sun and planets are totally unrelated to the scale of the orbits; drawn to true scale they would be less than a single dot's height on the screen. Even the orbits are difficult to represent on a single map. There are really two solar systems: the inner system (Mercury through Mars), and the outer system (Jupiter through Pluto). If you draw the outer system to scale, the inner system is reduced to a bunch of tiny, almost overlapping ellipses crowded near the Sun. (That's why it's so difficult to launch probes to the outer planets, and why they take so long to get there.) As an example of the grand scale of the outer solar system, consider the eccentricity of the orbit of Pluto. The *difference* in the distance from Pluto to the Sun between Pluto's perihelion and aphelion is almost *twenty times* the *total* distance from the Earth to the Sun!

The orbital path of comets with extremely elongated elliptical orbits (eccentricity close to 1), parabolic, or hyperbolic orbits cannot be shown in their entirety (parabolic and hyperbolic orbits are theoretically infinite in extent). Orbits of such comets are tracked to beyond the orbit of Jupiter, following both the inbound and outbound legs of the orbit.

Over the centuries, artists depicting the solar system and designers of mechanical orreries have resorted to a variety of dirty tricks to get around this problem of scale, and Home Planet implements most of them. First of all, you can choose to display either the entire solar system or just the inner system. When you display the entire system, the inner planets will be all mashed together (except in Equal mode, see below), but even though the discs may overlap you'll usually be able to see the relative longitudes around the sun. When you're interested in the details of the inner system (for instance, whether an opposition of Mars occurs at perihelion or aphelion), simply select "Inner" in the Planets box to zoom into the inner solar system.

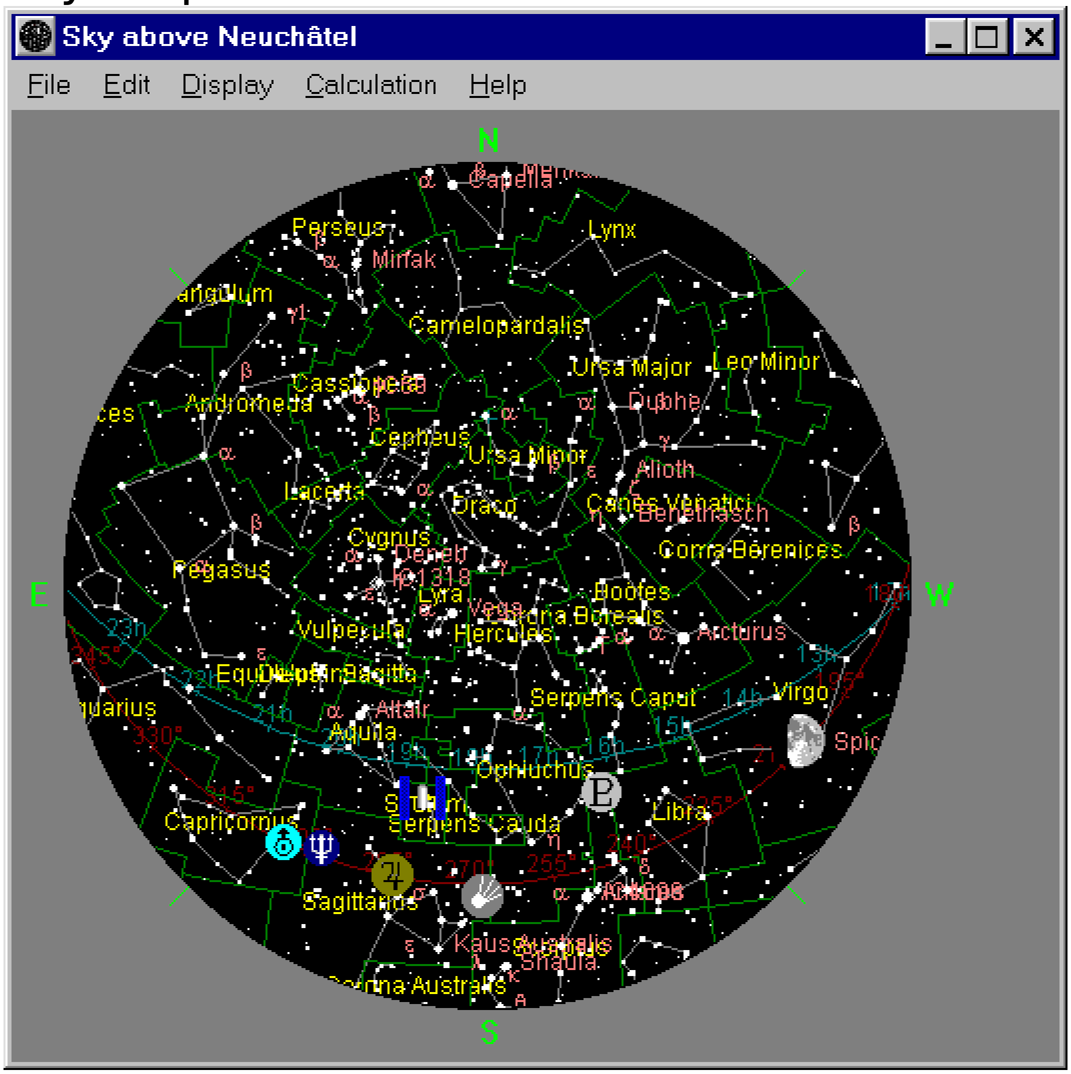
Regardless of whether you're viewing just the inner planets or the entire solar system, you can choose among three different scales for the orbits in the "Scale" box. The default, "Log," shows the orbits in a logarithmic scale which preserves their relative scale while compressing the vast empty space of the outer system. "Real" selects a true linear scale which shows just how empty the solar system is; in Real mode you really can't view the inner and outer system on the same display. "Equal" chooses a presentation you may recall from your elementary school "Science Is Good" textbook (assuming you're young enough to remember elementary school yet old enough to remember when Science *was* Good)--all the orbits are shown equally spaced from one another (with a tip of the hat to the eccentricity of the orbits of Mercury, Mars, and Pluto). The Equal view isn't included entirely for nostalgia; it's very useful for viewing the solar system as a whole when, for example, you're interested in events such as conjunctions (appulses) between Venus and Jupiter. If you have a high-resolution display board, you may want to expand the orrery window to give it more screen "real estate", especially with Real and Log scale displays.

Calculating the orbits of solar system objects for display in the orrery is a mindbogglingly computationally intense task. Calculating the position of any body in the solar system involves evaluating a series of tens to hundreds of perturbation terms, many of which involve trigonometric functions which must be calculated for use in, at most, one or two terms. When you first display the orrery window, expect a delay as Home Planet calculates the orbits. Once calculated, however, the orbits remain valid for a long time and Home

Planet needn't recalculate them until a century has passed.

Historical note: For decades I, and I suspect many other folks whose fondest childhood memories include pressing the button on the clockwork orrery at the science museum until their fingers turned blue waiting for *all the planets to line up*--just another half-hour, Mom!--believed that the word *orrery* was etymologically derived from *orbit*: after all, that's what it demonstrates! In fact, mechanical models of the solar system, invented c. 1700 by George Graham, have been called *orreries* ever since the English instrument maker John Rowley named a copy he made of Graham's machine "The Orrery" in honour of Charles Boyle, Earl of Orrery.

Sky map



The sky map shows the sky as it appears at the current time (real or simulated) above the location you've selected as the observing site. Stars visible to the naked eye and symbols representing the Sun, Moon (with correct phase), and planets currently above the horizon are shown in their correct positions in the sky. If you've selected an asteroid or comet to track from the Object catalogue and it's currently visible, the symbol representing it will also appear in the sky map. If you're tracking a satellite and it's visible from your site, its icon will appear at the correct position in the sky.

The sky map is a full-fledged window and may be resized, minimised, and maximised independently of Home Planet's Earth Map window. You can copy the sky map to the clipboard with the Edit/Copy menu item. Once copied to the clipboard, the map may then be pasted into other documents, printed, etc.

Map orientation

The sky map is drawn in the form normally used by astronomers. If you're in the Northern hemisphere, North is up and West is to the right. At first glance, East and West seem backwards, but remember that a sky map represents the dome of the heavens and that you use it (at least in your mind) by holding it over your head.   If you stand facing North and hold the map over your head, then East and West correspond to their terrestrial directions. Think about it.   If you're observing from the Southern hemisphere, South is up and East is to the right.

Sky colour

The background of the sky map is blue if the Sun is up, dark red if it's rising or setting, dark blue during twilight (when the Sun is between 18 and 6 degrees below the horizon), and black at night.   Planets and stars are shown even if the Sun is up and they aren't actually visible.   (When Venus is sufficiently elongated from the Sun and the sky is crystal-clear, with a little effort you can see Venus with the naked eye in broad daylight--the sky map tells you right where to look!).

Celestial coordinates

The celestial poles are marked with a light blue cross with arms pointing at the 0, 6, 12, and 18 hour marks along the celestial equator.   The equator is also drawn in light blue, with labeled tick marks at every hour of right ascension.   The ecliptic is plotted in dark red with ticks and labels every 15° of ecliptic longitude.   The point where the ecliptic intersects the celestial equator at 0 hours of right ascension and 0° ecliptic longitude is called the "March Equinox" or "First Point of Aries" (even though the equinox hasn't actually occurred at that point in the constellation of Aries for more than 2000 years--it's in Pisces now, and will pass into Aquarius in the year 2597 when the "Age of Aquarius" actually dawns some six hundred years after the rather premature but nonetheless catchy popular song heralding it).   You can turn the coordinate display on and off with the Display/Ecliptic, equator, poles menu item.

Constellations

To aid in orienting yourself, the names and outlines of the constellations and the borders between the constellations are normally shown on the sky map.   You can toggle these annotations on and off with the Display/Constellations, Display/Constellation names, and Display/Constellation boundaries menu items.   The constellations are defined in three database files which you may modify if you wish.   Constellation names can be drawn either horizontally or aligned with the closest horizon.   The Display/Align constellation names menu item controls whether this alignment is done.   Alignment of constellation names requires generating a separate text font for each constellation name; on a fast machine this adds only a few seconds to the generation of the sky map, but on slower machines this process can take *minutes*.   Consequently, alignment is off by default; turn it on to see how long it takes on your machine and whether you prefer this format.

Star display options

Plotting stars in the sky map is time-consuming; you can choose various levels of trade-off between the quality of the map displayed and the time required to update the screen as the sky changes.   The Display/Star quality menu item offers you three choices.   The default, High quality, paints stars using icons specially scaled based on star magnitude as used in printed star charts.   Medium quality draws bright stars as circles scaled by magnitude and renders dimmer stars as single pixels with brightness set according to magnitude (the accuracy of this brightness depends, of course, on the display capability of your screen). When Low quality is selected, all stars are drawn as single pixels.   If constellation outlines are displayed, this presentation is adequate to locate planets and satellites in the sky, particularly on lower resolution displays where the pixels are larger; you may find Low quality mode useful when using Home Planet on a laptop machine in the field during an observing session, and it's also an excellent choice to speed up animations of the sky map. The star quality you select for the sky map also applies to the Telescope display and Horizon view.

Star colours

Stars have colours which depend upon their temperature (or, more precisely, the spectral class). Medium and Low star quality displays approximate the star colour when plotting stars in the sky map and telescope window. The colour shown is representative of the star's temperature, but don't expect to see colours like this in the real sky--most stars are too dim to trigger the colour sensors (cones) in your eyes, so you see them as white. You can toggle star colour on and off with the Display/Star colours menu item. Star colours are not shown when you select High star quality because the technique used to plot High quality stars does not permit showing them in different colours.

Star names and numbers

Names of bright stars such as Vega, Capella, and Altair are normally shown on the sky map; you can toggle star names on and off with the Display/Star names menu item. Less prominent stars are identified by the Greek ("Bayer") letter or Flamsteed number within the constellation; you can turn this nomenclature on and off with the Display/Star Bayer/Flamsteed codes menu item.

Choosing the star catalogue

Home Planet is furnished with two built-in star catalogues. The default catalogue is based on "The Bright Star Catalogue, 5th Revised Edition" [Yale: Hoffleit & Warren 1991], which contains position, magnitude, spectral type, and proper motion data for 9096 stars brighter than magnitude 6.5. It is the most widely used digital star database, since it includes comprehensive information for all naked eye stars. Also included with Home Planet is the definitive Smithsonian Astrophysical Observatory Star Catalogue [SAO: 1966], updated to epoch J2000.0 and corrected by Roman and Warren in 1990. The SAO catalogue is the fundamental professional astrometric reference: it lists more than a quarter of a million stars, providing position, visual and photographic magnitude, proper motion, spectrographic information, and a wealth of other data. The SAO catalogue contains stars as faint as twelfth magnitude, but is generally considered to have a limiting magnitude (the point at which as many stars are missed as are included) of about 9.5. The master versions of these primary references, distributed on the Astronomical Data Center CD-ROM, were specially processed for use in Home Planet, annotating them with star names, Bayer letters and Flamsteed numbers, and other information. In addition, the databases were compressed to reduce the more than 60 megabytes of raw master database to less than four megabytes.

You can choose the database used to generate the sky, telescope, and horizon windows with the Display/Star catalogue menu item. You'll notice a difference even in the display of bright stars when you swap databases: assigning stellar magnitudes is a tricky business, and catalogues tend to differ among one another.

Solar system objects

Solar system objects, including the Sun, Moon (in its correct phase), planets, and any asteroid or comet chosen to be tracked from the Object catalogue are shown in the sky map as symbols at the correct positions in the sky. You can switch display of solar system objects on and off with the Display/Solar system objects menu item.

Deep sky objects

Bright nonstellar objects from the deep sky database are plotted as labeled icons in the sky map; you can hide or display them with the Display/Deep sky objects menu item.

Historical and animated skies

The sky map displays the sky as of the date and time set from the Home Planet Map window. You can use it, therefore, to show the sky at any point in history. What did the sky look like the day you were born? Just ask! Or set off on your own quest for the Star of Bethlehem: set the Observer's location to Jerusalem, the Universal time to 16:00 UTC February 25, -5 (6 B.C. as historians reckon it), and observe, shining as a beacon in the Western sky at dusk, a rare (not to repeat for 800 years) conjunction among Jupiter (traditional king of the gods), Saturn (ruling planet of Judah), and Mars, occurring in the constellation of Pisces the Fish (the House of the Hebrews) where the equinox had just entered, crossing the border from Aries where it had been since the Greeks. You'll recall that the early Christians recognised one another with the sign of a fish. Point the Telescope at the conjunction of planets in Pisces by clicking over them. A month before, in late January of 6 B.C., low in the western skies of Jerusalem, Mars, heading for its rendezvous with Jupiter and Saturn, passed near faint Uranus, dim yet easily seen by the naked eye in ancient skies unpolluted by the effluvia of modern life and the light of cities that blots out the stars. What a wonder indeed, this new dim wanderer in the sky, perhaps observed but never recorded. In Pisces, the fish. Highly unlikely, yet intriguing nonetheless.

Animation allows you to see how the sky turns above the Earth over a night or, by animating with a time step of one Sidereal day (the time it takes the fixed stars to return to the same position as seem from the Earth), how the Sun, Moon, and planets march through the sky over time. Choose an animation time step of one year to watch the slow-motion ballet of the outer planets.

Calculating precession

The north pole of the Earth doesn't stay pointed at a fixed direction in space. Like a wobbling top, the Earth precesses, tracing out a full circle in the sky every 25,800 years. Since the Earth's axis of rotation is inclined 23.5° to the ecliptic (the plane in which it orbits the Sun), the radius of the circle followed by the north pole in the sky is the same: 23.5°. As the Earth's axis slowly turns in space, the position of all the stars, as seen from Earth, changes. "Polaris" is only the pole star at the moment; it reaches its closest point to the actual north pole in the year 2105. 13000 years from now, brilliant Vega will point the way north, at which time our Polaris will be an obscure star almost 45 degrees from the pole. Precession is often called "the precession of the equinoxes", since one of its most obvious consequences is the slow progression of the Sun at the time of the equinoxes from constellation to constellation over the centuries.

Precession is both the bane and the guaranteed meal ticket of the positional astronomer. Astronomers record the positions of celestial bodies in an equatorial coordinate system--based on the Earth's poles and equator. But since the poles move, any position must be qualified by the date for which the position is valid (the "epoch"). Converting positions from one epoch to another is tedious yet necessary, and has provided gainful employment for generations of unimaginative astronomers. Home Planet can calculate the effects of precession over distant spans of time. All catalogues supplied with Home Planet are referenced to the current standard epoch of J2000.0 and are valid for most non-critical purposes for the 50 year period from 1975 through 2025. Since correcting the positions of tens or hundreds of thousands of stars for precession is time consuming, Home Planet normally neglects the effects of precession as long as the date is within that range: outside the half century centred on 2000 A.D., precession is calculated. You can control Home

Planet's handling of precession with the Calculation/Precession menu item. Checking Automatic selects the default mode where precession is ignored for 25 years on either side of 2000 and is calculated otherwise. Choosing Always causes precession to be calculated regardless of the date; this provides the utmost accuracy. Selecting Never disregards the effects of precession for all dates. You may want to choose Never if you're interested in following the proper motion of stars over the centuries and don't want to be distracted by precession.

Proper motion

The "fixed stars" are all actually moving relative to one another, tracing out their individual orbits around the galaxy. The reason we don't see the stars zipping around in the sky isn't that they don't move, indeed, they move at velocities totally outside our experience, tens of kilometers per second. We don't notice them moving over the course of our lifetimes because they are so incredibly far away. By comparing photographs taken decades apart, however, astronomers have measured the true motion of stars with regard to the Sun. The term "proper motion" is used to denote this actual motion of stars, as opposed to all the other apparent motion caused by our moving vantage point on the Earth. Proper motions have been catalogued for more than 40,000 stars, and Home Planet's star catalogues include proper motion for each star for which it has been measured. If you set the date to a time in the distant past or future with the Edit/Set Julian Date or Set Universal Time menu items, the Sky map and Telescope show where the stars will be seen to be from Earth on that date. By animating with a time step of Century or Millennium, you can watch the stars slowly drift into the constellations our distant ancestors will teach their children (set Calculation/Precession/Never to avoid being distracted by the motion of Earth's axis over time). For more information about proper motion, and an example of its effect on the Big Dipper over the next 100,000 years, follow this link.

Aiming the telescope

The sky map always shows the entire sky visible from your location. To view any part of the sky, use the Telescope display. You can activate the telescope with the Display/Telescope... menu item or, most conveniently, by clicking on the sky map at the point where you wish to aim the telescope; this opens the telescope window and automatically aims it at the indicated point in the sky. Once the telescope display is active, you may re-aim the telescope anywhere on the sky map just by clicking on the target point in any of the sky, telescope, or horizon windows.

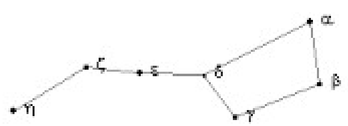
To examine the object catalogue from the sky map, use the Display/Object catalogue... menu item.

Proper motion

We frequently speak of "the fixed stars" as the one constant in a a sky where everything else is forever changing.   But even the "fixed stars" move, albeit slowly compared to a human life span.   When you look at the sky, it's easy to think of it, as the ancients did, as a great bowl resting on the horizon.   What's difficult to fully grasp is the immense *depth* of the sky. With your naked eye, you can see objects as close as a couple of light seconds (the Moon) or as far as a couple million light years (the great galaxy in Andromeda, M31).   All the stars you see in the sky are members of our galaxy, the Milky Way.   Each moves in its own orbit around the galaxy: the Sun takes about 225 million years to complete each circuit around the galaxy.   Compared to anything in everyday human experience, the stars are zipping right along: the rate of motion relative to the Sun and Earth is given in kilometers per *second*, with values for some stars over 100.

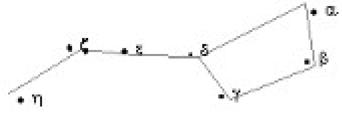
It is the immense distance of the stars which keeps their motion from being apparent over short intervals of time.   Even motion of 50 kilometers per second which, over a year causes a star to move more than one and a half billion kilometers--further than Saturn is from the Sun, isn't going to be particularly apparent when you're looking at it from a couple hundred light years away.   A light year is almost 10 million million kilometers.   Seen from a distance of two hundred light years away, or two thousand million million kilometers, motion of a billion and a half kilometers changes the observed position of a star only 0.15 arc seconds (and that's assuming all the motion is at orthogonal to the line of sight; if the motion is mostly toward or away from Earth, the apparent motion will be even less).   Even moving at 50 kilometers per second at a right angle to our line of view, more than 12,000 years will pass before the star's position in our sky changes by the diameter of the full Moon.   And the apparent motion of most stars seen from Earth is a small fraction of the rate in this example.

Ursa Major: 2000 A.D.



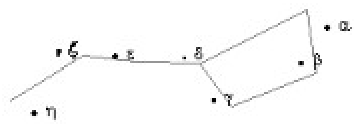
Still, even slow motion adds up over the millennia.   The constellations didn't look the same to our distant ancestors in the Stone Age; one wonders what figures they traced in that ancient sky, and what legends they invented to explain it all.   The motion that brought the "fixed stars" to where we see them today continues apace.   Who can imagine what our descendants will have learned and done five hundred centuries from now?   And yet even though that distant future is unknowable and unimaginable to us, we know what sky they will see when they gaze upward from the Home Planet of mankind.

Ursa Major: 50,000 A.D.



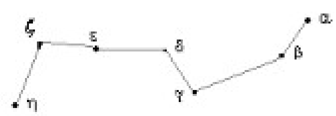
Already, the stars are drifting into noticeably different patterns.   (I've kept the outline of the Big Dipper as it appears today, so you can better see how the stars have moved from their original positions.)   What will the observers of that strange sky expect of the future before them, equally remote as that still distant yet well remembered milestone when life took its first step from the planet where it was born into a larger universe? And the sky a tenth of a million years from today will have changed into this:

Ursa Major: 100,000 A.D.



Now the stars have really begun to assume new forms--the outlines we draw in our star maps don't connect the dots in the sky any more. Let's redraw this constellation, which will still be as bright in Northern skies a thousand centuries hence.

The Inverted Dipper: 100,000 A.D.



Some dipper! The handle has turned into an inverted bowl, and a and b, the stars we teach our children to use as "The Pointers" to Polaris don't point anywhere in particular, certainly not toward Polaris which, for that matter, won't be anywhere near the North pole by then (due to precession, not its own motion, which appears rather small seen from Earth, about 680 light years away).

Astronomers call this slow-motion shuffling of the stars *proper motion*, not in the sense that other forms of motion (the daily, seasonal, and precessional changes we see in the sky) are in any way "improper", but using "proper" to signify that unlike those other apparent motions which simply reflect our vantage point on the moving Earth, proper motion results from the stars' own motion in space. Proper motion is "real motion", all the other, more dramatic, "motion" of the stars is only "apparent motion", due to the rotation of the Earth, motion of the Earth in its orbit, and a host of other, more subtle, effects (for example, aberration due to the finite speed of light).

Remember that proper motion is still "apparent" in the sense that we measure it based on how far the star moves in our sky. A star with a very fast proper motion is not necessarily moving unusually swiftly in space; in most cases it simply seems to move quickly because it's nearby and hence the baseline of the observation is short. The star with the greatest known proper motion is a dim star called Barnard's Star: it's only 5.91 light years away and moving unusually rapidly as well, so we see it to move 10.3 arc seconds per year. At this rate it takes only 180 years to move the diameter of the full Moon as seen from Earth. Most stars with large proper motion are undistinguished faint red nearby stars. Nature adores the mediocre, and the vast majority of stars are dim red dwarves--the stellar equivalent of 25 watt bulbs. Thus it shouldn't be surprising that most of the nearby stars are too faint to see. Naked-eye stars with large proper motion include:

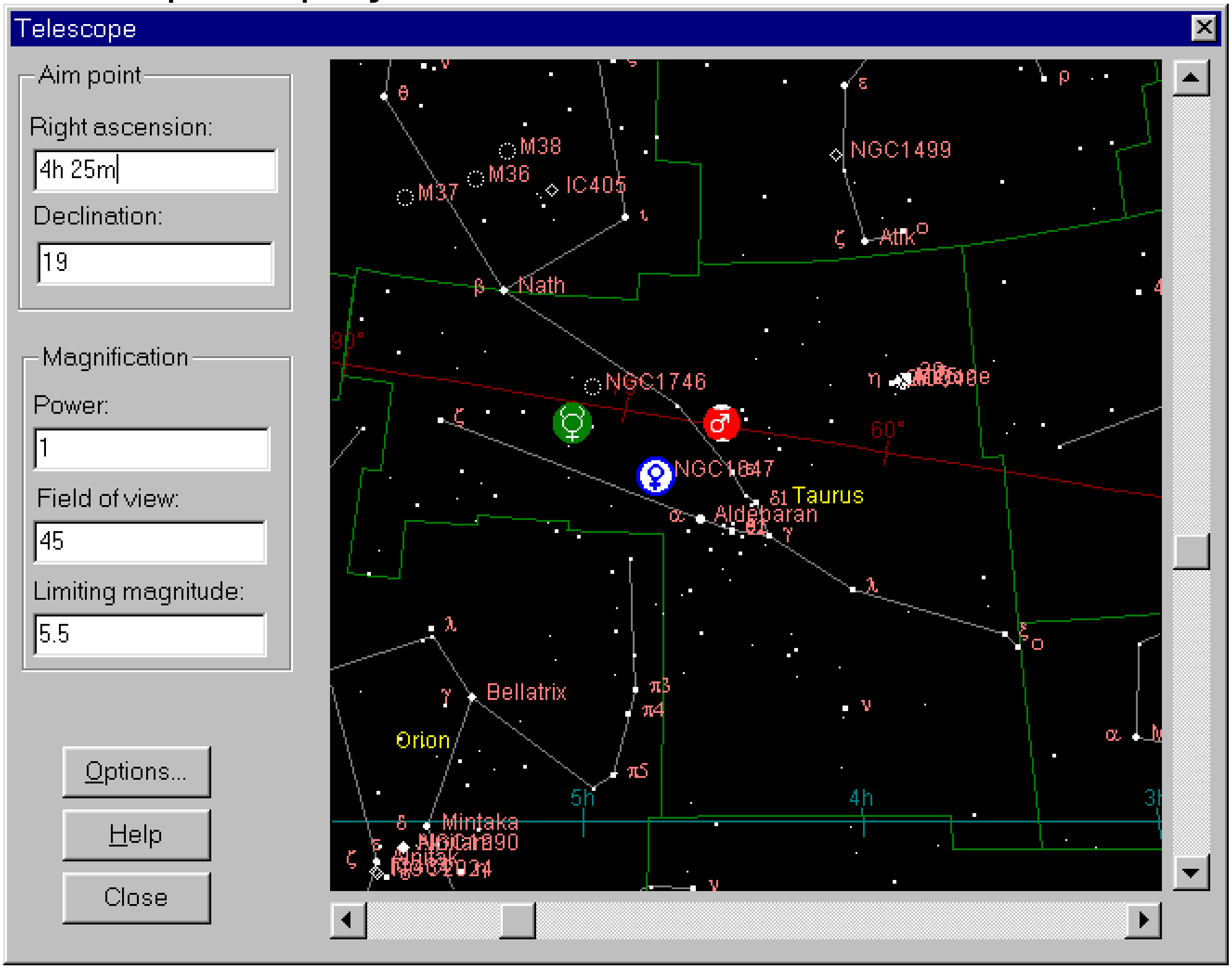
Star name	**Magnitude**	**Proper motion (arcseconds/year)**
61 Cygni	4.79	5.23
ε Indi	4.69	4.70
ο2 Eridani	4.41	4.08
μ Cassiopeiae	5.12	3.78
α Centauri	-0.29	3.71
82 G. Eridani	4.27	3.13

Arcturus	-0.04	2.28

Even among this crop, only α Centauri and Arcturus are genuinely bright stars.

You can explore the effects of proper motion on the constellations as the millennia pass by observing the Sky map and Telescope during an Animation with the time step set to Century or Millennium. When running the animations into the Deep Time of the remote future, it's best to disable calculation of the effects of the precession of Earth's axis of rotation by choosing Calculation/Precession/Never from the Sky map menu. On time scales where proper motion manifests itself, the usually glacial pace of precession becomes a giddy roller-coaster ride which only confuses you by spinning the sky around when what you're really interested in is where the stars are going, not which direction the Earth happens to be pointing in this particular century.

Telescope display



The telescope is activated from the Sky window either with the Display/Telescope menu item or by clicking on a location in the sky map. The telescope window is an ideal, dream telescope which remedies most of the major defaults of real optics. If only it observed the real universe rather than canned databases, amateur astronomers need never again get their eyeballs frozen to the eyepiece on cold January nights whilst guiding that "killer, above the fireplace" exposure of the Horsehead. Sigh....

Home Planet's telescope, constrained as it is to showing a simulated sky, does provide some attractive features your backyard scope can't compete with. First of all, Home Planet's telescope works just as well in daylight as at night--it punches through bright, sunny skies. Think of it as a Humble Space Telescope. Second (try this yourself at home with your Celestron!), it can *see through the Earth* as if it didn't exist. Go ahead, sit in Montréal and point Home Planet's telescope at Sigma Octantis; Home Planet doesn't mind. Finally, you can control the limiting magnitude and magnification of Home Planet's telescope independently without any of the usual constraints of real optics. Of course, you can't see stars dimmer than those included in Home Planet's databases, but there are none of the aberrations, limited field of view, or other optical annoyances to contend with. Further, Home Planet's telescope can optionally display names and outlines of constellations, the borders between constellations, the celestial poles, equator, and ecliptic, solar system bodies, labeled deep sky objects, and the names, magnitudes, and letter or number codes for stars. You can even select whether the telescope displays North up or South up to match your own backyard 'scope. All of these options can be set by clicking the "Options" button and entering your preferences in the Telescope options dialogue.

Aiming the telescope

If you have a high resolution display, you may wish to resize the telescope window so the sky display is larger. You can slew the telescope in right ascension with the horizontal scroll bar and in declination with the vertical scroll bar. To point the telescope in a specific direction (using the "setting circles", as it were), enter a right ascension and declination in the boxes at the left of the telescope panel. You can enter the right ascension either in terms of degrees, as hours and fractional hours, or as hours, minutes, and seconds. The following are all equivalent when entered in the Right ascension box:

3h 30m
3.5h
52.5

Declination may be entered either as degrees and a decimal fraction, degrees and minutes with a decimal fraction, or degrees, minutes, and seconds. The following Declination settings are equivalent:

45d 15m
45° 15'
45D 15' 0.00"
45.25

The telescope is updated when you press ENTER or click the mouse outside the right ascension or declination boxes. You can enter a right ascension and declination together, deferring the update of the telescope until both have been entered, by using TAB and SHIFT+TAB to go back and forth between the two fields.

Setting the limiting magnitude for stars

You can control the number of stars shown by changing the "Limiting magnitude" field. The default, 5.5, corresponds to the stars shown in the Sky window and roughly to the stars visible to the naked eye from typical observing locations with a reasonably dark sky. Increasing the limiting magnitude shows more and more stars, up to the limits of the star database. Stars are plotted in the telescope display in the same format you've selected for the Sky window with the Display/Star quality menu item.

Choosing magnification power

You can change the magnification of the telescope by editing either the Power or Field of view items (as with a real telescope, they are complementary). Increasing the power shows more detail but restricts what you can see through the telescope to a smaller portion of the sky. Increasing the field of view broadens what you can see but at the cost of squashing small detail all together. Note that the telescope, like the sky window, represents the Sun, Moon, planets, and satellites by icons rather than images shown to scale. Consequently, increasing the magnification of the telescope doesn't make the planetary images larger as you might expect. That would require texture mapping the best available maps of the planets at the correct local planetary hour angle, corrected for the angle of illumination as seen from the Earth. Perhaps in Release 10....

Aiming with the mouse

You can shift the telescope to a different location by clicking on the location where you'd like the telescope to point. You can point the telescope to any object visible in the Sky or Horizon windows by clicking on the object; the telescope will immediately slew to display it in the centre of the field.

Using the Object catalogue

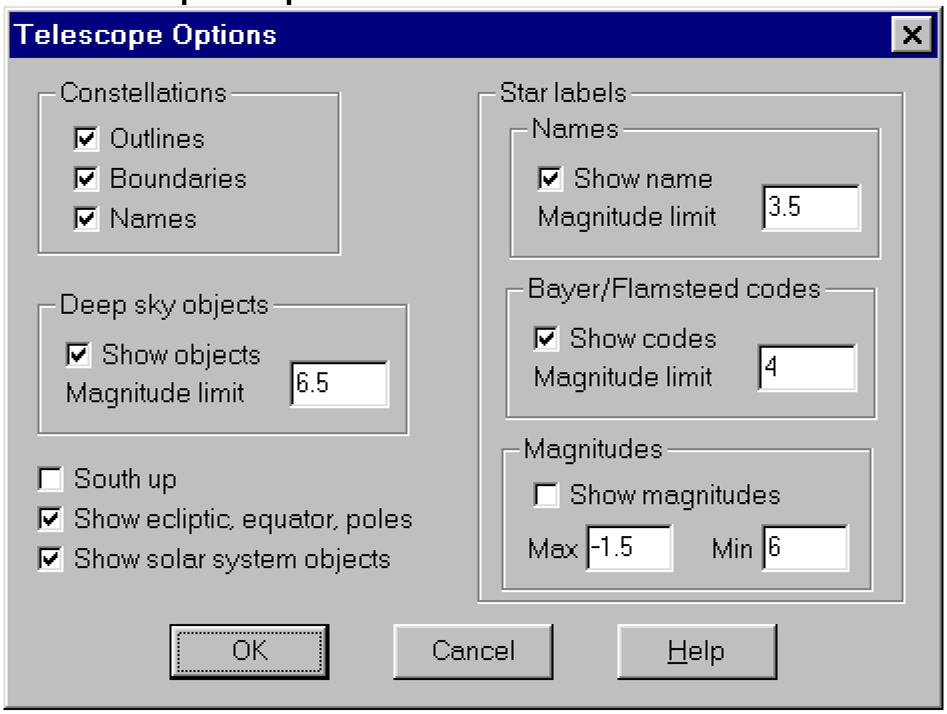
You an aim the telescope at any body whose position is given in the Object catalogue. Simply display the object, then press the "Select" button to direct the telescope toward it. Please refer to the description of the Object catalogue for further details. Conversely, you can display the Object catalogue description of an object observed in the telescope by moving the mouse cursor atop it and pressing the rightmost button on the mouse ("right clicking"). The closest object to the position in the sky you selected will be displayed by the Object catalogue. You can obtain the chart or plate number containing an object in the following atlases by right clicking on the object while pressing the SHIFT and/or CTRL keys as follows:

Keys	Atlas
SHIFT	Sky Atlas 2000.0
CTRL	Uranometria 2000.0
CTRL+SHIFT	Palomar Observatory Sky Survey

Observing satellites, asteroids, and comets

If you're tracking a satellite and/or have selected an asteroid or comet to be tracked from the Object catalogue, and the objects are visible in the telescope's field of view, their icons will appear in the correct location in the sky. Note that the effect of parallax is very important for satellites, particularly those in low orbits; make sure you've accurately specified your observing site so that the satellite can be displayed at the correct position in the sky as seen from your location.

Telescope options



You can control the display of various information in the Telescope window by clicking the "Options" button. The Telescope options dialogue appears, showing the current options; you may change whatever options you wish, then press "OK" to update the telescope display to reflect the new option settings. Options are grouped into several categories.

Constellations Controls visibility of constellation information. You can independently select whether constellation outlines (the lines that link the stars and form the constellation shapes), boundaries (borders between the constellations as defined by the International Astronomical Union), and names are displayed in the telescope window.

South up Allows inverting the telescopic image. Many real telescopes invert the image; by checking this box you can make the telescope window display an inverted image which may be easier to compare with what you see in your eyepiece. It's a lot easier than turning your monitor upside down or standing on your head.

Solar system objects Controls visibility of solar system objects such as the Sun, Moon, planets, and asteroids or comets chosen from the Object catalogue. Solar system bodies are represented in the telescope display by their conventional symbols.

Deep sky objects Controls visibility of deep sky objects (galaxies, nebulæ). You can disable the display of all deep sky objects by un-checking "Show objects". If "Show objects" is checked, deep sky objects brighter than the "Magnitude limit" will appear in the telescope; increase this limit to see more deep sky objects, decrease it to show fewer. Deep sky objects are represented by symbols indicating the type of object and its catalogue name.

Show ecliptic, equator, poles Controls display of coordinates on the sky. If this box is checked, the poles are marked with small light blue crosses with arms pointing toward the 0, 6, 12, and 18 hour marks on the equator, the celestial equator is drawn in light blue, labeled at each hour of right ascension, and the ecliptic is drawn in red with labels every 15° of ecliptical longitude.

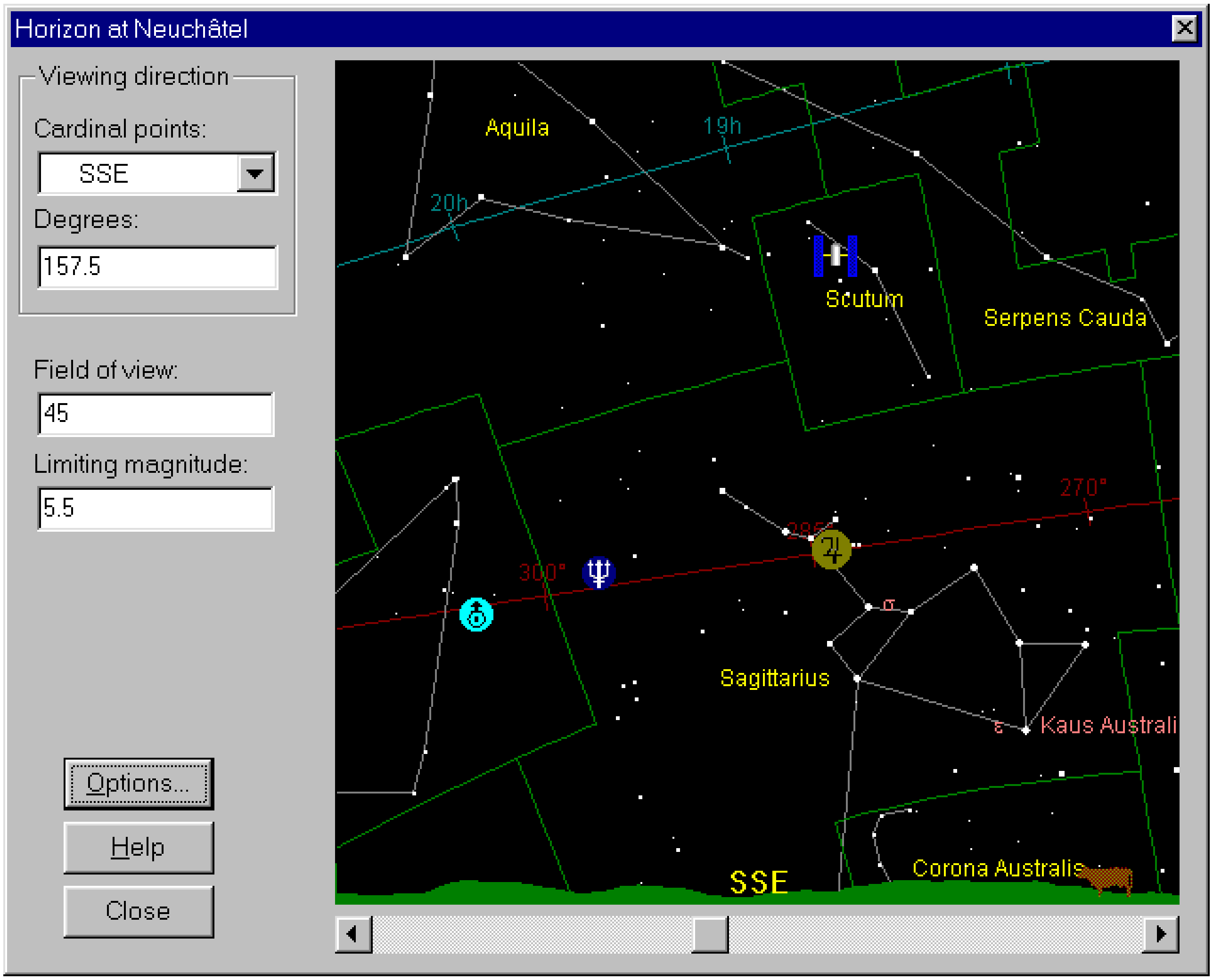
Star labels Controls labeling of stars with names and identity codes, and magnitudes. Many bright stars are named, for example "Polaris", "Altair", and "Zubenelgenubi", and principal stars of constellations are designated by Greek letters often called "Bayer letters" after Johann Bayer who first identified stars this way in his *Uranometria* of 1603. Multiple stars may bear the same letter and be distinguished by a numeric subscript. Stars are also identified by "Flamsteed numbers", which simply number the stars within a constellation in order of right ascension, and stars in southern constellations are frequently identified by roman letters.

You can independently control whether full names ("Polaris") or codes ("a", "61", "RR") are shown in the telescope window. If the "Show name" or "Show code" box is checked, stars brighter than the corresponding "Magnitude limit" will be so labeled. Labels are drawn to the right of the star, except when both a code and name appear; in that case the code is to the left of the star and the name to the right.

You can display the magnitudes of stars in a given range by checking the "Show magnitudes" box and entering the maximum and minimum magnitude of stars to be so labeled. Magnitudes are shown beneath the stars, to one decimal place with the decimal point omitted, as is the convention for star charts (decimal points being too easily confused with stars). Labeling stars with magnitudes is handy, for example, when you're observing a variable star and want to identify comparison stars within the field that cover the range of the variable.

All of the preferences you choose for the telescope are remembered by File/Save settings... and may be reset to their initial defaults by File/Default settings. The Telescope always displays the same Star catalogue selected in the Sky and shares the settings of Star quality, Star colour, and Precession calculation with the Sky map.

Horizon view



The horizon view is activated from the Sky window with the Display/Horizon menu item. It shows the view toward the horizon in any given direction, including all objects displayed in the Sky and Telescope windows. Controls on the left of the window allow you to specify the viewing direction and magnitude limit of stars shown. Other items in the display, such as names and outlines of constellations, boundaries of constellations, the celestial poles, equator, and ecliptic, solar system bodies, labeled deep sky objects, and the names and letter or number codes for stars can be selected by clicking the "Options" button and entering your preferences in the <u>Horizon view options</u> dialogue.

Changing viewing direction

If you have a high resolution display, you may wish to resize the horizon view window so the sky display is larger. When the horizon view is initially displayed, you're shown the view toward the North. You can change your viewing direction with the horizontal scroll bar, by selecting a direction from the "Cardinal points" list box, or by entering the azimuth in the "Degrees" box. Azimuths are measured the way sailors and surveyors do, from the North toward the East, and thus North is 0°, East is 90°, South is 180°, and West is 270°.

Setting the limiting magnitude for stars

You can control the number of stars shown by changing the "Limiting magnitude" field. The default, 5.5, corresponds to the stars shown in the Sky window and roughly to the stars visible to the naked eye from typical observing locations with a reasonably dark sky. Increasing the limiting magnitude shows more and more stars, up to the limits of the star database. Stars are plotted in the same format you've selected for the Sky window with the Display/Star quality menu item.

Setting the field of view

The field of view is initially set to 45°, corresponding to a normal lens on a camera and the usual human field of view. You can enter a smaller value to restrict the field of view or a larger value to increase it; a value of 90° shows the sky from the horizon all the way to the zenith. When you increase the field of view to large values, distortion due to the map projection increases, particularly in the corners of the window.

Using the Object catalogue

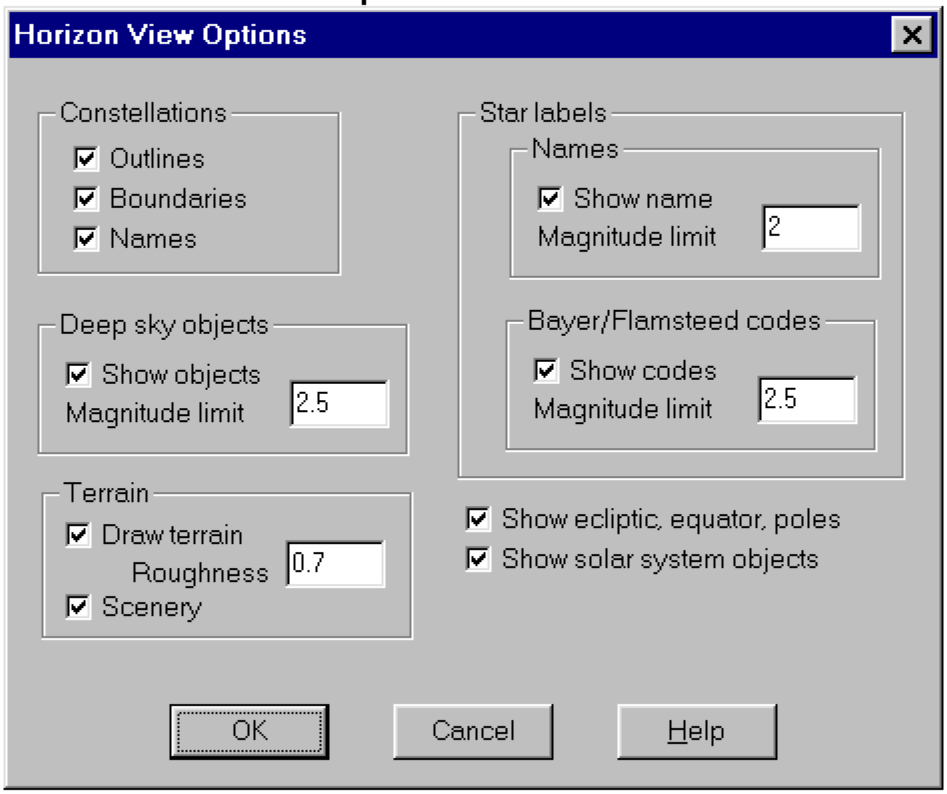
You can display the Object catalogue description of an object in the horizon view by moving the mouse cursor atop it and pressing the rightmost button on the mouse ("right clicking"). The closest object to the position in the sky you selected will be displayed by the Object catalogue. You can obtain the chart or plate number containing an object in the following atlases by right clicking on the object while pressing the SHIFT and/or CTRL keys as follows:

Keys	**Atlas**
SHIFT	Sky Atlas 2000.0
CTRL	Uranometria 2000.0
CTRL+SHIFT	Palomar Observatory Sky Survey

Observing satellites, asteroids, and comets

If you're tracking a satellite and/or have selected an asteroid or comet to be tracked from the Object catalogue, and the objects are visible in horizon view, their icons will appear in the correct location in the sky. Note that the effect of parallax is very important for satellites, particularly those in low orbits; make sure you've accurately specified your observing site so that the satellite can be displayed at the correct position in the sky as seen from your location.

Horizon view options



You can control the display of various information in the Horizon view by clicking the "Options" button. The Horizon options dialogue appears, showing the current options; you may change whatever options you wish, then press "OK" to update the horizon display to reflect the new option settings. Options are grouped into several categories.

Constellations Controls visibility of constellation information. You can independently select whether constellation outlines (the lines that link the stars and form the constellation shapes), boundaries (borders between the constellations as defined by the International Astronomical Union), and names are displayed in the horizon window.

Solar system objects Controls visibility of solar system objects such as the Sun, Moon, planets, and asteroids or comets chosen from the Object catalogue. Solar system bodies are represented in the horizon display by their conventional symbols.

Deep sky objects Controls visibility of deep sky objects (galaxies, nebulæ). You can disable the display of all deep sky objects by un-checking "Show objects". If "Show objects" is checked, deep sky objects brighter than the "Magnitude limit" will appear; increase this limit to see more deep sky objects, decrease it to show fewer. Deep sky objects are represented by symbols indicating the type of object and its catalogue name.

Show ecliptic, equator, poles Controls display of coordinates on the sky. If this box is checked, the poles are marked with small light blue crosses with arms pointing toward the 0, 6, 12, and 18 hour marks on the equator, the celestial equator is drawn in light blue, labeled at each hour of right ascension, and the ecliptic is drawn in red with labels every 15° of ecliptical longitude.

Star labels Controls labeling of stars with names and identity codes. Many bright stars are named, for example "Polaris", "Altair", and "Zubenelgenubi", and principal stars of constellations are designated by Greek letters often called "Bayer letters" after Johann Bayer who first identified stars this way in his *Uranometria* of 1603. Multiple stars may bear the same letter and be distinguished by a numeric subscript. Stars are also identified by "Flamsteed numbers", which simply number the stars within a constellation in order of right ascension, and stars in southern constellations are frequently identified by roman letters. You can independently control whether full names ("Polaris") or codes ("a", "61", "RR") are shown in the horizon view. If the "Show name" or "Show code" box is checked, stars brighter than the corresponding "Magnitude limit" will be so labeled. Labels are drawn to the right of the star, except when both a code and name appear; in that case the code is to the left of the star and the name to the right.

Draw terrain If checked, random terrain will be generated to give the horizon a more natural look. The "Roughness" box controls the sharpness of the features at the horizon; lower values generate smooth rolling hills, higher values more mountainous terrain. Drawing terrain along the horizon doesn't really obscure objects you're likely to actually observe. When you look toward the horizon, you're looking through the maximum depth of the Earth's atmosphere, precisely as at sunset, and objects near the horizon suffer the same "atmospheric extinction" as the rising or setting sun. Consequently, objects within a few degrees of the horizon must be extremely bright (Venus, for example) to be visible at all.

Scenery If you've selected "Draw terrain", you can place randomly-selected scenery along the horizon (houses, farms, livestock, etc.) by checking this box.

All of the preferences you choose for the horizon view are remembered by File/Save settings... and may be reset to their initial defaults by File/Default settings. The horizon view always displays the same Star catalogue selected in the Sky and shares the settings of Star quality, Star colour, and Precession calculation with the Sky map.

Customising scenery icons

The following is an advanced topic which assumes you're familiar with editing resources in a Windows DLL file and/or developing DLL's from scratch, and that you have the software tools such tasks require.   Most Home Planet users won't need to concern themselves with such details.   The information is presented here to provide those interested in such extensive customisation the means to accomplish it.

The Horizon view allows you to select that the horizon be adorned with fractally-generated terrain and randomly chosen scenery icons.   The scenery icons are defined in a file, **SCENERY.DLL**, supplied with Home Planet, and accessed using interface functions.   You can customise the icons used for scenery and accessible for display from Chart Object Catalogues either by directly editing the resources in the DLL with a tool such as Microsoft's App Studio, or by creating your own **SCENERY.DLL** which implements the same interface.

Editing SCENERY.DLL resources

The easiest way to modify and extend the scenery icon library is to edit the supplied file with a resource editor.   When you display the resources in the DLL, you'll see four numbered string resources:

1	**"15**	**; Number of icons to use at horizon"**
2	**"32**	**; Size of icons"**
3	**"10**	**; Density to sprinkle icons"**
4	**"16**	**; Total icons in file"**

Only the numbers are are significant; the comment text that follows is for documentation only.   In addition, you'll see 16 icons in the file, with numeric resource IDs from 1 to 16. You can add, replace, or delete icons in **SCENERY.DLL** using your resource editor.   Just be sure that you don't leave any icon numbers from 1 through the highest icon number unassigned and that you adjust the string resources to correspond to your changes to the icon resources.

String resource 1 specifies the number of icons, starting with number 1, which are eligible for random selection to appear in the Horizon view as scenery.   Icons with larger numbers will not be used by the Horizon view but can be explicitly displayed by chart catalogues using the "**H***nnn*" phrase in the "(Type)" field.

String resource 2 gives the width and height of the icons in the file in pixels, and should be left at the default of 32, as that is the only icon size presently used.   String resource 3 controls how densely icons from **SCENERY.DLL** appear along the horizon. The chance of an icon appearing at a given pixel along the horizon is 1/(icon_size   icon_density), the parameters given by string resources 2 and 3.   Thus, with the default values, an icon will be drawn, on the average, every 320 pixels along the horizon (note, thus, that decreasing the density parameter increases the frequency with which icons appear and vice versa).   The scenery drawing code automatically guarantees that icons are not drawn on top of one another.   If the image in an icon does not fill the 3232 pixel icon frame, it should be drawn justified against the left and bottom of the icon frame.

Icons with numbers higher than that given in string resource 1 will never be selected to appear in the Horizon view, but may be explicitly called out by number in chart catalogues. The total number of icons in **SCENERY.DLL** is specified by string resource 4.   Attempts to access icons with higher numbers will fail, even though they may be present in the DLL.

Replacing SCENERY.DLL

Much more sophisticated customisation of scenery generation is possible by replacing the supplied version of **SCENERY.DLL** with a user-defined version. The interface between Home Planet at this DLL is through the following functions. Whenever the horizon view is redrawn and the user has enabled terrain and scenery, the function:

```
void FAR PASCAL sceneryInit(
        double julianDate,          // Time and date
        double siteLat,             // Observer latitude
        double siteLon,             // Observer longitude
        double viewAzimuth,         // Azimuth of window center
        WORD imageHeight,           // Image height
        WORD imageWidth,            // Image width
        WORD randomNumber,          // A 15 bit random value
        WORD FAR *numIcons,         // Return: Number of icons
        WORD FAR *iconSize,         // Icon size
        WORD FAR *iconDensity);     // Icon density
```

is called. This provides the DLL complete information as to the time and date (real or simulated) at which the horizon is being drawn, the latitude and longitude of the observer, what direction the observer is looking, the height and width of the horizon window in pixels, plus a random number between 0 and 32767 that the DLL can use any way it wants. The function returns three values through pointers: the number of icons it can generate (if zero, scenery is disabled), the size of the icons provided, and the density parameter as described above. Although the **SCENERY.DLL** provided with Home Planet uses none of the information provided to **sceneryInit**, I'm sure you'll see how this information can be exploited to show leafy trees in summer, falling leaves in autumn, and bare limbs in winter, kangaroos if the observer is in Australia, and more.

Each time Home Planet decides, at random, to place an icon along the horizon, it calls:

```
void FAR PASCAL sceneryIcon(
        WORD xPos, WORD yPos,       // Where icon is to be drawn
        WORD randomNumber,          // A 15 bit random number
        HICON FAR *hIcon,           // Return handle to icon
        WORD FAR *hWidth);          // Width (advance) after this icon
```

informing **SCENERY.DLL** of the *X* and *Y* co-ordinates of the top left corner of the icon within the Horizon vew window and providing a random number between 0 and 32767. **sceneryIcon** should return the handle of the icon to be drawn in **hIcon**, and the width of the image within the icon in **hWidth** (this is used to keep icons from being drawn atop one another). The icon will be destroyed by Home Planet after being drawn.

At the end of generation of the Horizon view Home Planet calls:

```
void FAR PASCAL sceneryTerm(void);
```

to allow **SCENERY.DLL** to clean up any items it might have allocated in **sceneryInit**. Home Planet guarantees that **SCENERY.DLL** will not be called from any other application or instance between **sceneryInit** and **sceneryTerm**, allowing it to use local storage within the DLL without conflicts.

The above interface functions support the random generation of scenery for the Horizon view.   The following function simply returns an icon, by number, to Home Planet for plotting in a sky map when requested by a chart catalogue.   Note that this function returns any icon in **SCENERY.DLL** up to the number given by string resource 4; it is not restricted to those icons intended for use in the horizon view.

```
void FAR PASCAL getSceneryIcon(
        WORD iconNumber,            // Icon number to get
        HICON FAR *hIcon);          // Handle to icon or NULL = error
```

Returns the handle to the icon **iconNumber** defined with the DLL in **hIcon**.   If **iconNumber** is out of range or, for whatever reason, cannot be loaded, **NULL** is returned.   Icons returned by this function will be destroyed by Home Planet after being drawn.

Constellation databases

The Sky, Telescope, and Horizon windows optionally show the names, outlines, and borders of constellations. Home Planet plots these annotations based on database files kept in the same CSV (Comma Separated Value) format used by the Object catalogue. You can, if you wish, modify these databases by editing them with an application such as Microsoft Excel which reads and writes CSV format files, or with a simple ASCII text editor such as Windows Notepad.

You could, for example, modify the constellation outlines database to show more elaborate and artistic representations of the constellations, as found in old-time star maps. Our modern constellations are inherited from the Mesopotamians and Greek cultures, with more recent additions to the southern sky not visible to the Mediterranean cultures. Other cultures have entirely different systems of constellations; you can, for example, by modifying Home Planet's constellation name and outline databases, show the sky with the constellations of the Aztecs or ancient Chinese. Astronomers who tire of the classics could even ditch all those wearisome gods and animals in favour of with-it constellations such as:

The Five Original Marx Brothers
Ringo's Drums
The Electric Drill
The Last Bug
Bart's Skateboard
The Giant Rat of Sumatra

Each of the constellation databases specifies Right ascension and Declination coordinates in a special integer form. Right ascension is represented by an integer which, when divided by 1000, yields the right ascension in hours and fractional hours (note, *not* minutes and seconds). Declination is specified as a signed integer which, divided by 100, gives the declination in decimal degrees and fractional degrees (*not* arcminutes and arcseconds).

To convert right ascension in hours, minutes, and seconds into the integer form, use the formula:

RAint = INT((hours + (minutes / 60.0) + (seconds / 3600.0)) * 1000.0)

Declinations given in degrees, minutes, and seconds of arc are likewise converted as follows:

Decint = INT((degrees + (minutes / 60.0) + (seconds / 3600.0)) * 100.0)

These conversions are easily accomplished if you use Microsoft Excel to edit the constellation databases.

CNAMES.CSV: Constellation Name Database

The constellation name database stored in the file **CNAMES.CSV**, contains the names of the constellations and specifies where each name is drawn on the sky map. The standard file begins as follows:

```
;
;       Constellation names and location to draw them
;
;       RA * 1000, Dec * 100, Constellation_name
;
```

564,3925,Andromeda
10118,-3365,Antlia
16134,-7641,Apus
22697,-1053,Aquarius
19690,337,Aquila
17231,-5189,Ara
2676,2257,Aries
5947,4281,Auriga
14687,3233,Boötes

Each line simply specifies the integer right ascension and declination of the point at which the text will be centred and the name to be drawn there. Although the standard CNAMES.CSV is used exclusively to label constellations, you can add any labels you'd like to be plotted in the sky maps, for example:

0,9000,North Celestial Pole
0,-9000,South Celestial Pole
0,0,March Equinox
12000,0,September Equinox

CONLINES.CSV: Constellation Outline Database

The outlines (lines connecting the stars) for the constellations are defined in the **CONLINES.CSV** file; edit this file to change the figures in the sky. The standard file begins as follows:

;
; Format: <const-name>,<RA-from>,<Dec-from>,<RA-to>,<Dec-to>
;
; Right ascension in decimal hours * 1000 (12.234h => 12234)
; Declination in decimal degrees * 100 (-85° => -8500)
;
AND,1161,3561,2065,4233
AND,140,2908,655,3086
AND,23031,4233,23626,4644
AND,23626,4644,946,3850
AND,615,3371,140,2908
AND,655,3086,1161,3561
AND,946,3850,1158,4725
AND,946,3850,615,3371
ANT,10453,-3106,10945,-3713
ANT,10453,-3106,9486,-3595
APS,14798,-7905,16448,-7873

The first field gives the standard abbreviation for the constellation and is present for documentation only; it is not actually used when plotting the constellation outlines. The remaining four fields give the integer right ascension and declination of two points between which a line will be plotted. The default **CONLINES.CSV** plots modern schematic representations of the constellations in which all lines connect stars. This isn't a requirement, however; if you wish to add flowery embellishments not seen since Johann Bode's *Uranographia*, go right ahead. (Serious constellation drafters would be wise to avail themselves of a powerful and flexible CAD system which permits them to draw the constellations in a convenient map projection, then transform and extract the patterns in the format defined above. Modesty prevents my recommending such a tool.)

CBOUNDS.CSV: Constellation Boundary Database

Constellations were originally patterns of prominent stars; less visible stars between the major patterns were not considered part of any constellation. As astronomy became more of a formalised science and comprehensive star catalogues were prepared a need arose to precisely define the boundaries of the constellations so that every star could be assigned to one constellation or another. The constellation boundaries we use today were adopted in 1930 by the International Astronomical Union, based on a partial set of boundaries compiled in 1875 by Gould. Gould's original boundaries attempted to follow the informal curved boundaries used in earlier star maps but, for simplicity, ran purely east-west and north-south in the celestial sphere. But as the Earth's axis precesses with regard to the distant stars, completing a full circle every 25,800 years, equatorial coordinates change with regard to the fixed stars, so the original boundaries, given in terms of the sky of 1875, no longer run parallel to lines of longitude and latitude in today's sky. (Precession may seem like a minor effect, significant only in the very long term, but it can creep up on you. In the century and a quarter since 1875, precession has moved Polaris three quarters of a degree closer to the actual north celestial pole--that's one and a half widths of the full Moon!)

Consequently, it's necessary to adjust the constellation boundaries to account for precession. The boundaries in the standard **CBOUNDS.CSV** file supplied with Home Planet have been precessed in a simple fashion to the J2000.0 epoch used throughout Home Planet. Approximating the precise 1875 boundaries based on the best available published data would require plotting more than 13,000 vectors and didn't seem worth it. Still, if you demand ultimate accuracy, you're welcome to convert the constellation boundary data of Davenhall and Leggett [1989] found on the Astronomical Data Center CD-ROM "Selected Astronomical Catalogues, Volume 1" into a custom **CBOUNDS.CSV** file.

The standard **CBOUNDS.CSV** begins as follows:

```
;
;    Constellation boundary lines
;
;    Format:
;              Move=0/Draw=1,Right Ascension,Declination
;
;    Right ascension is decimal hours * 1000
;    Declination is decimal degrees * 100
;
0,7417,-8266
1,13967,-8316
1,13850,-7566
1,11333,-7566
1,9008,-7549
1,7617,-7532
1,7417,-8266
0,13850,-7566
1,13833,-7066
```

The format of the constellation boundary file is compressed to save space and decrease the time required to plot the boundaries. Each record begins with a code of 0 or 1, followed by an integer right ascension and declination in the same form used in all the constellation databases. If the code is 0, the start of a new sequence of connected lines begins at the given coordinates (you can think of this as a "pen up move"). If the code is 1, a vector is drawn from the last point to the new coordinates (this is then, a "pen down draw"). Note that the constellation boundary lines, "straight" (geodesics) along the celestial sphere, will appear curved when plotted in the sky map, telescope, or horizon windows.   Curvature is zero along the celestial equator and becomes more pronounced toward the poles.

Deep sky database

The Sky, Telescope, and Horizon windows can plot deep sky (nonstellar) objects such as galaxies, star clusters, and gaseous nebulæ at their correct positions among the stars. These objects are defined in a CSV (Comma Separated Value) database file named **DEEPOBJ.CSV**. You may, if you wish, modify this database file, either with an application such as Microsoft Excel which reads and writes files in CSV format, or with a simple ASCII text editor such as Windows Notepad. The format of the deep sky database is illustrated by this extract of the first few records.

```
;
;        Deep sky object database
;
76.725,-7.21667,0.3,IC2118,,DN,180x60,Eri,,spec:cB8ep-illum by Rigel
56.75,24.11667,1.2,M45,M45,OC,110,Tau,*,nmber: 130 - The Pleiades
247.3,-26.45,1.2,IC4606,,DN,85x80,Sco,,spec:cM1 - around Antares
84.05,-1.2,1.8,NGC1990,,DN,50x50,Ori,*,spec:BOe - around Eps Ori
85.175,-2.45,1.9,NGC2024,,DN,30x30,Ori,!,s:BOne-cmplx inner detail
85.25,-2.4,2.1,IC434,,DN,60x10,Ori,!!,"s:BOne-B33, Horsehead Neb"
```

The first three fields of each record give the right ascension and declination of the object (its centre, if extended) in *degrees*. Note that the right ascension in this database ranges from to 360°, not the more usual 0 to 24 hours! The third field specifies the object's visual magnitude (integrated magnitude for extended objects). The records in this database *must* be sorted in order of increasing magnitude (that is, decreasing brightness). Home Planet reads the deep sky database only until it encounters an object fainter than the limiting magnitude for deep sky objects in the current window, ignoring all subsequent records.

The fourth field gives the designation of the object in the primary catalogue that defines it, usually the New General Catalogue (NGC) or Index Catalogue (IC). The fifth field, if nonblank, gives the "popular name" of the object. For example, NGC1976, the Great Orion Nebula, is best known by its Messier Catalogue number, M42. It is therefore defined as follows:

```
83.85,-5.45,2.9,NGC1976,M42,DN,66x60,Ori,!!!,Great Orion Nebula
```

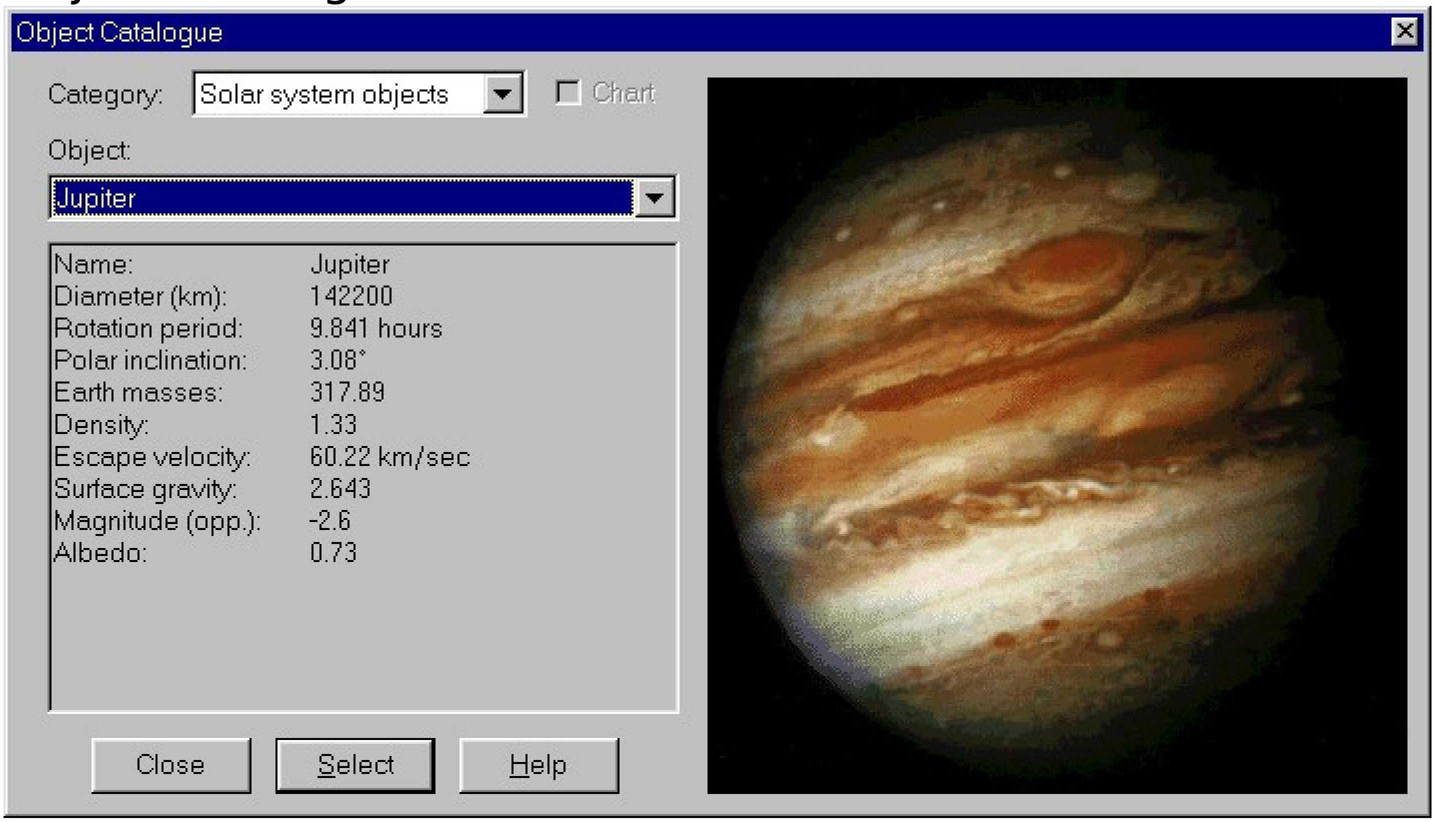
The popular name, if given, is shown in the sky and telescope displays instead of the primary catalogue number. The popular name can be descriptive rather than a dry catalogue number, for example "Rosette" or "Horsehead".

The sixth field specifies the object type, which determines which deep sky icon is used to represent it in the sky.

Code	Object Type
DK	Dark nebula
DN	Diffuse (gaseous) nebula
DS	Double star
EG	Elliptical galaxy
GC	Globular cluster
IG	Irregular galaxy
OC	Open cluster
PN	Planetary nebula
QS	Quasar
SG	Spiral galaxy

The seventh field gives the size of the object in arc seconds; if elongated its major and minor axis sizes are given separated by the letter "x". The eighth field indicates the constellation within which the object is found, using the conventional three letter abbreviation. The ninth and tenth field are the Burnham comment code for the object and a free form remarks field. The seventh through tenth fields are not presently used by Home Planet.

Object catalogue



The object catalogue is an extensible multimedia (text, image, and sound) database system which allows you to retrieve information about a wide variety of topics related to astronomy and space science. Extensive databases are included with Home Planet which you may expand, either by adding new objects to the existing categories or adding entirely new categories and databases. Astrophotographers, for example, can file images of various objects they've photographed and view them, along with information about the object and the exposure, directly within Home Planet. Chart catalogues permit catalogues to plot icons, lines, and text in the sky maps, allowing open-ended extension of their content.

Home Planet is supplied with the following object catalogues:

Solar system objects
Periodic comets
Comets from IAU Circulars
Constellation names
Named stars
Navigation stars
Asteroids, by name
Asteroids, by number
Asteriods from IAU Circulars
Messier objects
Deep sky objects popular with amateurs
Meteor showers
Spacecraft
3C radio sources
Sky Atlas 2000.0 chart numbers

Uranometria 2000.0 chart numbers
Palomar Observatory Sky Survey plate numbers
Sky Atlas 2000.0 chart boundaries

Images are included for all major solar system objects, three asteroids which have been imaged at close range (951 Gaspra, 4179 Toutatis, and 243 Ida), and selected deep sky objects and spacecraft. If you collect (or create) images of astronomical objects, you can file them in the object catalogue's image repository (see below), and Home Planet will automatically display them when you retrieve information about the object. If you have a large, high-resolution screen, you may wish to resize the Object catalogue window so the image is larger. You can also attach sounds to objects; for an example, choose the Moon in the "Solar system objects" catalogue.

Tracking Asteroids and Comets

When you're viewing the Comet or Asteroid databases, the "Select" button at the bottom of the object catalogue is enabled. Pressing it causes Home Planet to begin tracking the selected body based on the orbital elements given in the database. You can only track one asteroid or comet at a time. When an asteroid or comet is being tracked, its position appears in the Planetary Position panel, its orbit and the current position is displayed by the Orrery, and a symbol representing the body, if visible, will be shown in the Sky, Telescope, and Horizon windows. Once an asteroid or comet is selected, pressing "Select" a second time will aim the Telescope to show the current location of the object in the sky, activating the Sky and Telescope windows if they aren't already displayed.

Selecting Solar System and Celestial Objects

Any object catalogue which provides the celestial coordinates (Right ascension and Declination) of objects will activate the "Select" button when an object is displayed. Pressing "Select" aims the Telescope to show the current position of the object in the sky, activating the Sky and Telescope windows if they aren't already displayed. You can also select bodies in the Solar System from the "Solar system objects" catalogue: the telescope is pointed to the current position of the object, calculated as for the Planetary Position panel.

Identifying Objects from the Telescope or Horizon view

You can retrieve the object catalogue description of a body observed in the Telescope or Horizon windows by placing the mouse cursor on the object and pressing the right button on the mouse ("right clicking"). The object catalogue will show the description of the closest object in the catalogue to the location in the sky you designated. The catalogues supplied with Home Planet permit you to identify principal stars, solar system bodies, and deep sky objects this way. If you add catalogues of your own, you can also link them so objects therein may be retrieved from the telescope. Pressing the SHIFT or CTRL keys while right clicking on an object directs the search to specific object catalogues associated with these keys. The object catalogue furnished with Home Planet uses these keyboard modifiers to identify the chart or plate number in the following sky atlases which contains the location you clicked.

Modifier	**Atlas**
SHIFT	Sky Atlas 2000.0
CTRL	Uranometria 2000.0
CTRL+SHIFT	Palomar Observatory Sky Survey

For example, if you're tracking an asteroid and wish to see the field in which it appears on the Palomar Observatory Sky Survey, just hold down CTRL and SHIFT, right click on the asteroid icon in the telescope or horizon window, and the object catalogue will display the sky survey plate number containing the region of the sky the asteroid is currently crossing, along with information about the plate, including its microfiche number in the MicroSky edition. See "Adding new categories" below for an explanation of how to reassign these keys to search other databases.

Object catalogue database format (CSV)

All the databases associated with the object catalogue are kept in "CSV" (Comma-separated value) format, and may be modified and extended by editing them either with an ASCII text editor or with a spreadsheet or database application which reads and writes CSV format, such as Microsoft Excel.

Each database begins with a title record which provides the names for the fields in the records that follow; these names are used as the captions in the information panel displayed by the object catalogue. For example, here are the first few lines of the database of Messier objects:

```
Name,NGC,Constellation,Class,Right ascension,Declination,Magnitude,Angular size,Burnham,Remarks
M1,1952,Taurus,Planetary nebula,5h 34.5m,22° 1',8.2,6x4,!!,SNR (1054) - Crab Nebula
M2,7089,Aquarius,Globular cluster,21h 33.5m,0° 49',6.5,13,!!,II
M3,5272,Canes Venatici,Globular cluster,13h 42.2m,28° 23',6.4,16,!!!,VI - superb object
```

Each field in the CSV file is simply separated by commas, as you'd expect from the name. If a field contains a comma, you must enclose it in quotes, for example:

```
M65,3623,Leo,Spiral galaxy,11h 18.9m,13° 5',9.3,8.0x2.5,*,"Sb -M66, NGC3628 in field"
```

To enter a field which contains a quote mark, enclose the entire field in quotes and double any quote marks within it:

```
WNC   4,M 40,Ursa Major,Double star,12h 22.4m,58° 5',9.1,"50""",*,"Winnnecke 4 - sep. 50"""
```

In the example above, we've "forced" the quote mark used to represent arc-seconds.

You can include comments in CSV-format databases as lines with a semicolon "**;**" in the first column of the record.

Adding new categories

To add a new database to Home Planet's object catalogue, edit the database file called **OBJECTS.CSV**; this is the master index of object catalogues. The file is supplied as follows.

```
;
;        Object database
;
Solar system objects,planets.csv,4
Comets: periodic,comets.csv,2
Comets: new,cometnew.csv,2
Constellation names,constel.csv,5
Named stars,starname.csv,3
Navigation stars,navstar.csv,3
Asteroid names,asteroid.csv,1
Asteroids: unnamed,astuname.csv,1
Asteroids 1-4000,astnum1.csv,1
```

Asteroids 4001-5632,astnum2.csv,1
Asteroids: new,astrnew.csv,1
Messier objects,messier.csv,3
Deep sky objects,deepsky.csv,3
Meteor showers,meteor.csv,5
Spacecraft,spacecrf.csv
3C radio sources,3c.csv,9
Sky Atlas 2000.0,skyatl2k.csv,6
Uranometria 2000.0,u2000.csv,7
Palomar Sky Survey,poss.csv,8
Sky Atlas 2000 bounds,sc2kbnd.csv,5

The first field in each record is the title for the database which appears in the "Category" box of the Object catalogue. The second field is the name of the CSV file which contains the database for that topic. If no path name is supplied, the file is assumed to reside in the Home Planet directory, but by specifying an explicit path you may store databases anywhere you wish. The third field, used only for databases with which other components of Home Planet interact, identifies the type and format of database; for example, 1 indicates the database of asteroidal orbital elements, 2 the comet database, and 4 the database of solar system objects. You may add objects and new fields to these databases, but must preserve the order of the fields originally furnished with Home Planet. Databases of type 3 are expected to contain fields labeled "Right ascension" and "Declination". When an object is selected which contains nonblank values in these fields, the "Select" button is enabled. Pressing it aims the Telescope to the specified coordinates. Conversely, you can point at an object in the Telescope or Horizon view and click on it with the right button of the mouse, and the object catalogue will display its description. Note that you can define your own databases of type 3 and aim the telescope to objects within them; just make sure you include "Right ascension" and "Declination" fields which give coordinates in the form accepted by the telescope. Type 5 databases may be used to aim the telescope in the same manner as type 3, but objects within them are ineligible for retrieval from the Telescope with the right mouse button. Databases of types 6, 7, and 8 behave like type 3 databases and may be used both to aim the telescope and identify objects in the telescope and horizon windows. When you right click to identify an object, the search is directed to databases of type 3, 6, 7, or 8 by holding down the SHIFT and/or CTRL keys as given below.

Keys down	**Databases searched**
none	Type 3
SHIFT	Type 6
CTRL	Type 7
CTRL+SHIFT	Type 8

Suppose you'd like to add a catalogue to store descriptions of all the astrophotographs you've taken with your spiffy new CCD camera. First, add an entry for the new catalogue to **OBJECTS.CSV** as follows:

My CCD photographs,myccd.csv

Here we assume you're going to keep the database **MYCCD.CSV** in the directory where you've installed Home Planet.

Next, using Excel, another spreadsheet or database, or your trusty old ASCII text editor, create the database file. Remember that the first record provides the field names for the subsequent database items. Here's a start on such a file:

```
;
;       CCD Images taken with SpiffoCam 6
;
```

```
Object,Date,Exposure time,(Image),Remarks
Moon,8-Oct-92,1/1000,MOON1,My first picture
Pleiades,8-Oct-92,1 sec,M45A,Prime focus
"Orion nebula, M42",8-Oct-92,45 sec,ORINEB,8mm eyepiece projection
```

Adding images to the database

Now you can examine a catalogue of your own astrophotographs right within Home Planet. But wouldn't it be neat to be able to view the *images themselves* as you read the catalogue information? Nothing could be simpler. Whenever Home Planet retrieves a database item from an object catalogue, if a field named "(Image)" is present, it looks for a file with name given by the value of that field. This file is expected to have been placed in the **IMAGES** subdirectory of the Home Planet release directory with a file type of "**.BMP**". The "(Image)" field is not listed in the "Object" box.

Thus, when you select the second record of the database, which will be listed in the "Object" box as "**Pleiades**," Home Planet looks for a file named "**IMAGES\M45A.BMP**" in its working directory and, if found, displays it (appropriately scaled to fit) in the image box of the object catalogue.

If a database does not contain an "(Image)" field, Home Planet attempts to load an image with filename equal to the first word of the first field of the record. This allows you to add images to databases without having to specify explicit image file names.

Aliases for images

Many astronomical objects have multiple names: different catalogue numbers, popular names, nicknames, etc. Home Planet provides an "alias database" to allow a single image file to satisfy references to the object in different catalogues under different names. The alias database is kept in the file **ALIAS.CSV**. The file furnished with Home Planet begins as follows:

```
;
;    Objects with multiple names
;
; Name,Also known as
;
;           Big catalogue names for Messier objects
;
NGC205,M110
NGC221,M32
NGC224,M31
NGC581,M103
```

and goes on to list the NGC and IC designations of all the Messier objects. If you look up an object with an "(Image)" field of "NGC224" in an NGC or deep-sky catalogue, Home Planet first searches for an image named **NGC224.BMP** in the IMAGES directory. If none is found, it searches **ALIAS.CSV** for an alias. Upon finding one, it then tries to display **IMAGES\M31.BMP**. If an image with that name exists, it will be shown in the image box.

Adding sound to the database

You can associate sound with items in the object catalogue in much the same manner as you add images. Define a database field named "(Sound)" and enter, in this field, the name of a wave audio ("**.WAV**") file stored in the **SOUNDS** directory. For example, consider the following database:

```
;
;        Sounds of Space
;
Description,(Sound),Source
Apollo 11 countdown,A11CD,NASA
The Eagle has landed,EAGLAND,NASA
One small step...,ARMSTEP,NASA
Voyager Jupiter music,VOYJMUS,JPL
```

If you select the second data record in the database, "The Eagle has landed", Home Planet attempts to open the file "**SOUNDS/EAGLAND.WAV**". If successful, the sound file is played through the wave audio output device (if any) provided by the computer.

Chart catalogues: drawing on the sky map

A *chart catalogue* is an object catalogue which, in addition to the object selection, identification, and sound and image annotation described above, contains objects, specified as icons, straight or curved lines, and text which can be painted on the sky map displayed by the sky, telescope, and horizon windows by checking the "Chart" box at the right of the catalogue selection list box when the chart catalogue is selected. If the selected catalogue is not a chart catalogue, the Chart box is not enabled. Once selected, a chart catalogue continues to be plotted in the sky map until deselected by clearing the Chart box or selecting a different chart catalogue--switching to a different object catalogue does not disturb the plotting of the chosen chart catalogue.

A chart catalogue contains "Right ascension" and "Declination" fields which specify positions in the sky map as do other catalogue files and, in addition, contains one or both of the fields "(Type)" and "(Label)". As with other fields with names enclosed in parentheses, the (Label) and (Type) fields do not appear in the Object information box. The first field in the CSV record is used, as always, as its label in the Object selection list box. If this field is blank (in other words, the CSV record begins with a comma), the record will not appear in the list box and cannot be selected.

When an object catalogue which meets the above requirements is selected, the "Chart" check-box to the right of the "Category:" list box is enabled. If you check it, any displayed Sky windows (Sky, Telescope, or Horizon) are re-drawn with the objects in the selected chart catalogue plotted at the given positions. Positions in a chart catalogue are specified in J2000.0 and precessed, if necessary, to the epoch being plotted. No provision is made for proper motion of chart catalogue objects.

What is plotted on the sky map at the Right ascension and Declination given in the record is specified by the (Type) and (Label) fields. The (Type) field allows one or more icons to be drawn or line drawing commands performed, while the (Label) field allows text annotation to be displayed. Either or both of the (Type) and (Label) fields may be void for a given record in the catalogue. If both are void, that record plots nothing on the sky map and behaves as a conventional object catalogue record.

The (Type) field

Icons in the Type field are selected by the following codes. Multiple items may be plotted by a single (Type) field by separating them with semicolons.

Deep sky icons:

DK Dark nebula
DN Diffuse nebula
DS Double star
EG Elliptical galaxy
GC Globular cluster
IG Irregular galaxy
OC Open cluster
PN Planetary nebula
QS Quasar
SG Spiral galaxy

Star icons:

S1 Smallest star icon

S9 Largest star icon

Planet icons:

P0 Sun
P1 Mercury
P2 Venus
P3 Earth
P4 Mars
P5 Jupiter
P6 Saturn
P7 Uranus
P8 Neptune
P9 Pluto

Satellite icons:

B0

B9

Satellite icons are as shown in the Choose Satellite Icon dialogue, with the left column of icons **B0**-**B4** from top to bottom, and the right column **B5**-**B9**.

Scenery (horizon) icons:

H*nnn* (*nnn*: 1 or more digits. 1 = first icon)

In addition to icons, specifications in the (Type) field may draw lines on the sky map, either straight lines directly between co-ordinates or lines that follow parallels of celestial latitude and meridians of celestial longitude. Lines can be drawn in any of 10 predefined colours. The line drawing commands are:

C*n* Set pen colour to *n*, where

0 = black
1 = red
2 = yellow
3 = green
4 = cyan
5 = blue
6 = magenta
7 = white
8 = light grey
9 = dark grey

MV Move to RA, Dec
LT Straight line to RA, Dec
CT Curved line to RA, Dec

The line drawing commands work with a logical pen which is moved by successive records in the catalogue. The **MV** command is a pen-up move to the co-ordinates of the record while **LT** and **CT** draw lines, straight or curved respectively, from the last pen position to the co-ordinates of the current record, then update the pen position to those co-ordinates.

The (Label) field

The (Label) field supplies text to be drawn at the given co-ordinates. If a simple non-quoted string is given, it is drawn left-justified and centred vertically to the right of the co-ordinates. You can control the justification and colour of text by enclosing the text in single quotes (a single quote can be included in the string by writing two single quotes in a row) with text mode specification characters following the closing quote:

Horizontal alignment:

< Left justify (default)
> Right justify
| Centre

Vertical alignment:

- Middle (default)
^ Top
_ Bottom

Colour:

0-**9** as for line drawing above

You can include multiple text items in one (Label) field by using the quoted string form and separating the items with semicolons.

Example chart catalogues

The following are the first few lines of a chart catalogue based on the Third Cambridge Radio Survey Catalogue (3C). Each line contains a (Type) field which plots icon 16 from the scenery database (**SCENERY.DLL**), a trangle icon used to indicate a radio source and a (Label) field containing the catalogue designation for the object. This catalogue is included with Home Planet as the file **3C.CSV**.

```
Name,Right ascension,Declination,Flux density,Error class,Galactic lat,Galactic long,4C number,(Label),
(Type)
3C3,0h 8.502m,-5d 58.307m,8.2,a,-66.5,95.2,4C-06.01,3C3,H16
3C6.1,0h 16.536m,79d 14.659m,13.7,a,16.5,121.2,4C+78.01,3C6.1,H16
3C9,0h 20.425m,15d 40.642m,16.3,a,-46.5,112.1,4C+15.02,3C9,H16
3C10,0h 25.480m,64d 10.604m,14.2,a,1.4,120.1,4C+63.01,3C10,H16
```

This catalogue can be used conventionally to select and aim the telescope at various entries, or to identify objects pointed to in the telescope or horizon windows. If the "Chart" box is checked when the catalogue is selected, all visible 3C objects will be plotted in sky maps.

Here's the first few lines of a chart catalogue that has no items for user selection, but which plots the chart boundaries of Sky Atlas 2000.0 and displays each chart number at its centre.

This chart catalogue is supplied in the file **SC2KBND.CSV**.

```
,Right ascension,Declination,(Type),(Label)
;	+50 parallel
,0h,50d,c3;mv
,0h,50d,ct
;	+50 - +90 meridians
,0h,50d,mv
,0h,90d,lt
,8h,50d,mv
,8h,90d,lt
,16h,50d,mv
,16h,90d,lt
,4h,70°,,'1'|-1
,12h,70°,,'2'|-1
,20h,70°,,'3'|-1
;	+20 - +50 meridians
;
```

Type 9 object catalogues

Chart catalogues can be declared in **OBJECTS.CSV** with any of the database types appropriate for catalogues which contain "Right ascension" and "Declination" fields: types 3, 5, 6, 7, and 8. An additional type, 9, allows you to make objects in the chart catalogue eligible for identification by right clicking in the Telescope and Horizon windows only if the chart catalogue is currently charted in the sky map.

Consider the 3C catalogue of radio sources mentioned above. This catalogue contains more than 300 sources which cover the northern sky quite densely and, furthermore, often coincide with objects better known as their optical counterpoints such as M1 (the Crab Nebula) or M82. If this catalogue were eligible for selection at all times, many objects you pointed to might result in finds within the 3C catalogue even though they were not visible on the map. This could be very confusing. Making such catalogues type 9 prevents this; right clicking selects objects in the catalogue only when they are visible in the sky maps.

Reading IAU and MPE Circulars

Newly discovered and recovered asteroids and comets, as well as other time-sensitive astronomical information are available via electronic mail by subscribing to the International Astronomical Union (IAU) and Minor Planet Electronic (MPE) Circulars published by the Minor Planet Center of the Smithsonian Astronomical Observatory.

Circulars providing orbital elements for asteroids and comets are in a format primarily intended to be read by humans, but sufficiently uniform so the information can be extracted by a computer program. Two MS-DOS utility programs, **ASTRELEM.EXE** and **COMETEL.EXE**, are included with Home Planet to perform this extraction.

Both programs process the Circulars in the form they are received by electronic mail; no manual editing is required beforehand. Further, both programs can read files containing any number of circulars along with other unrelated electronic mail, identify the relevant information, and extract it. Thus, if you file Circulars (or, for that matter, all of your electronic mail) in a Unix-style mail folder (which is simply a text file with all the messages concatenated together), either of these programs may be run on the entire mail archive to extract all the elements therein.

Since these are MS-DOS programs, they must be run from the MS-DOS prompt. To run them, launch the MS-DOS Prompt window from the Program Manager and enter the commands as described below. Both programs may, of course, be run directly on MS-DOS if Windows is not running. Let's assume that you've stored, in a file named **CIRCMAIL.TXT**, the text of IAU Circular 6037 (25 July 1994) which announced (among other things), Comet McNaught-Hartley (1994n) to be a short period comet and Minor Planet Electronic Circular MPEC 1994-O02 (26 July 1994) which provided orbital elements and an ephemeris for newly-discovered asteroid 1994 LC1.

The elements contained within the Circulars appear as follows. For the comet:

```
PERIODIC COMET McNAUGHT-HARTLEY (1994n)
T = 1994 Nov. 11.202 TT             Peri. = 300.216
      e = 0.61969                        Node   =   38.118    2000.0
      q = 2.60969 AU                     Incl. =   17.655
        a =   6.86205 AU       n = 0.054831       P =   17.98 years
```

and for the asteroid:

```
1994 LC1
Epoch 1994 June 17.0 TT = JDT 2449520.5                    Williams
M 345.07105                  (2000.0)               P                   Q
n    0.21329451       Peri.   316.61148       +0.87927374       +0.47291691
a    2.7742756        Node      15.45382       -0.35758532       +0.73417484
e    0.5183673        Incl.     12.30985       -0.31465923       +0.48717235
P    4.62                H      16.5              G     0.15
```

To extract the elements of all the comets in a file, in this example **CIRCMAIL.TXT**, use the MS-DOS command:

COMETEL CIRCMAIL.TXT COMETNEW.CSV

where the second file name, in this case, **COMETNEW.CSV**, is the file into which the extracted orbital elements, in Home Planet's CSV format, should be written. The file **COMETNEW.CSV** appears in the Object Catalogue under the category "Comets: new", so using this file name (in the directory where you've installed Home Planet) renders the extracted elements immediately accessible from the Object Catalogue. In our example, with just the one comet in the file, the extracted CSV file will be:

```
Name,Perihelion time,Perihelion AU,Eccentricity,Long. perihelion,Long. node,Inclination,Semimajor axis,Period
McNAUGHT-HARTLEY (1994n),1994-11-11.202,2.60969,0.61969,300.216,38.118,17.655,6.86205 AU,17.98 years
```

Similarly, you can extract the elements for all asteroids in the file with the command:

ASTRELEM CIRCMAIL.TXT ASTRNEW.CSV

As above, we've chosen to write the output file into a file, **ASTRNEW.CSV**, which already appears in the Object Catalogue under the category "Asteroids: new", permitting it to be used without adding a new category to **OBJECTS.CSV**. The CSV file generated by this command is:

```
Name,Magnitude H,Magnitude G,Mean anomaly,Arg. perihelion,Long. node,Inclination,Eccentricity,Semimajor axis,Epoch (MJD)
1994 LC1 (Unnamed),16.5,0.15,345.07105,316.61148,15.45382,12.30985,0.5183673,2.7742756,49520
```

These programs were implemented as stand-alone MS-DOS programs, as opposed to Windows applications or simply being integrated into Home Planet, for a variety of reasons. First of all, there are no hard and fast rules for identifying asteroid and comet elements within a collection of one or more Circulars, not to mention when these Circulars may, themselves, be scattered among megabytes of other archived E-mail. Consequently, the logic that **ASTRELEM** and **COMETEL** use to accomplish this was developed by examining a large number of Circulars and testing on real-world mail archives. The programs employ a variety of heuristics or, in as they are called in the vulgate, kludges, which may not work in every case. Further, there is no guarantee that the format in which elements are published in the Circulars will not change in the future. Minor variations have occurred over the past year, all of which are accommodated by the current programs, but further changes may eventually be needed. Finally, many people receive electronic mail on machines other than their Windows personal computers. In this case it's far more convenient to be able to automatically extract the elements from mail directly on the machine that receives it, rather than transferring a huge amount of irrelevant mail, then processing it on the PC.

All these reasons make it desirable to include source code for the **ASTRELEM** and **COMETEL** utilities with Home Planet, so they can be modified if necessary and/or be converted to run on other machines. Since it is a major project to make a Windows application run on any other architecture and, in any case, Windows program development requires a much larger and more complicated set of tools than compiling a simple C program, these programs were developed as MS-DOS utilities. The source code for both programs is supplied in the **TOOLS** subdirectory of the Home Planet distribution. Both programs use only standard C library functions, and both should require little or no modification to run on Unix workstations; they have been tested on Silicon Graphics and Sun Microsystems machines and work fine on both.

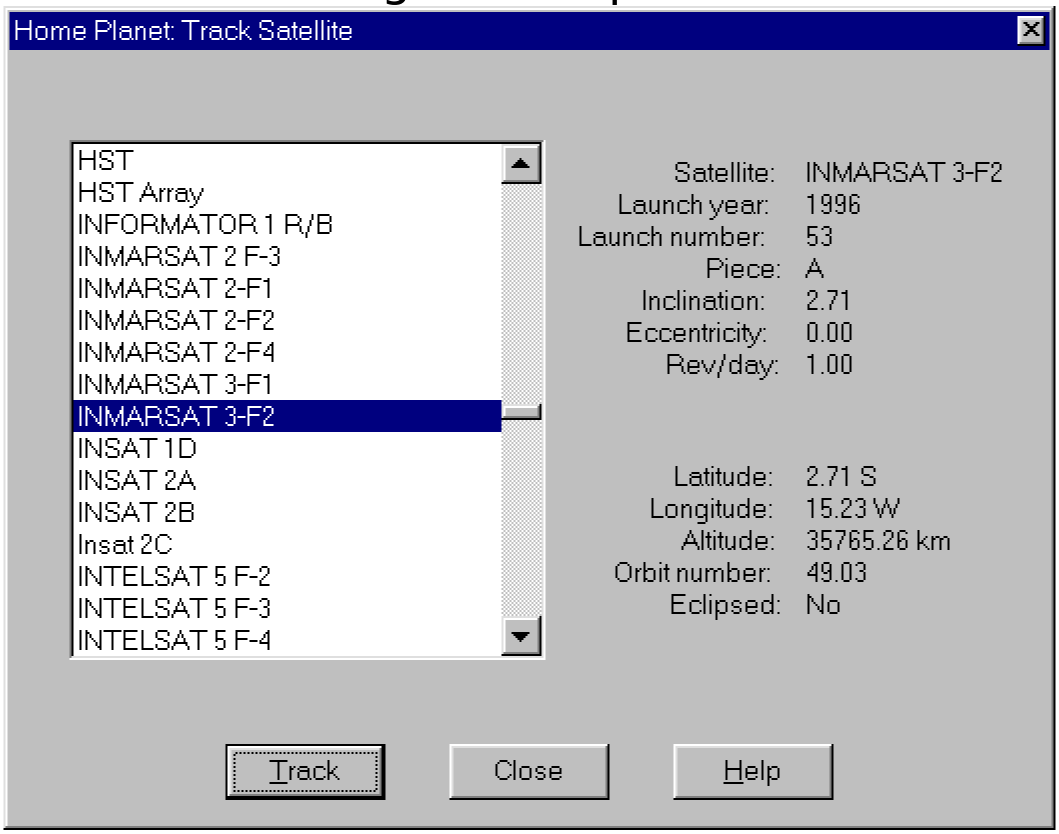
The cuckoo clock

Since this program was designed and implemented in the Jura mountains of Switzerland, renowned for centuries as the watchmaking capital of the world, it's only fitting that Home Planet include a cuckoo clock.

If your computer is equipped with a wave audio output device, Home Planet announces the hour with an appropriate number of authentic cuckoo chirps and the half hour with a single chirp.

If you cannot abide the cuckoo clock, toggle the Edit/Cuckoo Clock menu item to disable the tweety bird, and use the File/Save settings item to make the choice permanent (*dommage*).

Satellite tracking control panel



In order to track satellites with Home Planet, you need a database of their orbital elements. Home Planet initially loads a default database named **SATELITE.SAT.** To select other databases and for information on how to obtain updated satellite databases from various online services and data networks, please refer to the section Satellite database selection. You can select a different satellite database with the dialogue box described there or, simpler still, just drag the icon of the satellite database file you wish to use from the File Manager and drop it anywhere in the Satellite Tracking control panel.

To track a satellite, open the Satellite Tracking control panel with the Satellite/Track satellite... menu item. The panel presents you with a list box of all satellites in the currently-selected database. At the right of the control panel is real-time information on the satellite currently being tracked, initially blank since you haven't yet chosen a satellite.

Scroll the list box to the satellite you wish to track and select it, either by double clicking on the satellite name or by highlighting it with a single click and then pressing the Track button. Information about the satellite appears in the fields at the right of the control panel, including its instantaneous position above the Earth, its altitude, and whether or not it's in the Earth's shadow. More detailed descriptions of these fields are given below.

Once you've selected a satellite to be tracked, its name appears in the title bar of the Map window, and an icon representing the satellite's current position above the Earth is displayed in the Map window. You can choose among several icons to represent the satellite; please refer to Satellite icon selection for details. If the satellite is visible from the chosen observing site, its icon will also appear in the Sky window and Horizon view at the correct position with regard to the stars. Further, if the Telescope is aimed so the satellite falls within its field of view, the satellite icon will appear in the telescope display as well.   To see the view from the satellite, use the Display/View Earth from/Satellite menu item in the Map window or, while the Satellite tracking control panel is displayed, double click on the satellite icon in the Map window.

The Satellite tracking control panel remains displayed until you close it with the Close button or the Control menu.   Even if you close the control panel, the satellite you've chosen continues to be tracked.   You can redisplay the control panel at any time from the Satellite/Track satellite... menu item or simply by double clicking on the satellite icon in the Map window.   To cease satellite tracking, choose the "-none-" item which appears first in the list of satellites.

The name of the satellite you're tracking is remembered by File/Save settings... and will be tracked automatically every time you launch Home Planet.

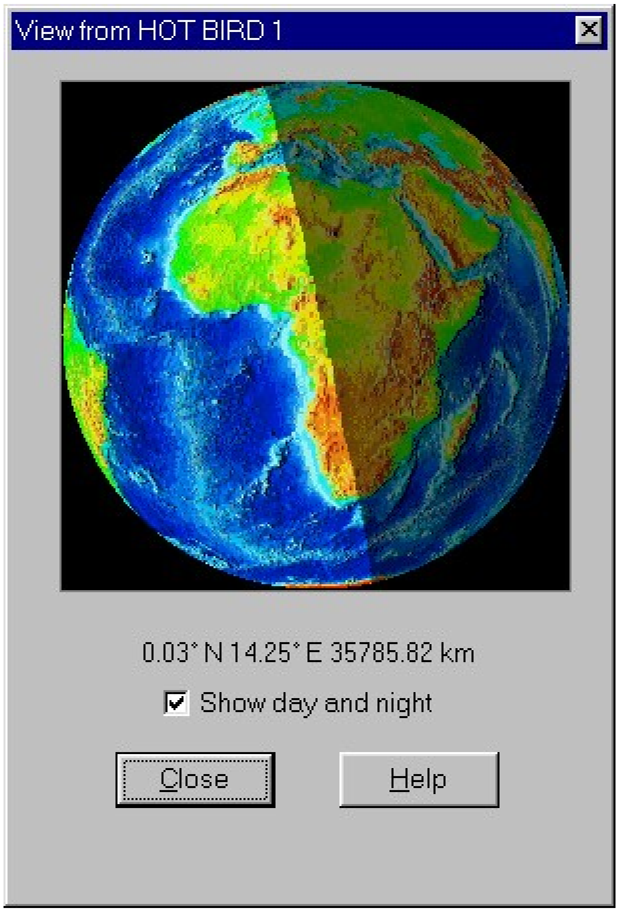
When you're running an animation, the satellite icon and control panel are updated to reflect the date and time of the animation.   Animations of satellite motion can give you an excellent sense, for example, of how Sun-synchronous orbits for Earth resources satellites work, or how the highly elliptical orbits of the Russian Molniya communication satellites allows them to "loiter" above high-latitude regions of that country from which geostationary satellites above the equator would be invisible and yet, due to their two-day orbital period, require no complicated tracking.   Satellite animations generally run faster and produce a smoother display if you first select 16 Colour mode for the Map window.

Items displayed about the satellite being tracked are as follows:

Satellite	Name of the satellite in the database.
Launch year	Year in which the satellite was launched.
Launch number	Serial number of launch within that year. Launch numbers weren't assigned until 1963, so older satellites such as Vanguard 1 (yes, it's still up there, and at an altitude of more than 3000 km, it's going to be for a long time) bear a launch number of 0.
Piece	Many launches place several objects into orbit in addition to the main payload; all of these objects share the same launch number and are distinguished by a piece code which is "A" for the main payload and successive letters denote other objects. Common abbreviations you'll encounter in the satellite name field for "extra pieces" are "R/B" for "rocket booster" and "DEB" for "debris".
Inclination	Orbital inclination with respect to the Earth's equator.
Eccentricity	Orbital eccentricity given as elliptical eccentricity. Zero denotes a perfectly spherical orbit and 1 a parabolic orbit.
Rev/day	Revolutions per day about the Earth, with respect to the distant stars. Thus a geostationary communication satellite completes 1.00 Rev/day even though, as seen from the surface of the rotating Earth, it doesn't move at all.
Latitude	Latitude of the point on Earth directly beneath the satellite.
Longitude	Longitude of the point on Earth directly beneath the satellite.
Altitude	Altitude of the satellite above the Earth's mean surface. The Earth is considered a sphere of its average radius, neglecting the equatorial bulge and local topography.
Orbit number	Number of revolutions completed since the object was launched.
Eclipsed	Yes if the object is in the Earth's shadow, No otherwise. Note that high-orbiting satellites are rarely in eclipse because, seen from their vantage point, the Earth doesn't cover much of the sky and only rarely

occults the Sun.

View Earth from...



The View from panel allows you to see the Earth from various viewpoints. Select the view with the Display/View Earth from menu item which provides you the following choices:

Sun (Day side)
Moon
Satellite
Night side
Above observatory

The "Satellite" selection is disabled unless you're currently tracking a satellite. You can also display the view from the currently tracked Satellite by double clicking on the satellite icon in the Map window when the Satellite tracking control panel is already displayed.

The view shown by the panel is what you'd see from the chosen vantage point, oriented so North is up, with your view stretching from horizon to horizon. Obviously, from the Sun, Moon, or a high-altitude satellite such as geosynchronous communications satellite you'll see a lot more of the globe than from a low Earth orbit satellite such as the Hubble Space Telescope (HST) or Mir. If you've selected "Above observatory", you'll see the Earth as seen by a viewer in deep space hovering above your observing site--this lets you see the day and night regions of the Earth relative to your position which is useful for forecasting radio propagation.

The image of the Earth can be displayed in two different formats, chosen with the Display/View Earth from menu item.   If you've set the Map window to Grey scale or Full colour, the default for the View from display is "Earth image," created by projecting the Map window onto a sphere through a ray-tracing technique known as *texture mapping*.   This produces a beautiful image, including the terminator (night and day border), but is very time consuming to compute.   If you select "Map," a vector map is generated from the same map database used when you've set the Map window to Monochrome or 16 Colour format.   Earth image (texture mapped) rendering of the View from window is available only when the Map window is in Grey scale or Full colour mode.   If you find geography on the night side of Earth difficult to see in Earth image mode, toggle "Show day and night" off; this will illuminate the entire globe regardless of the Sun's actual position.   (Day and night are not shown when Map display is selected, so this option is not presented then.)

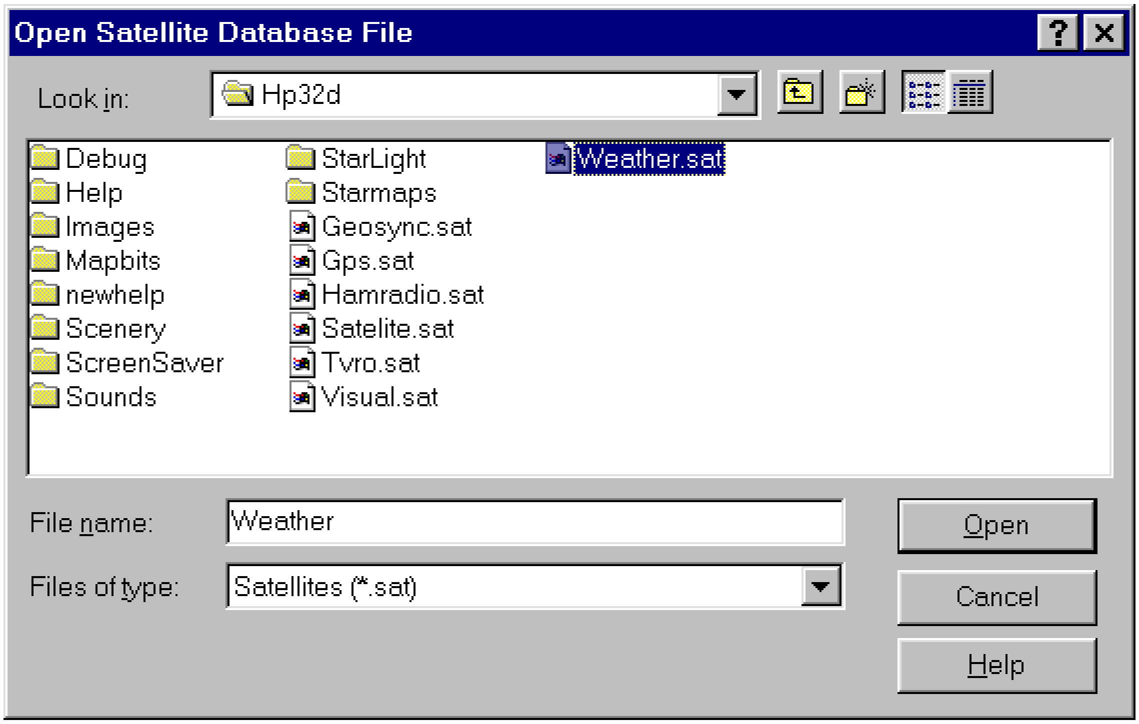
As the vantage point changes (assuming it isn't from a geostationary satellite), the view is updated periodically.   Rendering the view from a satellite is extremely compute-intensive (even in Map mode the database used to draw the globe contains more than 38,000 latitude and longitude measurements which must be projected in three dimensions from the chosen viewpoint).   To avoid totally bogging down slower computers which take a while to do all this computation, Home Planet measures how long it takes to compute the view, then updates the image at intervals of three times this computation time (less if the viewpoint isn't moving very rapidly).

Below the image of the Earth, the current latitude, longitude, and altitude are displayed. (The altitude isn't displayed if the view from above the observatory is chosen since it's irrelevant in that case.)   The position is updated every time the view is recomputed, so it always reflects the view you see.   The position is shown in grey when Home Planet is recomputing the view.   You can resize the View from window to make the image of the Earth larger, if you wish.

Displaying the view from a satellite allows users of Earth resources satellites to determine visibility and content of data on current passes.   It allows you to instantly see whether a given satellite is visible from your location (enabling communication through amateur radio satellites, for example, or for trying to catch a glimpse of the Space Shuttle or Mir).   But it can also be fun.   For a good time, try riding along one of the Russian Molniya high-latitude communication satellites for an entire orbit (use Animation to speed things up if you're impatient).   Geostationary satellites have to be in equatorial orbit, and hence aren't effectively visible from high latitudes.   A large part of the Russian landmass is sufficiently far North that conventional geostationary communication satellites aren't usable.   The Molniya comsats are a clever work-around to this problem.   They're in highly elliptical orbits with a period of precisely two orbits per day with apogees high above the Arctic.   This means, even though they move, they're close to stationary when at apogee and they arrive and depart twice a day on a perfectly predictable schedule.   By launching enough to guarantee that at least one will be at apogee at all times, you can provide continuous communication satellite service to high latitudes.

Twice a day, each Molniya dives down from its station and whips around the Earth with a perigee of less than 800 kilometres.   The perigee pass is extremely fast, since all the potential energy of the high apogee becomes kinetic energy at the perigee pass.   Viewing the Earth from a Molniya from apogee to apogee is like a roller-coaster ride.

Satellite database selection



This dialogue allows you to specify the database of satellites presented when you display the Satellite Tracking control panel. (You can also select a satellite database file by dragging its icon from the File Manager and dropping it in the Satellite Tracking control panel.)

The satellite database is stored in "NORAD two-line orbital element format". In order to accurately track satellites, you must have *current* orbital elements; the sample files supplied with Home Planet will almost certainly be hopelessly out of date, though adequate to demonstrate satellite tracking. If you need accurate positions (to aim satellite dishes, schedule contacts with amateur radio satellites, calculate remote sensing satellite passes, check availability of Global Positioning System satellites, or determine the visibility of Mir or the Space Shuttle from your location, for example) you'll have to obtain up-to-date elements.

There are several different systems of nomenclature for satellites. What is commonly called the Hubble Space Telescope or HST is often stored in satellite databases under its NASA Object Number of 20580 or its International Designator of 1990-037B, which breaks down to the year of its launch, the launch number in that year, and the piece code from that launch. Home Planet's Object catalogue contains a database covering all satellites from Sputnik through late 1993. To access this database, choose Display/Object catalogue... from the menu, then select the "Spacecraft" database in the Category box. You may then select any satellite in the database by scrolling through the Object box. The satellite names are in alphabetical order, so you can accelerate the search by typing the first letter of the satellite name; this will immediately scroll to the first satellite with a name beginning with that letter.

Current orbital elements in NORAD two-line format may be downloaded from the Celestrak Web site:

http://www.celestrak.com/

Here is the detailed format of NORAD element sets:

Data for each satellite consist 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.NNNNNNNNNNNNNN
```

Line 0 is a eleven-character name.

Lines 1 and 2 are the standard Two-Line Orbital Element Set Format identical to that used by NORAD and NASA. The format description is:

Line 1

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)

Line 2

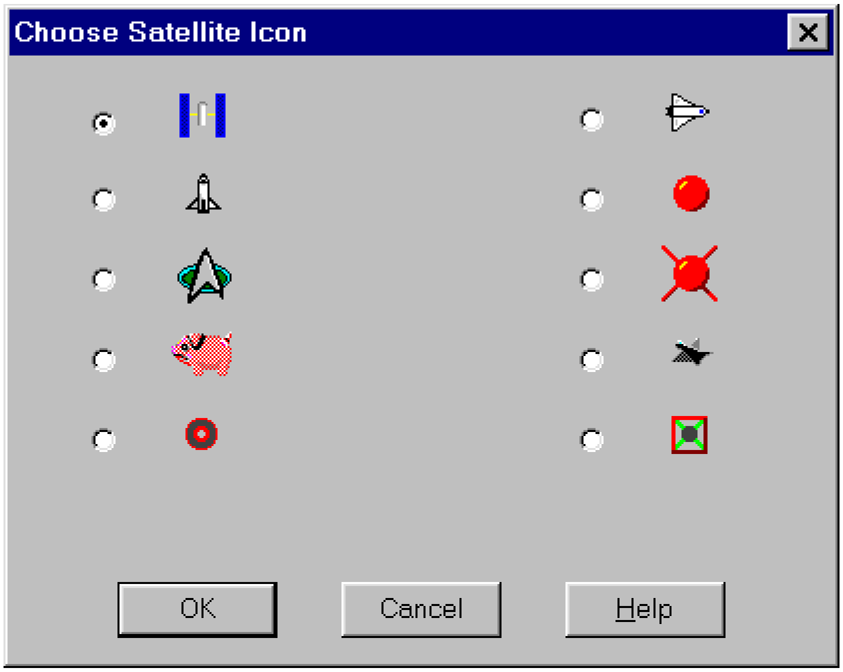
Column	Description
01-01	Line Number of Element Data
03-07	Satellite Number
09-16	Inclination [Degrees]
18-25	Right Ascension of the Ascending Node [Degrees]
27-33	Eccentricity (decimal point assumed)
35-42	Argument of Perigee [Degrees]
44-51	Mean Anomaly [Degrees]
53-63	Mean Motion [Revs per day]
64-68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

All other columns are blank or fixed.

Example:

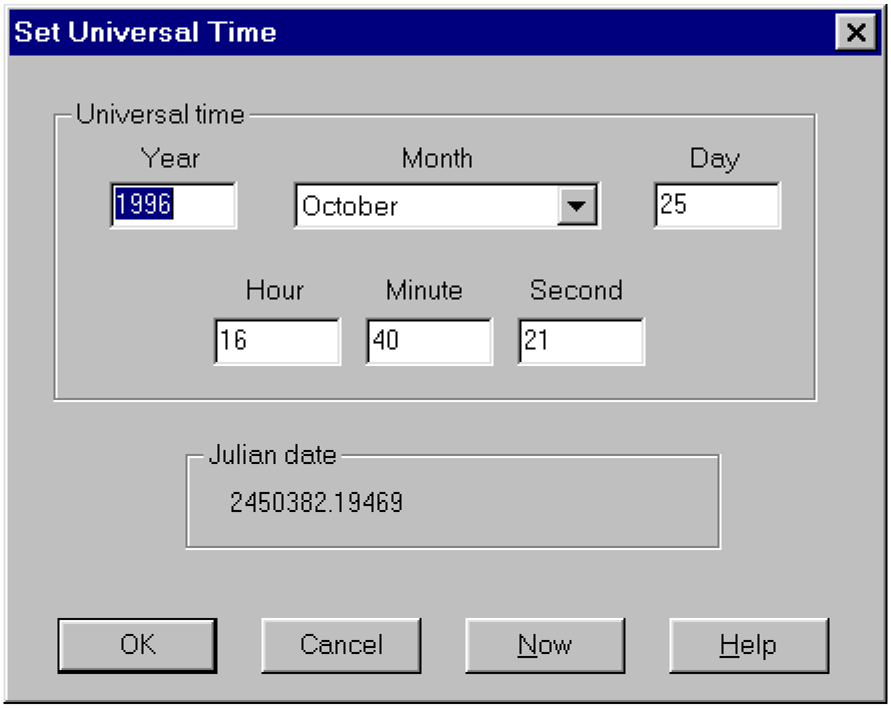
```
NOAA 6
1 11416U          86 50.28438588 0.00000140          67960-4 0  5293
2 11416  98.5105  69.3305 0012788  63.2828 296.9658 14.24899292346978
```

Satellite icon selection



This dialogue allows you to choose the icon used to display the current position of the satellite being tracked.   The chosen icon is remembered by File/Save settings.

Set Universal time



This dialogue allows you to enter an arbitrary Universal (Greenwich Mean) date and time and see the Julian date corresponding to that moment. The Julian date is updated dynamically as you change the Universal time. Click OK to have Home Planet display the situation at the specified Universal time (doing this will halt automatic updates; select Animate/Run to resume them). Clicking Now resets the Universal time to the current date and time.

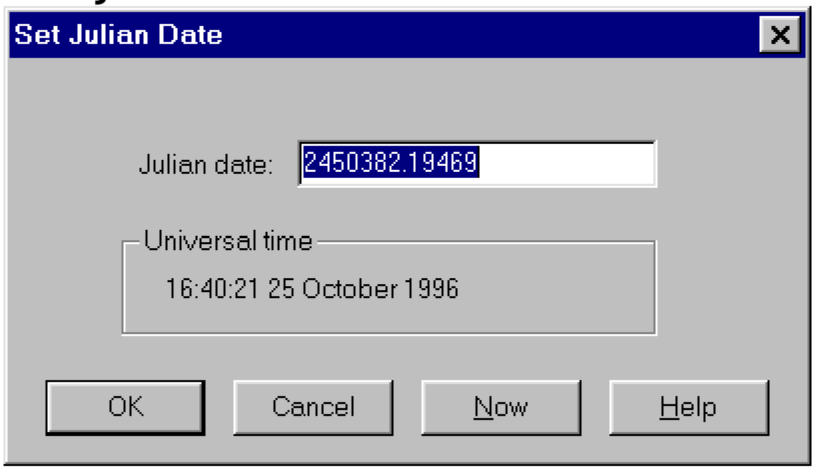
Home Planet's ability to display the Earth and sky at any moment in history lets you quickly answer questions such as that posed in the April 1992 issue of *Sky & Telescope* (page 437): did Paul Revere's midnight ride really occur under the full Moon, or did Longfellow add the Moon to his poem purely for atmosphere? Entering the time and date of Revere's ride: 05:00:00 UTC April 19th, 1775, in the Set Universal time panel and then examining the Sun/Moon information panel we find the Moon was 87% full that night, waning from the last full Moon at 21:53 UTC on April 15th, 1775. Home Planet tells us that the Moon was indeed close to full that night, confirming Revere's own recollection that "the Moon shone bright". Further, the position of the Moon on the Map display confirms the Moon was ascending in the southeastern sky as seen from Boston as Revere began his ride. To double check, select Display/View Earth from/Moon.... The display shows that, seen from the Moon, the east coast of North America was just coming into view and thus, from Boston, the Moon was rising.

If you use this dialogue as a "Julian date calculator", be sure to remember that Julian dates change at noon Greenwich time rather than midnight.

You can enter dates as far back as Julian day 0, January 1, -4712 and as far into the future as you wish. Note that astronomers and historians use different conventions for years before 1 A.D. In history books, the year that preceded 1 A.D. is called 1 B.C.; zero not having come into use in European culture at the time. Astronomers consider the year before 1 A.D. as "year 0". Thus when an astronomer talks about an eclipse having occurred in the year -412, that's the year historians refer to as "413 B.C.". In converting historical dates to Julian days, Home Planet assumes the canonical date for the adoption of the Gregorian calendar, Friday, October 15th, 1582. Many countries shifted to the Gregorian calendar much later; in Great Britain, not until 1752. When investigating events in history, make sure you express all dates after October 15th, 1582 in the *Gregorian* calendar.

To convert a Julian date to Universal time, use the Edit/Set Julian date dialogue.

Set Julian date

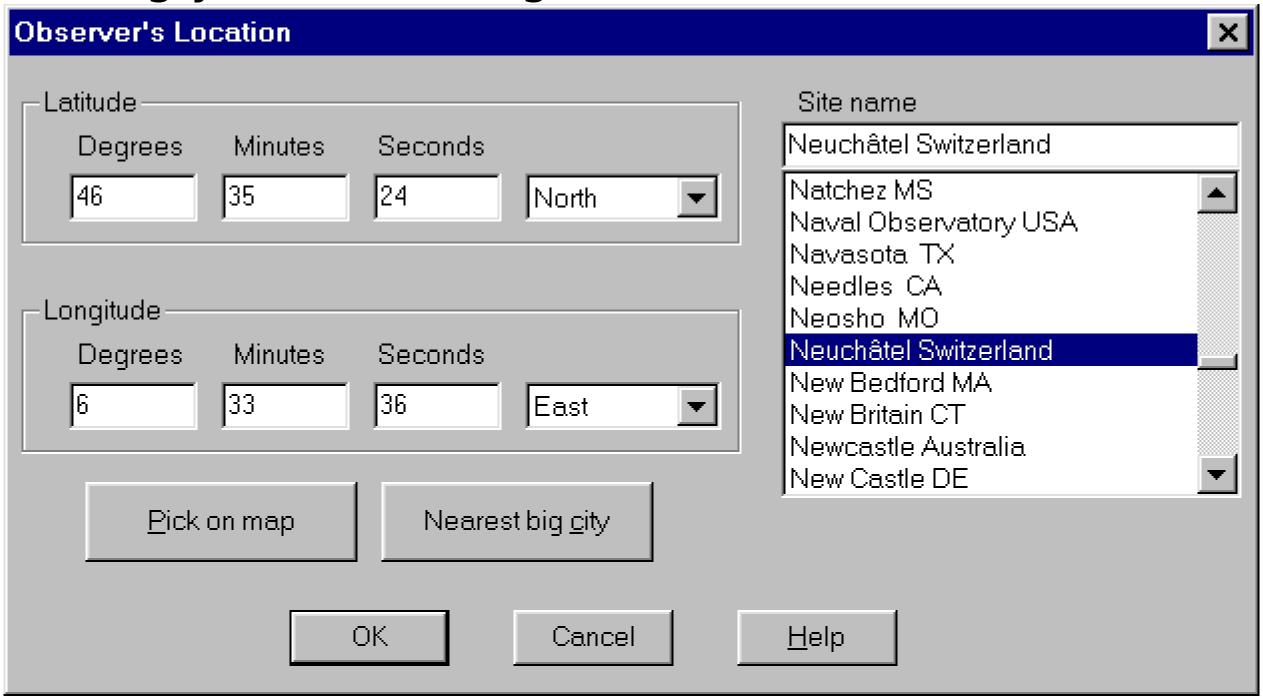


This dialogue allows you to enter a Julian date (remember that the day number changes at noon, not midnight) and see the corresponding Universal time displayed. The Universal time is updated dynamically as you change the Julian date. Click OK to have Home Planet display the Earth and sky at the specified Julian date (doing this will halt automatic updates; select Animate/Run to resume them). Clicking Now resets the Julian date to the current date and time.

You can enter any Julian date zero or greater. For Julian dates for years before 1 A.D., note that astronomers and historians use different conventions those years. In history books, the year that preceded 1 A.D. is called 1 B.C.; zero not having come into use in European culture at the time. Astronomers consider the year before 1 A.D. as "year 0". Thus when an astronomer talks about an eclipse having occurred in the year -412, that's the year historians refer to as "413 B.C.". In converting Julian days to historical dates, Home Planet assumes the canonical date for the adoption of the Gregorian calendar, Friday, October 15th, 1582. Many countries shifted to the Gregorian calendar much later; in Great Britain, not until 1752. When investigating events in history, make sure you express all dates after October 15th, 1582 in the *Gregorian* calendar.

To convert a Universal time to Julian date, use the Edit/Set Universal time dialogue.

Setting your observing site



In order to calculate the appearance of the sky from your location on Earth and determine when you will see celestial bodies rise and set, Home Planet needs to know where you're observing from: more precisely, your latitude and longitude.

To set your observing location, choose Edit/Set Observer's location... from the menu. The Observer's Location dialogue appears, showing the current (or default) observatory location. Home Planet is supplied with a database of more than 1300 locations including world capitals, isolated islands, and many communities in the North America. If your location is included in the standard database, simply pick it from the list box at the right of the dialogue and your observing location will be specified. To save this location for subsequent Home Planet sessions, use the File/Save settings menu item.

If your observing site isn't included in the database, you have several options. First and simplest, just choose a location from the database that's reasonably close to your site; as long as it's within a hundred kilometres or so, you'll hardly notice the difference (unless you're concerned with where low-orbiting satellites will appear in your sky). You can edit the "Site name" to your own location if pride of place is important to you. Be sure to save settings so your selection is remembered.

Rugged individualists (or blue water sailors) so far from any known habitation that the database comes up short can enter their location (assuming they know it--which end of this sextant thingie do 'ya look in and just when did I last wind the chronometer?) in the Latitude and Longitude boxes. Make sure you select North/South and East/West lest you find yourself in the wrong hemisphere. When you edit the latitude and longitude this way the site name clears. Enter a name for your site before closing the Observer's location dialogue.

The map-savvy but number-averse can simply point and click on their location on the globe. Press the "Pick on map" button; the dialogue momentarily disappears. The arrow cursor is replaced by crosshairs with which you choose a location in the Map window and select by clicking. The Observer's Location dialogue then reappears with the Latitude and Longitude boxes filled in with the location you picked on the map. If you'd like to replace those coordinates (or those you've explicitly entered) with the latitude and longitude of the closest major city in the database, press the "Nearest big city" button.

Finally, if you won't settle for anything less than a full listing of your observing site in the database, you can edit the site database file, **SITENAME.TXT** in the directory into which Home Planet was installed. The format of this file is as follows:

Column	Meaning
1	Sign of latitude, "+" if North, "-" if South
2-7	Latitude in decimal degrees * 10000. For example, 414975 means 41.4975 degrees.
8	Blank
9	Sign of longitude, "+" if West, "-" if East
10-16	Longitude in decimal degrees * 10000. For example, 1181447 means 118.1447 degrees.
17	Blank
18-End	Place name. If the first character of the place name is "+", this is a "major site" which is a candidate for the "Nearest city" search. Otherwise the name simply appears in the list of site names available for explicit selection.

Note that the latitudes and longitudes in this database are given in *decimal degrees*. If you're adding new locations from a source that gives degrees, minutes, and seconds, be sure to convert to decimal degrees!

To illustrate the observing site database format, here is an extract from the database supplied with Home Planet:

```
+426403 +0713205 Lowell MA
-090000 -0135000 +Luanda Angola
+335847 +1018425 +Lubbock TX
+413633 +1138400 Lucin UT
+311617 +0947167 Lufkin TX
-150000 -0290000 +Lusaka Zambia
+496000 -0062000 +Luxembourg Luxembourg
+374150 +0791433 Lynchburg VA
+424633 +0709483 Lynn MA
+396533 +0924817 Macon MO
+328367 +0836267 Macon GA
+440067 +0971133 Madison SD
+430730 +0893819 +Madison WI
+405000 +0038000 +Madrid Spain
+030000 -0084000 +Malabo Equatorial Guinea
+422000 +1124500 Malad City ID
+365550 +0899117 Malden MO
+424233 +0710667 Malden MA
+045000 -0730000 +Male Maldive Islands
+120000 +0865000 +Managua Nicaragua
+260000 -0510000 +Manama Bahrain
```

Setting your local time zone

The time and date on MS-DOS systems are stored in local time. In order to calculate the position of the Sun, Moon, and satellites as seen from Earth, Home Planet needs to know what time zone you're in or, in other words, the relationship between the local time provided by your computer and Universal (or Greenwich Mean) time (UTC or GMT).

The time zone is usually configured when you install the operating system on your computer. If it is set incorrectly, the local time may be correct but the information Home Planet displays regarding the sky will be incorrect for that time. You can change the time zone at any time with the “Date/Time” icon in the Control Panel.

DDE Server implementation

Home Planet provides a comprehensive set of astronomical information to other applications through Dynamic Data Exchange (DDE). Current information may be retrieved by a simple request, or hot links can be established so current data are supplied automatically to the client application. If you have a computer-controlled telescope, a suitable application can use the telescope aiming information furnished by Home Planet to aim the telescope at locations selected from Home Planet's Telescope or Object Catalogue windows. An Excel workbook, **HPDDE.XLS**, is supplied with Home Planet to illustrate the use of Home Planet's DDE facilities and document the information available:

Time

Julian date:	2448935.97295	11/9/92 11:21	=HPlanet|Time!jdate
Greenwich mean sidereal time:	14.60945		=HPlanet|Time!gmst

Sun

Right ascension:	224.85248	14h 59m 25s	=HPlanet|Sun!ra
Declination:	-17.00296	-17° 0.2'	=HPlanet|Sun!dec
Distance from Earth (AU):	0.99035		=HPlanet|Sun!distanceAU
Distance from Earth (km):	148145373		=HPlanet|Sun!distanceKM
Angle subtended:	0.53836		=HPlanet|Sun!subtends
Ecliptic longitude:	227.31731		=HPlanet|Sun!Elong
Longitude of subsolar point:	-5.71079		=HPlanet|Sun!long

Moon

Right ascension:	32.7846	2h 11m 08s	=HPlanet|Moon!ra
Declination:	17.13732	17° 8.2'	=HPlanet|Moon!dec
Distance from Earth (km):	392745.7244		=HPlanet|Moon!distanceKM
Distance from Earth (Earth radii):	61.22142		=HPlanet|Moon!distanceER
Angle subtended:	0.50709		=HPlanet|Moon!subtends
Ecliptic latitude:	3.69884		=HPlanet|Moon!Elat
Ecliptic longitude:	36.3837		=HPlanet|Moon!Elong
Longitude of sublunar point:	-173.64291		=HPlanet|Moon!long
Age of moon in days:	13.84844		=HPlanet|Moon!age
Phase:	0.99052		=HPlanet|Moon!phase
Lunation:	864		=HPlanet|Moon!lunation
Last new moon:	2448921.85699	10/25/92 20:34	=HPlanet|Moon!PhLastNew
First quarter:	2448929.38213	11/2/92 09:10	=HPlanet|Moon!PhFQuarter
Half:	2448937.39009	11/10/92 09:21	=HPlanet|Moon!PhHalf
Last quarter:	2448944.48634	11/17/92 11:40	=HPlanet|Moon!PhLQuarter
Next new moon:	2448951.38328	11/24/92 09:11	=HPlanet|Moon!PhNextNew

Telescope

Active:	1	Yes	=HPlanet|Telescope!active
Right ascension:	237.68238	15h 50m 44s	=HPlanet|Telescope!ra
Declination:	25.06254	25° 3.8'	=HPlanet|Telescope!dec
Azimuth:	152.74467	27.255 from N	=HPlanet|Telescope!azi
Altitude:	66.56789		=HPlanet|Telescope!alt

The last column in the spreadsheet gives the name of the variable exported by Home Planet for each quantity provided. Time and date are returned by Home Planet in terms of Julian date and fraction; refer to **HPDDE.XLS** for an Excel formula which converts Julian date to Excel's 1900-based "serial number" date and time format.

A few comments about some of the variables exported:

Time!gmst — This is the Greenwich Mean Sidereal Time expressed as hours and a fraction. For example, 12:30:00 GMST is returned as 12.5.

Sun!subtends — This is the angle subtended by the Sun's disc. You can compare this to

	Moon!subtends to determine if a solar eclipse will be total or annular.
Sun!long	This is the longitude on Earth of the point beneath the Sun (i.e. where the Sun is at the zenith). Longitude is given in degrees from Greenwich, with positive numbers signifying west longitudes and negative numbers east longitudes.
Moon!lunation	This is the serial number of the current lunation (interval between consecutive New Moons) in E. W. Brown's numbered series of lunations beginning on January 16th, 1923.
Moon!Ph...	The dates and times of the Moon phases are given as Julian dates. Remember that Julian days start at noon, not midnight.
Telescope!active	If the Telescope window is displayed, this is 1, otherwise 0. The telescope aim point is valid only if this value is 1.
Telescope!ra	Right ascension of the telescope aim point, in degrees.
Telescope!dec	Declination of the telescope aim point, in degrees.
Telescope!azi	Azimuth of the telescope aim point, in degrees. Azimuth is measured, astronomer style, westward from the South.
Telescope!alt	Altitude of the telecope aim point, in degrees. If negative, the selected object is below the horizon.

Computerised telescope aiming

Home Planet can be used to control a computer-driven telescope, integrating the many ways Home Planet allows you to locate and display celestial objects with a real-world telescope that looks outward on the universe, not inward at a database. Home Planet's computerised telescope aiming facility is not limited to any specific telescope hardware; it is implemented in an open fashion which allows any telescope with computer drive capability, even one-off home-made 'scopes, to be controlled. Computerised telescope aiming is accomplished by making the aim point of Home Planet's Telescope window available to other applications via the DDE server. Given a Windows-based telescope control program which communicates with Home Planet and a CCD camera, one could point to an object in a Home Planet sky map (or select one from the Object Catalogue), point the telescope at that location in the sky, and display a CCD image taken through the telescope in a separate window, all without ever leaving your computer. In fact, with data communications or network access, the telescope you control could be on the other side of the Earth or, for that matter, in orbit around it. There *will* be an amateur space telescope before long; the idea is so *cool*, it is simply inevitable! Amateur radio satellites have already pioneered most of the communication and control technologies needed to build one. And when it makes orbit, Home Planet will be able to drive it.

Meanwhile, back on Earth, if you have a drive program for your telescope which interfaces with Home Planet's DDE aiming information, you need only install it and follow the instructions. The information that follows is for developers who wish to write custom software that works with Home Planet's telescope control facility and is, of necessity, technical in nature and assumes familiarity with DDE destination application architecture. Once a driver is created for a given telescope, users need not be concerned with these details.

Telescope driver implementation

A telescope driver is simply a regular Windows application which acts as a DDE destination application, receiving the telescope aiming information made available by Home Planet, reformatting it as required by the telescope being driven, and then sending commands to the telescope's drive controller to point to the given location. Driver applications may contain much additional functionality: focusing controls, CCD camera drivers and image display windows, etc. but the interface with Home Planet remains the same. A telescope driver may be written in any language which supports DDE; the most obvious choices are Visual Basic and C/C++, but it is entirely possible, for example, to implement a driver using the macro language of Microsoft Excel.

DDE communication occurs via links identified by a *source application*, the *topic*, and the *item* of information being exchanged. All communications between Home Planet and a telescope driver use:

Source application:	**Hplanet**
Topic:	**Telescope**

Items available via DDE are:

active	If the Telescope window is displayed, this is 1, otherwise 0. The telescope aim point is valid only if this value is 1.
ra	Right ascension of the telescope aim point, in degrees.
dec	Declination of the telescope aim point, in degrees.
azi	Azimuth of the telescope aim point, in degrees. Azimuth is measured

astronomer style, westward from the South.

alt Altitude of the telecope aim point, in degrees. If negative, the selected object is below the horizon.

Applications should examine first examine **active**; if it's zero, Home Planet's Telescope window is not displayed and the other variables are meaningless. Whenever the user changes the aimpoint of the Telescope window, the **ra**, **dec**, **azi**, and **alt** variables are updated to reflect the co-ordinates of the centre point in the Telescope window. Note that all of these values are given in degrees and fractional degrees, even right ascension. To convert right ascension to hours and fractional hours, divide by 15 (360 / 24).

The **azi** and **alt** variables are calculated from **ra** and **dec** based upon the selected observing site. Note that **azi** and **alt** are valid only at the moment the telescope position changes; updates are not updated continuously as the Earth rotates--telescopes are assumed to have a clock drive which tracks the object being observed. Most telescope drivers will use **ra** and **dec** directly, relying on their own polar alignment and clock to convert equatorial to local horizontal co-ordinates. Note that a driver can, if it wishes, obtain the current Julian date and Greenwich mean sidereal time from topic **Time**, items **jdate** and **gmst**, and update the telescope's drive computer with the current values from Home Planet. If the **alt** value is less than zero, the aim point is currently below the horizon and inaccessible to the controlled telescope. An intelligent driver program might, in this case, store the **ra** and **dec** values so that the telescope could be aimed at the designated object the moment it rose above the horizon.

Driver programs may find other information made available by Home Planet via DDE useful. The location of the Sun can be used to prevent the telescope from pointing closer than a given angular distance of the Sun, avoiding damage to detectors. The location of the Moon allows tracking the Moon even if the telescope's drive lacks a lunar rate option.

If you're using the telescope aiming facilty to control a telescope at a remote location, be sure to set the telescope's location as your observing site. Otherwise, calculation of altitude and azimuth, parallax, etc. will be done based on the location of your computer, not the telescope with which you're actually observing.

Developers interested in driving telescopes from Home Planet's DDE interface should start by examining the display of telescope aiming information presented in the Excel workbook **HPDDE.XLS** supplied with Home Planet. Experimentation with the DDE links in this file will illustrate the information provided to a telescope driver application by Home Planet.

Clipboard support

You can copy the current image displayed in the Map or Sky map windows to the clipboard with the Edit/Copy menu item in those respective windows. There are no menu commands to copy the other Home Planet information panels to the clipboard, but you may accomplish this by clicking in those panels and then pressing ALT+PRINTSCREEN, which causes Windows to copy a bitmap image of the panel to the clipboard.

Animation

The Animate menu allows you to animate the motion of the Earth, sky, and satellites by stepping quickly forward or backward by various time intervals.   The items on the Animation menu are:

Animate

Toggles animation on and off.   When the Animate item is not checked and "Stop" appears below it, the real time and date are displayed.   The local time is displayed only with the real time display; when animating (or displaying a specified date and time) only the Universal time appears.

Stop/Run

This item toggles whether Home Planet advances the time, whether real time or the simulated time in an animation.   You can halt an animation or freeze the current time by selecting Stop.   Stop is also selected when you enter a specific date and time with the Set Julian Date or Set Universal Time panels.   To restore the passage of time, simply select Run.

Time step

Displays a sub-menu which lets you choose the interval by which time advances or retards in each animation step.   Choose Minute or Hour to watch the Earth turn, Day to learn intuitively why the Moon's phases change, and Month to watch the seasons pass.   Choosing Sidereal day allows you watch the Sun, Moon, and planets move against an unchanging background of the fixed stars.   You can explore deep time by choosing animation time steps of decades, centuries, or millennia.   As millennia pass, the "fixed stars" are no longer fixed; aim the telescope at a constellation and watch the proper motion of its stars carry them into the patterns that will light the sky of your distant descendants.

Direction

Lets you specify whether time steps forward or backward in an animation.

Speed

Controls how quickly the animation runs.   Set to Slow if your computer can't update the window rapidly enough to allow interaction, and Fast if you have a high-performance computer and crave more action.

If your computer and graphics board are relatively slow, you can improve the performance of animations by setting the Display/Map window to Monochrome or 16 Colour mode, which greatly reduces the computation required to update the screen for each animation step.

Other applications receiving information from Home Planet via its DDE Server will continue to obtain current (real time) information despite an animation's being presented in Home Planet's display windows.

Saving preference settings

If you've changed any of Home Planet's preferences, you can cause them to be applied in subsequent executions of Home Planet by choosing the File/Save settings menu item. Picking this item causes the current Home Planet configuration to be written to the file **HPLANET.INI** in your Windows directory.

You can restore the default settings for all configuration parameters by picking File/Default settings from the menu. To make the defaults permanent, pick File/Save settings after File/Default settings.

The meaning of life

Amateur astronomers hoping to share their love of the sky sometimes speak of "the friendly stars". Certainly anyone who comes to really know the sky cannot look upward without seeing old friends visited before, friends to call on again and again, whether with a telescope, binoculars, or just lying in a grassy field on a warm spring evening, taking in the heavens with that venerable instrument, the human eye.

Yet learning more about the universe makes it seem, in many ways, less friendly. For the stars are not lamps hung in the sky to guide us at night, but raging nuclear furnaces separated by emptiness so immense our minds cannot grasp its extent. To study astronomy is to encounter violence beyond the human experience: stars which explode, incinerating their planets, or burn out into eternally dark cinders; sources of radiation so intense they outshine whole galaxies, powered by black holes that swallow entire stars; gravity that crushes atoms into subatomic particles or into nothingness; whole galaxies that explode, collide with one another, and devour their neighbours; a universe born in a creation fire still glowing today and destined--we know not which--either to collapse and be crushed from existence or expand into an eternity of darkness and cold. Awesome it is to contemplate, but awful in its seeming hostility to life.

Awesome because what we discover in the sky seems so alien to our own experience. Awful because to look at the sky is to ask, in the larger sense, "What is my place in the universe?". We look upward from a small globe teeming with life and see an endless void: empty, lifeless, and violent. To learn that not just one's own personal existence, not just all of humanity's experience, but that life itself appears insignificant and irrelevant to the universe is to stand humbled under cold and unfriendly stars.

Look upward to sky; look downward at the Earth. Upward, blackness punctuated by points of fire, worlds by the dozens in our neighborhood, and all of them lifeless. Downward, a globe not just home to a multitude of living creatures, but fashioned by life: its life-sustaining atmosphere itself created and maintained by life. Earth is not merely home to life; in a real sense it is alive, but alone.

But are not the stars home to other forms of life, perhaps other intelligent species already sensing our electromagnetic birth cry and preparing to welcome us into the galactic community? Almost certainly not: there is every reason to believe we are alone in the galaxy, and perhaps in the universe.

What is the meaning of life? The meaning of life is *to live*. To live is to expand the scope of life itself, by replicating, by adapting, by modifying the environment, and by evolving into other forms of life. Over three billion years ago, through a fantastically improbable sequence of coincidences, the Earth became alive--we find the traces of primitive organisms in some of the most ancient rocks. For almost two billion years, these single-celled creatures (prokaryotes), whose modern-day descendants are bacteria and blue-green algae, were the sole representatives of life. Not until about a billion and half years ago did single celled creatures with a structure resembling the cells in our bodies (eukaryotes--cells with a nucleus) appear. Only 700 to 800 million years ago did these single cells (protozoa) organise into multicellular life (metazoans). All the enormous variety of life we observe on Earth has evolved since: in a relative instant compared to the 4.5 billion year history of the Earth. And now, evolution has produced beings who look upward at the sky, downward at the Earth and ask, insistently, persistently like the children we are on the cosmic scale, "Why? Why? Why?".

The meaning of life is to live. To live is to expand the scope of life itself, by replicating, by adapting, by modifying the environment, and by evolving into other forms of life. We are the inheritors of more than three billion years of ceaseless global molecular experimentation, of competition among individuals and species, of a relentless expansion of life into new environments and emergence of new capabilities. How can we have the arrogance to believe, so recently evolved ourselves to a stage that we can truly be said to think, that we are unique--that no other intelligent beings see our Sun as a star in their sky and, as arrogantly, consider themselves unique?

It was physicist Enrico Fermi who first remarked, "If they existed, they would be here". Life expands its own scope. Life on Earth extends from the mid-oceanic ridges where the Earth's very crust is born, to the peaks of the highest mountains and the most remote regions of the Antarctic. In the span of one human lifetime, transcending the limits of our bodies through the cleverness of our minds, our own species has descended to the deepest points in the ocean, visited the most remote places on the planet, learned to fly in the air and then beyond into space, and on July 20, 1969 set foot on another world which had never before been host to life. Products of billions of years of ever-expanding life, the very molecules of which we are made drive us to spread life ever further. Already, our robot proxies have visited all the major worlds of our solar system, seeking life and finding none.

Is it reasonable to expect that life will cease to expand at the very moment it becomes capable of spreading further, outward, onward? That after billions of years and countless quadrillions of organisms, life will remain huddled on one small planet, awaiting the day when the Sun dies and ends it all? No. Already we have taken our first steps outward. Once the expansion begins in earnest, it will spread exponentially. It took three billion years of evolution before life managed to assemble individual cells into complex creatures, then only a quarter as long to evolve beings capable of carrying life to other worlds. Using only technologies we currently possess, and traveling no faster than the Voyager probes already bound starward, we could begin to explore the galaxy. Even at so slow a speed--requiring between ten and a hundred thousand years to travel between stars, if each new outpost launched its own emissaries of life onward, life would spread everywhere in the galaxy in only 300 million years--less than half the time it took the first multicellular creatures to evolve into beings audacious enough to think such thoughts. Using technologies likely to be developed in the next century, founded on scientific knowledge already in hand, life could populate the galaxy in just 4 million years--comparable to the time it took the first hominids to radiate from the Home Continent to the farthest corners of the Home Planet.

Four million or even three hundred million years is an eyeblink of time compared to the 10 billion years elapsed since the galaxy reached the stage where beings like us could develop. If intelligent life is common then why, over the billions of years that preceded our appearance, has no species evolved earlier already filled the galaxy?

"If they existed, they would be here", says Fermi. *So where are they?* Nowhere in evidence. Intelligent beings with technologies millions of years beyond our own, spread to the far ends of the galaxy, should not be difficult to detect. We already possess the means to detect even primitive technological civilisations like our own at a distance of hundreds of light years.

If they existed, they--the first intelligent species to expand outward among the stars--would be here. And since we look around and see nobody but ourselves, then it is only reasonable to conclude, "We are here, so we are them." We evolved here and we have not yet begun to sow the seeds of life among the stars, but surely we will. Three billion years ago, one planet, the Home Planet, came to life. Slowly life spread across the Home Planet, gaining complexity and diversity until it could think of going yet further.

In a short time on the cosmic scale, beings throughout the galaxy will gaze at the friendly stars in their skies. They will look upward and see, not a hostile and lifeless galaxy, but one teeming with life--the legacy of the planet that came to life and then brought life to a galaxy. They will not be human, no more than we are australopithecus or fish or bacteria, yet they, in their number and diversity trillions of times beyond the scope of life on Earth, will be our children, heritors of our coming to understand the meaning of life and the rôle humans are to play in its grand pageant.

And surely, some residents of the Home Galaxy will then look inward upon its friendly stars, and then outward. Contemplating the endless universe not yet alive and the eternity ahead, they will ask themselves, "What is the meaning of life?". And discovering it, they will go onward.

> And finally there is the reasonable certainty that this sun of ours must some day radiate itself toward extinction; that at least must happen, until some day this earth of ours, tideless and slow moving, will be dead and frozen, and all that has lived upon it will be frozen out and done with. There surely man must end. That of all such nightmares is the most insistently convincing. And yet one doesn't believe it. At least I do not. And I do not believe in these things because I have come to believe in certain other things---in the coherencey and purpose in the world and in the greatness of human destiny. Worlds may freeze and suns may perish, but there stirs something within us now that can never die again.
>
> We are in the beginning of the greatest change that humanity has ever undergone. There is no shock, no epoch-making incident, but then there is no shock at a cloudy daybreak. At no point can we say, here it commences, now, last minute was night and this is morning. But insensibly we are in the day. What we can see and imagine gives us a measure and gives us faith for what surpasses the imagination.
>
> --- H. G. Wells, "The Discovery of the Future," *Nature*, **65**: 326-331 (1902).

References:

Rood, Robert T. and James S. Trefil. *Are We Alone?* New York: Charles Scribner's Sons, 1983.

Barrow, John D. and Frank J. Tipler. *The Anthropic Cosmological Principle.* Oxford: Oxford University Press, 1988.

Amateur astronomer's bookshelf

If you'd like to learn more about astronomy, the following books are an excellent place to start; they form the core of many an amateur astronomer's library. These are general references describing the sky; for details of the algorithms used in Home Planet please consult References for astronomical programming and the list of Astronomy databases.

Ottewell, Guy. *The Astronomical Companion.* Greenville SC (USA): Furman University, 1979. Buy this book. I can think of no better place for a beginner to start; no better way for an old-timer to learn new details of the sky. Ottewell is one of the genuine geniuses of our time in the graphic presentation of complicated scientific data. I won't try to describe the wonders in this book; once you own it you'll understand what I'm talking about.

Ottewell, Guy. *Astronomical Calendar.* Greenville SC (USA): Furman University, (annual). Events of the current year, interpreted in Ottewell's unique style. The stars and planets month by month, eclipses, conjunctions, asteroids and comets, space flight, and occultations. It's all here, ready to plan the next twelvemonth at the telescope.

Sky & Telescope. Cambridge (Massachusetts, USA): Sky Publishing, (monthly). This is the one to subscribe to. For more than 50 years, this magazine (and its predecessors) have walked the line between professional and amateur astronomy, consistently providing material of value and interest to both communities. Not to read *S&T* is to be cut off from monthly updates of breaking news, information about what to observe, news from the professional world, and a wealth of information for telescope makers, astrophotographers, and folks interested in astronomical computing.

Audouze, Jean and Guy Israël. *The Cambridge Atlas of Astronomy*. Cambridge (England): Cambridge University Press, 1990. What appears at first glance to be a massive, colourful coffee-table book is actually an in-depth astronomical reference. It's expensive, but up-to-date and thorough.

Tirion, Wil. *Sky Atlas 2000.0.* Cambridge (Massachusetts, USA): Sky Publishing, 1981. Computer displays are nice, but any serious stargazer needs a real ink-on-paper star atlas. Tirion's atlases set a new standard for graphical quality and ease of use not likely to be surpassed in our generation. Sky Atlas 2000.0 is available in a deluxe edition (colour used to indicate object type, Milky Way boundaries, etc.), a field edition (white stars on a black background), and a desk edition (black stars on a white background).

Tirion, Wil, Rappaport, Barry, and George Lovi. *Uranometria 2000.0* (2 vols). Richmond: Willmann-Bell, 1987. Venturing much deeper into the sky, including more than 300,000 stars as faint as magnitude 9.5, this massive atlas (more than 500 charts in two hardbound volumes) is an essential companion to the serious amateur with a medium to large telescope and a love for the deep sky. A multitude of nebulæ and galaxies are plotted, destinations for the star-hopper setting sail from the few bright stars that appear on charts of this scale and depth.

Sinnott, Roger W. (ed). *NGC 2000.0.* Cambridge (Massachusetts, USA): Sky Publishing, 1988. This is a revised and updated (including precession to epoch J2000.0) version of the Revised New General Catalogue and Index Catalogue which have been the primary sources for nonstellar objects for more than a century. A diskette containing a subset of the data in the printed NGC 2000.0 book is available from Sky Publishing, and the same data are included on the Astronomical Data Center CD-ROM. The public domain data from which this copyrighted publication was derived may be found on the same CD-ROM, but require substantial effort to render into such an easily-used form.

Hirshfeld, Alan, Sinnott, Roger W., and François Ochsenbein. *Sky Catalogue 2000.0* (2nd ed., 2 vols). Cambridge (Massachusetts, USA): Sky Publishing, 1991. The first volume of more than 700 large format pages lists more then 50,000 stars as faint as 8th magnitude, giving J2000.0 positions, HD and SAO catalogue numbers, spectral type, proper motion, distance, and additional information. The second volume lists more than 8000 double and multiple stars, all variables stars as bright as ninth magnitude at maximum, and a host of open and globular clusters, nebulæ and extragalactic objects. The stellar data in volume 1 of this reference are available from Sky Publishing on floppy disc.

Deen, Glen. *MicroSky*. Plano Texas: Deen Publications, 1993. The Palomar Observatory Sky Survey (POSS), done with the famous Mount Palomar 48-inch Schmidt camera in the early 1950s is one of the primary resources for astronomical research. Copies of the 936 original red and blue plates are a central asset of professional observatory libraries. For decades amateurs have dreamed of obtaining a copy of the POSS of their own, but the price (around US$7000 from Caltech) made this unattainable. Several years ago Glen Deen asked, "Why not distribute the POSS on microfiche?" and set out to make it a reality. After an incredible amount of difficult work, the microfiche POSS will become available to amateurs. Version 1.1 Volume 1 with 61 microfiche is now in stock. Volume 2 is now in production and is available on a subscription basis. Completion of Volume 2 is expected in 1996. Other versions without computer plotted maps and data tables are completed and in stock. Each microfiche contains 8 reduced images of the original 14 inch telescope plates. Next to the image a map and data table identifies bright stars, NGC and IC objects, and SAO stars. Coordinate grids make it easy to locate objects without tedious plate measuring. Deen has not only made the POSS affordable: he's improved it. Stars fainter than 20th magnitude are visible on these microfiche. Obviously, you'll need a microfiche reader to view these images, and a microscope to see the tiniest details. Current price for MicroSky is US$300. The object catalogue of POSS plates included with Home Planet includes the MicroSky microfiche and field number, so CTRL+SHIFT right clicking a position in the Telescope or Horizon windows directs you immediately to the image of that region of the sky.

These references can be obtained from the following sources:

(Guy Ottewell's publications only)
Astronomical Workshop
Furman University
Greenville, SC 29613
USA
Phone: ++1 (803) 294-2208

Sky Publishing Corp.
P.O. Box 9111
Belmont, MA 02178-9111
USA
Phone: ++1 (800) 253-0245
Fax: ++1 (617) 864-6117.

Willmann-Bell, Inc.

P.O. Box 35025
Richmond, VA 23235
USA
Phone: ++1 (804) 320-7016
Fax: ++1 (804) 272-5920.

(MicroSky only)

Deen Publications, Inc.
P.O. Box 867088
Plano, TX 75086-7088
Phone: ++1 (214) 517-6980
Internet: glen@metronet.com

References for astronomical programming

The algorithms used in Home Planet may be found in the following books. If you're interested in developing software for astronomy, these books are highly recommended. In addition, *Sky & Telescope* magazine has a monthly *Astronomical Computing* column which publishes algorithms and discusses their applications. To build a complete astronomical application, the algorithms provided in these references must be melded with the painstakingly compiled databases which are the raw material of astronomical knowledge. For more general information about astronomy, consult the references in the amateur astronomer's bookshelf.

Meeus, Jean. *Astronomical Algorithms. 2nd ed*. Richmond: Willmann-Bell, 1998. A must-have; if you only buy one book, make sure it's this one. Algorithms are presented mathematically, not as computer programs, but source code implementing many of the algorithms in the book can be ordered separately from the publisher in either QuickBasic, Turbo Pascal, or C. Meeus provides many worked examples of calculations which are essential to debugging your code, and frequently presents several algorithms with different tradeoffs among accuracy, speed, complexity, and long-term (century and millennia) validity.

Duffett-Smith, Peter. *Practical Astronomy With Your Calculator. 3rd ed.* Cambridge: Cambridge University Press, 1981. Despite the word *Calculator* in the title; this is a valuable reference if you're interested in developing software which calculates planetary positions, orbits, eclipses, and the like. More background information is given than in Meeus, which helps those not already versed in astronomy learn the often-confusing terminology. The algorithms given are simpler and less accurate than those provided by Meeus, but are suitable for most practical work.

Taff, Laurence G. *Celestial Mechanics: A Computational Guide for the Practitioner*. New York: Wiley-Interscience, 1985. This book could also be subtitled "Newtonian Gravitation: User Reference Manual." When you get serious about the tough problems in calculating orbits, this is where to turn. But beware: between the covers of this essential reference are over 500 pages of gnarly brassbound mathematics, so get ready for a neural marathon before you write a line of code.

Bate, Roger R., Donald D. Mueller, and Jerry R. White. *Fundamentals of Astrodynamics*. New York: Dover, 1971. This book, originally developed during the Apollo era as a textbook for the U.S. Air Force Academy, is the most accessible introduction to orbital mechanics I've encountered. Less rigorous and up-to-date than Taff's *Celestial Mechanics*, it focuses on explaining principles rather than exhaustive last-decimal-point accuracy. An especial joy awaits the reader of this volume: the writing is nothing less than poetic...(speaking of Lagrange on page 53) "From the very first his writings were elegance itself; he would set to mathematics all the problems his friends brought to him, much as Schubert would set to music any stray rhyme that took his fancy."

Tattersfield, D. *Orbits for Amateurs With a Microcomputer*. New York: Halsted Press (Wiley), 1984. This book focuses entirely on one problem: calculation of the orbits of comets. Both the calculation of ephemerides for comets with known elements and orbit determination from observations are covered. Formulæ, worked examples, and sample programs in vanilla BASIC are provided.

Bretagnon, Pierre and Jean-Louis Simon. *Planetary Programs and Tables from -4000 to*

+2800. Richmond: Willmann-Bell, 1986. If you want the utmost (outside of JPL) accuracy for the planets, it's here.

Colwell, Peter. *Solving Kepler's Equation Over Three Centuries*. Richmond: Willmann-Bell, 1993. Given *M* in the interval [0, p] and *e* in the interval [0, 1], solve for *E* in the equation *M* = *E* - *e* sin *E*. This is solving Kepler's equation, and it lies at the heart of any program which computes the position of bodies in elliptical orbits. Over the centuries, this problem, which has no closed-form solution, has attracted the attention of a pantheon of eminent mathematicians and astronomers including Kepler, Cassini (father and son), Laplace, Lagrange, Cauchy, Bessel, Newton, Euler, and Gauss. Colwell tells this story in a manner that is both mathematically rigorous and historically engaging.

These and many other standard references for mathematical and positional astronomy can be obtained from:

Willmann-Bell, Inc.
P.O. Box 35025
Richmond, VA 23235
USA
Phone: ++1 (804) 320-7016
Fax: ++1 (804) 272-5920.

Another excellent source of material relating to all aspects of astronomy, including computer-related materials such as astronomical databases is the bookselling arm of *Sky & Telescope* magazine:

Sky Publishing Corp.
P.O. Box 9111
Belmont, MA 02178-9111
USA
Phone: ++1 (800) 253-0245
++1 (617) 864-7360
Fax: ++1 (617) 864-6117.

Astronomy databases

The following sources of data are essential in developing astronomical applications. The algorithms used to interpret these data are found in the References for Astronomical Programming. These raw databases assume a thorough understanding of the fundamentals of astronomy; to acquire that knowledge, start with the references listed in the amateur astronomer's bookshelf.

Selected Astronomical Catalogues, Volume 1

This CD-ROM, prepared by the international Astronomical Data Center, is a joint production of NASA, the National Space Science Data Center, and the International Astronomical Union. It contains 114 different astronomical catalogues covering astronomy, spectrographic surveys, and photometry: both stellar and nonstellar objects. Most of the widely referenced catalogues are here, including the full 57 megabyte Smithsonian Astrophysical Observatory (SAO) catalogue, the Revised New General Catalogue of Nebulæ (RNGC), the Bright Star Catalogue, the JPL Ephemerides, the Henry Draper catalogue, the UBV photometric catalogue, and many more. All data are supplied both in FITS and ASCII file format, with extensive file format documentation. This CD-ROM set is available for US$32.00 plus shipping and handling of US$2.50 for U.S. orders or US$10.00 for non-U.S. orders from:

National Space Science Data Center
Code 933.4
Goddard Space Flight Center
Greenbelt, MD 20771
USA
Phone: ++1 (301) 286-6695
FAX: ++1 (301) 286-4952
Internet: request@nssdca.gsfc.nasa.gov

NSSDC accepts Visa, Mastercard, and American Express as well as checks and money orders in U.S. dollars. NSSDC also distributes CD-ROMs containing the IRAS Sky Survey, complete Magellan Venus mapper data, Viking Mars imagery, and Voyager images of the outer planets, plus MS-DOS and Macintosh software to display the data. Each data set is available for US$20 for the first disc and US$6 for each additional CD-ROM in the data set. Please contact NSSDC for additional information.

Hubble Space Telescope Guide Star Catalog (CD-ROM) Version 1.1

Do you like stars? *Really* like stars? Well here's the CD-ROM set for you! The Hubble Space Telescope can see deeper in space with more angular resolution than any telescope in history. But how do you *aim* it? And how you do you keep it on target during a long exposure? Just like the amateur astronomer who feels his fingers solidifying and dropping off one by one as photons drip, two by two, onto his gas-hypered 2415 emulsion, you have to *guide*. Unlike the amateur who can easily find a bright star in the field, the Hubble, when seeking the faintest objects in the universe must guide by some of the dimmest stars in the sky. The Guide Star Catalogue contains almost 19 million objects, more than 15 million of which are stars, with a magnitude limit of 16. It is the same database used when pointing the actual Hubble Space Telescope. The Hubble Guide Star Catalogue is highly specialised: no spectral data are included, nor are objects cross-identified with other common catalogues. It remains, however, the definitive catalogue of faint stars. The CD-ROM comes with the Macintosh software used by Hubble investigators to select guide stars, and MS-DOS software which allows retrieval of objects from the catalogue in textual form. The Guide Star Catalogue is available for US$59.95 plus tax, shipping, and handling from:

Astronomical Society of the Pacific
390 Ashton Avenue
San Francisco, CA 94112
USA
Phone: ++1 (415) 337-2624

IAU Circulars

The IAU Circulars provide a means for distributing time-sensitive information to observers. The Circulars announce novæ and supernovæ, radio and X-ray transients, newly-discovered and recovered comets and, in companion bulletins published by the Minor Planet Center asteroid discoveries and related information. IAU circulars used to be delivered by telegram or in the mail, but are now distributed by electronic mail. A subscription costs US$6.00 per month, and includes E-mail delivery of Circulars as they are published, and log-in privileges to a machine with an archive of Circulars as well as asteroidal orbital elements from the Minor Planet Center. You can subscribe to the circulars by sending a check (In US$) payable to the "Central Bureau for Astronomical Telegrams" to:

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Cambridge, MA 02138
USA

FAX: ++1 617 495 7231

For more information, write to the above address or E-mail to:

IAUSUBS@cfa.harvard.edu

Two utility programs, included with Home Planet, convert asteroid and comet elements in the form published in the Circulars from the Minor Planet Center into a format which can be used by Home Planet's asteroid and comet tracking facilities.

About the author

John Walker founded Autodesk, Inc. in 1982, was its president through 1986 and chairman until 1988.

Autodesk (ACAD-NASDAQ), one of the five largest personal computer software companies, has become a leader in the computer aided design industry; its first product, *AutoCAD*, is the *de facto* worldwide standard for computer aided design and drafting.

John Walker is co-author of *AutoCAD* and other Autodesk products, including *AutoSketch*, *AutoShade*, and *Cellular Automata Laboratory*. He is also author of various public domain programs including *Moontool; Moontool for Windows*; *Speak Freely*; *SETTIME*; *XD*; *BGET*; *ATLAST*; *DICTOOL*; *PSTAMPR*; *RANDOM*; *DIESEL*; *SMARTALLOC*; and the PBMPLUS utilities *ppmforge*, *pgmcrater*, *sldtoppm*, and *ppmtoacad*. He has been recognised in *Scientific American* as having created, in 1975, the first (benign) computer virus. He was smeared by Wall Street Journal hatchetman G. P. Zachary in a front-page profile on May 28, 1992, and in reply produced and directed the video *Reporter At Work*, a *samizdat* hit in high-tech circles, offering unique uncut coverage of a high-stakes boardroom confrontation between an entrepreneur and a reporter sent to ruin him.

Walker's first book, *The Autodesk File*, was published in 1989 by New Riders Publishing. It chronicles Autodesk's growth from $60,000 pooled by a bunch of programmers to a billion dollar company in less than eight years. The fourth edition of *The Autodesk File*, updated through the end of 1993, is available on the World-Wide Web at
http://www.fourmilab.ch/autofile/www/autofile.html

His second book, *The Hacker's Diet: How To Lose Weight and Hair Through Stress and Poor Nutrition* is also available on the Web:
http://www.fourmilab.ch/hackdiet/www/hackdiet.html

For access to all of Walker's public domain software and writings, visit his home page:
http://www.fourmilab.ch/

If his diet book doesn't make the bestseller list and land him a guest shot with Oprah, Walker is entirely prepared to complete his manuscript-in-progress: *CatSports---How to Improve Any Game by Replacing the Ball with a Cat*.

Fore!

John Walker
Neuchâtel, Switzerland
November, 1994
42,500 lines of code