ECU Pro V6.1 User's Manual

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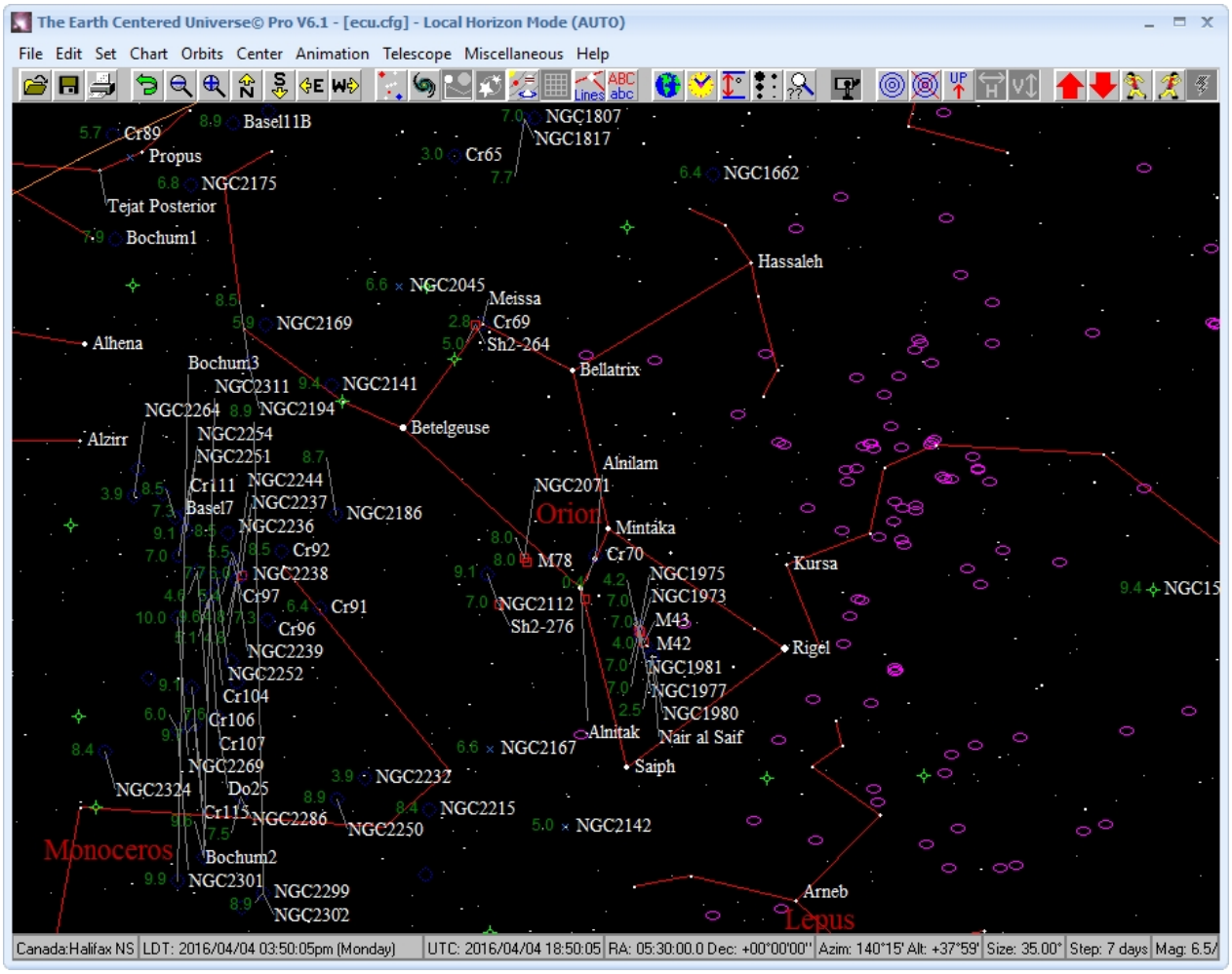
THE EARTH CENTERED UNIVERSE™ PRO

Planetarium and Telescope Control Software

(operates with Windows 7/8/8.1/10 – 32 and 64-bit)

User's Manual

Version 6.1F — Manual Revision June 2020



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Getting Started

Thank you for choosing to purchase "The Earth Centered Universe Pro", ECU for short (pronounced: eee-see-you). ECU is a *Planetarium and Telescope Control Program* capable of simulating most of the phenomenon of the Earth's sky. This includes, but is not limited to the stars, variable stars, double stars, planets, Sun and Moon, comets, asteroids, and "deep sky" objects.

ECU is designed as an observing tool for the observing amateur astronomer, but is equally useful to the "armchair" astronomer or other person interested in learning more about astronomy.

ECU also provides a comprehensive interface with the many telescope models supported by the ASCOM Initiative through their telescope drivers. It also includes built-in support for other computerized telescopes and telescope-to-computer interfaces.

Many of the concepts and terms used in this manual are common in amateur astronomy, but may not be familiar to all users. The author recommends the purchase of a good beginner book in astronomy as a guide to the understanding of the concepts provided by this program. An excellent book for beginners is **NIGHTWATCH: An Equinox Guide to Viewing the Universe** by Terence Dickinson, which is available in most well stocked bookstores or libraries.

ECU operates on a wide variety of PCs in common use today including those that use Windows XP through 10. This manual assumes that the user is familiar with the operation of typical Windows programs.

A large amount of effort in software development has gone into "The Earth Centered Universe" by Dave Lane over nearly 25 years. For those who are curious, it is written in the Embarcadero Delphi language (based on the Object Pascal language) and is currently comprised of about 1200 pages (~68,000 lines) of program code. This release includes enhancements over the previous versions (ECU was first released as V1.1 in March of 1992).

The author would be most pleased in hearing your comments and suggestions for improvements to ECU or this manual. I would also like to hear about any "bugs" which you detect so they can be fixed in a future release.

System Requirements

The minimum system requirements are listed below:

Hardware:	Nearly any Intel or AMD-based PC Compatible Computer
Operating System:	Runs within the Microsoft XP*, 7, 8, 8.1, and 10 operating systems (32 or 64-bit)
Memory Used:	20 megabytes (some program features may require more memory, especially if you have an abnormally high resolution display, or if you are using the optional databases (variable star, double star, Hubble Guide Star Catalog, or US Naval Observatory star catalog).
Hard Disk Space:	15 to 480 megabytes of disk space depending on the installation options selected
Graphics Card:	A VGA or better graphics card (800x600 pixels). XGA recommended (1024x768 pixels with at least 64k colors)
Mouse/Touchpad:	Windows compatible pointing device
Printer (optional):	Windows compatible printer

Telescope (optional):	An ASCOM-compatible telescope
Internet:	Some features require an active internet connection

* ECU runs on Windows XP, but is NOT supported.

Installation Instructions

Installation is performed by using an installer program. This program is named **ecu61pro.exe** and is downloaded from the internet file. To install, follow these steps below:

- Locate the file **ecupro61.exe**. If you downloaded it, it will be in your web browser's "Downloads" directory. If you chose the version without the Hubble Guide Star Catalog included, the file will be named **ecupronogsc61.exe**.
- Run it (usually be double-clicking on it). This starts ECU's installer program.
- Follow the instructions presented on-screen and go through all the install steps until the installer exits.
- You will be presented various options to install various astronomical databases. If you don't know what these are, see the Databases and Calculations section of this manual. In the case of the Hubble Guide Star Catalog, to save disk space you can choose stars from only part of sky.
- If you intend to use any of the non-ASCOM (built-in) you need to also install the Nova Astronomics COMPort driver. The file is named **NovaAstroCOMPortInstaller.exe**.

Program Settings

ECU stores all of its configuration settings and other files as follows:

- **ecu.cfg** - this file is located in the user's "Documents\ecupro61" directory. It is the default configuration file loaded when ECU starts up. It is a binary file (and thus cannot be edited

directly by the user). It contains nearly all user programmable settings. User's can save and load any number of configuration files using other names. See the Save As... and Open... menu items. The .cfg files also contain the currently active asteroid and comet orbits.

- **ecu.ini** - this file is located in the user's "AppData\ecupro61" directory. It can, but is not usually not edited by the user. It contains:
  - installation settings (files and directories)
  - registration information
  - recent object search strings
  - the current program "style"
  - orbit search parameters
  - user settabale web sites addresses
  - last ECU window position, size and mode

- **default.cfg** - this file is located in the user's "Documents\ecupro61" directory. It is used to store the default configuration settings used by Restore Defaults.

- **webdefault.ini** - this file is located in the user's "AppData\ecupro61" directory. It is used to store the web site address default settings used by Restore Defaults.

- **location.ecu** - this file is located in the user's "AppData\ecupro61" directory. It contains the Geographic Location database. It can, but is not usually not edited by the user.

- **masterorbit.orb** - this file is located in the user's "AppData\ecupro61" directory. It contains the Master Asteroid Orbit database.

Notes

1. The Documents and AppData directories used by this version of ECU can be easily found using the two **Browse** buttons displayed by the Directory/File/Web Setup... menu item.
2. If you had previously installed V6.0 of ECU, your previous settings will not be overwritten, as they were stored in another directory (up one level from V6.1 files and in the "ecu" directory). To restore your V6.0 settings, use the **Browse ECU Docs Dir** button (mentioned in item 1. above) to find the ECU documents folder, then navigate up one level, find the "ecu" folder and move **ecu.cfg** to the new location (ecupro61). Then use the **Browse ECU App Dir** button, navigate up one level, find the "ecu" folder and move **location.ecu** to the new location (ecupro61).
3. If a configuration file name is specified on the command line, it uses the specified file rather than the default **ecu.cfg** file. This is useful for setting up shortcuts to quickly bring up saved astronomical events. You can also "associate" files of type ".cfg" so that when you double-click on a configuration file, Windows will launch ECU and load that file automatically. For information on how to set this up, search for the words "default programs" in your windows on-line help.
4. You can also drag-n-drop to drop .cfg files onto the ECU window - they will be opened automatically.

Starting ECU

ECU is started by selecting the **ECU Pro V6.1** entry of the Windows "Start" menu or the icon on the desktop.

The start-up of ECU typically takes only a few seconds. The first time it is run, you will be prompted to enter registration information – including an unlock code. This information was provided to you by e-mail. You will only need to enter this information once for each Windows user that uses ECU.

Before the ECU main windows appears, several data files, plus the default configuration file are loaded into memory. If any problem is encountered while starting up (due to bad or missing files, not enough memory, etc.), a small dialog box displaying a descriptive message is displayed on the screen. Pressing 'OK' will return control to *Windows.* If all is successful, the first opening screen will appear greeting the user with a colorful display of the constellation of ORION (this of course is just the default and can be changed to anything you want by overwriting the default configuration file).

The first thing you need to do is set your geographic location and time zone. This is done by using the Geographic Location... item in the Set menu. After completing this step, select **Save** from the **File** menu.

Notes

1. You can run any reasonable number of copies of ECU simultaneously as you wish; however, some advanced features may not work if you try to do these at the same time from two different copies (such as internet downloading of orbit data and telescope features).
2. ECU remembers the size and position of its main window when it exits, and it restores that size and position when it re-starts.

I suggest you read next few sections next, as they introduce the User Interface. However, if you just want to explore, that's fine, too. I think you will find ECU's usage quite intuitive, but there are some powerful hidden user interface features that you may miss out on if you don't at least skim through the manual.

The Menu Reference section is reference information for all of the menu selections.

Databases and Calculations describes the astronomical calculations and object databases either included with or supported by ECU.

The Identify Objects Box section is definitely worth-a-read since it describes how to get information about astronomical objects.

If you will be connecting a computerized telescope to your computer, see Using the Telescope Interface.

User Interface

This section describes ECU's User Interface and includes the following sub-sections:

- Sky Chart — the **Sky Chart** is the main reason ECU exists - learn about it here.
- Status Information — ECU provided status information by a **Status Box** and **Status Line**.
- Mouse Controls — the mouse or touch pad is used in many ways to interact with ECU.
- On-Screen Controls — the on-screen controls include the **Scroll Bars**, **Tool Bar**, and **Status Line** Speed Buttons.
- Keyboard Shortcuts — many common functions of ECU can be operated from the keyboard.
- Identify Objects Box — provides various information pertaining to a selected object.

Sky Chart

Most of ECU's main window is occupied by the **Sky Chart**. There are three chart orientation modes used to draw the sky. These are the **Star Atlas** mode, the **Local Horizon** mode, and the **Manual Rotation Angle** mode. The **Star Atlas** mode depicts the sky similarly to conventional printed star charts — that is, with the lines of declination horizontal, lines of right ascension vertical, and north up. The **Local Horizon** mode depicts the sky as it would appear relative to the Earth's horizon from the current geographic location — that is, "up" in the sky is "up" on the screen. Select the mode in the Orientation... menu selection.

The **Local Horizon** mode provides a more accurate simulation of the sky, the only penalty is that it draws a bit slower than the **Star Atlas** mode. This reduction is speed will only be noticeable when using very slow computers by today's standards.

The **Manual Rotation Angle** mode is used to rotate the chart to any arbitrary angle as specified by the user. The angle used is with respect to the Star Atlas mode. For example, 0 degrees of manual rotation would produce the same result as the Star Atlas mode.

The **Sky Chart**, and all reported numeric equatorial positions, use epoch J2000.0 coordinates.

The objects and items displayed in the **Sky Chart** are listed below:

- **Grid** — the equatorial (aligned to right ascension and declination) or local horizon (aligned to azimuth and altitude) coordinate grids help illustrate the sky projections just described. The grid is automatically scaled so that a sufficient number of lines always cross the screen.

- **Stars** — stars are displayed as varying sized dots according to the star's brightness. The larger the dot, the brighter is the star.

- **Lines** — there are many lines displayed by ECU. These include:
  - constellation figure lines
  - constellation boundary lines
  - horizon line
  - ecliptic line
  - meridian line
  - galactic equator line
  - telescope field of view lines

- **Markers** — these are "cross" style markers shown at the:
  - Zenith (the overhead point)

- Nadir (the point opposite the Zenith)
- North and South poles
- North and South galactic poles

- **Targets** — these are user-definable circular and/or rectangular that can be placed anywhere on the **Sky Chart** or can follow the telescope's position in real time.

- **Labels** — there are text labels displayed for solar system objects, constellation names, and labels for the coordinate grid, ecliptic and horizon lines, and markers. There are extensive options for labeling stars and deep sky and other objects. The fonts for all labels are programmable.

- **Solar System objects** — the planets, sun, anti-sun, moon, comets and asteroids are displayed. The Sun and Moon are displayed at their correct size. The phase of the Moon is also shown. Planets are displayed as a small point (similar in size to a medium brightness star, except with a unique color). Comets are displayed using the special symbol below, which resembles a comet. If a comet tail length is specified, its projected length is shown on the sky by a line.

- **Deep sky objects** — deep sky objects are displayed in six different categories, each using a different symbol. These symbols, shown below in order, are Galaxies, Open Clusters, Globular Clusters, Bright Nebulae, Planetary Nebulae, and Other. If zoomed in close enough, many objects (those whose sizes are known) will be displayed at their correct size compared to the background stars. Galaxies are displayed according to their correct size, shape, and orientation.

- **Variable Stars** — variable stars are displayed using the standard symbol, which is a varying-sized solid dot within a hollow dot. There are five sizes used according to the star's expected maximum brightness, if known. The 5 magnitude bands used are: brighter than 2nd magnitude, 2 to 5, 5 to 8, 8 to 11, and fainter than 11th magnitude. Those with unknown magnitudes are displayed using the smallest symbol.

- **Double Stars** — double stars are displayed using the standard symbol, which is a varying-sized solid dot with a horizontal line through it. There are five sizes used according to the pair-of-star's combined brightness, if known. The 5 magnitude bands used are: brighter than 1st magnitude, 1 to 3, 3 to 5, 5 to 7, and fainter than 7th magnitude. Those with unknown magnitudes are displayed using the smallest symbol.

Status Information

ECU has two forms of status information displays.

Status Line

First, there is a **Status Line** at the bottom of the program window. This configurable **Status Line** is highly configurable and can be enabled or disabled. The information that can be displayed includes:

- geographic location
- local mean time
- universal time

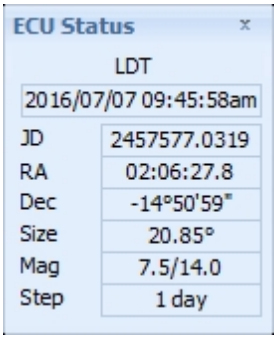
- right ascension and declination
- azimuth and altitude
- chart size
- animation step size
- limiting magnitude (stars and deep sky)
- sky darkness

The **Status Line** is the preferred method to display status information, since it does not cover any of the **Sky Chart**.

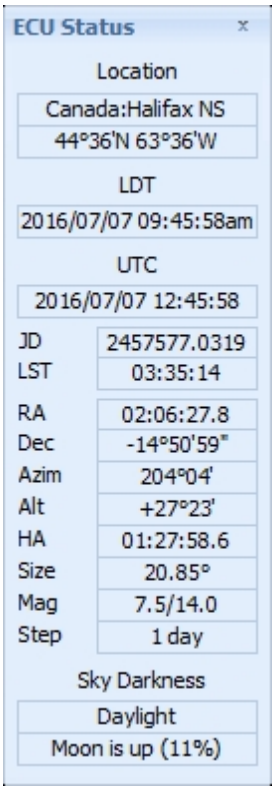
Status Box

The second method to display status information is using either a large and small Status Box placed at the upper left corner of the **Sky Chart**.

The small **Status Box** contains the following information: local mean time, right ascension and declination, chart size, magnitude limits (for stars and deep sky objects), and animation step size.



The large **Status Box** adds the following information: geographic location, latitude and longitude, universal time, azimuth and altitude, hour angle, and sky darkness.



Below is a description of all of the items included in both the **Status Line** and **Status Boxes**.

- **Location** — the geographic location on the Earth's surface where the observer is located. In the large **Status Box**, the latitude and longitude of the observer is displayed below the place name as degrees and minutes. Positive latitudes are North of the equator and positive longitudes are West of the Greenwich meridian.
- **Local Mean Time (LMT)** — contains the date and time of the local civil time. The date is always in the format year/month/date. The time is either displayed as hh:mm in 24 hour time or hh:mmpm in am/pm format. If daylight savings time is enabled, the title changes from LMT to LDT (Local Daylight Time).
- **Universal Time (UTC)** — contains the universal date and time (that of the Greenwich meridian). The date is always in the format year/month/date. The time is always displayed as hh:mm in 24 hour time format. If the mouse is hovered over the UTC label, the UTC is displayed in a popup as a decimal date.
- **Julian Date (JD)** — contains the Julian Date.
- **Local Sidereal Time (LST)** — contains the current local sidereal time (this is the right ascension of objects presently crossing the meridian).
- **Right Ascension (RA) and Declination (Dec)** — contains either the right ascension and declination of the center of the **Sky Chart** or the location pointed to by the mouse, if the track coordinates feature is enabled. The RA is formatted in hours, minutes, and seconds as hh:mm:ss.s. The Dec is formatted in degrees, minutes, and seconds as +dd° mm' ss".
- **Azimuth (Azim) and Altitude (Alt)** — contains either the azimuth and altitude of the center of the **Sky Chart** or the location pointed to by the mouse, if the track coordinates feature is enabled. The azimuth is the angle, in degrees and minutes, from the Northern horizon towards the East. The altitude is the angle, in degrees and minutes, measured vertically from the horizon.
- **Hour Angle (hours)** — contains the number of hours west of the meridian (in hours, minutes, and seconds).
- **Chart Size (Field)** — contains the number of vertical degrees currently shown by the **Sky Chart**. The minimum chart size is 0.1 degrees and the maximum is 185 degrees.
- **Animation Time Step (Step)** — contains the value of the time step used by the animation mode in minutes, hours, days, months, or years. In the large **Status Box**, if an arbitrary time step has been entered, the word "Manual" may be shown instead of the actual value.
- **Magnitude (Mag)** — contains the faintest magnitude that stars, deep sky objects, variable stars, and double stars are displayed in the **Sky Chart**.
- **Sky Darkness** — contains information about sky darkness influenced by the Sun and the Moon.

  By the Sun:

  "Daylight" means the Sun is above the horizon
  "Sun is down" means the Sun is below the horizon (between sunset and civil twilight
  ">Civil Twilight" means the sky darkness is between civil and nautical twilight
  ">Nautical Twilight" means the sky darkness is between nautical and astronomical twilight
  "Sky is dark" means the sky darkness has reached astronomical twilight

  By the Moon:

  "Moon is up" means that the Moon is above the horizon – also displayed is the phase of the Moon as the percent of illumination.
  "Moon is down" means the Moon is below the horizon.

Mouse Controls

The mouse (or other pointing device, such as a touch-pad or touch screen) forms a vital part of the user interface. The cursor (the shape of the mouse pointer) is used to inform the user of how the mouse is currently being used. If it is a "cross-hair", it is used for selecting a window, centering, or measuring an angle. If it is a "target" you are in the process of identifying an object. If it is a "hand" then you can drag the sky around as you move the mouse. The cursor is always a cross-hair while moving about within the **Sky**

Chart. If it is an arrow, it is used for operating the menus, **Scroll Bars**, buttons, or dialog boxes. If it is an hour-glass, ECU is busy performing some other task; usually drawing the **Sky Chart** or searching the object databases.

The specific operation of the mouse with each mouse button, scroller wheel, and with shift and control keys are described separately next:

Left Mouse Button

The left mouse button, while the cursor is within the **Sky Chart**, is used for the following functions:

- **Select an object** — if the left mouse button is pressed (and released) near the center of an object, the Identify Objects Box, will appear identifying and describing one or more objects. A cross-hair will appear on the screen identifying the object currently selected. If more than one object is in the vicinity, the **Next** button can be pressed to update the dialog box with new information for the next object. If another object is selected, the current dialog box will be replaced with a new one.

- **Zoom a window** — the second function performed by the left mouse button is its ability to draw a rectangle on the screen that is used to re-position and re-scale the **Sky Chart**. The rectangle is drawn by positioning the mouse at one corner, dragging the mouse (with the left mouse button pressed) to another corner, and then releasing the button. The center of the rectangle defines the new chart center and the vertical height is used to scale the display. Note that depending on the Left Mouse Button Mode the left mouse button may be substituted for the shift key.

The left mouse button also interacts with the **Tool Bar**, **Scroll Bars**, and **Status Line**.

Right Mouse Button

The right mouse button, while the cursor is within the **Sky Chart**, is used for the following functions:

- **Center the mouse position** — if the right mouse button is pressed (and released), the current mouse position will become the new center of the **Sky Chart** at the current scale. This feature is very useful for quickly "panning" about the sky.

- **Measure an angle** — the second function provides the ability to measure angles on the sky. Angles are measured by positioning the mouse at one location and dragging the mouse (with the right mouse button pressed) to another location. A new box appears that displays the angular measure, in real-time, between the two points in both degrees, minutes and seconds, and in decimal degrees.

It also provides:
  - the position angle between the two points
  - the differences in Right Ascension and Declination between the two points
  - the differences in Azimuth and Altitude between the two points.

This feature is useful for those who find objects with their telescope by offsetting angular distances in each axis from a bright star.

The right mouse button also interacts with the **Tool Bar** and **Status Line**.

Scroller Wheel

When the mouse scroller wheel is rotated, the chart size is zoomed out as the wheel is turned towards you and zoomed in as the wheel is turned away from you. The step size is 10% of the current chart size. On many laptop computers you can pinch or spread two fingers on the touch pad to perform the same function.

Shift Key

When the "Shift" key is held down while the mouse cursor is within the **Sky Chart**, the sky can be dragged in any direction as the mouse cursor is moved. The cursor changes to a "hand" to indicate that this mode is active. Note that depending on the Left Mouse Button Mode, the shift key may be substituted for the left mouse button.

Control Key

When the "control" (Ctrl) key is held down while the mouse cursor is within the **Sky Chart**, the coordinate displays in the **Status Box** and/or **Status Line** update as the mouse cursor is moved. This mode works with Track Coordinates enabled.

On-Screen Controls

The on-screen controls include the **Scroll Bars**, **Tool Bar**, and **Status Line** Speed Buttons. Each is described below:

Scroll Bars

Two **Scroll Bars** are used to rapidly move the center of the **Sky Chart** about the celestial sphere. The **Scroll Bars** can be enabled or disabled and have two modes as controlled the User Settings dialog box.

RA/Dec — The vertical bar is used to change the Declination. +90 degrees is at the top; -90 degrees is at the bottom. Pressing the end arrows will move the pointer (and the **Sky Chart**) by one degree and pressing along the bar will move the pointer by 10 degrees. The horizontal bar is used to change the Right Ascension. 23 hours 59 minutes is at the left; 0 hours is at the right. Pressing the end arrows will move the pointer by 4 minutes and pressing along the bar will move the pointer by one hour. When sliding the **Scroll Bars** by dragging the pointer, observe at the Right Ascension and Declination displays to know when to stop.

Azim/Alt — The vertical bar is used to change the Altitude with reference to the local horizon. +90 degrees is at the top (the Zenith); -90 degrees is at the bottom (the Nadir). Pressing the end arrows will move the pointer (and the **Sky Chart**) by one degree and pressing along the bar will move the pointer by 10 degrees. The horizontal bar is used to change the Azimuth with reference to the local horizon. 0 degrees (North) is at the left; 358.5 degrees is at the right. Pressing the end arrows will move the pointer by 1.5 degrees and pressing along the bar will move the pointer by 15 degrees. When sliding the **Scroll Bars** by dragging the pointer, observe at the Azimuth and Altitude displays to know when to stop.

Tool Bar

Seven groups of graphical buttons are provided for quick access commonly used functions. Many buttons also represent the status of the function they represent. For example, if the grid button (16th from the left) is highlighted the grid is currently being drawn; if the grid button is mostly gray, the grid is not being drawn.

Each button is described below in the order that they appear on the **Tool Bar**. Note that as the mouse hovers over a **Tool Bar** button, a "hint" regarding its function is displayed momentarily on the **Status Line** below.

Tool Bar Button Name	Left Mouse Button Click	Right Mouse Button Click
Open File	Shows the Open... dialog box	
Save File	Saves the current configuration settings to the current configuration file	
Print Chart	Prints a **Sky Chart**	Shows the Chart Setup dialog box
Undo	Equivalent to the Undo menu selection	
Zoom Out	Zooms out the **Sky Chart** by a factor of two	Causes the **Sky Chart** it be zoomed out to the maximum chart size of 185 degrees
Zoom In	Zooms in the **Sky Chart** by a factor of two	Causes the **Sky Chart** to be zoomed in to the minimum chart size of 0.1 degrees
North	Centers the **Sky Chart** above the northern horizon	Re-centers the **Sky Chart** 10 degrees to the north
South	Centers the **Sky Chart** above the southern horizon	Re-centers the **Sky Chart** 10 degrees to the south
West	Centers the **Sky Chart** above the western horizon	Re-centers the **Sky Chart** 1 hour to the west
East	Centers the **Sky Chart** above the eastern horizon	Re-centers the **Sky Chart** 1 hour to the east
Deep Sky	Toggles the display of deep sky objects	Equivalent to the Deep Sky... menu selection
Variable Stars	Toggles the display of variable stars	Shows the Magnitude Limits... dialog box
Double Stars	Toggles the display of double stars	Shows the Magnitude Limits... dialog box
Solar System	Toggles the display of solar system objects	Shows the Solar System... dialog box
Grid	The coordinate grid cycles through showing the equatorial (aligned to right ascension and declination), the local horizon (aligned to azimuth and altitude) grid, and turning off the grid altogether	Equivalent to the Custom Horizons... menu selection
Lines	Toggles the display of lines and points	Equivalent to the Lines/Points... menu selection
Labels	Toggles the display of text labels	Equivalent to the Labels... menu selection
Geographic Location	Shows the Geographic Location... dialog box	Shows the Geographic Location... dialog box
Time	Equivalent to the Local Date and Time... menu selection	Equivalent to the Universal Date and Time... menu selection
Chart Size	Equivalent to the Chart Size...	Causes a pop-up menu to appear that

Tool Bar Button Name	Left Mouse Button Click	Right Mouse Button Click
	menu selection	allows the chart size to be set to one of several pre-set sizes
Magnitude Limits	Equivalent to the Magnitude Limits... menu selection	Equivalent to the Stars... menu selection
Database Search	Equivalent to the Database Search... menu selection	Equivalent to the Object from List... menu selection
Telescope	The operation of the telescope interface is "toggled" on and off	Equivalent to the Primary Settings... menu selection
Place Chart Target	A Chart Target is placed at the center of the **Sky Chart**	Equivalent to the Targets... menu selection
Clear Chart Target	The last Chart Target placed is cleared	All Chart Targets are cleared
Chart Mode	The **Sky Chart** mode is cycled between **Sky Atlas**, **Local Horizon**, and **Manual Sky Rotation** modes. The icon displayed indicates the current mode — "UP" means Local Horizon mode, "N" means Sky Atlas mode, and "?" means Manual Sky Rotation mode	Equivalent to the Chart Orientation... menu selection
Flip Horizontal	The horizontal chart flip is "toggled" on and off	
Flip Vertical	The vertical chart flip is "toggled" on and off	
Increase Time Step	The animation time step is increased by one step	Equivalent to the Time Step... menu selection
Decrease Time Step	The animation time step is decreased by one step	Equivalent to the Time Step... menu selection
Reverse One Step	The time is stepped backward by one animation time step	
Advance One Step	The time is stepped forward by one animation time step	
Animation Start/Stop	The animation mode is "toggled" on and off	Equivalent to the Control... menu selection

There are two other special mouse operations that relate to the **Tool Bar**. If the left mouse button is pressed in an unused region of the **Tool Bar**, the state of the **Status Box** is "toggled" on and off. If the right mouse button is pressed in an unused region of **Tool Bar**, the **Status Line** is "toggled" on and off.

Status Line Speed Buttons

A left mouse button click while over the boxes on the **Status Line** displays the associated dialog box. For example, if the left mouse button is pressed within the box that displays the magnitude limits, the Magnitude Limits... dialog box will pop-up.

In addition, pressing the right mouse button over:

- the geographic location display causes the Sync Location or Time from GPS dialog box to be

shown
- the local or UTC time display causes the Julian Date/Sidereal Time box to be shown
- the chart size display causes a popup menu to appear that allows the chart size to be set to one of several pre-set sizes
- the animation step size display causes a multi-level menu to pop up allowing one of the fixed animation steps to be set

There are two special mouse operations that relate to the **Status Line**. If the left mouse button is pressed in an unused region of the **Status Line**, the **Scroll Bars** are "toggled" on and off. If the right mouse button is pressed in an unused region of the **Status Line**, the **Tool Bar** is "toggled" on and off. Note that as the mouse hovers over the **Status Line**, a "hint" regarding the button's function is displayed on the far right of the line.

Keyboard Shortcuts

To make operation easier and faster, many common functions of ECU can be operated from the keyboard. These are listed below:

F1	equivalent to: **Help** ⇒ **User's Manual...**
Alt-O	equivalent to: **File** ⇒ **Open...**
Alt-S	equivalent to: **File** ⇒ **Save**
Alt-A	equivalent to: **File** ⇒ **Save As...**
Alt-X	equivalent to: **File** ⇒ **Exit**
Alt-F4	equivalent to: **File** ⇒ **Exit**
Ctrl-Z	equivalent to: **Edit** ⇒ **Undo**
Alt-T	equivalent to: **Set** ⇒ **Time** ⇒ **Local Date and Time...**
Alt-U	equivalent to: **Set** ⇒ **Time** ⇒ **Universal Date and Time...**
Alt-G	equivalent to: **Set** ⇒ **Geographic Location...**
Alt-M	equivalent to: **Field** ⇒ **Magnitude Limits...**
Alt-P	equivalent to: **Field** ⇒ **Planets...**
Alt-Z	zooms the **Sky Chart** to full zoom out (180 degrees)
Shift-Z	zooms the **Sky Chart** to full zoom in (0.1 degrees)
Ctrl-F	equivalent to: **Center** ⇒ **Database Search...** (find)
Shift-M	centers the **Sky Chart** on the Moon
Shift-S	centers the **Sky Chart** on the Sun
N	centers the **Sky Chart** facing north
S	centers the **Sky Chart** facing south
E	centers the **Sky Chart** facing east
W	centers the **Sky Chart** facing west
Z	centers the **Sky Chart** on the local zenith (the overhead point)
PgUp	zooms out by one step
PgDown	zooms in by one step
Escape	stops the execution of animation mode
B	silences the system beeper if it is "beeping" while searching for an object with the telescope encoder interface
+	equivalent to: **Animation** ⇒ **Forward One Step**
-	equivalent to: **Animation** ⇒ **Reverse One Step**
Insert	increases the animation time step by one notch
Delete	decreases the animation time step by one notch
Ctrl-T	equivalent to: **Telescope** ⇒ **Move Telescope to Chart Center**
T	centers the **Sky Chart** at the current telescope position
U	causes ECU to look for changes to the US Naval Observatory star catalog files
Right-Arrow	moves the mouse pointer to the right by 5 pixels*
Ctrl-Right-Arrow	moves the mouse pointer to the right by 1 pixel*
Left-Arrow	moves the mouse pointer to the left by 5 pixels*
Ctrl-Left-Arrow	moves the mouse pointer to the left by 1 pixel*
Up-Arrow	moves the mouse pointer up by 5 pixels*

Ctrl-Up-Arrow	moves the mouse pointer up by 1 pixel*
Down-Arrow	moves the mouse pointer down by 5 pixels*
Ctrl-Down-Arrow	moves the mouse pointer down by 1 pixel*
Spacebar	presses the left mouse button*
Ctrl-Spacebar	presses the right mouse button*
Ctrl	causes the coordinate displays to track the mouse position (while key is held down)*
Shift	causes the **Sky Chart** to be dragged as the mouse position is moved (while key is held down)*

Identify Objects Box

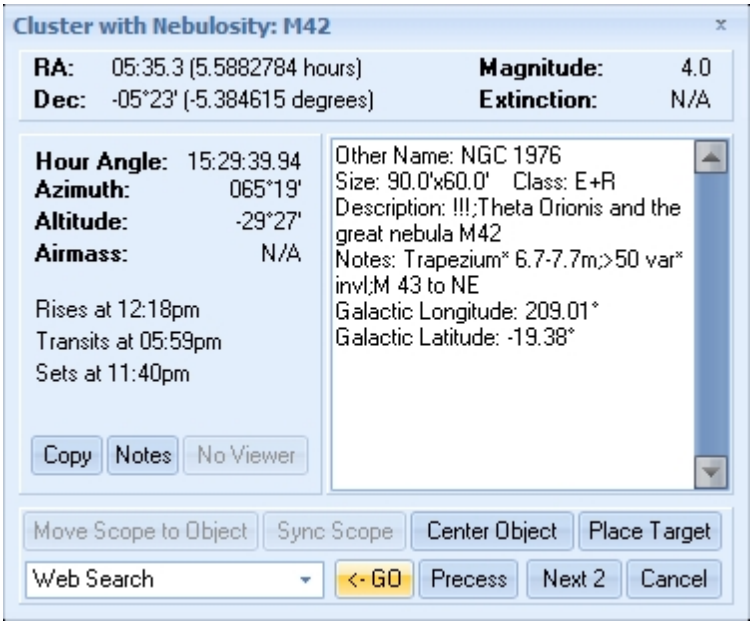
The **Identify Objects Box**, which is displayed by "clicking" near any object on the **Sky Chart** with the left mouse button, provides various information pertaining to the selected object.

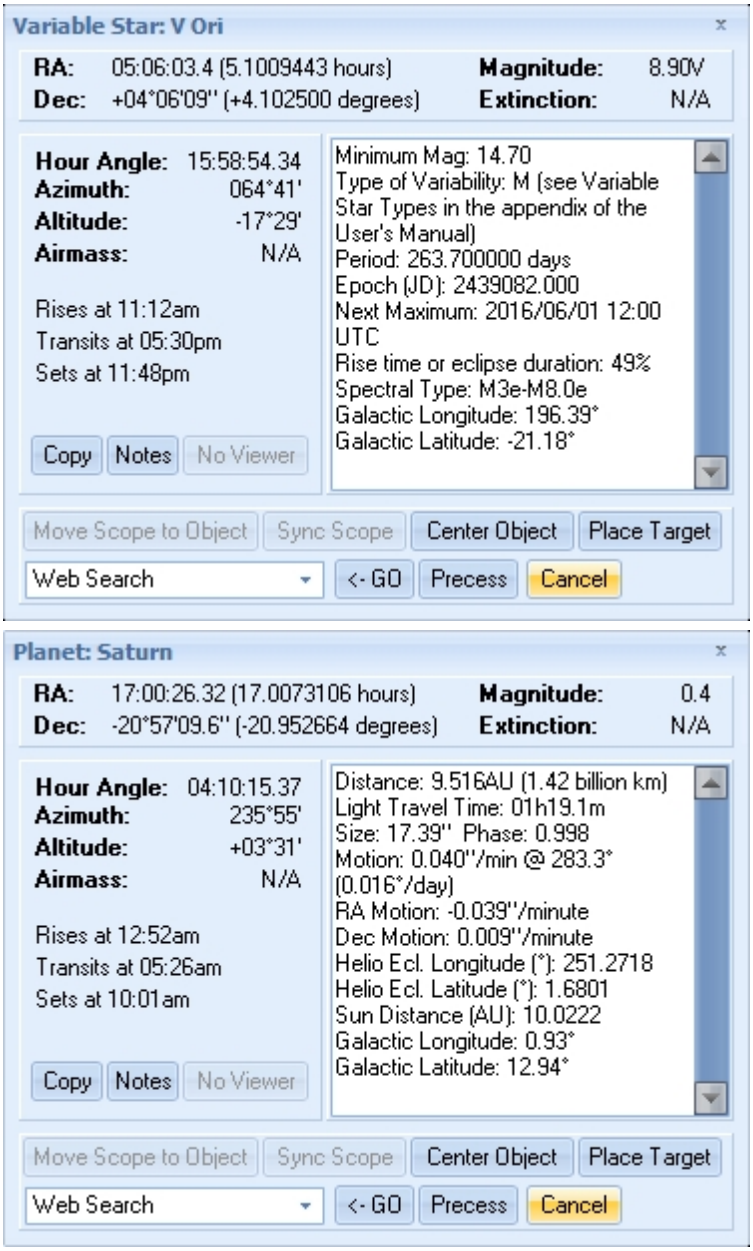
If more than one object is in the vicinity, the **Next** button will be highlighted and indicates the number of remaining objects. It can be pressed to update the dialog box with new information for the next object. The **Cancel** button then changes to a **Prev.** (previous) button allowing you to back track to the previous object. If the **Sky Chart** is redrawn, the ability to bring up data on additional objects is disabled.

Information Display

The information common to all object types includes the **Right Ascension and Declination** (in J2000.0 coordinates), the **Altitude and Azimuth** with reference to the local horizon, the **Latitude and Longitude** with respect to the **Galactic Equator**, and the local time that the object **rises**, **transits** (is highest in the local sky) and **sets**. If you hover the mouse over the transit time, the altitude at time of transit will be displayed (non-solar system objects).

Two other parameters are given: **Air Mass** and **Extinction**. Air mass is an estimate of how much atmosphere you are looking through compared to straight up — as air mass increases objects become dimmer, more red in color, and seeing (atmospheric turbulence) becomes worse. The Air Mass increases as objects become closer to the horizon. Extinction is an estimate (in magnitudes) for how much an object is "dimmed" due to the current air mass.





Each object type is listed below with each one's specific information that is provided in addition to the common information:

- **Sun** — the sun's distance, in astronomical units and in kilometers; its light travel time, in minutes; its size, in minutes of arc; the solar longitude; its rate of motion, in arc-seconds per minute; and the heliocentric ecliptic coordinates of the Earth.

- **Moon** — the moon's distance from the Earth, in kilometers; its size, in minutes of arc; its phase; its phase angle (and age, in days); its illuminated fraction (in percent); and its rate of motion, in arc-seconds per minute.

- **Planets** — the planet's magnitude; its distance from the Earth, in astronomical units and in kilometers; its light travel time, in hours and minutes; its size, in seconds of arc; its phase (0 to 1); its rate of motion, in arc-seconds per minute; and its heliocentric ecliptic coordinates.

- **Comets or Asteroids** — its magnitude; its distance from the Earth and the Sun in astronomical units and in kilometers; its light travel time, in hours and minutes; its solar elongation; for asteroids, its phase angle; its rate of motion, in arc-seconds per minute; and its heliocentric ecliptic coordinates.

- **Yale Bright Star Catalogue Stars** — the star's magnitude; its Bayer/Flamsteed identification; its Yale Catalogue number; its SAO Catalogue number; its Henry Draper Catalogue number; its spectral classification; its color as B-V; and its proper motion.

- **SAO Catalogue Stars** — the star's magnitude; its SAO Catalogue number; and its spectral classification.

- **Tycho-2 Catalogue Stars** — the star's magnitude (in both B and V colors); its Tycho-2 Catalogue number, its Hipparcos number (if applicable), its HD number (if applicable), its measured parallax (with uncertainty), the implied distance (in light years with uncertainty), and its proper motion.

- **Hubble Guide Stars** — the star's magnitude; its GSC Catalogue number; its estimated position error; its estimated magnitude error; its magnitude band; and its Plate ID.

- **US Naval Observatory Stars** — the star's magnitude (both blue and red, if known); its identity (by zone file and star number), and the plate number (POSS or SRC) that it originated from.

- **SAC Deep Sky Objects** — the object's magnitude; its primary and other names; its description; its size; its position angle; the object class and various notes are displayed.

- **PGC Galaxies** — the galaxy's magnitude; its primary and up to four other names; its morphological type, its size; its position angle; its class and its radial velocity. The radial velocity is also converted into its distance using the Hubble relationship (with a Hubble constant of 70 km/s per megaparsec).

- **Variable Stars** — the star's maximum and minimum magnitude; the designation of the variable star; its type of variability; its period; its spectral type; its rising time (or duration of eclipse); and the Julian date of a previous maximum. The date and time of a future maximum (or minimum for eclipsing variable stars) is computed using the period and the epoch of the previous maximum.

- **Double Stars** — the combined magnitude of the pair; the discoverer code of the pair; its Durchmusterung catalog number; the magnitudes of both stars; the separation and position angle at up to two dates; and its spectral type.

- **Planetary Nebulae** — the PK and PNG object name; any other name (usually NGC or IC); the object's magnitude; its size; and its status.

- **User Objects** — the object's magnitude (if known); its user number; and its text description.

Viewing Images

Viewing images of objects is provided by an image viewer program with the name of the image file to view. This is accomplished by pressing the **Image** button. If an image for the identified object or the image viewer program is not present, the **Image** button will be disabled.

To setup an image viewer program, see Directory/File/Web Setup... . The location of the image files (two locations on your computer are searched) is also controlled by the user in the same Directory/File/Web Setup... dialog box.

ECU looks for image files in a number of ways. In the simplest form, the name of the image files must be the same as the primary or other object name that appears in the **Identify Objects Box** for the object. For example, an image of the Moon would be called "moon.jpg", if the image were in "JPG" format. Or an image of NGC7009 (the Saturn Nebula) would be called "NGC7009.JPG".

The filename used is usually exactly the same as the object's primary name, however, because of the

restrictions on the naming of files imposed by Windows, some names of objects may not work directly (for example, if the name contains letters such as ":", "." or "\" that are not allowed in filenames). In these cases, **ECU** creates a "compatible" filename automatically. The easiest way to determine is the "compatible" filename is to use the "Notes" feature to see what filename it creates, since it uses the same algorithm.

There is also a more advanced way to search for image files. This method uses for a file ending in ".txt" (a text file) that the user creates with a text editor. This text file should contain the image file names one per line. Up to 50 images of each object can be specified. Filenames specified can be either:

1. unqualified — containing no directory information, in which case the specified image file must be in the same directory as the text file
2. fully-qualified — containing the complete location of the image file (including drive and directory).

An example image "text" file named "M42.TXT" and stored in the "c:\Program Files\ecu6\images1" directory for the Orion Nebula (M42) is:

```
m42.jpg                  - an image file in "c:\Program Files\ecu6\images1" directory
orion.jpg                - another image file in same directory
c:\ecu\images\m42.jpg    - an image file in another directory
c:\images\m42a.jpg       - an image file in yet another directory
c:\images\m42b.jpg       - an image file in same directory with different name
d:\images\m42.jpg        - an image file from the CD-ROM image directory
```

Notes

You can add your own "notes" about any object by clicking on the **Notes** button. ECU then creates a file named after the object, stores it in the "notes" directory (see section Directory/File/Web Setup...), and starts a text editor program (also see Directory/File/Web Setup...). Below is a sample file, which would be created for Messier Object 42 (the Orion Nebula). It includes both known names of the object.

Depending on the "Add Date/Time to notes file" setting in the Directory/File/Web Setup..., a time/date stamp (the current date and time in local and UTC formats) is optionally added to the file.

```
Object Name: M42
Other Name: NGC 1976

LMT: 2016/12/25 09:18pm (UTC: 2016/12/26 01:18)
Today's Notes:
```

After adding your notes, remember to save the file and close the text editor program. If the file was already present, it is not overwritten, but rather a new time/date stamp is appended to the bottom of the existing file allowing the user to add more notes.

The filename created is usually exactly the same as the object's primary name with ".TXT" added to the end. In the example above, the file would have been called "M101.TXT". Because of the restrictions on the naming of files imposed by Windows, some names of objects may work directly (for example, if the name contains letters such as ":", "." or "\" that are not allowed in filenames). In these cases, ECU creates a "compatible" filename automatically.

Internet Features

Several different types of web searches can also be invoked directly from the **Identify Object Box**. Note that each object type only makes available the appropriate search types.

Select the desired type of web search using the drop-down list and then press the **GO** button. The object's primary name or the object's position (as appropriate) is used for the search string. A web-browser window will appear with the result of the search. You must be connected to the Internet to use this feature.

The available types of web searches are:

a) **Web Search** — performs a usual web search using the Google**.**
b) **Image Search** —performs an image search using the site images.google.com. This search is surprisingly effective at finding images of many astronomical objects, however you can get some unusual results for some objects (eg. M16 returns mainly images of assault rifles!).
c) **Retrieve DSS Image** — retrieves an image of the sky, from the Digitized Sky Survey, located at the object's location. The size of the image is set using the DSS Image Size... menu item.
d) **SIMBAD Database Search** — performs a search of the on-line SIMBAD Astronomical database hosted at simbad.u-strasbg.fr/Simbad. This database provides basic data, cross-identifications and bibliography for astronomical objects outside the solar system.
e) **NED Search** — performs a search of the on-line NASA/IPAC Extragalactic Database hosted at nedwww.ipac.caltech.edu.
f) **AAVSO Search** — performs a search of the on-line AAVSO VSX Database which can be used to access charts, light curves, and observation data for variable stars in the AAVSO database.
g) **GCVS Search** — performs a search of the on-line General Catalog of Variable Stars database hosted at the Sternberg Astronomical Institute in Moscow, Russia.

The web site address used for each search type is set in the Directory/File/Web Setup... menu item.

Other Buttons

The **Copy** button copies all of the text content to the clipboard so that it can be pasted into other applications.

The **Precess** button precesses the object's coordinates to the epoch of the current date. Pressing the **Center Object** button will cause the **Sky Chart** to be re-drawn centered at the identified object. Pressing the **Place Target** button will cause a default Chart Target to be placed at the location of the selected object.

If the telescope interface is enabled, you will see the buttons **Sync Scope** and **Move Scope to Object** buttons used by the telescope functions. See Using the Telescope Interface for details.

Menu Reference

The menu selections control most of the features of ECU and are divided into ten categories as listed below.

- File — the file menu handles the loading and saving of the configuration settings of ECU, the printing of **Sky Charts**, and Object Report functions.
- Edit — edit includes the Undo feature and control of the **Tool Bar**, **Scroll Bars**, **Status Line**, **Status Box**, colors, fonts, and program styles.
- Set — the set menu allows the setting of the time and date, geographic location, and calculation settings.
- Chart — the chart menu controls the chart orientation and if and how the stars, variable and double stars, deep sky objects, planets, sun/moon, comets/asteroids, grid, lines and points, chart targets, and labels are displayed. It also allows for various zoom settings.
- Orbits – the orbits menu includes most functions related to comet and asteroid orbits.
- Center — the center menu provides many ways to set the center of the **Sky Chart**.
- Animation — the animation menu controls the various features of the animation mode.
- Telescope — the telescope menu includes all of the telescope control functions.
- Miscellaneous — the miscellaneous menu provides access to various functions which didn't seem to fit well anywhere else. These include the display of Sun/Moon data and sidereal time and Julian date, various Internet functions, and the settings for various files and directories used by ECU.
- Help — the help menu provides access to ECU's online manual, various websites, and the program credits.

Many of the commonly used menu items have Keyboard Shortcuts, Tool Bar or Status Line Speed Buttons to allow quick access to their features.

File Menu

The **File** menu provides access to the following functions:

- loading and saving of the configuration settings,
- the setup of and printing of high-quality **Sky Charts**, and
- the setup and generation of Object Reports.

Open...

The **Open...** menu selection presents a dialog box allowing a new configuration file to be selected, then subsequently loaded. The keyboard equivalent to this menu selection is **Alt-O**.

Note

Please note that configuration files created with all versions from V3.0 to V6.0L of ECU can be opened and are automatically converted to V6.1 format. Configuration files from versions older than V3.0 cannot be read.

Save

The **Save** menu selection saves the configuration settings to the current configuration file name. The current

file name is always displayed on the title line of ECU's main window. The keyboard equivalent to this menu selection is **Alt-S**.

Save As...

The **Save As...** menu selection saves the configuration settings to the file specified by the file name selected in the dialog box presented. The keyboard equivalent to this menu selection is **Alt-A**.

Revert

The **Revert** menu selection re-loads the configuration settings from the current configuration file name. The current configuration file name is always displayed on the title line of ECU's main window. This function is useful, for example, if you have loaded a configuration file (or started ECU), made some changes to these configurations, then subsequently changed your mind and want to start over at the last saved configuration.

Restore Defaults

This menu selection sets all configuration settings to the system defaults. If the special file "default.cfg" exists in the user's "Documents" area (sub-directory "ecu61"), those settings will be used instead of the permanent settings programmed into ECU. In addition, certain web site address default settings are read from the file "webdefault.ini" which is automatically created or updated whenever the user saves a configuration file named "default.cfg".

This feature is intended to allow the user to set his/her own "default" settings, which are likely to differ from the author's favorite settings since you probably don't live in Halifax, Nova Scotia!

This feature should be used carefully, since it changes all of the configuration settings at once (and cannot be undone with the Undo feature).

Print Chart

The **Print Chart** menu selection prints a high-quality **Sky Chart** on the printer selected and setup in Printer Setup... . The chart is printed with the same settings used to draw the on-screen chart (except for the fonts, which have their own settings).

The chart is printed in two formats. In both formats, a title box can be printed at the bottom of the page containing the chart title, geographic location, the universal and local date and time, the center of the chart as the right ascension and declination, the center of the chart as the azimuth and altitude, and the height of the field in degrees.

If the printer is set in portrait mode (or, if the height of the paper is larger than its width), a legend box can be drawn above the title box. If the printer is set in landscape mode (or, if the width of the paper is larger than its height), a legend box can be drawn on the right side of the page.

Chart Setup... controls many aspects of how the chart is printed.

Printer Setup...

The **Printer Setup...** menu selection shows the Windows standard printer setup dialog box allowing the user to select and setup a printer. The printer used is selected from the pick list. To change the default settings for the selected printer, press the **Properties...** button. All changes to printer settings remain in effect until ECU is closed.

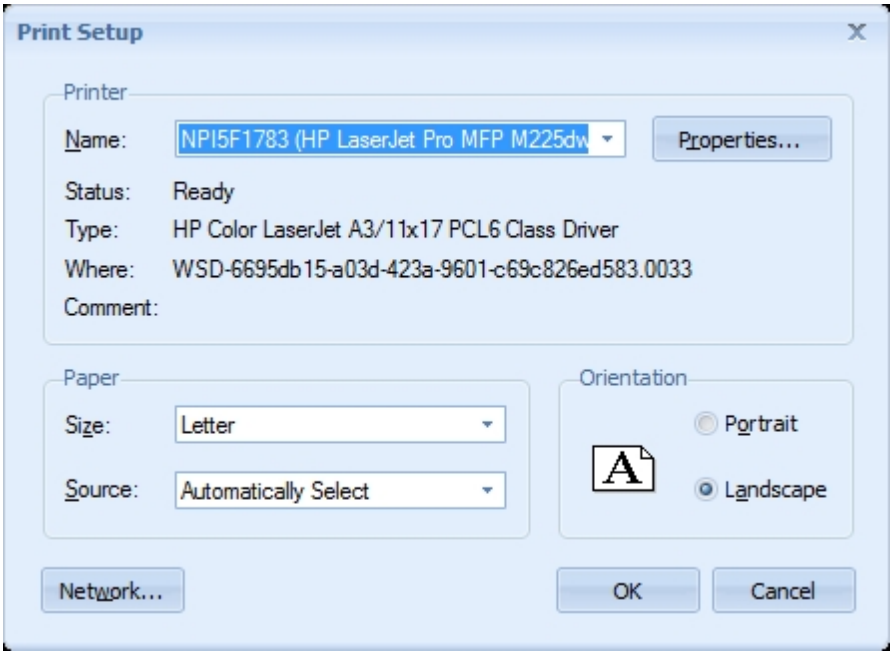


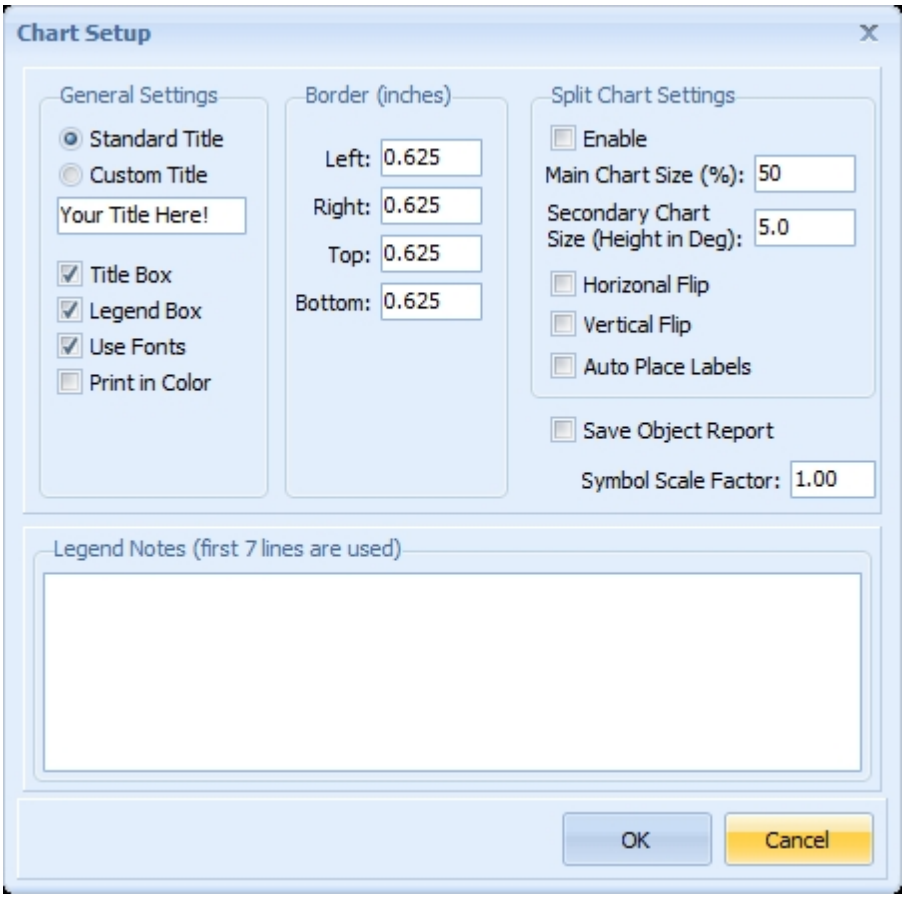
Chart Setup...

This menu selection presents a dialog box allowing the user to customize the appearance of the printed charts.

General Settings

The title line of the chart can be customized by selecting the **Custom Title** radio button and entering new title text below it. The **Title Box** check box shows the chart title, time, geographic location and other data, can be enabled or disabled. The **Legend Box** check box shows the symbols used for stars of different brightness and deep sky objects of different types.

The **Use Fonts** check box controls if the printer fonts programmed in Printer Fonts... are used to draw the chart. If it is not checked, the default font for the selected printer is used. When the **Print in Color** check box is checked, charts are printed in full color (using the same colors used for the on-screen chart) rather than only using black. There are additional printer-only colors for the border lines and legend and title box text. See Colors and Styles... to customize the colors printed.



Border

The four border distances, in inches, can be individually set. This, in effect, allows the chart size to be controlled. This feature is very useful, after disabling the title and legend boxes, for making charts that can be "pasted" into other documents, such as an astronomy club newsletter.

Legend Notes

The first seven lines are used to add descriptive text to the "Notes" section of the chart legend box.

Split Chart Settings

Checking the **Enable** check box enables the generation of split charts. This feature prints two charts on one page. The first "main" chart (located on the top of the page in a "portrait" mode chart or on the left side of the page for a "landscape" mode chart) is printed in the normal way, as if there were no second chart printed. The "secondary" chart is centered at the same sky position, but is printed at the specified chart size, usually to produce a zoomed-in chart of the same sky area.

The **Main Chart Size** setting specifies the percentage of the available page space that is used for the main chart.

The **Secondary Chart Size** setting specifies the chart height (in degrees) for the secondary chart. This setting can be smaller or larger than the main chart.

The **Horizonal** and **Vertical Flip** settings relate only to the "secondary" chart. See Chart Orientation... for more information.

The **Auto Place Labels** check box is used to enable the auto-placing of labels for the secondary chart. This feature attempts to avoid the overlapping of text labels in crowded fields. Note that the main Auto-Place

Labels setting in Labels... is used to control this feature for the main chart.

Save Object Report

Checking this check box causes an Object Report file to be generated based on the objects printed in the chart. Note that this report will usually contain a slightly different list of objects than a report generated by Save Object Report..., which uses objects plotted on the on-screen chart.

Symbol Scale Factor

The **Symbol Scale Factor** setting allows the user to increase or decrease the size of the star, deep sky, and other symbols drawn on the chart. Printers of varying resolutions (pixels per inch) may produce higher quality output at values other than the standard setting of 1. Experiment with this setting to determine the best setting for your printer. If values smaller than one are used, the symbols will be drawn proportionately smaller. Likewise, if values larger than one are used, the symbols will be drawn proportionately larger.

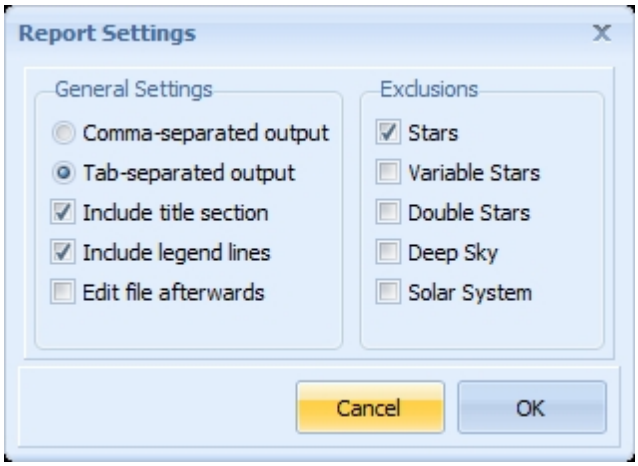
Save Object Report...

This menu selection generates and saves an Object Report to the file specified by the file name selected in the dialog box presented. The Object Report is generated based on the objects currently shown on the on-screen chart and the settings specified in the next section. Note that if the "Edit file afterwards" setting is enabled, the file generated will be automatically loaded into your specified text editor (usually Notepad).

Report Settings...

This menu selection presents a dialog box allowing the user to control various settings of the Save Object Report feature, which is used to generate detailed reports of the objects plotted on the on-screen chart or plotted on printed charts.

These detailed reports can be easily imported into spreadsheet or database programs such as Microsoft Excel and contain a variety of detailed information that varies by object type.



General Settings

Select either **Comma-separated output** or **Tab-separated output** to specify the character that is used to delimit fields in the file. Tab format is recommended, but either is easily imported into Microsoft Excel. The **Include title section** check box specifies if the title section is to be included in the report. This section includes information such as the geographic location, date and time, sky position, and chart size pertaining to the data included in the report. The **Include legend lines** check box specifies if the legend lines are to be included in the report. The **Include legend lines** check box includes a line identifying the fields for each

object type.

The **Edit file afterwards** check box determines if the Object Report file generated will be automatically loaded into your specified text editor (usually Notepad).

Exclusions

The exclusions section allows you to exclude groups of objects from being included in the report file. Note that this is exclusion, not an inclusion. For example, if only "Stars" is checked all object types (currently displayed) except stars will be included in the report file.

Exit

The **Exit** menu selection is used to close ECU. If the configuration settings have changed, a message box appears asking to user to specify if the settings are to be saved to the current file name. Pressing "Yes" (or the enter key) will save the configuration settings to the current file name. Pressing "No" will close ECU without saving the configuration settings. Pressing "Cancel" will stop the close process. If there is no user response within five seconds, the "Yes" option will done. The keyboard equivalent to this menu selection is **Alt-X** or **Alt-F4**.

Edit Menu

The **Edit** menu provides access to the following functions:

- the Undo capability,
- copying the chart to the clipboard,
- various user settings such as the operation of the **Tool Bar**, the **Scroll Bars**, and status information displays,
- the Track Coordinates feature,
- the control of colors and styles,
- the setting of font types, styles, and sizes.

Undo

The **Undo** menu selection reverses the last operation. This is very useful when you have made a "slip of the mouse" and wish to get back to where you last were. You can "Undo" up to the last 10 changes to the ECU configuration. The keyboard equivalent to this menu selection is **Ctrl-Z**, or you can press its **Tool Bar** button. Depending on the setting described in the next section, you can either undo just the last operation, or up to the last 10 operations.

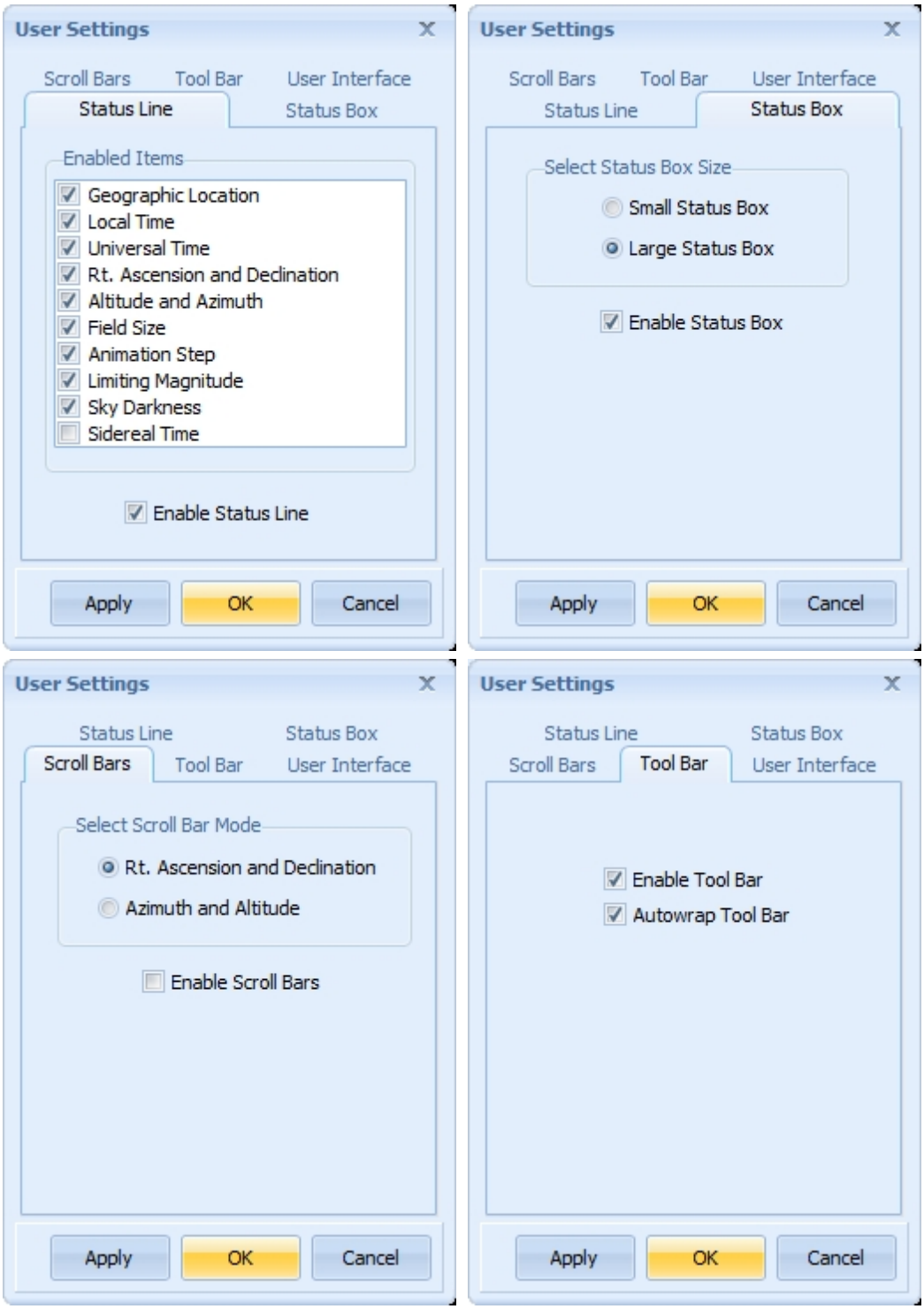
Copy Chart to Clipboard

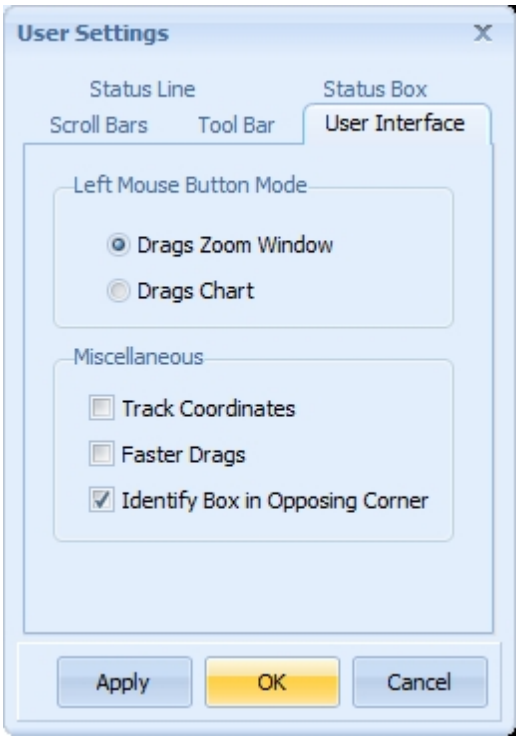
The **Copy Chart to Clipboard** menu selection "copies" the current on-screen **Sky Chart** to the Windows clipboard (as a bit map). It can then be "pasted" into other applications.

User Settings...

This **User Settings** menu selection shows a multi-tabbed dialog box allowing the control of:

- **Status Line** - the **status line**, located at the bottom of the ECU main window, can be enabled or disabled using the check box. Ten check boxes control which items are included. For a description of each item, see Status Line.
- **Status Box** - a large or small-sized Status Box can be displayed at the upper left corner of the chart area.
- **Scroll Bars** - the **Scroll Bars** can be used to control the center of the **Sky Chart** in equatorial or horizon coordinates.
- **Tool Bar** - the **Tool Bar** can either "wrap" to two lines if the ECU window is not wide enough.
- **User Interface**
  - moving the mouse with the left mouse button pressed can either:
    - drag a box that is used to resize and re-center the chart (and the shift key is used to drag the position of the chart)
    - drag the position of the chart - this is most useful when a touch screen is used (and the shift key is used to drag a box that is used to resize and re-center the chart)
  - Track Coordinates - when enabled the coordinate displays track the mouse position instead of the chart center.
  - when an object is clicked on, the Identify Objects Box can either appear in the screen center OR in the opposite corner of the chart from the selected object.


User Settings
Scroll Bars
Tool Bar
User Interface
Status Line
Status Box
Enabled Items
Geographic Location
Local Time
Universal Time
Rt. Ascension and Declination
Altitude and Azimuth
Field Size
Animation Step
Limiting Magnitude
Sky Darkness
Sidereal Time
Enable Status Line
Apply
OK
Cancel
User Settings
Scroll Bars
Tool Bar
User Interface
Status Line
Status Box
Select Status Box Size
Small Status Box
Large Status Box
Enable Status Box
Apply
OK
Cancel
User Settings
Status Line
Status Box
Scroll Bars
Tool Bar
User Interface
Select Scroll Bar Mode
Rt. Ascension and Declination
Azimuth and Altitude
Enable Scroll Bars
Apply
OK
Cancel
User Settings
Status Line
Status Box
Scroll Bars
Tool Bar
User Interface
Enable Tool Bar
Autowrap Tool Bar
Apply
OK
Cancel



Track Coordinates

When **Track Coordinates** is enabled the coordinates shown in Status Information displays track the mouse position instead of the chart center.

Toolbar On

The **Tool Bar On** menu selection controls if the **Tool Bar** is displayed or not.

Status Line On

The **Status Line On** menu selection controls if the Status Line is displayed or not.

Scroll Bars On

The **Scroll Bars On** menu selection controls if the Scroll Bars are displayed or not.

Status Box On

The **Status Box On** menu selection controls if the Status Box is displayed or not.

Colors and Styles...

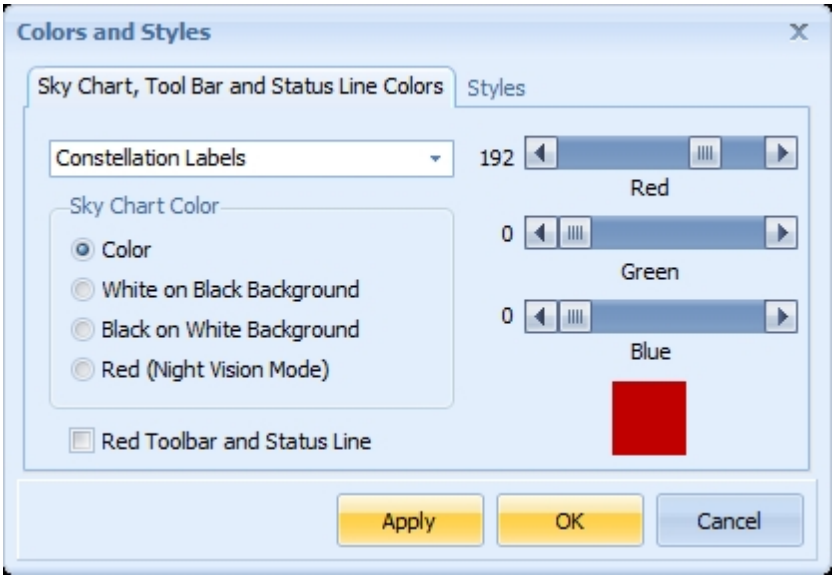
The **Colors and Styles...** menu selection presents a two-tabbed dialog box allowing the user to set the colors and styles used in ECU.

Sky Chart, Tool Bar, and Status Line Colours

In the first tab of the dialog box you can:

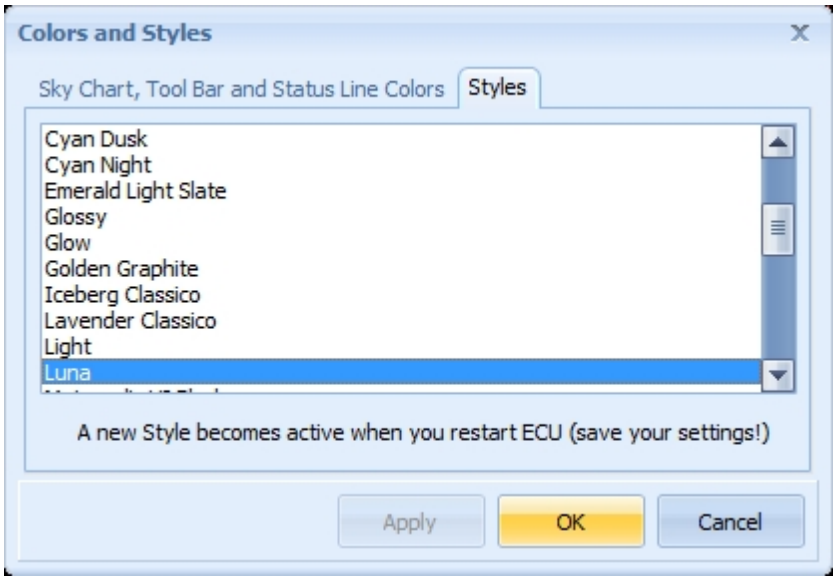
- set the **Sky Chart** to use full color or three monochromatic modes:
  - **Color** mode makes the background black and all elements drawn in full color.
  - **White on Black Background** mode makes the background black and all elements drawn white.
  - **Black on White Background** mode makes the background white and all elements drawn black.
  - **Red** mode makes the background black and all elements drawn red. This mode can be used with **Red Tool Bar and Status Line** mode to help maintain dark adaptation when ECU is used at the telescope.

- set the individual colors used to draw most elements in the **Sky Chart** and various elements of ECU's user interface and printed charts
  - the colors of individual **Sky Chart** (and printed chart) drawing elements are controlled by first selecting the element from the "drop down pick list" in the top left of the dialog box.
  - pressing the down arrow will cause a "pick list" to be displayed with a scroll bar on the right hand side
  - using the scroll bar, simply select the drawing element whose color you wish to change
  - the three horizontal scroll bars on the right side of the dialog box will be set to the color of the selected drawing element and the actual color is shown in a box beneath the scroll bars



Styles

In the second tab of the dialog box you can set the program "style" which controls the overall visual appearance, fonts, and colors used by ECU. Select the desired style from the list and press the **OK** button to save it. The new style only becomes active the next time ECU re-started (remember to save the settings), The style used in this User's Manual is called "Luna". The default style is called "Windows".



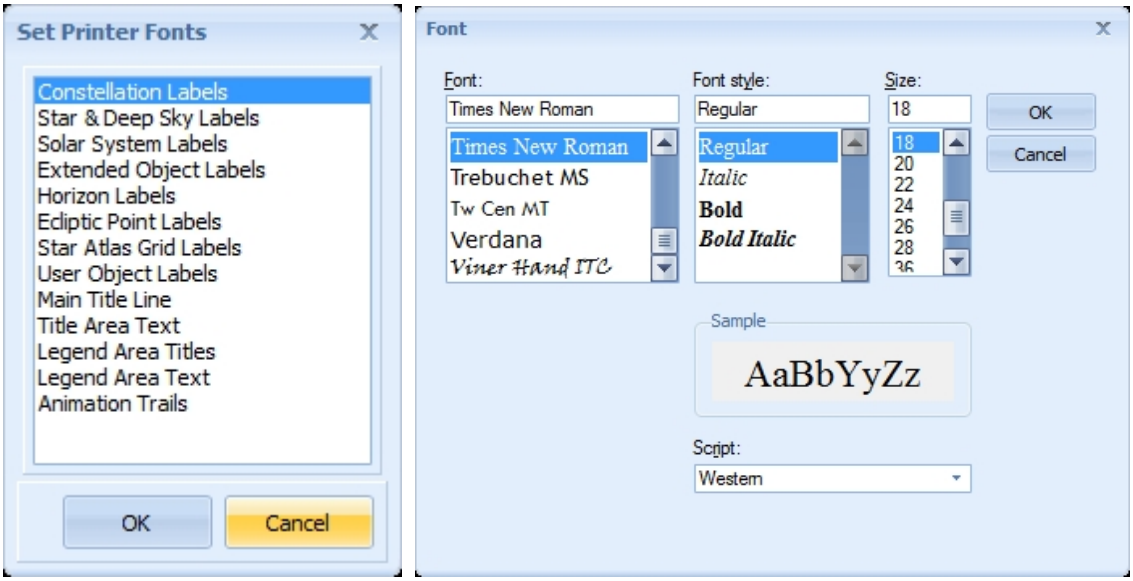
Fonts

The **Fonts** menu selection provides a sub-menu allowing the complete control of fonts used in:

- the **Sky Chart** (on-screen and printed) and
- the title and legend areas of printed charts.

Printer Fonts...

The **Printer Fonts...** menu selection presents a dialog box allowing the user to customize the fonts used in the printed **Sky Charts**. A list box is presented containing the 13 text items whose fonts can be customized.

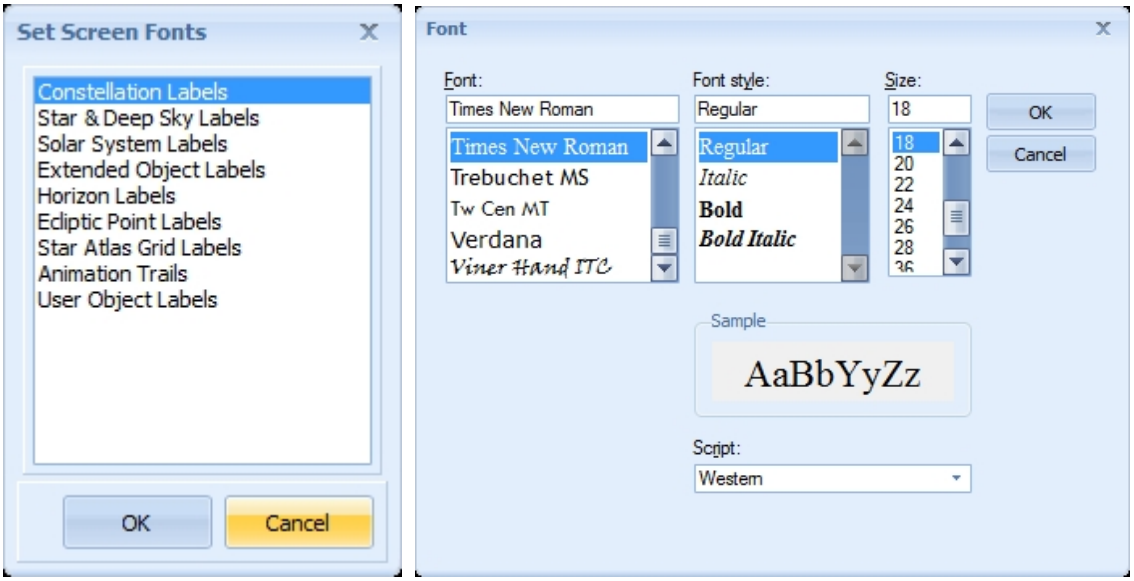


Select the desired item and then press the **OK** button. The standard Windows font control dialog box will then be presented as shown above. The font, font style, and size can be selected. After exiting the Font dialog box by pressing 'OK', the **Set Printer Fonts** dialog box will be re-appear allowing another font to be

changed. When finished changing the printer fonts, press the **Cancel** button.

Screen Fonts...

The **Screen Fonts...** menu selection presents a dialog box allowing the user to customize the fonts used in the on printed **Sky Charts**. A list box is presented containing the 9 text items whose fonts can be customized.



Select the desired item and then press the **OK** button. The standard Windows font control dialog box will then be presented as shown above. The font, font style, and size can be selected. After exiting the Font dialog box by pressing 'OK', the **Set Screen Fonts** dialog box will be re-appear allowing another font to be changed. When finished changing the screen fonts, press the **Cancel** button.

Use Fonts

The **Use Fonts** menu selection toggles whether or not the Screen Fonts are to be used in the on-screen **Sky Chart**. If marked by a 'check mark', the fonts will be used. If it is not checked, the Windows standard system font is used.

Increase Font Size by 20%

The **Increase Font Size by 20%** menu selection increases, by 20%, the size of all screen fonts.

Decrease Font Size by 20%

The **Decrease Font Size by 20%** menu selection decreases, by 20%, the size of all screen fonts.

Set Menu

The **Set** menu provides access to the following functions:

- setting ECU's date and time,
- time settings,
- geographic location setting, and
- control of various calculation settings.

Setting ECU's Time and Date

The four time and date related menu selections shows a tab of the multi-tabbed **Enter Date and Time** dialog box as follows:

- Date and Time
- Julian Date
- Settings

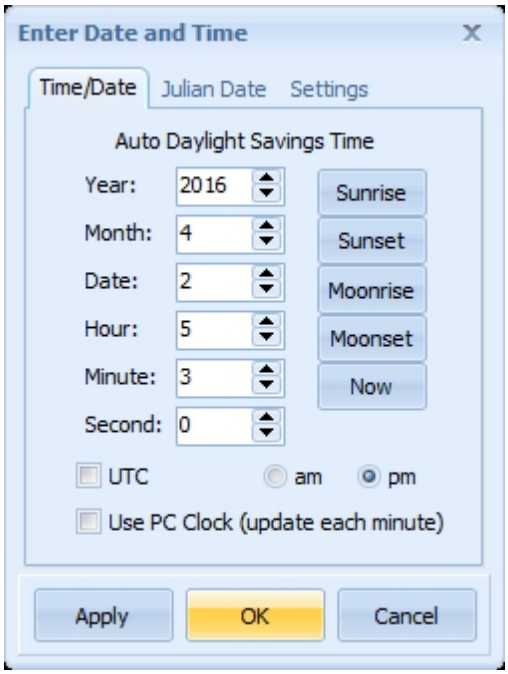
Time/Date...

Use the **Time/Date** tab to set the date and time used by ECU.

Setting a Specific Date and Time

Type in or use the up/down arrows to set the year, month, date, hour, minute, and second. If the Time Format is set to AM/PM mode use the am/pm radio buttons.

The year can be set from 4713BC to 9999 AD. Unlike convention outside of astronomy circles, there is a year 0, so, for example, if the year 6 BC is to be desired, -5 should be used. You are reminded what type of time you are entering - the choices being "Local Standard Time", "Daylight Savings Time", and "Universal Time".



The **UTC** check box is used to switch between Universal Time or Local Time. Universal Coordinated Time (which is nearly the same as Greenwich Mean Time - the time used in Greenwich, England) is the time used by astronomers to avoid the ambiguity of the many time zones used on Earth (internally, ECU uses UTC in all its calculations). UTC is always entered in 24-hour format.

Using your PC's Clock Time

The **Use PC Clock** check box is used to set the time and date to the **current** time (as provided by your PC's clock). When enabled, ECU's time to become synched to your pc's system clock. This will also cause the **Sky Chart** to update automatically once per minute, therefore simulating the actual sky's movements in near-real-time. After setting this mode, you might wonder why the stars are not marching by as the time changes. This is because the default behavior of ECU is to "lock" the center of the **Sky Chart** to a specific equatorial coordinate (as opposed to a specific local horizon coordinate). This behavior can be changed – see the Animation Locks...

Sun, Moon and Now Buttons

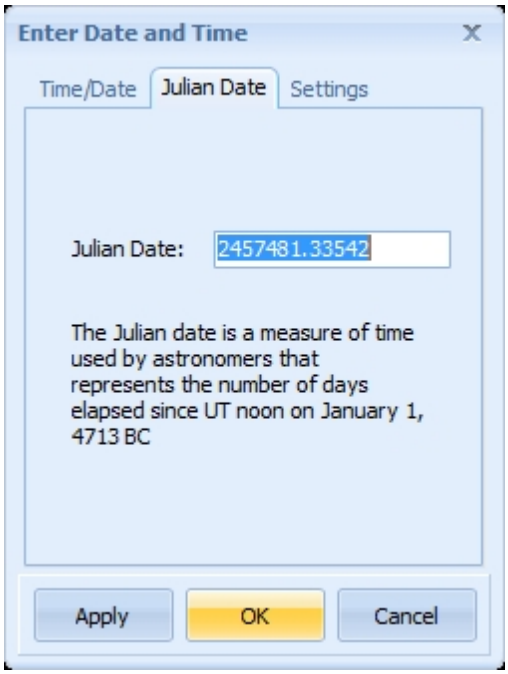
Five buttons are provided which make it easy to set the time to:

- when the Sun rises on the day currently specified
- when the Sun sets on the day currently specified
- when the Moon rises on the day currently specified
- when the Moon sets on the day currently specified
- the current date and time (from your PC's clock

Julian Date...

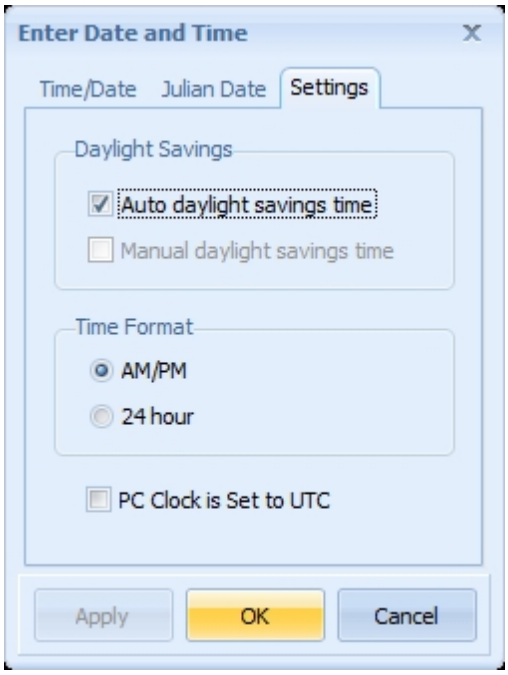
The **Enter Date and Time** dialog box has a **Julian Date** tab that allows the time and date to be set using a Julian Date.

The Julian Date is a measure of time used by astronomers that represents the number of days elapsed since UTC noon on January 1, 4713 BC. Its greatest benefit is its simplicity - time is represented by a single number (no dates, hours, etc.). It is most commonly used by those who observe and study variable stars.



Time Settings...

The **Enter Date and Time** dialog box has a **Settings** tab that allows control of a number of related settings.



Daylight Savings Time Mode

These settings are used by ECU to convert from local time to Universal Time.

The **Auto daylight savings time** check box controls whether ECU automatically sets the Daylight Savings or Standard Time mode. This should be enabled for most locations in Canada and the USA and the European Union. As the rules in Canada/USA are different than those in Europe, ECU **guesses** which rules to use by the current longitude (east of 30 degrees west longitude is assumed to be in Europe).

For Canada/USA, it handles the current (George Bush-enacted) rules and the older rules in place between

1915 and 2007. In Europe, it handles the rules in place between 2006 and the present. Before those years the time is always set to Standard Time. If you are not observing from these locations or in a location that does not use daylight savings time at all (eg. Saskatchewan, Canada), disable this mode.

Manual daylight savings time, when checked, indicates that local time is to be interpreted as a daylight savings time, otherwise it is interpreted as standard time.

Time Format

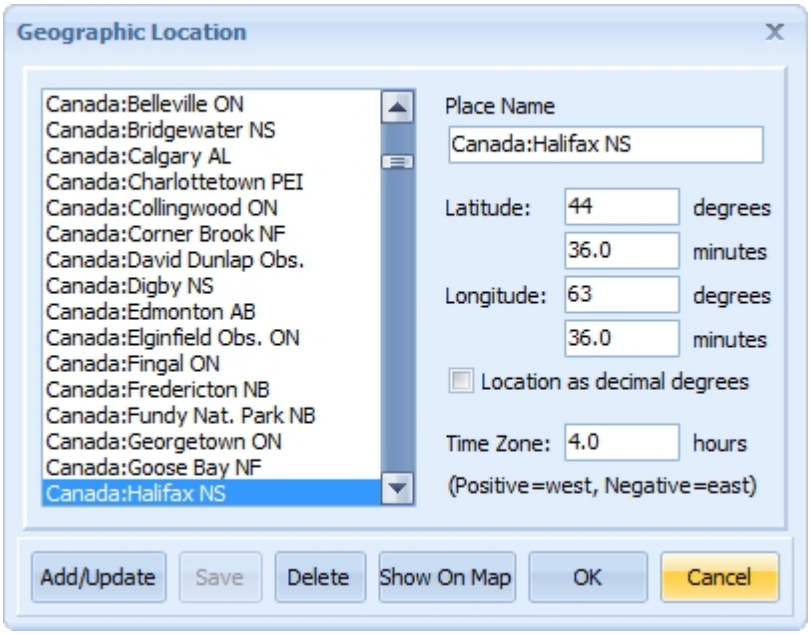
When time is displayed by ECU, it can be shown in either 12-hour (AM/PM) or 24-hour format. Use the **Time Format** radio buttons to choose the the mode you desire.

PC Clock Mode

The **PC Clock is Set to UTC** check box determines whether the computer's clock is to be interpreted as local time or UTC. If 'checked', the computer's clock should be set to UTC, if not it should be set to your 'local' time.

Geographic Location...

The **Geographic Location...** menu selection presents a dialog box allowing the selection of a location on the Earth's surface. The location can be selected from the provided list of hundreds of locations around the world or you can enter the latitude, longitude, and time zone of a location of your choice.



To select a pre-programmed location, use the list box on the left side to select the desired location. It is sorted in order of "Country:City". Its place name, latitude, longitude, and time zone will be displayed on the right side. Press "OK" to use this location.

To add a new location, enter a Place Name, Latitude, Longitude, and Time Zone on the right side. The latitude is entered as integer degrees (North is positive, South is negative) and decimal minutes. The longitude is also entered as integer degrees (West of the prime meridian is positive, East is negative) and decimal minutes. The time zone is entered in hours West of UTC (the time of the Greenwich meridian; enter a negative for the Eastern hemisphere). For convenience, you can also enter the position in decimal minutes. As an example, the latitude above could also be specified as 44.6 in the "degrees" field and "0" in the minutes field.

The **Show On Map** button shows the current location on a Google Map.

At this point, if you press the **Add/Update** button on of two things happens:

- if the Place Name was not changed, the existing entry is updated
- if the Place Name was changed, a new entry is added to the database

Pressing **Save** will save the database and use this new location.

To delete a location from the database, select it in the list box, then press the **Delete** button. To finish, press the **Save** button to save the database.

Geographic Location File

The database file used to store the geographic locations is user programmable. See The default file used is "location.ecu". See Directory/File/Web Setup... to change it. The format used for this file is a plain text file and is formatted as shown by the following sample entries below:

```
44.58 63.65 4 Canada:Halifax NS
47.83 71.25 5 Canada:Quebec QUE
43.65 79.38 5 Canada:Toronto ONT
42 83 5 Canada:Windsor ONT
51.50 0.17 0 UK:London
```

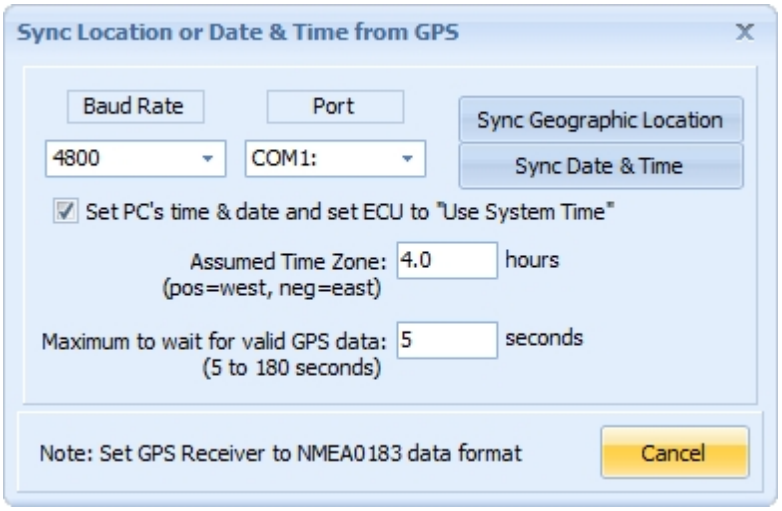
The first three entries on each line, which are separated by spaces, are the latitude (decimal degrees North of the Equator), longitude (decimal degrees West of the Prime meridian), and time zone (hours West of UTC). The fourth entry is the name of the location.

Sync Location or Time from GPS...

The **Sync Location or Time from GPS...** menu selection presents a dialog box the allows the geographic location or date and time to be set using a Global Positioning System (GPS) receiver.

The pre-requisites for using this feature are:

- Your receiver must support and be set to transmit data according to the NMEA0183 standard.
- Your receiver must be connected to one of your PC's available communications ports, and the baud rate and COM port setting must be set correctly in the dialog box.
- Your receiver must have achieved satellite lock.



To sync the geographic location, set or confirm the "Assumed Time Zone" entry in the dialog box, and press the **Sync Geographic Location** button. To sync the date and time, also set or confirm the "Assumed Time Zone" item in the dialog box and press the **Sync Date & Time** button. The accuracy of time setting should be plus or minus 1-2 seconds.

The "Maximum to wait for valid GPS data" value can be up to three minutes. The default setting of 5 seconds is sufficient for most GPS receivers, however some PC-based GPS receivers do not begin acquiring satellites until the communications link is established and as such require much longer to return valid data.

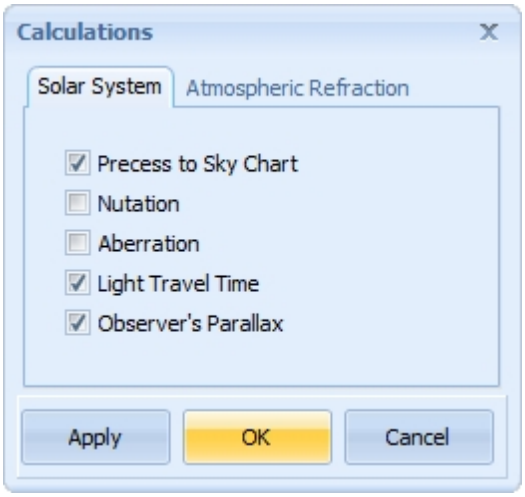
If you also wish to set your PC's time (as opposed to just ECU's time), check the corresponding check box.

Calculations...

The **Calculations...** menu selection shows a two-tabbed dialog box allowing several calculation options pertaining to the Solar System and Atmospheric Refraction to be changed.

Solar System

This tab controls various aspects of the solar system calculations. For maximum plotting accuracy (with respect to the background stars), set all check marks to their checked state except Nutation and Aberration. This is very important when simulating eclipses or other astronomical phenomenon where the observer's geographic location is important.



Precess to Sky Chart

When checked, this specifies that Solar System object positions and the horizon and meridian lines be adjusted (due to the effect of precession of the Earth's axis of rotation) to match the epoch J2000.0 coordinates used by the **Sky Chart**.

Nutation

When checked, this specifies that Solar System object positions (except for comets and asteroids) be corrected for the effects of Nutation. Nutation is at maximum, a 9 arc-second wobble in the Earth's precession circle primarily caused by the gravitational pull of the Moon.

Aberration

When checked, this specifies that Solar System object positions (except for comets and asteroids) be corrected for the effects of Aberration. Aberration is the apparent displacement of the position of an object due to the finite speed of light. This effect is due to the rotation of the Earth and the motion of the Earth through the solar system.

Light Travel Time

When checked, this specifies that Solar System object positions (except the Moon) be corrected for the effects of the Light Travel Time. The Light Travel Time correction recognizes that the observer sees an object at where it used to be in the past due to the time it has taken its light to reach Earth.

Observer's Parallax

When checked, this specifies that Solar System object positions be corrected for the effects of the Observer's Parallax. The Observer's Parallax is the effect of an apparent shift of an object's position for observers located at different locations on the Earth. This effect is what causes the Solar Eclipses and Occultations of the Moon to be only observable from certain locations on the Earth's surface. It is very important that this be enabled when simulating solar eclipses or other astronomical phenomenon where the observer's geographic location is important.

Atmospheric Refraction

This tab controls if and how the effects of Atmospheric Refraction are applied to Local Horizon line, Local Horizon grids, Azimuth and Altitude reported values, and object Rise/Set calculations. Atmospheric Refraction causes an object to appear higher in the sky that it actually is. The bending (or refraction) of light as it passes through the Earth's atmosphere causes this effect. To a small extend, the amount of refraction depends on the air temperature and atmospheric pressure, so these values can be changed.

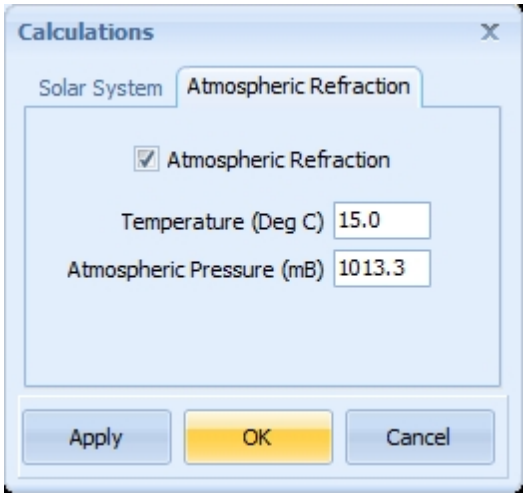
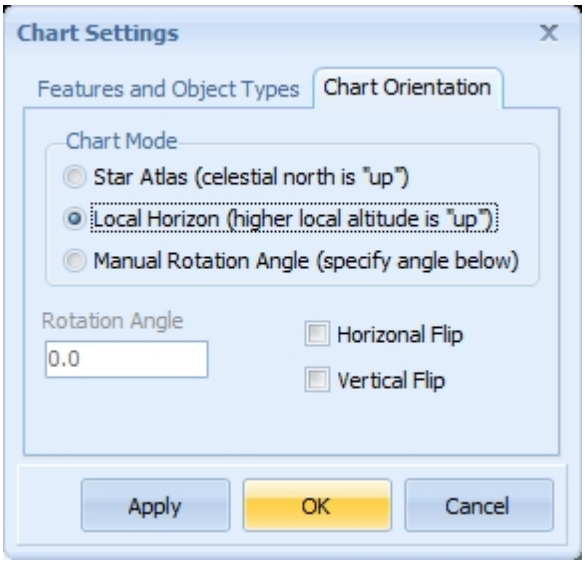


Chart Menu

The **Chart** menu provides extensive control over the orientation, content, and scale of the **Sky Chart**.

Chart Orientation..

The **Orientation..** menu selection shows the **Chart Orientation** tab of the **Chart Settings** dialog box.



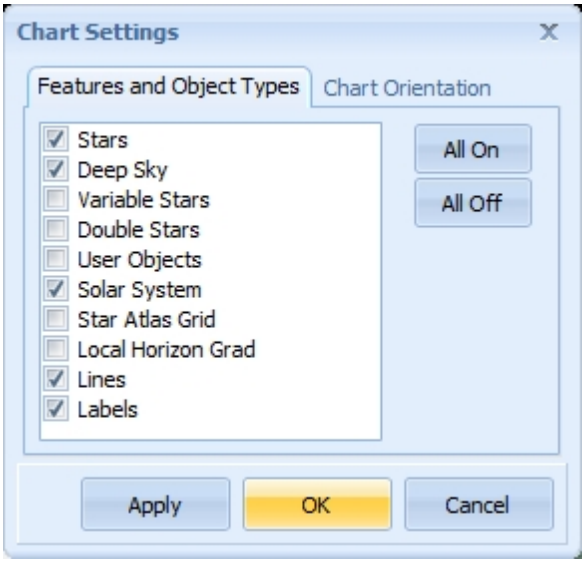
The Chart Mode (the rotation of the sky) can be set to one of **Star Atlas**, **Local Horizon**, or **Manual Rotation Angle.** See the Sky Chart section for more details. When "Manual Rotation Angle" is selected, any arbitrary rotation angle can be specified (0-359 degrees).

The **Horizontal Flip** check box indicates if the **Sky Chart** is drawn as a mirror image (flipped left to right). This is useful by itself to simulate what the sky will look like though a telescope that produces an upright but reversed image, such as a refractor or Schmidt-Cassegrain with a star diagonal installed. Used in conjunction with **Vertical Flip**, the **Sky Chart** is drawn upside-down and reversed left to right, to simulate the view though a Newtonian telescope.

The Vertical Flip check box indicates if the **Sky Chart** is drawn upside-down (flipped top to bottom). If this selection is used in conjunction with **Flip Horizontal**, the **Sky Chart** is drawn upside-down and reversed left to right, to simulate the view though a Newtonian telescope.

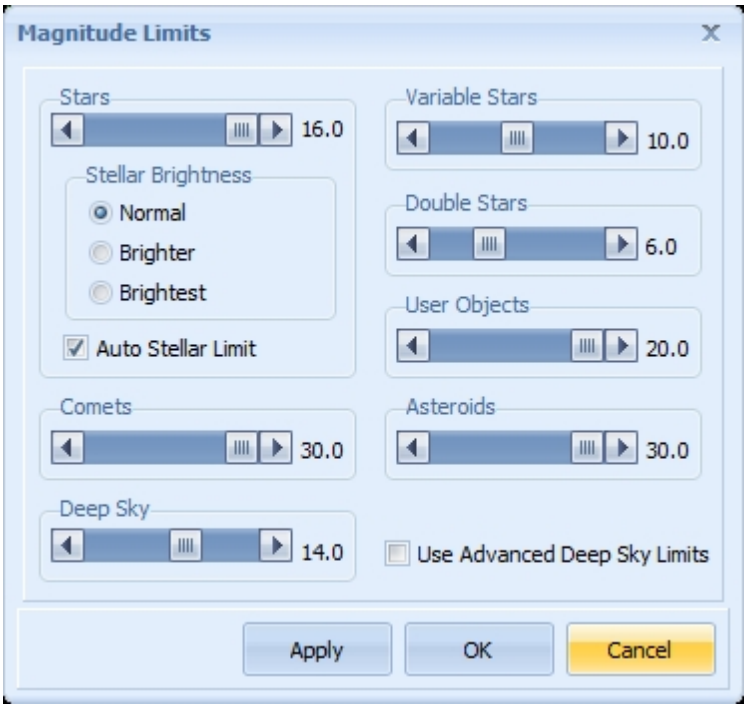
Features and Object Types...

The **Orientation..** menu selection shows the **Features and Object Types** tab of the **Chart Settings** dialog box which contains ten check boxes used to control if stars, deep sky objects, variable stars, double stars, user objects, solar system objects, grid lines, other lines/points, and labels on drawn on the **Sky Chart**. The **All On** and **All Off** buttons make it easy to quickly all items on or off. Each of these items has an equivalent button on **Tool Bar**.



Magnitude Limits...

The **Magnitude Limits...** menu selection shows a dialog box allowing the user to individually set the limiting magnitude for stars, deep sky objects, variable stars, double stars, user objects, comets, and asteroids. It also allows the drawing size of the stars to be controlled. For those new to astronomy, the magnitude of objects refers to an object's brightness. It is a logarithmic scale whereby smaller magnitudes are brighter and larger magnitudes are fainter.



Magnitudes are set using the scroll bars - the set magnitude is displayed immediately to the right of each scroll bar.

For stars, the actual stellar limiting magnitude that used depends on the state of the **Auto Stellar Limit** check box. If "checked", the stellar limit depends on the chart size and which star databases are presently enabled, however, the scroll bar sets the faintest stars that will be drawn. If not "checked" all stars in the database are drawn up to the limit set. However, if the chart size is greater than 45 degrees, then only the Yale or brighter Tycho-2 stars are shown (to magnitude 6.5). If the chart size is greater than 5 degrees, then only the Yale, SAO, and Tycho-2 stars are shown (and not stars from the Hubble Guide Star Catalog or US

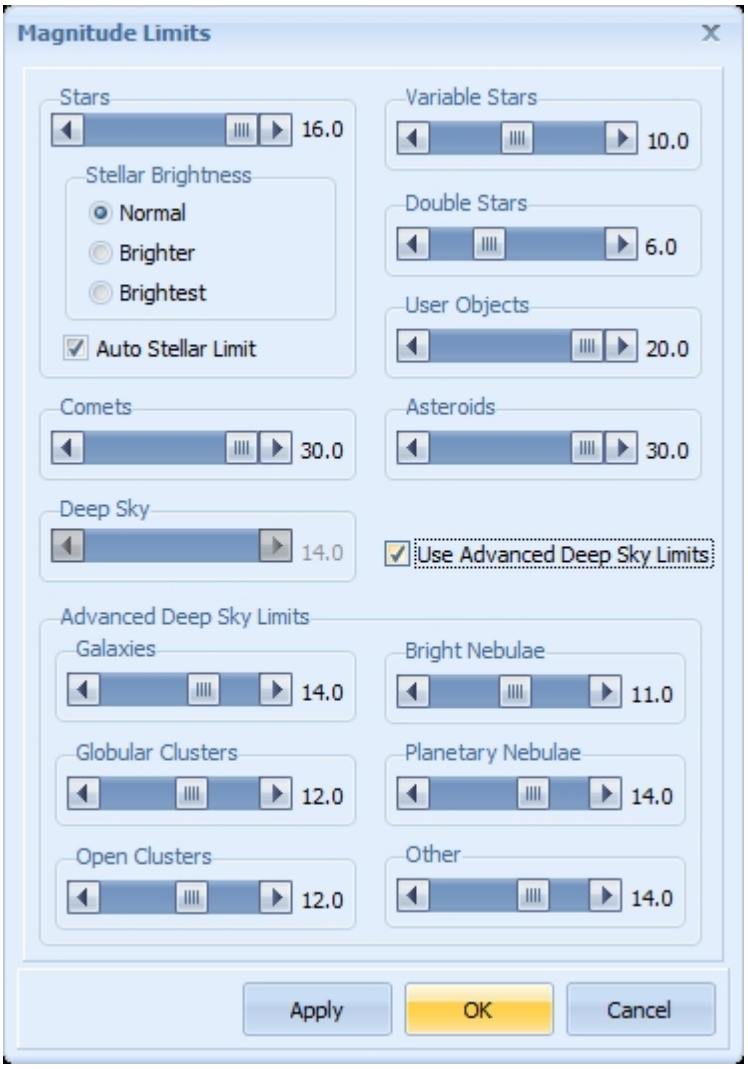
Naval Observatory Catalog).

A negative side effect of the non-Auto mode is that the **Sky Chart** will take longer to re-draw (due to many more stars being drawn).

The size of stellar symbols is dependent upon the "Stellar Brightness" setting. The "Normal" setting produces the most realistic displays, however the "Brighter" and "Brightest" settings may be easier to see when used in the dark at low screen brightnesses.

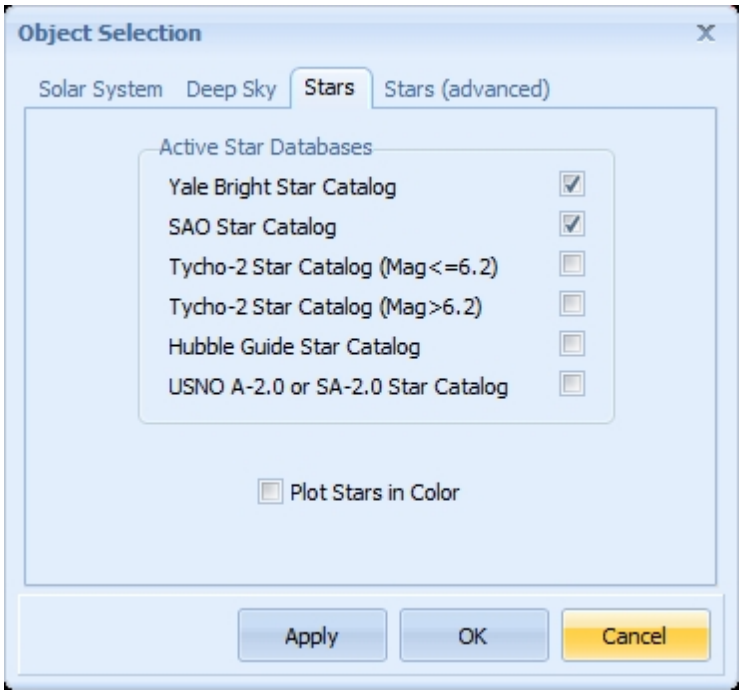
If the Deep Sky magnitude limit is set to 20, all objects will be shown, even those whose magnitude is unknown (for example, Dark Nebulae).

Deep Sky objects have an "Advanced Deep Sky Limit" mode allowing individual limits for each of the six main object types. By checking "Use Advanced Deep Sky Limits", the dialog box enlarges to show the advanced magnitude limits. These are used instead of the single Deep Sky magnitude limit.



Stars...

The **Stars...** menu selection shows the **Stars** tab of the **Object Selection** dialog box, which, along with the **Stars (advanced)** tab controls the operation of all of the stellar databases.



Active Star Databases

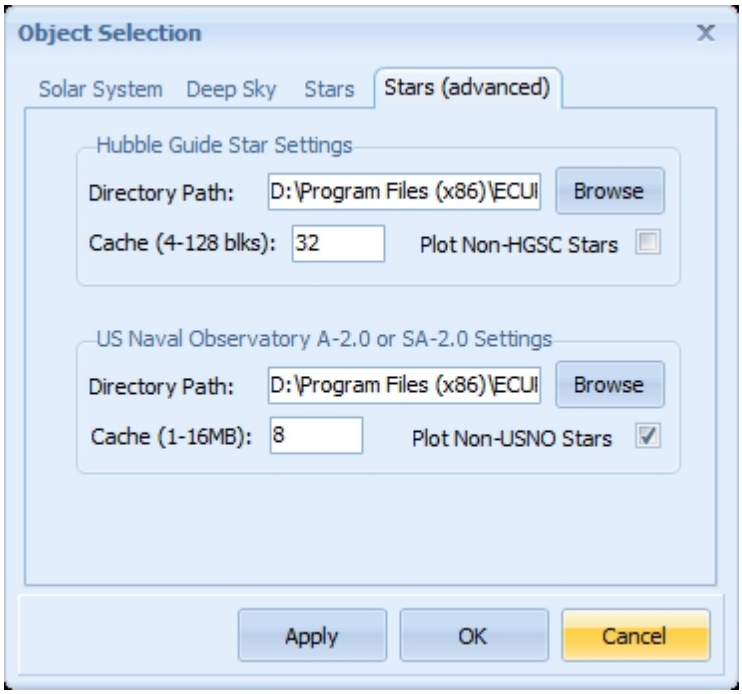
Each of the six stellar databases that are included or supported by ECU can be individually enabled or disabled with their corresponding check box. For more information about these databases and for some advice on which databases you should use see the Stellar Databases section. In particular, some of these databases (Yale/SAO vs. Tycho-2 bright and faint) are designed to work together in pairs to ensure nearly complete magnitude coverage without duplicated stars.

Plot Stars in Color

The **Plot Stars in Color** check box determines whether or not stars are displayed as white or in an exaggerated color based on either a star's color index (B-V) or spectral type. Ten unique colors are used to represent the B-V and spectral type range from less than -0.25 ("O" type hot blue stars) to greater than 2.5 ("S" type very red stars). This feature is available for stars in the Yale Bright Star, SAO, and Tycho-2 catalogs.

Advanced Star Settings

On the **Stars (advanced)** tab of the dialog box are settings for Hubble Guide Star Catalog (HGSC) and US Naval Observatory Star Catalog settings.



Hubble Guide Star Settings

After configured, and enabled (see Active Star Databases above), these stars are drawn whenever the chart size is smaller than 5 degrees in vertical height. This limit allows for a fast re-draw time and a density of stars that is not overwhelming.

The following items can be configured:

- **Directory Path** — set this item location where HGSC files are stored. This setting will normally be set correctly during the installation of ECU, however you may wish to change it to a hard disk with more space available, other than where ECU is installed.
- **Plot Non-HGSC Stars** — if checked, the non-HGSC stars (Yale, SAO, and Tycho-2) are plotted in addition to the HGSC stars.
- **Cache** — The HGSC is divided into over 9000 regions of the sky. This entry determines how many of these regions will be "cached" in memory. Values from 4 to 128 regions can be entered. If you have a lot of memory in your system, it is recommended that a higher cache size be used.

US Naval Observatory Settings

Note that the US Naval Observatory's (USNO) A-2.0 and SA-2.0 databases are not included with ECU due to licensing issues. They can, however, be downloaded from the Internet by individual users. After configured, and enabled (see Active Star Databases above), the USNO stars are drawn whenever the chart size is smaller than 5 degrees in vertical height. This limit allows for a fast re-draw time and a density of stars that is not overwhelming.

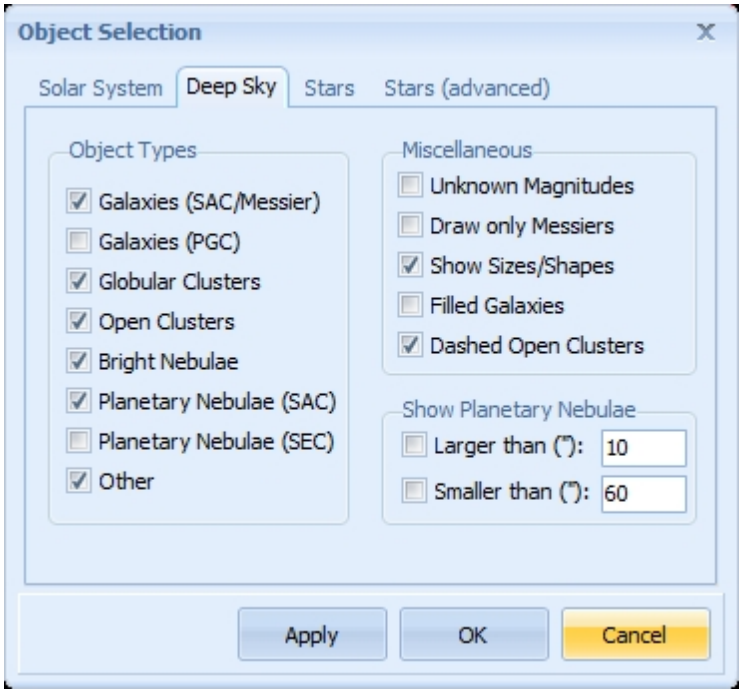
The following items can be configured:

- **Directory Path** — set this item to the location of the USNO files. This may be a location on your hard disk or perhaps on a DVD. If changing CDs or DVDs, note that **ECU** only looks for new USNO files when ECU is restarted, when the U key is pressed or when this dialog box exited with the "OK" or **Apply** button.
- **Cache** — The USNO databases are divided into many regions of the sky. This entry determines how much memory is allocated in order to "cache" USNO stars in memory. Values from 1 to 16 megabytes can be entered.
- **Plot Non-USNO Stars** — if checked, the non-USNO stars (Yale, SAO, and Tycho-2) are plotted

in addition to the USNO stars. This feature is provided because the USNO database is missing many bright stars and therefore is best used in conjunction with either the Tycho-2 or Yale/SAO databases.

Deep Sky...

The **Deep Sky...** menu selection shows the **Deep Sky** tab of the **Object Selection** dialog box, which controls which types of deep sky objects are included on the **Sky Chart** and how they are drawn.



Object Types

Eight check boxes select the types of deep sky objects included on the **Sky Chart**. Galaxies are separated into two categories:

- Galaxies from the SAC/Messier databases
- Galaxies from the Principal Galaxy Catalog

Planetary nebulae are also separated into two categories:

- Planetary Nebulae from the SAC/Messier databases
- Planetary Nebulae from the Wallace/SEC database

Miscellaneous

Five check boxes are used as follows:

- **Unknown Magnitudes** - if checked, objects with no known magnitude are plotted regardless of the Deep Sky magnitude limit set.
- **Draw only Messiers** - if checked, only deep sky objects from the Messier Catalog are drawn.
- **Show Sizes/Shapes -** if checked, ECU will draw objects the correct size, shape, and orientation; if this information is known. Many objects are quite small in angular size, so you may have to zoom in quite close to see this feature in action.
- **Filled Galaxies** - if checked, the circles or ovals representing galaxy sizes and shapes filled in as a solid color**.**

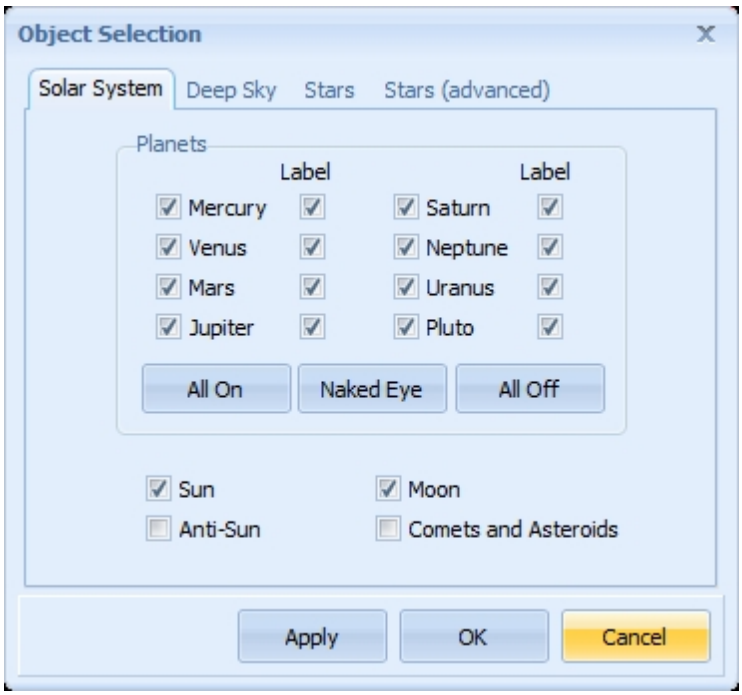
- **Dashed Open Clusters** - if checked, open clusters (on printed charts only) will be plotted using a dashed line rather than a solid line. This feature is provided because the dashed lines on some printers are very thin and not very easy to see.

Show Planetary Nebulae

Two check boxes and two edit boxes are used to set a range of size, in arc-seconds, that planetary nebulae are displayed. For example, to show a range of 5 to 20 arc-seconds, enable both check boxes and enter 20 in the "Smaller than" field and 5 in the "Larger than" field.

Solar System...

The **Solar System...** menu selection shows the **Solar System** tab of the **Object Selection** dialog box, which controls which planets and other solar system objects are included on the **Sky Chart**. Note that Solar System objects must also be enabled in order for them to display.



Planets

Each planet includes a check box indicating if the respective planet is displayed and a second check box indicating if the planet's name is also displayed. Three buttons are also provided which make it easy to:

- **All Off** - turn all the planets off
- **All On** - turn all the planets on
- **Naked Eye** - make only the planets visible to the naked eye visible

Note that we love Pluto, and still consider it a planet in ECU!

Other Solar System

Four additional check boxes control whether or not the Sun, Moon, Anti-Sun (the point in the sky opposite the Sun), and Comets & Asteroids are displayed.

Sun

The **Sun** menu selection toggles whether or not the Sun is displayed on the **Sky Chart**. Note that Solar System objects must also be enabled in order for the Sun to be displayed.

Moon

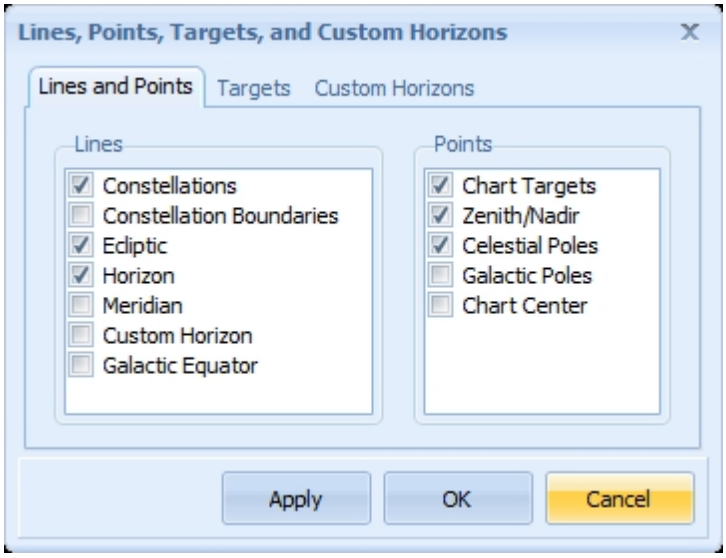
The Moon menu selection toggles whether or not the Moon is displayed on the **Sky Chart**. Note that Solar System objects must also be enabled in order for the Moon to be displayed.

Comets/Asteroids

The **Comets/Asteroids** menu selection toggles whether or not the Comets and Asteroids (this relates of objects configured in the Orbits menu) are displayed on the **Sky Chart**. Note that Solar System objects must also be enabled in order for them to display.

Lines/Points...

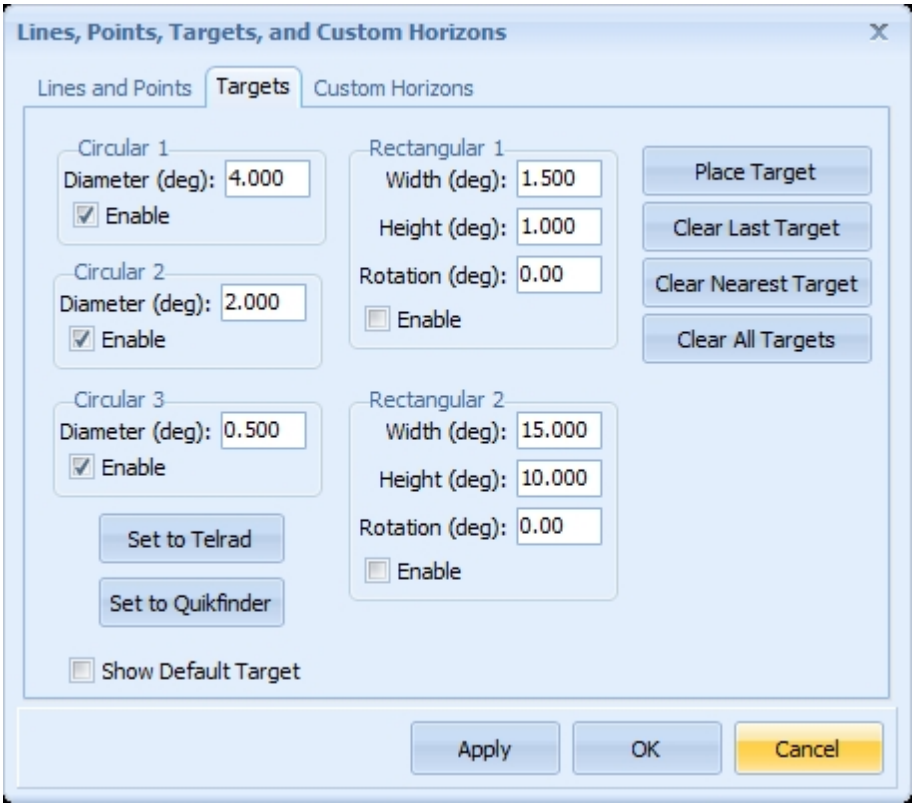
The **Lines/Points...** menu selection shows the **Lines and Points** tab of the **Lines, Points, Targets, and Custom Horizons** dialog box, which controls which of the various lines and points are shown.



Check boxes are included to enable or disable the constellation lines, constellation boundary lines, ecliptic line, horizon line, custom horizon line, meridian line, galactic equator line, chart targets, zenith and nadir points, celestial pole points, galactic pole points, and the center of the chart.

Targets...

The **Targets...** menu selection shows the **Targets** tab of the **Lines, Points, Targets, and Custom Horizons** dialog box. Each Target is comprising of up to three circles and two rectangles. Up to 100 Targets can be placed at arbitrary locations on the celestial sphere, in addition to one more Target located at the center of the **Sky Chart**. The Default Target can also be made to follow a telescope's current position. Targets are useful for showing the angular size on the sky observed in a telescope using a particular eyepiece, or viewed by your DSLR or CCD camera. They can also be useful on printed charts to aid in "star-hopping" to an object.



Default Target

Angular size values for each field of view indicator can be entered from 0.05 to 90 degrees. Each field of view can be individually enabled by "checking" its corresponding **Enable** check box. The rectangular fields of view indicators can also be rotated over a range of 0 to 180 degrees. The **Set to Telrad** and **Set to QuikFinder** buttons automatically set the fields of view to match the popular Telrad and Rigel QuikFinder zero-power telescope finder devices.

It is easy to determine what angular values to enter for your telescope and eyepiece combination without knowing the focal length of your telescope or the parameters of your eyepiece. Simply position a star located within a few degrees of the celestial equator just off the east side of your eyepiece field and time, in seconds, how long it takes to cross the field. Make sure your clock drive is turned off. The size of the field of view, in degrees, is:

```
0.004166 * time(s)
```

Default Target Button

This check box indicates if the Default Target is displayed at the center of the **Sky Chart**.

Place and Clear Targets Buttons

Four buttons are used to add or remove targets from the **Sky Chart** as follows:

- **Place Target** - places a Target at the current center of the **Sky Chart**. The Target is placed according to the Default Target settings. Up to 100 Targets can by placed on the **Sky Chart**. If all 100 Targets have already been placed, you will hear a "beep."
- **Clear Last Target** - clears the last Target placed on the **Sky Chart**.

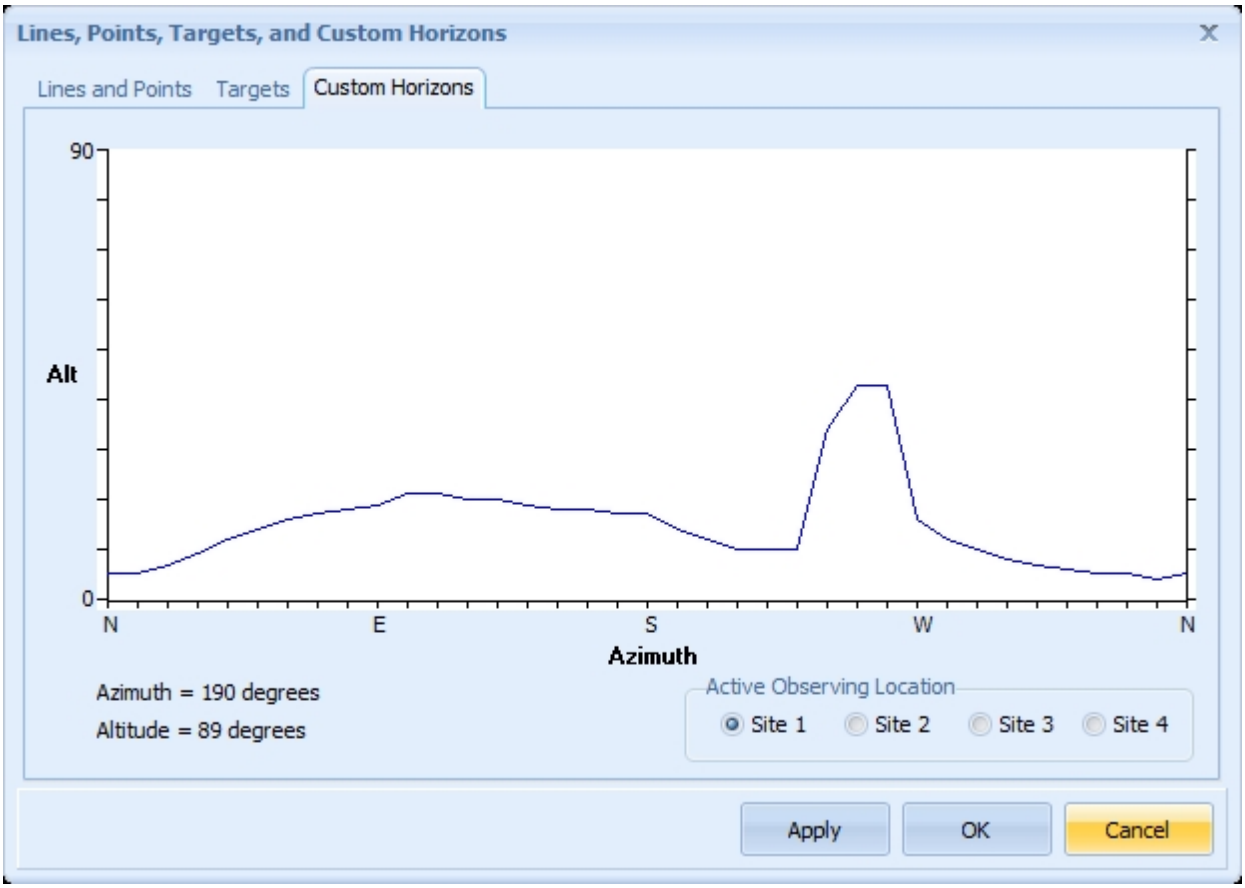
- **Clear Nearest Target** - clears the Target nearest to the current center of the **Sky Chart**.
- **Clear All Targets** - clears all Targets.

Place a Target

The **Place A Target** menu selection places a Target at the current center of the **Sky Chart**. The Target is placed according to the Default Target settings. Up to 100 Targets can by placed on the **Sky Chart**. If all 100 Targets have already been placed you will hear a "beep."

Custom Horizons...

The **Custom Horizons...** menu selection shows the **Custom Horizons** tab of the **Lines, Points, Targets, and Custom Horizons** dialog box. This tab allows the user to set the profiles of up to four custom horizon lines and to select which one is active. These profiles are intended to represent your local horizon considering obstructions (e.g. buildings, trees, etc.) at your observing sites.



The graph shown represents 0 to 350 degrees of azimuth (from North) at 10-degree steps. To set a horizon profile, first select one of the sites (Site 1 to Site 4), then place the mouse cursor over the graph. Press and hold the left mouse button as you drag it across the graph to set the horizon profile. You can do this as many times as you wish until the profile is set as desired. If you hold down the Control key as you drag the mouse, the custom horizon will be flat.

To display the active site, be sure to also enable the Custom Horizon in the **Lines/Points...** dialog box.

Labels...

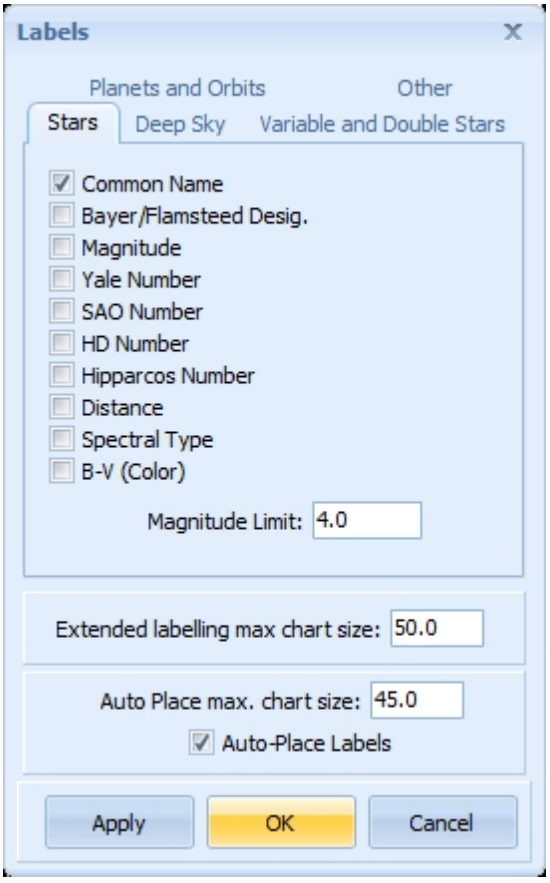
The **Labels...** menu selection shows a multi-tabbed dialog box that allows the user to control the display of all text labels. The label types are divided into five groups that are described separately below.

There are two settings that are common to most label types:

- the "Extended Labelling max chart size" sets the largest chart size for which extended labels are drawn. Extended labels include all labeling immediately to the left or right of an object. The purpose if this is to reduce the text "clutter" when "zoomed out", while maintaining the desired detail when "zoomed in".
- The **Auto Place Labels** check box determines whether or not most text labels are automatically placed to avoid overlapping text on the screen or a printed chart. A line is drawn between the moved text and the object that it pertains to. Screen updates can be quite a bit slower with this feature enabled, so "Auto Place max. chart size" is used to set a reasonable maximum chart size to auto-place labels.

Stars

Stars support a variety of labeling. The primary designation, which is drawn to the right of the star, can be either (or neither) its common name (for a select group of bright stars) or its Bayer/Flamsteed designation (either a Greek letter or a number). The Greek letters themselves are drawn. To the left of each star a variety of "extended" information can be drawn, separated commas, including the star's magnitude, Yale number, SAO number, HD number, Hipparcos number, distance, spectral type, and B-V color.

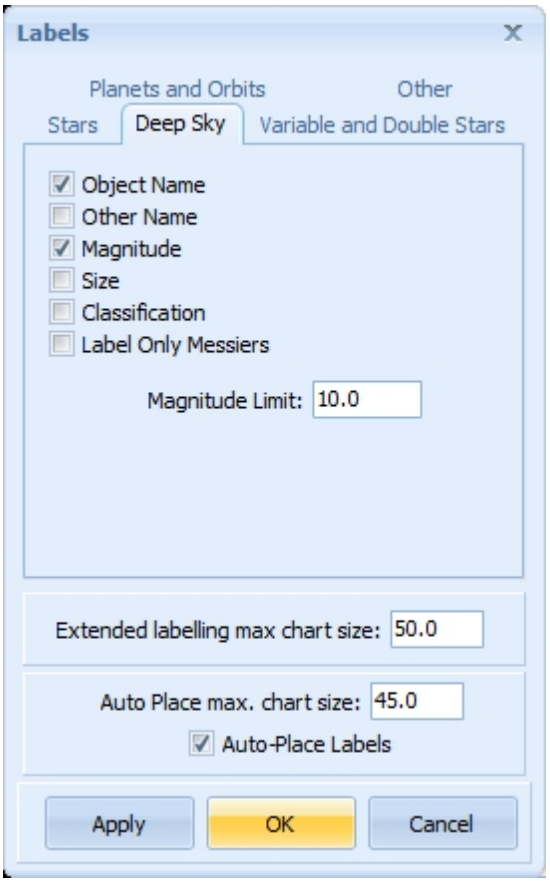


The "Magnitude Limit" field is used to set the faintest stars which will have their labels drawn (except for Bright Star labels).

Deep Sky

Deep Sky objects support a variety of labeling. The object's primary and other name, can be drawn to the

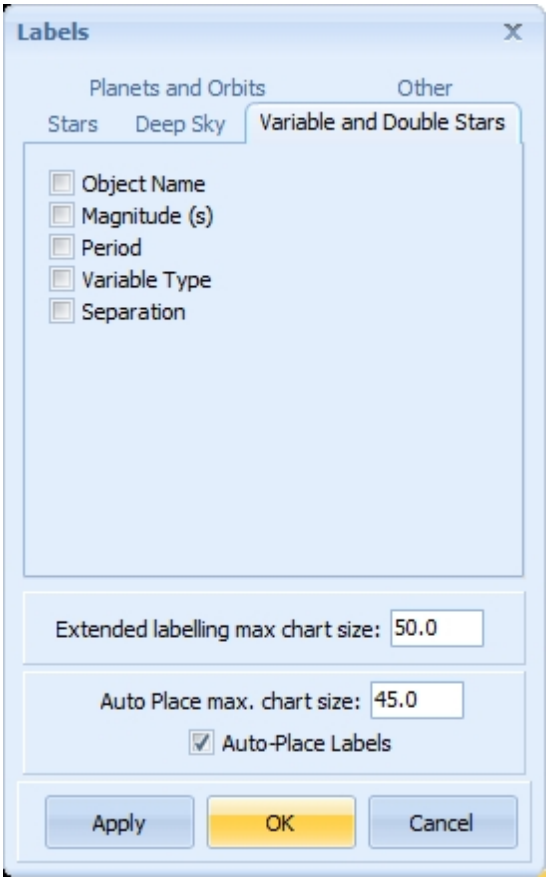
right of the object. To the left of each object a variety of "extended" information can be provided, separated by commas, including the object's magnitude, size, and classification.



When the **Label Only Messiers** check box is checked, labels will only be drawn for objects in the Messier Catalog. This dramatically reduces label "clutter", if you are only interested in those objects. The "Magnitude Limit" field is used to set the faintest objects which will have their labels drawn. If its set at magnitude 20, even labels for objects will unknown magnitudes will be displayed. These settings also apply to User Object labels in which only the **Object Name** and **Magnitude** check boxes are relevant.

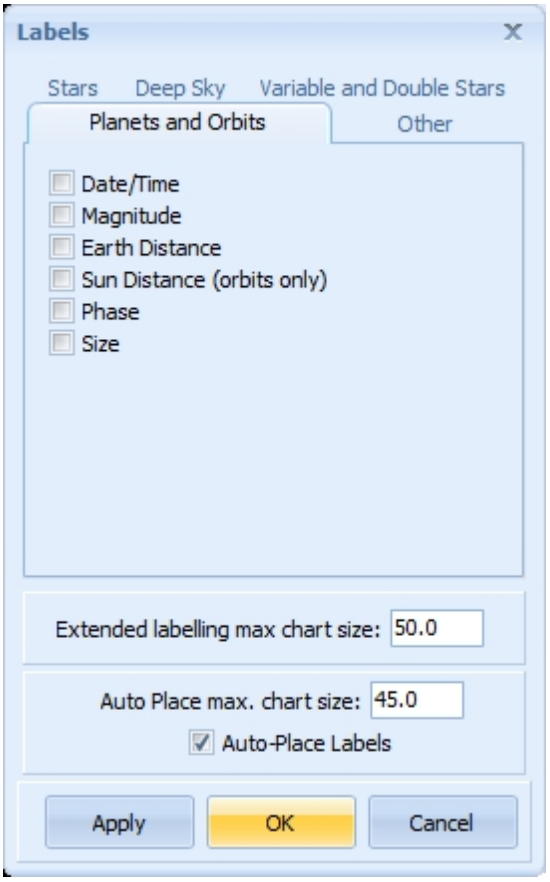
Variable and Double Stars

Variable and Double Stars support a variety of labeling. The star's name is drawn to the right of the object. To the left of each object a variety of "extended" information can be provided, separated by commas, including, for variable stars, the magnitude range, period, and variable type and for double stars, the magnitudes of the components and the separation.



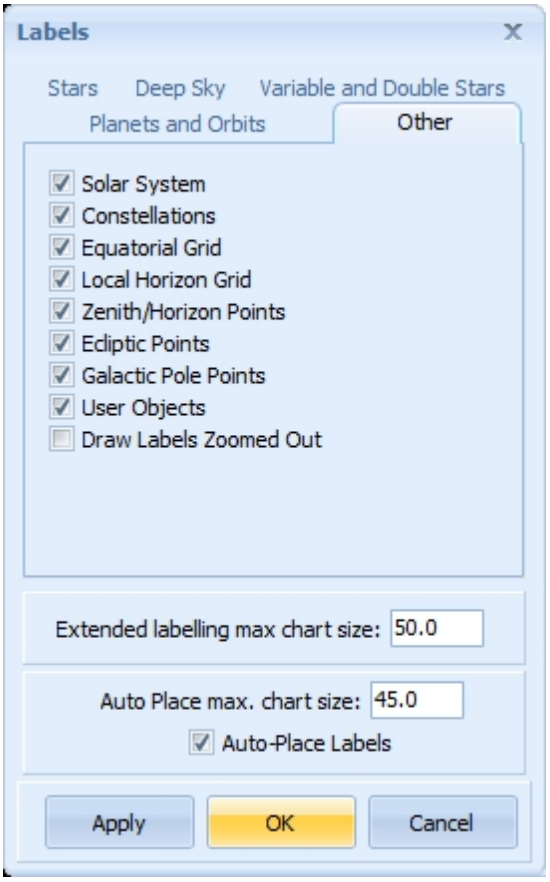
Planets and Orbits

Planets and Orbits support a variety of labeling. The object's name is drawn to the right of the object. To the left of each object a variety of "extended" information can be provided, separated by commas, including the current date and time, the object’s magnitude, distance to the Earth and Sun, phase, and size.



Other

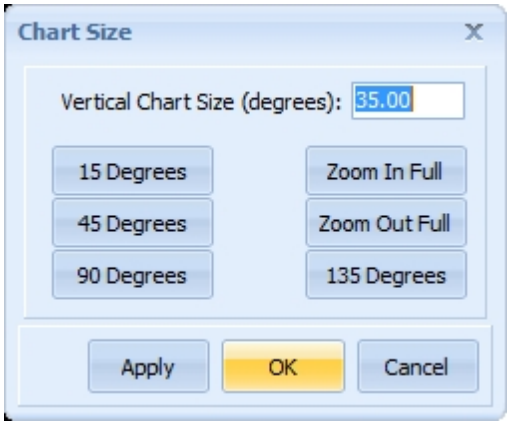
The ‘Other’ check boxes controlling whether the solar system, constellation, coordinate grid, zenith/horizon points (N,S,E,W, etc.), ecliptic points (VE - vernal equinox, SS - summer solstice, etc.), galactic pole points, and user object labels are to be drawn.



The check box **Draw Labels When Zoomed Out** controls whether the major labels are drawn when the chart size is larger than 60 degrees.

Chart Size...

The **Chart Size...** menu selection shows a dialog box allowing the user to enter the vertical chart size, in degrees. The valid range is 0.1 to 185 degrees. Six buttons provide easy access to pre-set chart sizes.



Zoom

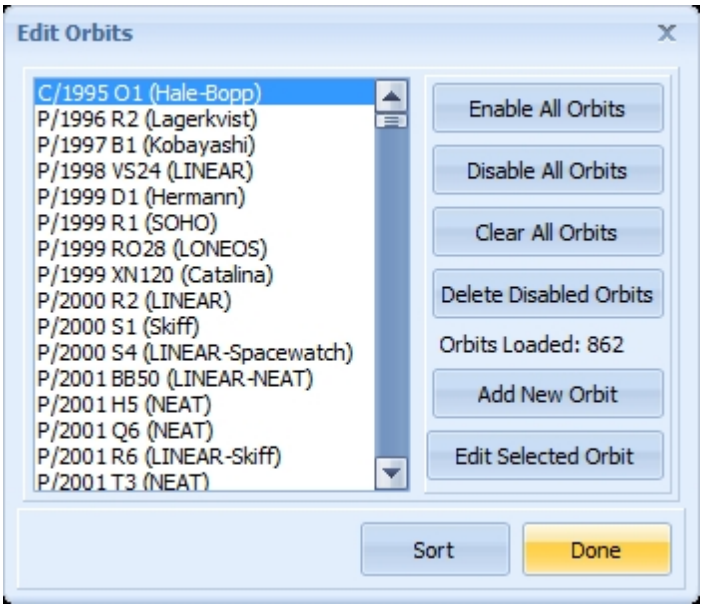
The **Zoom** menu selection shows a sub-menu allowing the **Sky Chart** to be Zoomed in or out to a variety of pre-determined chart sizes. These include Zoom In Full, which zooms in to the minimum allowable field size (0.1 degrees), 15 degrees, 45 degrees, 90 degrees, and Zoom Out Full, which zooms out to the maximum allowable chart size (185 degrees).

Orbits Menu

The **Orbits** menu provides access to all features relating to the comet and asteroid orbit databases. Each menu selection is described separately in the following sub-sections.

Edit Orbits...

The **Edit Orbits...** menu selection shows a dialog box allowing the management of the currently-loaded database of comet and asteroid orbital elements.



- **Enable All Orbits** - this button enables all orbits currently loaded. Enabling an orbit makes it visible on the **Sky Chart**.
- **Disable All Orbits** - this button disables all orbits currently loaded.
- **Clear All Orbits** - this deletes all orbits currently loaded.
- **Delete Disabled Orbits** - this deletes all orbits presently disabled. This is intended to be used after using Filter Orbits....
- **Add New Orbit** - pressing this button shows a new dialog box allowing a new comet or asteroid to be manually added to the currently-loaded database. See below.
- **Edit Selected Orbit** - select one of the comets or asteroids from the list box whose orbit you wish to change and press Edit Selected Orbit. See below.
- **Sort** - this button sorts the list of orbits alphabetically.
- **Done** - when finished editing or adding orbits press the **Done** button.

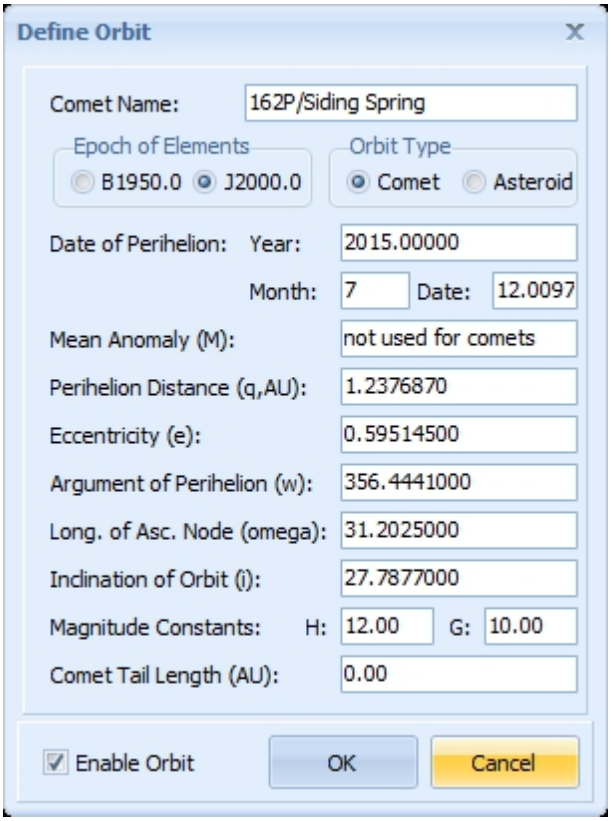
Adding or Editing Orbits

After pressing the add or edit buttons, a new dialog box is shown that allows orbital elements of a comet or asteroid to be edited.

- **Orbit Type** — select the type of orbit to be used; either comet or asteroid.
- **Comet or Asteroid Name** — a textual name that is displayed next to the comet or asteroid (maximum of 40 characters). When adding a new orbit, be sure to change the name from the default "Comet/Asteroid XXXX".
- **Date of Perihelion or Date of Epoch** — if the orbit type is ‘comet’, the date of perihelion is to

be entered here. If the orbit type is 'asteroid', then the date of the epoch is to be entered here. The date is entered as either decimal years or as year, month, and decimal days. If the month is set to zero, the decimal years are used and the month and date are ignored. If the month is valid (1 to 12), the year, month, and date are used.

- **Mean Anomaly (M)** — angle of an asteroid at the epoch in degrees. Not used for comet orbits.
- **Perihelion Distance (*q*) or Semi-major Axis (a)** — the distance of the comet from the Sun in astronomical units (AU) at Perihelion or the semi-major axis of the asteroidal orbit in AU.
- **Eccentricity (*e*)** — the eccentricity of the orbit from 0 to 5.
- **Argument of Perihelion (ω)** — the argument, in degrees, of the perihelion.
- **Longitude of Ascending Node (Ω) —** the longitude, in degrees, of the ascending node.
- **Inclination of Orbit (*i*) —** the inclination of the orbit in degrees.
- **Epoch of the Elements** — the epoch of the elements, either B1950.0 or J2000.0.
- **Magnitude Constants** — the magnitude constants H and G, are used to estimate the brightness of the comet or asteroid. Each comet or asteroid has a different set of constants. Comet brightness predictions are notoriously extremely unreliable.
- **Comet Tail Length** — the estimated length, in astronomical units (AU) of the comet's tail. Normally this value will be set to zero, however if it's set to a value greater than zero, ECU projects the tail onto **Sky Chart** in the correct direction (opposite the Sun) and the correct projected length. A good initial guess of a tail length is 0.1 AU. Not used for asteroids.
- **Enable Orbit** - this check box enables the orbit for display on the **Sky Chart**.

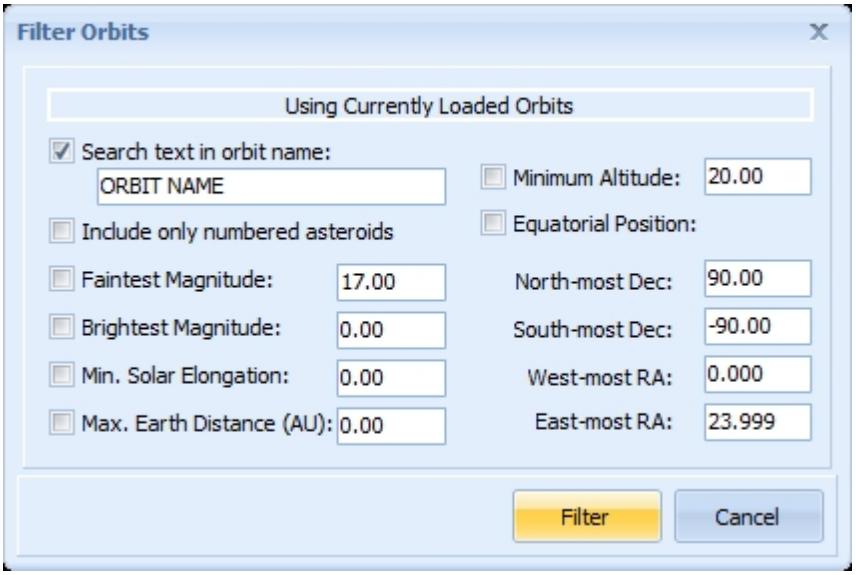


Filter Orbits...

The **Filter Orbits...** menu selection shows a dialog box allowing the user to search through the currently-loaded database of orbital elements in order to select (filter) orbits based on several criteria using the current date, time, and geographic location. These selected orbits are enabled for display and the rest are disabled. Note that the non-selected orbits are not deleted and remain in the database. They can be deleted in Edit Orbits...

There are seven criteria used for filtering, each preceded by check box that enables the criteria:

- **Search text in orbit name** — this criterion compares the name of the object with the text entered. If the text entered is contained within (full name or a subset of) the orbit name, then the object is selected. This comparison is case-insensitive.
- **Include only numbered asteroids** — this criterion limits the search to "numbered" asteroids. Practically, this just limits searches to orbits with names beginning with a "(" character, which is the common way numbered asteroids are named.
- **Faintest magnitude** — this criterion selects only objects whose magnitude is brighter than the value entered.
- **Brightest magnitude** — this criterion selects only objects whose magnitude is fainter than the value entered.
- **Minimum Solar Elongation** — this criterion selects only those objects whose angular distance from the Sun is greater than the value entered (in degrees).
- **Maximum Earth Distance** — this criterion selects only those objects that are closer to the Earth than the value entered (in astronomical units).
- **Minimum Altitude** — this criterion selects only those objects that are higher above the local horizon than the value entered (in degrees).
- **Equatorial Position** — this criterion selects only those objects in a region specified in the sky by right ascension (hours) and declination (degrees) coordinates.



Append New Orbits

The **Append New Orbits** menu selection toggles whether or not new orbits replace any orbits currently defined (un-checked) or if they append to the currently-loaded database (checked). This feature affects the operation of Load Orbits..., Download Orbits..., and Search Orbits....

Load Orbits...

The **Load Orbits...** menu selection loads orbital information for comets and asteroids from a file into ECU's active database. Up to 25,000 comets and asteroids can be active at any one time.

The file loaded will either replace any orbits currently loaded or will be appended to the currently-loaded orbits, depending on the state of the Append New Orbits setting.

The format of the file loaded is specific to ECU (see Orbit Files).

Save Orbits...

The **Save Orbits...** menu selection saves the currently loaded database of orbital elements. The format of the file saved is specific to ECU (see Orbit Files).

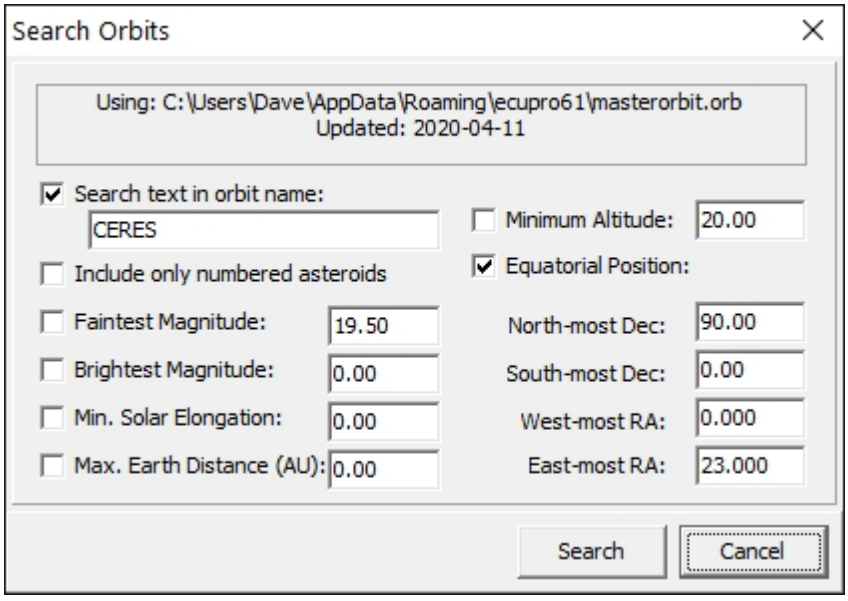
Search Orbits...

The **Search Orbits...** menu selection shows a dialog box allowing the user to search through **Master Asteroid Database** (downloaded in Download Orbits...) and select orbits based on several criteria using the current date, time, and geographic location.

These selected orbits with either replace any orbits currently-loaded or append to the currently-loaded database, depending on the state of the Append New Orbits item in the "Orbits" menu. Note that the search stops when 25,000 orbits have been selected (this is the maximum number of orbits that can be loaded at one time).

The top line in the dialog box shown below indicates the orbit database file being used and when it was last updated - this is normally the Master Asteroid file, but can be any other file in ECU Orbit File format. To change the file used, see Directory/File/Web Setup....

There are six criteria used for searching. A check-box precedes each criteria item. Each criteria is described below:

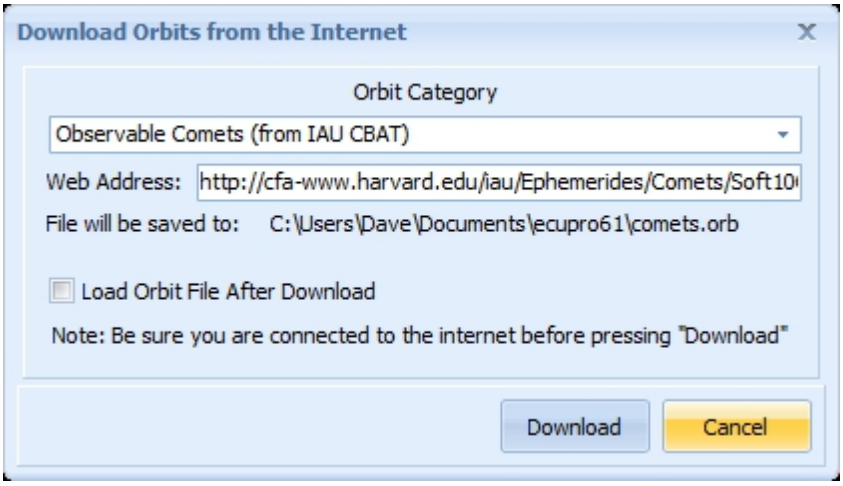


- **Search text in orbit name** — this criterion compares the name of the object with the text entered. If the text entered is contained within (full name or a subset of) the orbit name, then the object is selected. This comparison is case-insensitive.
- **Include only numbered asteroids** — this criterion limits the search to "numbered" asteroids. Practically, this just limits searches to orbits with names beginning with a "(" character, which is the common way numbered asteroids are named.
- **Faintest magnitude** — this criterion selects only objects whose magnitude is brighter than the value entered.
- **Brightest magnitude** — this criterion selects only objects whose magnitude is fainter than the value entered.
- **Minimum Solar Elongation** — this criterion selects only those objects whose angular distance from the Sun is greater than the value entered (in degrees).

- **Maximum Earth Distance** — this criterion selects only those objects that are closer to the Earth than the value entered (in astronomical units).
- **Minimum Altitude** — This criterion selects only those objects that are higher above the local horizon than the value entered (in degrees).
- **Equatorial Position** — this criterion selects only those objects in a region specified in the sky by right ascension (hours) and declination (degrees) coordinates.

Download Orbits...

The **Download Orbits...** menu selection shows a dialog box used to download up-to-date orbital elements of comets and asteroids from the Internet. The orbit files must be in ECU's Orbit File format.



The drop-down list provides several pre-determined sources of orbit data and three user-defined sources. The first four sources retrieve data from the **International Astronomical Union's Minor Planet Center** and provide data for currently observable comets, critical minor planets (asteroids whose orbits need more observations), near earth objects (NEOs) and unusual minor planets, and bright minor planets at opposition. For information about these data, see: http://www.minorplanetcenter.net/iau/Ephemerides/Soft10.html

The next two sources retrieve:

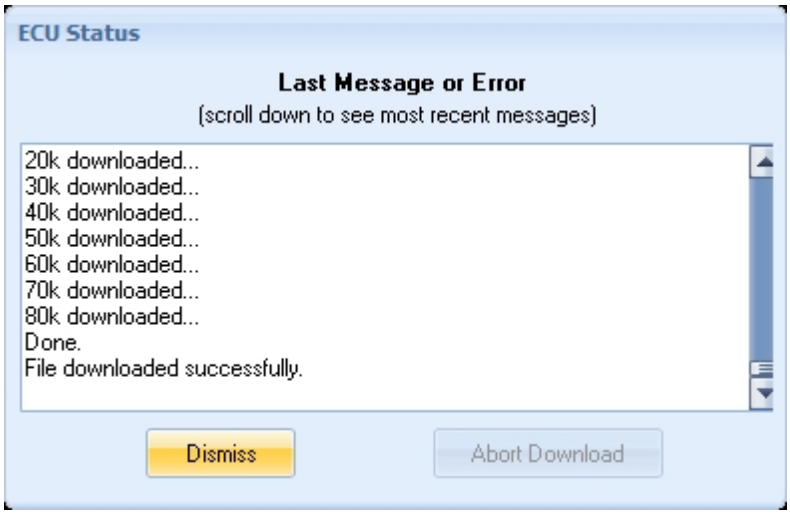
- the entire **Lowell Observatory Orbit Database** direct from Lowell Observatory - see https://asteroid.lowell.edu/main/astorb
- the entire **Minor Planet Center Orbit Database** from the International Astronomical Union's Minor Planet Center - see https://minorplanetcenter.net/data (first item)

These databases contain approaching 1 million asteroids (and are growing every day), therefore it can take **a very long time** to download. It is generally only necessary to update these files about every few months in order to obtain reasonably accurate asteroid positions. After these files are downloaded, they are converted into ECU's orbit format.

If you have trouble downloading these large databases from within ECU, you can download it separately in a web browser and then use the Convert Lowell Orbit File... or Convert MPC Orbit File... menu items to convert the downloaded file into ECU format.

To download data, select the "Orbit Category", note the Internet URL (http and ftp addresses are supported) address and make any necessary changes, note the location where the orbit file will be saved to, and press the **Download** button. Be sure you are connected to the internet before pressing **Download**.

An **ECU Status** box will appear which will show the progress of the download. You can abort the download using the **Abort Download** button. After the download has completed, press the **Dismiss** button.



To automatically load the orbit file into the active configuration after it has been downloaded (except for the Lowell Observatory database), check the **Load Orbit File After Download** check box before pressing the **Download** button. When the file is loaded, it will either replace any orbits currently defined or append to the currently-loaded database, depending on the state of the Append New Orbits item.

This feature depends on source data not provided by Nova Astronomics. Nova Astronomics can not provide any assurances that these outside agencies will continue to provide this data indefinitely. If these sources become unavailable, contact us and we may be able to provide an alternate source.

Convert Lowell Orbit File...

This menu selection is used to convert a Lowell Observatory Asteroid Elements database file downloaded directly from Lowell Observatory into ECU Orbit File format.

Convert MPC Orbit File...

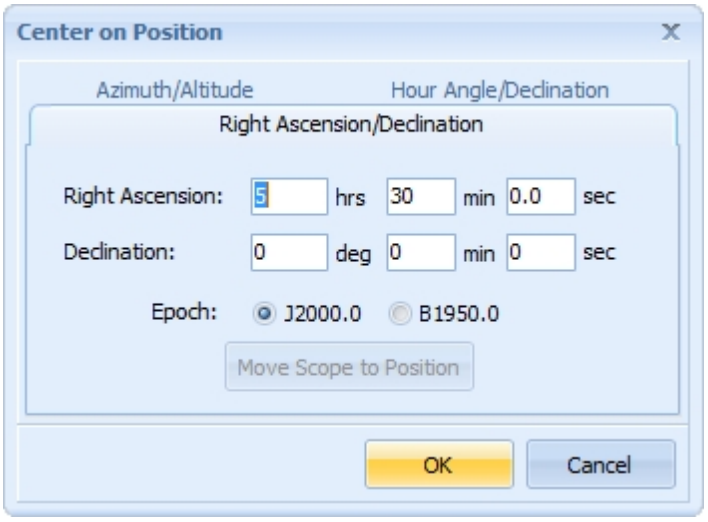
This menu selection is used to convert a IAU Minor Planet Center minor planet orbit database file downloaded directly from the Minor Planet Centre into ECU Orbit File format.

Center Menu

The **Center** menu allows the user to quickly center the **Sky Chart** by searching ECU's databases, several forms of coordinates, or from pre-programmed list of objects.

Right Ascension/Declination...

The **Right Ascension/Declination...** menu selection shows **Right Ascension/Declination** tab of the **Center on Position** dialog box. This allows the user specify a Right Ascension and Declination to center the **Sky Chart** on.

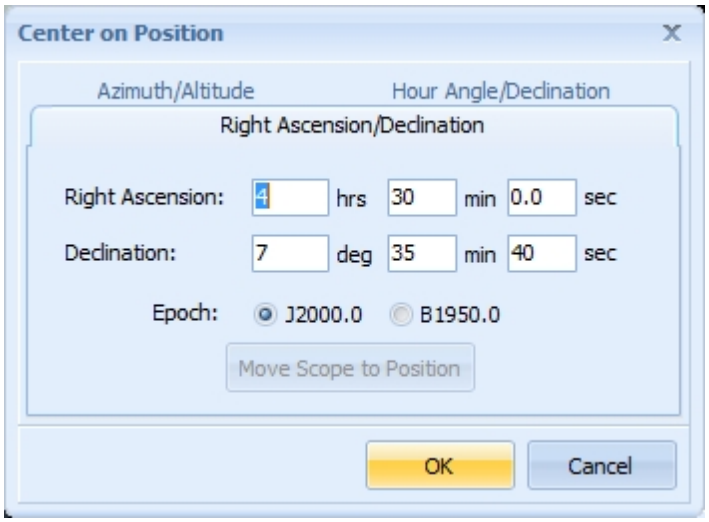


The Right Ascension is entered as integer hours, integer minutes, and seconds. The Declination is entered as integer degrees, integer minutes, and seconds.

In order to be more flexible, decimal hours (RA) or degrees (Dec) and decimal minutes are also accepted – in this case, set the minutes and seconds fields (as appropriate) to 0. Use the **Epoch** setting to specify the epoch of the coordinates.

Azimuth/Altitude...

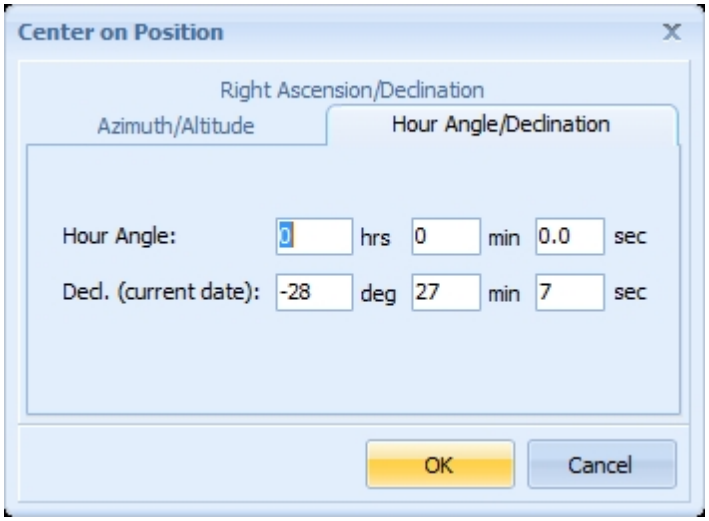
The **Azimuth/Altitude...** menu selection shows **Azimuth/Altitude** tab of the **Center on Position** dialog box. This allows the user specify an Azimuth and Altitude, with reference to the local horizon using the current date and time and geographic location, to center the **Sky Chart** on.



Both the Azimuth and Altitude are entered as integer degrees, integer minutes, and decimal seconds. In order to be more flexible, decimal degrees and decimal minutes are also accepted – in this case, set the minutes and seconds fields (as appropriate) to 0.

Hour Angle/Declination...

The **Hour Angle/Declination...** menu selection shows **Hour Angle/Declination** tab of the **Center on Position** dialog box. This allows the user specify an Hour Angle and Declination to center the **Sky Chart** on. Hour Angle is the number of hours that a location is west of the meridian.

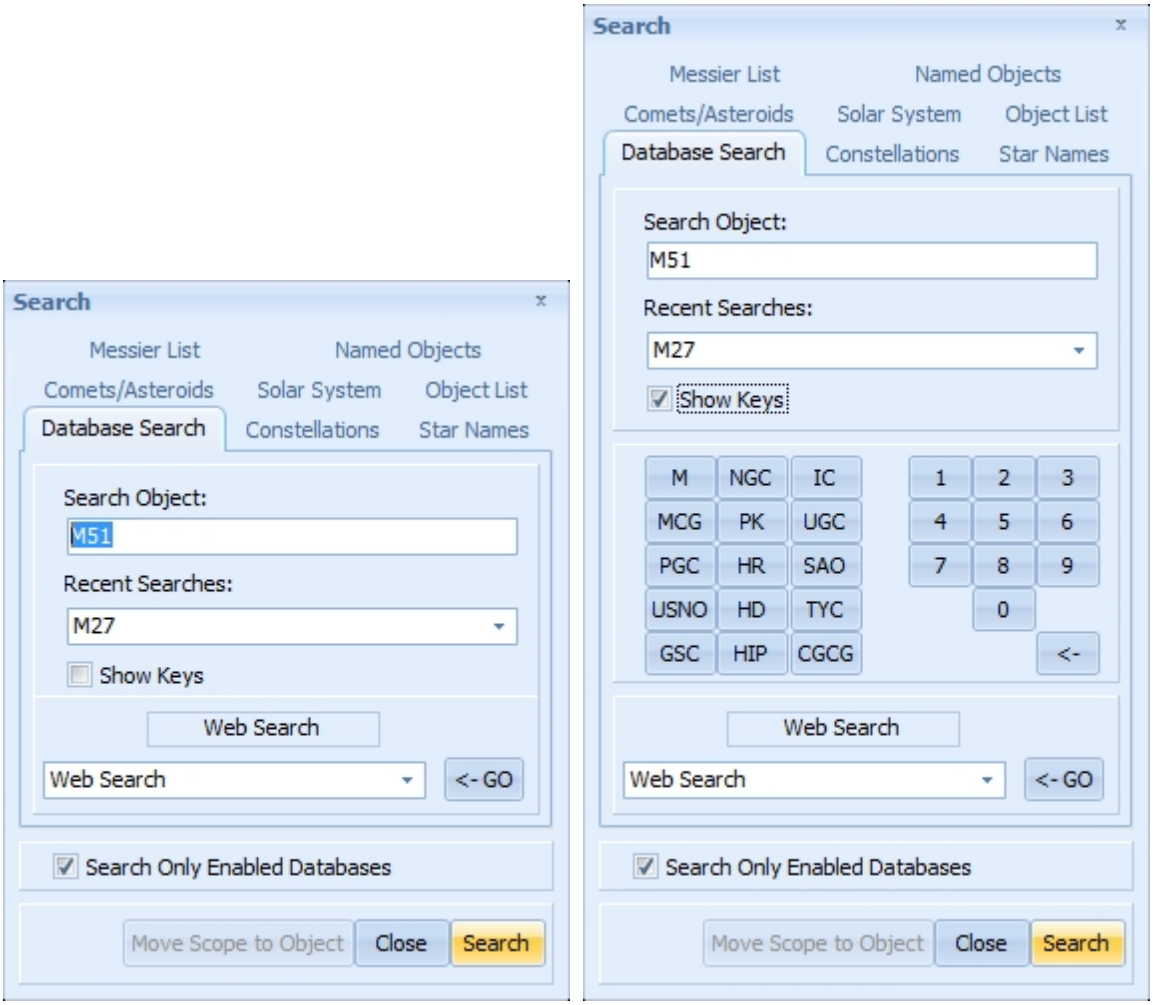


The Hour Angle is entered as integer hours, integer minutes, and decimal seconds. The Declination is entered as integer degrees, integer minutes, and decimal seconds. The position is interpreted as being in the Epoch of the current date and precessed to Epoch J2000 before being used.

In order to be more flexible, decimal hours (HA) or degrees (Dec) and decimal minutes are also accepted – in this case, set the minutes and seconds fields (as appropriate) to 0.

Database Search...

The **Database Search...** menu selection shows, at the upper right corner of the ECU main window, the **Database Search** tab of the **Search** dialog box. Unlike most other dialog boxes, the Search dialog can be left displayed as long as the user wants.



To search, enter the name of the object in the "Search Object" field.

There are several keyboard shortcuts for commonly entered objects — specifically "N" is equivalent to "NGC", "U" is equivalent to "UGC", "I" is equivalent to "IC", and "S" is equivalent to "SAO". Therefore typing "N3434" is equivalent to typing "NGC3434". The line of text entered is converted to upper case to avoid ambiguities and all spaces are removed before the search is started.

The last 10 searches are saved, which you can select them using the "Recent Searches" drop-down list.

The **Show Keys** check box makes the dialog box larger and shows a grid of buttons that can be used to enter common search objects using the mouse instead of the keyboard. This may make searching easier when ECU is used at the telescope.

The **Search Only Enabled Databases** check box, near the bottom of the dialog box, restricts the search to only those object types or databases enabled for display (typically as set by the settings in the Chart menu).

When the **Search** button is pressed, a search of ECU's databases commences and if successful, the screen is redrawn with the object at the center of the **Sky Chart**. If the **Move Scope to Object** button is pressed, the telescope (if enabled) is centered on search object. If the search is not successful, a message box will appear informing the user of this.

The object types that can be searched are listed below:

- **Constellations** — the 88 constellations can be searched by entering their complete formal name (e.g. ‘Ursa Major’).

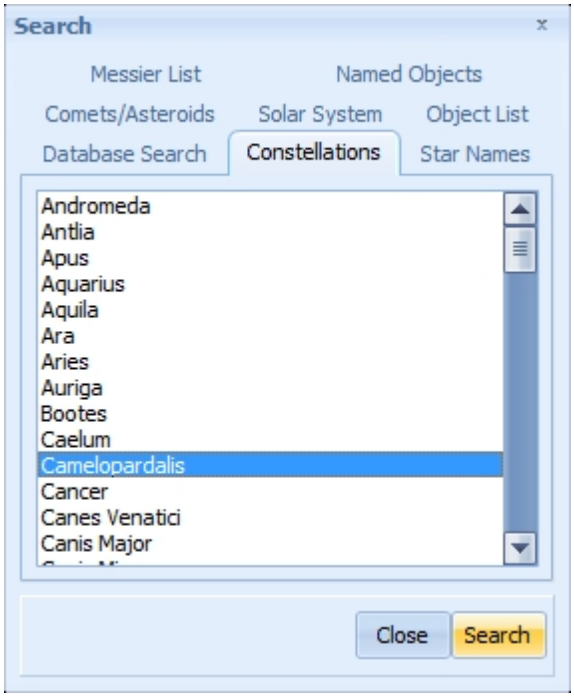
- **Common Star Names** — bright stars can be searched by entering their common name (e.g. ‘Deneb’).
- **Solar System Objects** — the Sun, Moon, and major Planets can be searched by entering their name (e.g. ‘Saturn’).
- **Comets and Asteroids** — are searched by name. Their full names can be shorted such that, for example:
  - Comet "C/2015 W1 (Gibbs)" can be found using its designation "C/2015W1"
  - Comet "127P/Holt-Olmstead" can be found using just "127P"
  - Asteroid "(117032) Davidlane" can be found using either "(117032)" or "Davidlane"
  - Asteroid "(164221) 2004QE20" can be found using either "(164221)" or "2004QE20"
- **Stars by catalog number** — any star in the Yale Bright Star (YBSC) database can be searched by entering its Smithsonian Astrophysical Observatory (SAO) catalogue number with the prefix ‘SAO’, its Yale number with the prefix ‘HR’, or its Henry Draper (HD) catalogue number with the prefix ‘HD’. For example, to find the SAO star number 49898, enter ‘SAO49898’. Note that entering ‘sao 49898’ would be just as effective because the case of the input and spaces are ignored.
  - When searching for SAO stars, if a search of the brighter YBSC database is unsuccessful, the search continues using the SAO database.
  - Tycho-2 stars are searched by the TYC prefix, the region number (4 digits), and star number (6 digits), for example: "TYC 0296 01051 1". Many Tycho-2 stars also can be found by their HIP or HD numbers.
  - Hubble Guide Stars are searched by entering the GSC prefix, the region number (5 digits), and star number (5 digits), for example: "GSC 00057 00050".
  - US Naval Observatory stars cannot be searched.
- **Stars by Bayer Letter —** the brightest stars in the Yale Bright Star (YBSC) database can be searched by their Bayer Letter designation.
  A prefix of "B" is used, plus a three letter abbreviation for the Greek Letter and then finally the three letter "standard" abbreviation for the constellation. For example, to search for Beta Bootes, "b bet boo" would be entered. Capitalization and spacing are not important.
- **Stars by Flamsteed Number —** the brightest stars in the Yale Bright Star (YBSC) database can be searched by their Flamsteed Number. A prefix of "F" is used, plus the Flamsteed number and then finally the three letter "standard" abbreviation for the constellation. For example, to search for (4) Corona Borealis, "f 4 crb" would be entered. Capitalization and spacing are not important.
- **Deep Sky Objects** — deep sky objects can be searched by entering either their primary name or ‘Other Names:’ as stored in the SAC deep sky database (see Section 4.), by any of the up to five catalog numbers available for PGC galaxies, or by any of the three catalog numbers available for Wallace-SEC planetary nebulae. For example, the Andromeda Galaxy can be found by entering either its official name ‘NGC224’ or its common name ‘M31’.
- **Variable Stars** — variable stars can be searched by entering the variable star designation, such as "AL Gem" or "V1024 Ori". With numbered variable stars, it is important to use 4 digits for the number after the V.
- **Double Stars** — double stars can be searched by entering the discoverer designation, such as "STF 1744".
- **User Objects** — user objects can be searched by entering the text associated with the objects "comment" field.
- **RA/Dec Position** — you can search for a specific equatorial position in the following format. The search string needs to start with # and be followed by the right ascension, a comma, then the declination. The RA can be either a decimal number or hours:minutes or hours:minutes:seconds. The Dec can be either a decimal number or degrees:minutes or degrees:minutes:seconds. Eg: #12:10:37.1,-5:50:01

Web Search

Six different types of web searches can also be invoked. Enter the search text, select the desired type of web search using the drop-down list and then press the **GO** button. A web-browser window will appear with the result of the search. You must be connected to the Internet to use this feature. For a description of the available web searches, see Internet Features.

Constellation...

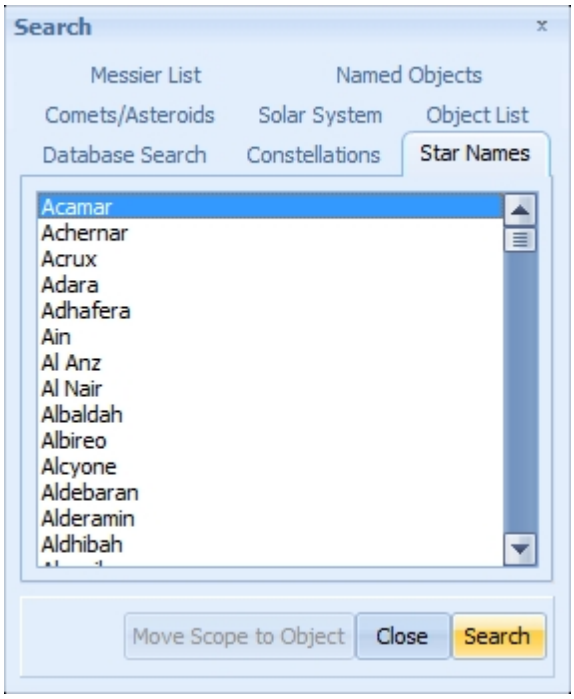
The **Constellations...** menu selection shows, at the upper right corner of the ECU main window, the **Constellations** tab of the **Search** dialog box. Unlike most other dialog boxes, the Search dialog can be left displayed as long as the user wants.



Select the desired constellation from the list of 88 constellations shown in alphabetical order and either double-click the mouse or press the **Search** button. ECU will center the **Sky Chart** on the selected constellation. The size of the chart is not changed, so you may have to zoom out to see the whole constellation.

Star Name...

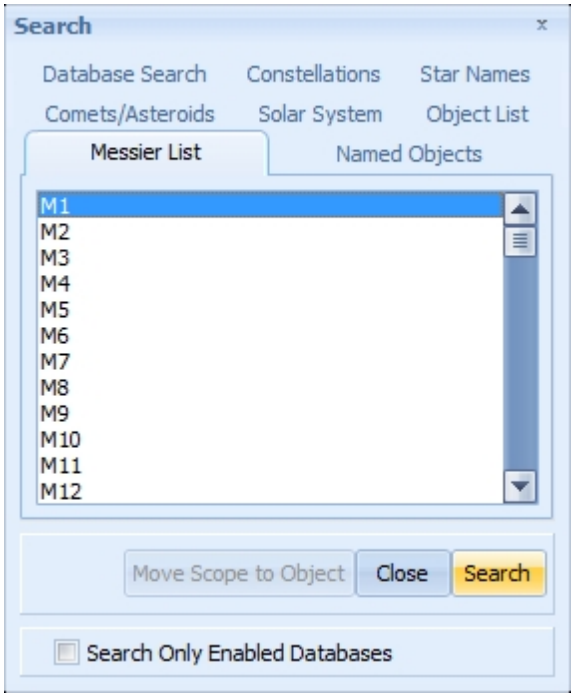
The **Star Name...** menu selection shows, at the upper right corner of the ECU main window, the **Star Names** tab of the **Search** dialog box. Unlike most other dialog boxes, the Search dialog can be left displayed as long as the user wants.



Select the desired constellation from the list of star names shown in alphabetical order and either double-click the mouse or press the **Search** button. ECU will center the **Sky Chart** on the selected star.

Messier List...

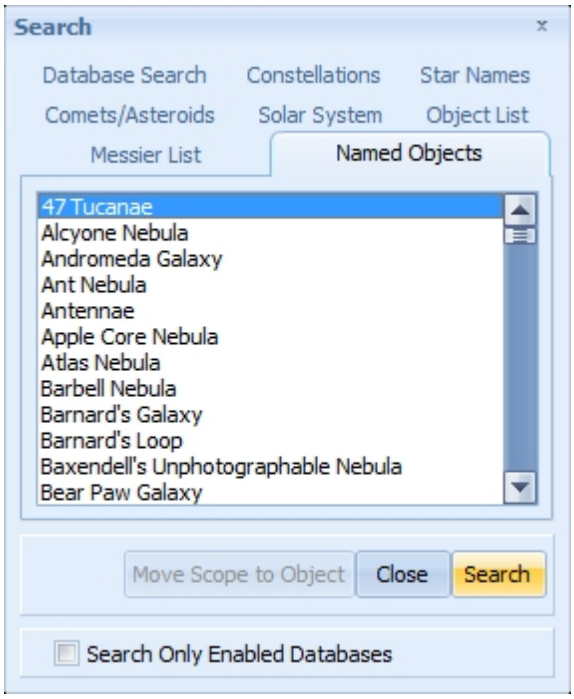
The **Messier List...** menu selection shows, at the upper right corner of the ECU main window, the **Messier List** tab of the **Search** dialog box. Unlike most other dialog boxes, the Search dialog can be left displayed as long as the user wants.



Select the desired Messier object from the list of 110 objects shown in numerical order and either double-click the mouse or press the **Search** button. ECU will center the **Sky Chart** on the selected object.

Named Object...

The **Named Object...** menu selection shows, at the upper right corner of the ECU main window, the **Named Objects** tab of the **Search** dialog box. Unlike most other dialog boxes, the Search dialog can be left displayed as long as the user wants.



Select the desired object from the list shown in alphabetical order and either double-click the mouse or press the **Search** button. ECU will center the **Sky Chart** on the selected object.

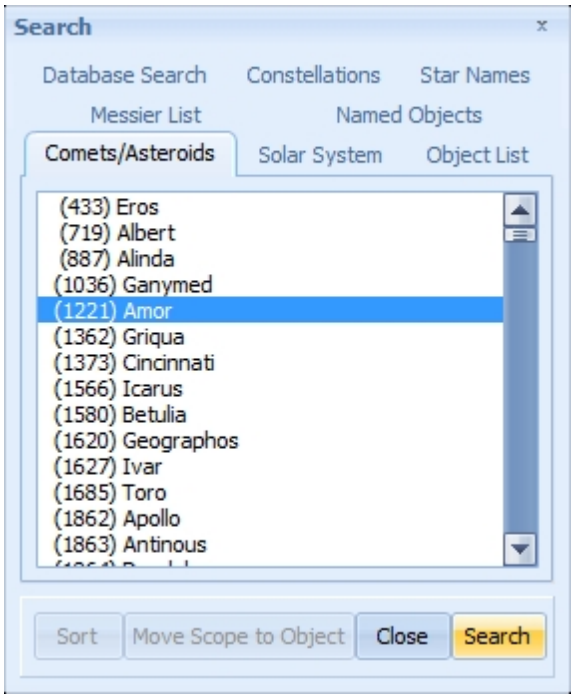
Most of the deep sky objects with common names are included, however advanced users can add you own favorites to the list. The list is stored in a plain text file called "DSNAMES.ECU" and is formatted as shown by the following sample entries below. You can edit this file in any text editor, such as the Windows "Notepad".

```
47 Tucanae                                NGC104
Andromeda Galaxy                          M31
Antennae                                  NGC4038
Barbell Nebula                            M76
Barnard's Galaxy                          NGC6822
```

The first entry on each line is the common name. The second entry is another name by which the object is known as, usually an NGC or M catalog number. This other name must begin at column 41 (inline with all the others) and be searchable in ECU's databases.

Comet/Asteroid...

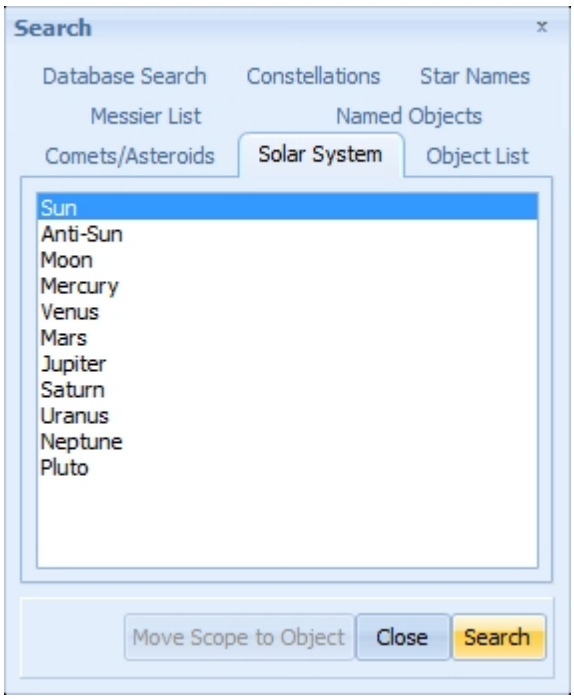
The **Comet/Asteroid...** menu selection shows, at the upper right corner of the ECU main window, the **Comet/Asteroids** tab of the **Search** dialog box. Unlike most other dialog boxes, the Search dialog can be left displayed as long as the user wants.



The list of comets and asteroids is shown in the order they were loaded into the orbit database. Pressing the **Sort** button sorts them into alphabetical order (numbers first). Select the desired comet or asteroid from the list and either double-click the mouse or press the **Search** button. ECU will center the **Sky Chart** on the selected object.

Solar System Object...

The **Solar System...** menu selection shows, at the upper right corner of the ECU main window, the **Solar System** tab of the **Search** dialog box. Unlike most other dialog boxes, the Search dialog can be left displayed as long as the user wants.



Select the desired object from the list and either double-click the mouse or press the **Search** button. ECU will center the **Sky Chart** on the selected object.

Object from List...

The **Object From List...** menu selection shows, at the upper right corner of the ECU main window, the **Object From List** tab of the **Search** dialog box. Unlike most other dialog boxes, the Search dialog can be left displayed as long as the user wants.

Object List Introduction

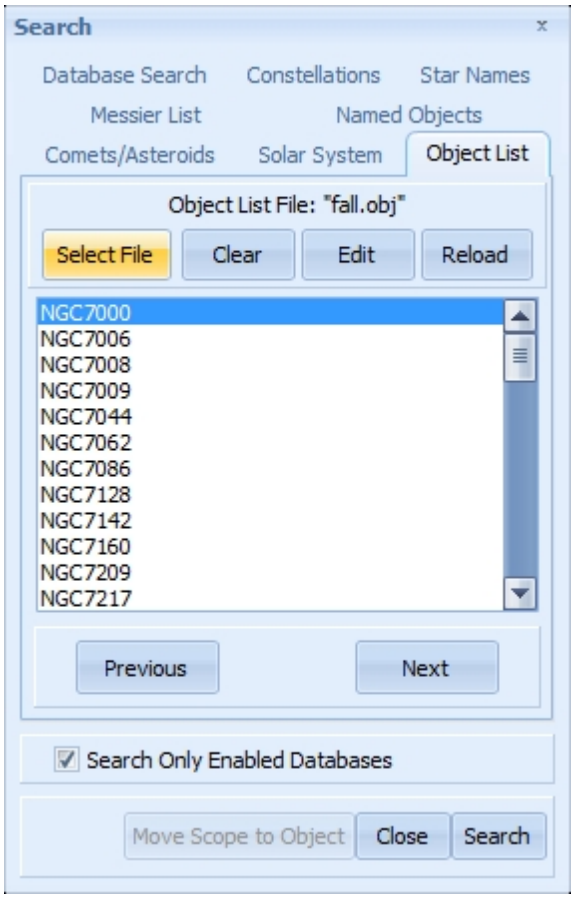
Object List files are text files that contain lists of objects that can be searched in the database. Object List files have the extension ".obj" by default and are easily created and edited any text editor such as the Windows Notepad program.

A sample file is shown below:

```
; an example object list file
M31 ; the andromeda galaxy
NGC7331
HR 345
Albireo ; a nice double star
#5.54,-34.45 ; RA=5.54h Dec=-34.45d
#10:05:01,+35:10:12 ; RA=10h05m01s Dec=+35d10m,12s
```

All lines beginning with a semi-colon are ignored — that is, they are comments. If a semi-colon occurs on an object line, the rest of the line is considered a comment, and is ignored. Lines beginning with a "#" character are used to specify a position in right ascension and declination (in decimal format or in hour:minute/ hour:minute:second and degree:minute/degree:minute:second format) separated by a comma.

Several Object List files are provided with ECU. "MARATHON.OBJ" lists of the messier objects in a convenient order for completing a messier marathon (in March, it is possible from northern latitudes to observe most of the 110 messier objects in one night). "FALL.OBJ", "WINTER.OBJ", SPRING.OBJ", and "SUMMER.OBJ" are four files contained the respective season's "Herschel-400" deep sky objects.



List Management Buttons

- The **Select File** button is used to choose an a object list file to use. The list box below will display the objects contained in the file once loaded.
- The **Clear** button is used to clear the currently-loaded object list file.
- The **Edit** button is used to edit the current object list file. If none has been selected a new file called "new.obj" is used. The default text editor is used to edit the file, unless one was specified in Directory/File/Web Setup...
- The **Reload** button reloads the current file - use this if you have made changes to the file.

Selecting Objects

Select a specific object in the currently-loaded list by selecting it. You can search and center the selected object by either double-clicking the mouse or by pressing the **Search** button.

Advance to the next object with the **Next** button. If already at the last object in the list, it will loop back to the first object.

Reverse to the previous object with **Previous** button. If already at the first object in the list, the last object in the list will be used.

Direction

The **Direction** menu selection contains a sub-menu of all the cardinal points on the local horizon plus the Zenith (the overhead point). If a cardinal point menu item is selected, the **Sky Chart** is centered in that direction with an altitude of one-half the current chart size (this puts the horizon along the bottom of the chart when in Local Horizon mode). If the chart size is greater than 90 degrees, it is set to 90 degrees.

If "Zenith" is used the **Sky Chart** is centered at the current overhead point.

Current Telescope Position

The **Current Telescope Position** menu selection causes the **Sky Chart** to be centered at the current telescope position. It does not move the telescope.

Animation Menu

The **Animation** menu controls all functions of ECU's animation mode. The animation mode is used to simulate astronomical events that are affected by changes in the time. The animation mode has the following features.

- the time step size can be from 1 second to 4 years or any arbitrary number of seconds, minutes, hours, months, days, or years.
- the time can be stepped in either forward or reverse.
- the time between screen updates can be set from 0 to 60 seconds. The maximum speed at which animations can run is dependent on the complexity of the **Sky Chart** and the speed of your computer. To optimize for the maximum frame rate, turn off any objects and features you don't need (e.g. deep sky objects, grids, un-needed orbits, labels, etc.). You can experiment with how various elements affect the speed by enabling animation mode and turning things off and on.
- solar system objects can be trailed with dots and/or lines drawn behind them. Text labels that include the date and/or time can also be displayed. Trails for comets and asteroids are limited to the first 1,000 orbits.
- the number of steps used in the trail can be set from 10 to 500.
- the trail history can be stored as either the object's Right Ascension/Declination or it's Azimuth/Altitude.
- the **Sky Chart** center can be made to 'lock' on any solar system object, or point with reference to the local horizon.
- the time can be manually stepped, either forward or in reverse.
- all of the features of ECU can be used while the animation mode is running due. Animation is paused, however, when you are using the mouse to select a new field size or drag to a different position.

Animation mode is best learned by experimentation; however, the menu items which control the animation mode are described in the following sections.

Start

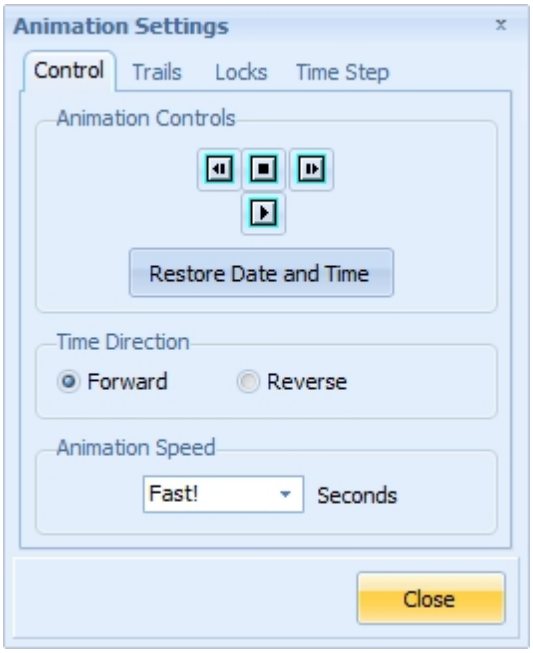
The **Start** menu selection starts the animation mode.

Stop

The **Stop** menu selection stops the animation mode. The ESC key can also be used to stop the animation mode.

Control...

The **Control...** menu selection shows, at the upper right corner of the ECU main window, the **Control** tab of the **Animation Settings** dialog box. This tab controls starting, stopping, manual time changes, and other parameters of the Animation Mode. Unlike most other dialog boxes, this dialog can be left displayed as long as the user wants.



Animation Controls

Four buttons from top left do the following:

- Steps the time backward by one time step.
- Stops animation mode.
- Stops the time forward by one time step.
- Starts animation mode.

The **Restore Date and Time** button restores the date and time to what it was prior to the last time the animation mode was started or the last time this button was pressed. This feature is useful for experimenting with the animation mode without having to keep resetting the time back manually again and again.

Time Direction

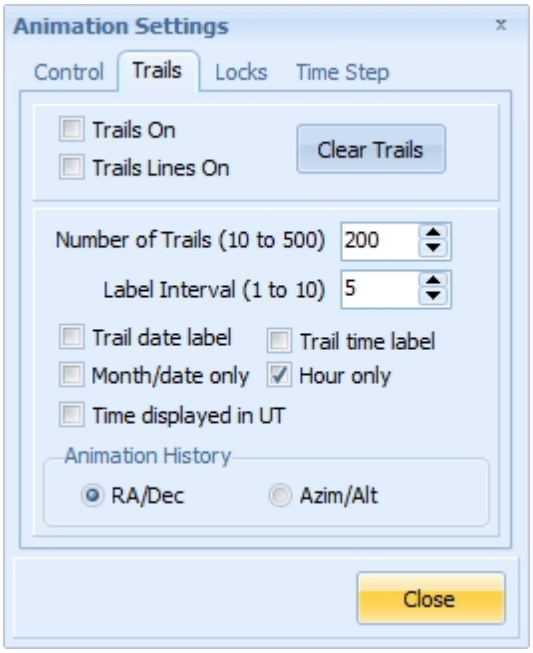
The **Time Direction** radio buttons, **Forward** and **Reverse**, control the direction in which time is stepped when the animation mode is running.

Animation Speed

The animation update speed (the interval between **Sky Chart** updates) can be set to one of several pre-set speeds (0 to 60 seconds). The "Fast!" speed will cause the **Sky Chart** to be drawn as fast as your computer can!

Trails...

The **Trails...** menu selection shows, at the upper right corner of the ECU main window, the **Trails** tab of the **Animation Settings** dialog box. The Trails tab controls a number of parameters relating to the trail crosses and trail lines that show the path of Solar System objects. Unlike most other dialog boxes, this dialog can be left displayed as long as the user wants.



Trail Controls

The **Trails On** check box enables the drawing of trails (small crosses) that show the path of Solar System objects in the sky.

The **Trails Lines On** check box enables the drawing of trail lines that show the path of Solar System objects in the sky.

The **Clear Trails** button clears the current trail history and removes any existing trail crosses or lines.

Trail Settings

The following trail settings can be controlled:

- **Number of Trails** — sets the maximum number of trail crosses and/or trail lines.
- **Label Interval** — set the spacing of the date/time labels drawn next to a trail cross or trail line intersection. Adjusting this setting allows the user to control the amount of clutter caused by the date/time labels.
- **Trail date label** — this check box controls whether or not the date is included in the date/time labels.
- **Month/date only** — checking this item eliminates the year from the date labels.
- **Trail time label** — this check box controls whether or not the time is included in the date/time labels.
- **Hour only** — checking this item eliminates the minutes from the time labels.
- **Time displayed in UTC** — checking this item causes the date/time labels to be in Universal Time rather than local time.

Animation History

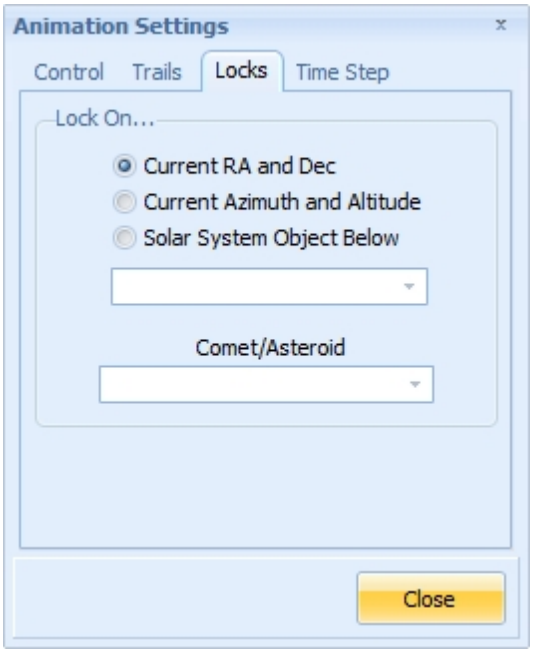
The Animation History setting, **RA/Dec** and **Azim/Alt**, control whether the animation history (the previous positions) is saved as the Right Ascension and Declination of the object or as the Azimuth and Altitude with reference to the local horizon. The latter setting is useful for observing an object's path relative to the local horizon.

A good example of this would be to plot the positions of the planet Mercury as it passes through an eastern

or western elongation and becomes visible in the evening or morning sky. Beware, however, that the actual positions shown in the object trails (except for the current position) are **not** correct with reference to the background stars for the time shown. Also, this setting operates slower, because the computational overhead is higher. For normal use, ensure that this setting is set to **RA/Dec**.

Locks...

The **Locks...** menu selection shows, at the upper right corner of the ECU main window, the **Locks** tab of the **Animation Settings** dialog box. The selected lock position or object becomes "locked" to the center of the **Sky Chart** as the time changes. Unlike most other dialog boxes, this dialog can be left displayed as long as the user wants.



Current RA and Dec

Selecting the **Current RA and Dec** radio button causes the animation mode to be locked on the current Right Ascension and Declination. In practice, this in fact turns locking off.

Current Azimuth and Altitude

Selecting the **Current Azimuth and Altitude** radio button causes the animation mode to be locked on the current altitude and azimuth, with respect to the local horizon. This feature is very useful for 'watching' a particular horizon as the constellations rise or set, or as a planet such as Mercury crests above the horizon.

Selecting this lock-mode effects two other program behaviors:

- When Using your PC's Clock Time is active, at each-minute time update the **Sky Chart** to remains centered at the current altitude and azimuth instead of the current equatorial position.
- When a configuration file is loaded with this lock mode enabled, the **Sky Chart** is centered on the Altitude and Azimuth in effect when the configuration file was saved instead of the Right Ascension and Declination saved in the file.

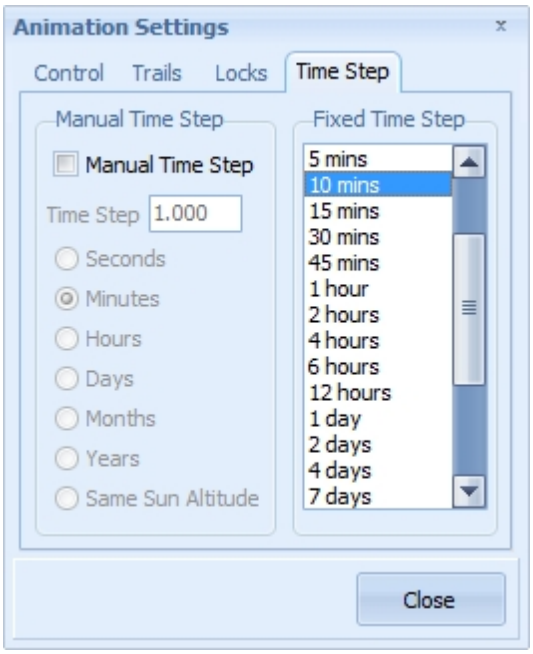
Solar System Objects

Selecting the **Solar System Object Below** radio button allows the lock object to be set to any major Solar

System object (Sun, Anti-Sun, Moon, or Planets) or any enabled comet or asteroid.

Time Step...

The **Time Step...** menu selection shows, at the upper right corner of the ECU main window, the **Time Step** tab of the **Animation Settings** dialog box. This tab the time step to set from one of the pre-set "fixed" time steps or to enter an arbitrary "manual" time step. Unlike most other dialog boxes, this dialog can be left displayed as long as the user wants.



Fixed Time Step

To set a pre-set time step, uncheck the **Manual Time Step** check box, then select a time step from the list box.

Manual Time Step

To set an manual (arbitrary time step), check the **Manual Time Step** check box, then select one of the time unit radio buttons (Seconds, Minutes, etc.), then enter the desired step size as a number (decimals are allowed).

A special time step called "Same Sun Altitude" causes a time step to the next or previous day when the Sun is at the same altitude. This is handy for simulating events that take place near the time of sunrise/set.

Telescope Menu

The **Telescope** menu provides access to all telescope functions. This section serves as a reference for the telescope menu selections. See Using the Telescope Interface for detailed telescope interface operating instructions.

Enable Telescope Interface

The **Enable Telescope Interface** menu selection initiates or terminates communication with the computerized telescope or interface box connected to your computer's RS232 port or controlled via an ASCOM (AStronomy Common Object Model) driver. This menu selection can also be accessed using its **Tool Bar** button.

If you are using an ASCOM-controlled telescope and/or focuser any connection errors are displayed within an "ECU Status" window that appears whenever an ASCOM error occurs.

For non-ASCOM hardware, if an error occurs, a message box will appear on the screen explaining the error. The first possible error will occur if ECU cannot open the communications port. If this error occurs, make sure that you have selected a port that exists and is not in use by another program running on your system. The second possible error occurs if ECU cannot communicate with the telescope interface. If this error occurs, make sure the telescope interface is properly configured and is connected properly and turned on. **Some telescope interfaces also need to have their serial port enabled** and in some cases be "aligned" before they will respond to commands.

Depending on the telescope or interface type either one or two windows (coordinate and control boxes) may appear and a cross-hair may be drawn on the **Sky Chart** to show the telescope's current sky location.

If the Telescope Interface is enabled, selected this menu item again will disable it.

Move Telescope to Chart Center

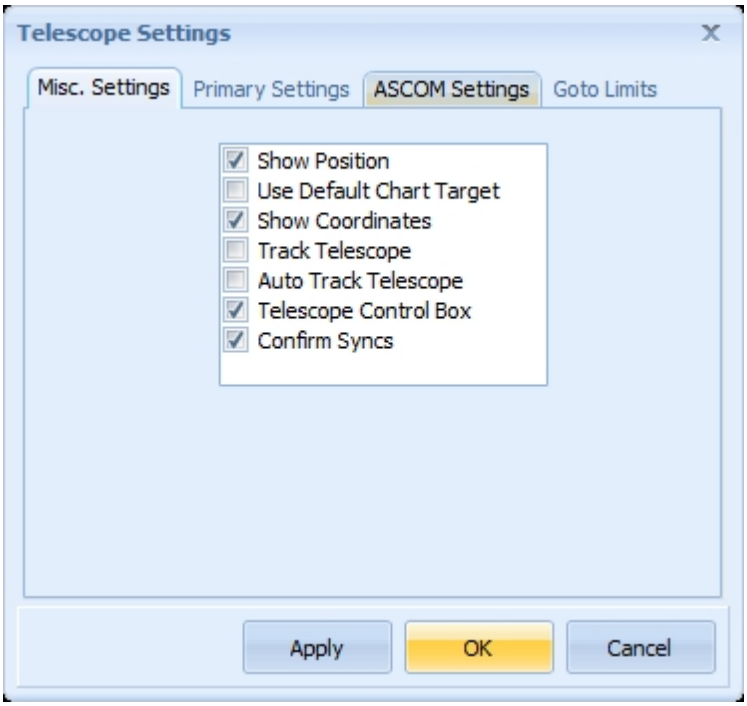
The **Move Telescope to Chart Center** menu selection causes the telescope to be moved to or guided to the position occupied by the center of the **Sky Chart**. The keyboard equivalent to this menu item is **Ctrl-T**.

Sync Telescope to Chart Center

The **Sync Telescope to Chart Center** menu selection causes the telescope to be synchronized or "re-aligned" on the position occupied by the center of the **Sky Chart**. This menu selection is only enabled for telescope or interface types that support this feature.

Miscellaneous Settings...

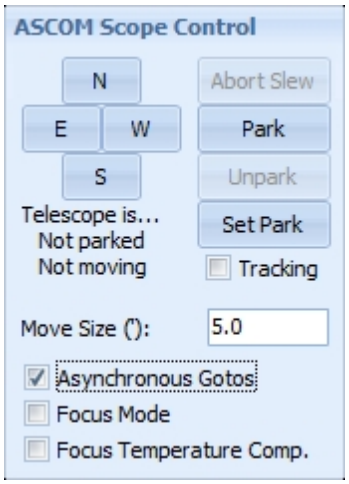
The **Miscellaneous Settings...** menu selection shows **Misc. Settings** tab of the **Telescope Settings** dialog box.



The following miscellaneous settings can be enabled or disabled using check boxes:

- **Show Position** - this determines if a cross-hair or Field Target is drawn on the **Sky Chart** to track the current position of the telescope in the sky.
- **Use Default Field Target** - this determines whether a simple cross-hair or the default Chart Target is used to show the current position of the telescope. The selected, a Chart Target follows the position of the telescope and can be correctly-sized to match the current chart size.
- **Show Coordinates** - this determines if the current position of the telescope (in Right Ascension and Declination) is shown in small box positioned at the lower left corner of the **Sky Chart**.
- **Track Telescope** - this determines if the **Sky Chart** is to track the current position of the telescope. If active, and the telescope position cross-hair moves out of the **Sky Chart**, the chart is re-drawn with the current telescope position at the center. The behavior of the Track Telescope feature is augmented by the Auto Track Telescope feature (see next section).
- **Auto Track Telescope** - this feature, when activated, changes the behavior of the Track Telescope feature (see previous section). The purpose of this feature is to avoid the situation that occurs when the Track Telescope feature is enabled and the user centers on a new object (using one of the Center menu items) that causes the **Sky Chart** to be redrawn away from where the telescope is currently pointed. Normally, the Track Telescope feature would then immediately cause the **Sky Chart** to "pop" back to the location of the telescope. With Auto Track Telescope turned on, and a "center object" operation occurs, the Track Telescope feature is momentarily turned off. It is turned back on automatically when a center scope operation is initiated. This will cause the sky to once again follow the scope if it moves outside of the **Sky Chart**.
- **Telescope Control** - this determines if the telescope control window is displayed. This window is used to manually control the motion and focus position of a telescope that supports one or both of these features (e.g. the Meade LX200). For some telescopes other control features are provided.

  The specific descriptions here are for ASCOM-type telescopes, however other telescopes operate in a similar fashion. The box is initially positioned at the lower right corner of the **Sky Chart**. It can, however, be moved by the user.



To move the telescope manually, enter a move size in arc-minutes and then press the desired direction button; for example, "N". The check box **Asynchronous Gotos** affects all goto operations. When checked, goto commands start and controlled is immediately returned to the user. If not checked, the mouse cursor will change to a "wait" cursor and ECU waits until the goto command completes before control is returned to the user.

Additionally, four buttons are provided to abort slews (gotos), park and unpark the telescope, and set the park location.

To focus the telescope, enable the **Focus Mode** check box. The **N** and **S** buttons will change to **F+** and **F-**. Enter a focus step size and then press either the **F+** or **F-** buttons. Another check box is provided to enable temperature compensation, if your focuser supports this feature.

- **Confirm Syncs** - this indicates if the user is prompted to confirm telescope sync operations. This makes it less likely that you will accidently sync your telescope on the wrong object or location.

Set Telescope Time and Geographic Location

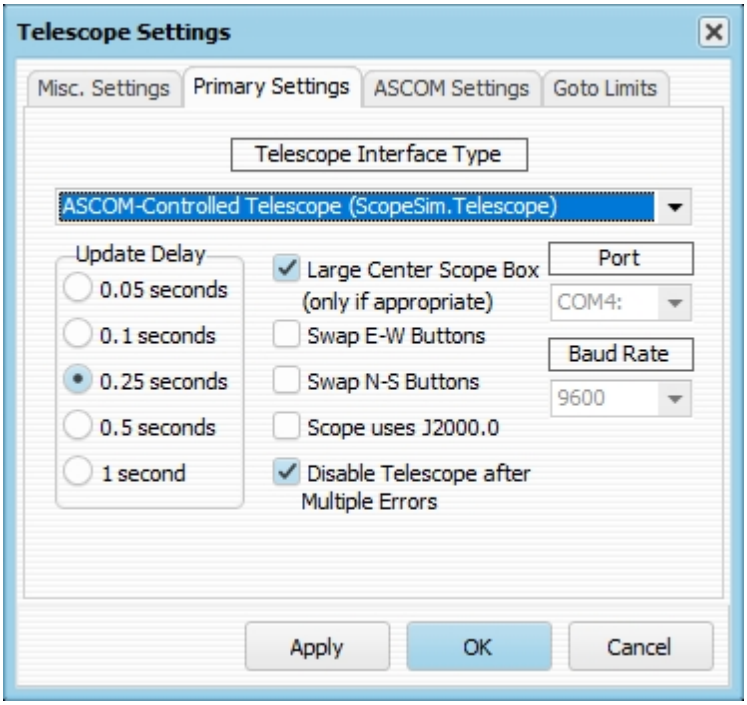
Two buttons named "Set Telescope Time" and "Set Telescope Geog. Location" appear when LX200-type telescopes are enabled (except for the Autostar I/II and WinCTC).

The **Set Telescope Time** button sets the time used by many telescopes, including Meade LX200s, LXD mounts, Autostar-based telescopes, Losmandy Gemini, and the Astro-Physics GTO mount, to the current time as provided by your PC's clock. If you use this function, make sure that the PC's time has been set very accurately; otherwise telescope positioning accuracy may be degraded. Note that with the Astro-Physics GTO mount, ECU sets the time automatically as part if its initialization.

The **Set Telescope Geog. Location** button sets the geographic location used by many telescopes, including Meade LX200s, Meade LXD mounts, Autostar-based telescopes, Losmandy Gemini, and the Astro-Physics GTO mount, to that currently set in ECU. Note that with the Astro-Physics GTO mount, ECU sets the location automatically as part if its initialization. Note that if this function generates an error with the Meade Autostar telescope, this is a sign that the firmware in your Autostar should be upgraded (see the Meade website for details on how to do this).

Primary Settings...

The **Primary Settings...** menu selection shows **Primary Settings** tab of the **Telescope Settings** dialog box. This tab is used to select the telescope type and various other telescope interface settings.



Telescope Interface Type

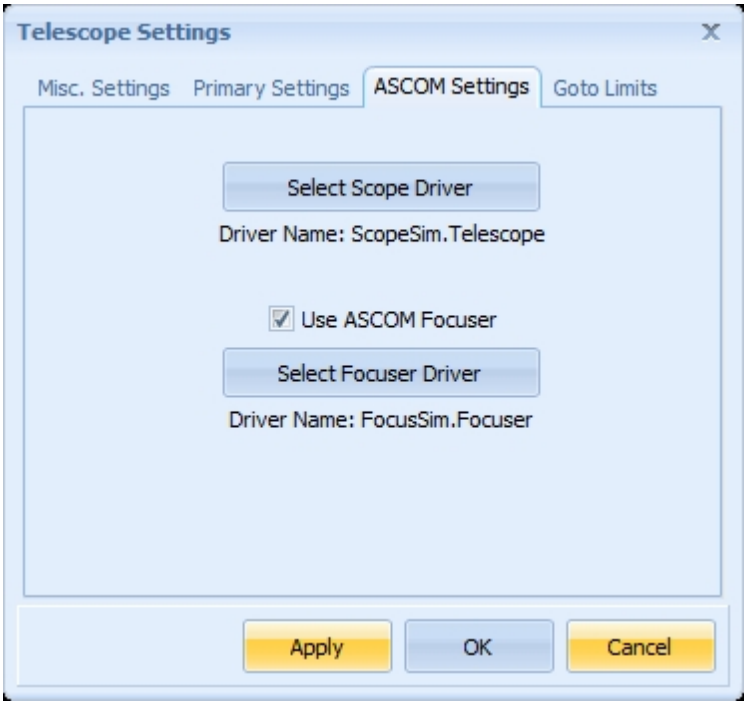
The telescope interface type can be set to one of the following:

- Meade Classic LX200 and LXD650/750 mount
- Meade Autostar I & II (LX200GPS, ETX, LX90, LXD55, etc.)
- Micro-Guider III and 5, or Ouranos Interface
- ASCOM-Controlled Telescope
- Orion CTI & JMI SGT-MAX (V2.00 and later)
- JMI SGT-MAX (before V2.00)
- NGC-MAX, NGC-Sky Vector, Celestron Adv. Astro Master
- Sky Engineering Sky Commander/Losmandy DSC
- Meade Magellan I
- Meade Magellan II
- Astro-Physics GTO Mount
- Starmaster Sky Tracker
- Losmandy Gemini System (Levels 1 to 3)
- Micro-Guider I or II
- Orion Intelliscope Object Locator
- BBAstroDesigns "scope.exe" (Vers. > February 2004)
- Vixen SkySensor 2000 in LX200 mode
- Micro-Guider III/Burke-Gaffney Observatory
- COAA WinCTC Telescope Controller

ASCOM Telescopes

The "ASCOM-Controlled Telescope" type refers to the many telescope and focuser models supported by the **ASCOM Initiative** through their telescope drivers (see www.ascom-standards.org). This presently includes dozens of models — see www.ascom-standards.org/Downloads/ScopeDrivers.htm for the most current list.

If your telescope has an ASCOM driver available we recommend, except for encoder interfaces, to use the "ASCOM" telescope type. Using ASCOM drivers with **ECU** is described in detail in Using an ASCOM Telescope.



After selecting "ASCOM-Controlled Telescope", change to the ASCOM Settings tab and select the the scope driver. If you intend on using an electric focuser, activate the check box **Use ASCOM Focuser** and select a focuser driver too.

Encoder Interfaces

Note that in the text of this manual, the Micro-Guiders, Ouranos interface, Orion CTI, SGT-MAX, NGC-MAX, NGC-Sky Vector, and Advanced Astro Master (and compatibles) are referred to as an "encoder interface". All of these encoder interfaces operate (from **ECU**'s perspective) in a similar fashion so are described together in Using an Encoder Interface.

Goto Type Telescopes

Similarly "GOTO" type telescopes or mounts such as the Meade LX200s, LXD, and Autostar, Astro-Physics GTO, Gemini, Sky Tracker, and the SkySensor are also described together in Using a "Goto" Type Telescope.

RA/Dec Type Interfaces

And finally, "RA/Dec" type telescope interfaces such as the Sky Commander and Meade Magellans are described together in Using an "RA/Dec" Type Telescope.

Update Delay

The "Update Delay", or speed is selected by pressing one of the "radio" buttons. The "Update Delay" is the dead time between attempts to communicate with the telescope interface. The actual update rate that you should choose depends on the response time of the interface and the speed of your computer. The slower rates should only be used if you find the telescope functions slow down your PC too much or your telescope interface is unresponsive from its keypad. When you select a telescope interface type, an appropriate "Update Delay" is automatically selected for you.

Port and Baud Rate (not applicable to ASCOM telescopes)

The "Port" selection should be set to the RS232 port that you are using to connect the telescope interface to. To avoid a conflict, ensure that this port is not a port used by another device.

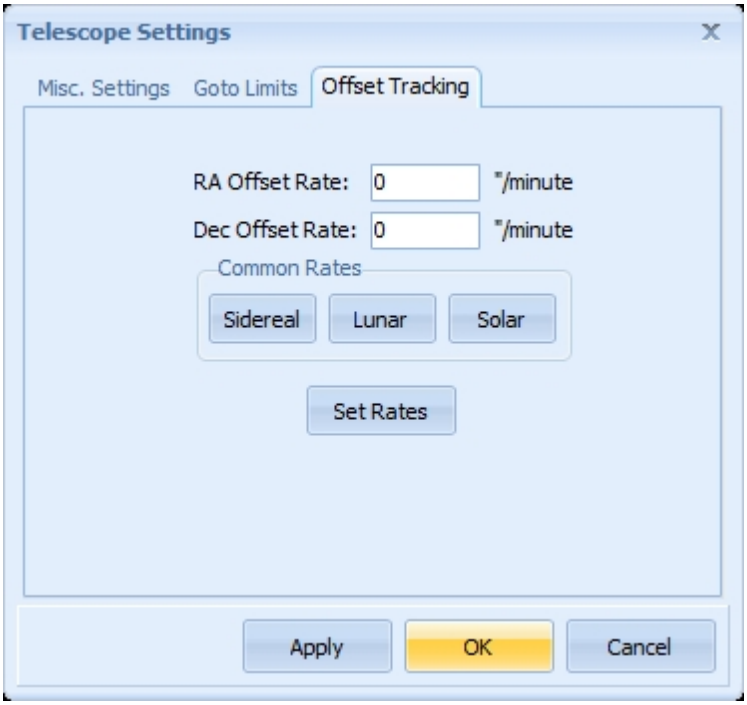
Note that an appropriate baud rate is automatically set when you select a telescope interface type, so unless you know what you are doing, don't change the automatically selected baud rate.

Other Settings

- The **Large Center Scope Box** check box enables a feature that causes an extra-large display of coordinates used by "encoder interface" and "RA/Dec" type telescope to guide you to an object.
- **Swap E-W Buttons** and **Swap N-S Buttons** check boxes are used to swap the function of the directional buttons of the telescope control window.
- If checked, the "Disable Telescope After Multiple Errors" setting causes the telescope interface to be automatically disabled after 10 successive unsuccessful attempts to query a telescope's position.

Offset Tracking...

The **Offset Tracking...** menu selection shows **Offset Tracking** tab of the **Telescope Settings** dialog box. This tab is only available when an ASCOM telescope is enabled and it can be left displayed as long as the user wants.



Some ASCOM telescopes allow the tracking rates to be adjusted from their default sidereal rate. The sidereal rate is the correct rate to follow the stars.

To set an offset tracking rate, first:

- **Sidereal Rate** - press the **Sidereal** button.
- **Lunar Rate** - press the **Lunar** button. This rate is optimized for tracking the Moon.
- **Solar Rate** - press the **Solar** button. This rate is optimized for tracking the Sun.

- **Arbitrary Rate** - manually enter the rates in arc-seconds per minute.
- **Rate for any Solar System** - click on the object - the offset rates are updated automatically.

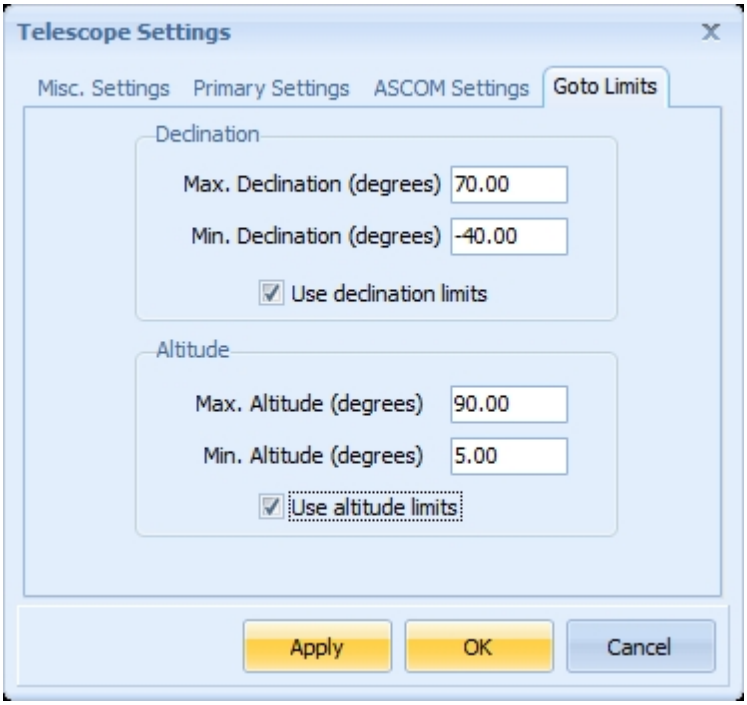
Then press the **Set Rates** button to send them to the telescope.

Note: Remember, after you are finished observing a moving object, to set the rate back to sidereal rate.

Goto Limits...

The **Goto Limits...** menu selection shows **Goto Limits** tab of the **Telescope Settings** dialog box. When the telescope interface is enabled and it can be left displayed as long as the user wants.

It is used to set parameters that can limit the motions of an ASCOM-controlled or "GOTO" Type telescope. If either of the **Use declination limits** or the **Use altitude limits** check boxes are checked, the telescope motions (only as initiated by a "goto" command from ECU) will be restricted to the minimum and maximum declinations and/or altitudes entered.

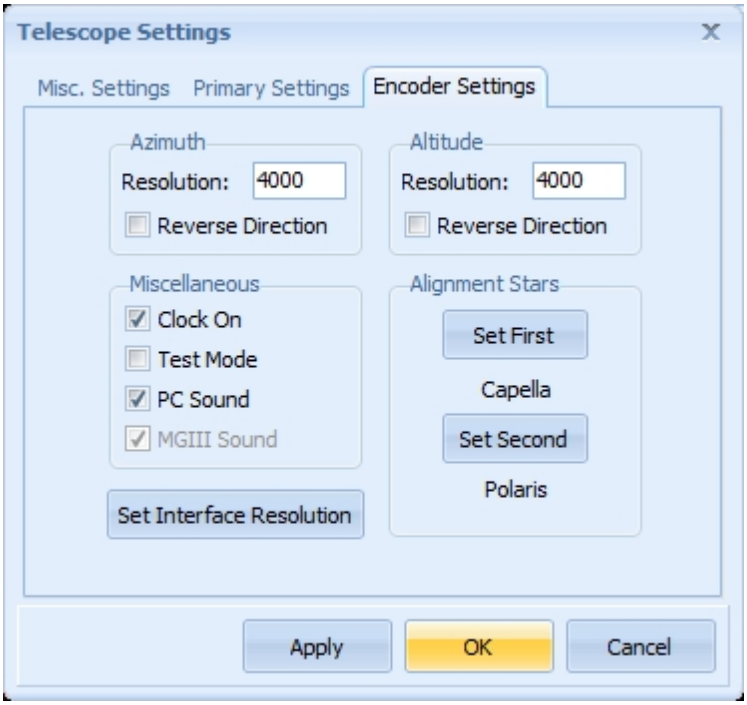


In order for the altitude limits to work correctly, be sure you set the time and geographic location set correctly. When a telescope is requested to move to a location outside of the valid range, a message box is displayed informing the user.

This feature is very useful to those who wish to either restrict telescope motions to a minimum altitude or, perhaps more importantly, to limit how far north an SCT telescope is allowed to move — some of these telescopes, especially with CCD cameras attached can damage the telescope and/or camera if there were allowed to move too far north.

Encoder Settings...

The **Encoder Settings...** menu selection shows **Encoder Settings** tab of the **Telescope Settings** dialog box. This tab is used to set the encoder interface settings and set alignment stars for Encoder Interfaces.



Altitude and Azimuth Encoder Settings

If you are using any of the other encoder interfaces, enter the actual encoder resolution for each axis of the telescope. These are usually the same for each axis, but do not have to be. **Be sure to include the effects of any mechanical components, such as gears or pulleys.**

The setting of the direction check boxes is telescope specific and requires some experimentation that is explained in Using an Encoder Interface.

The **Clock On** check box should always be checked except if your telescope is a Dobsonian mounted on a Poncet or other equatorial table. Consult *Nova Astronomics* if your telescope is in this category and you require guidance.

When **Test Mode** is checked, a special encoder test mode is entered. This mode's operation is explained in section 6.2.1.

When **PC Sound** is checked, the PC's speaker is used for the sound produced when finding an object. Likewise, if you have a "Micro-Guider III", its built-in sound will be used if **MGIII Sound** is checked.

Set Interface Resolution

The **Set Interface Resolution** button is used to "program" the number of counts per revolution for each optical encoder into the encoder interface. This procedure only needs be carried out once and is only necessary when using a **JMI SGT-MAX** (firmware version of 1.70 or later) or an **Orion Sky Wizard CTI** encoder interface.

Both the SGT-MAX and CTI are essentially the same device, however they act differently depending on their firmware version. You may have to open the device to determine the version number — it is written on the label of the largest "chip." For versions of the SGT-MAX earlier than V2.00, you should select "JMI SGT-MAX (before V2.00)" as the telescope interface type. For versions 2.00 and later and all versions of the Orion CTI, select "Orion CTI & JMI SGT-MAX (V2.00 and later)."

Before pressing the button, enter the actual encoder resolutions for each telescope axis (altitude=declination and azimuth=right ascension) and press the **Apply** button. Then press the button to "program" the encoder interface. If an error message is displayed, check your connections and make sure

the encoder interface is turned on.

When using a version of the SGT-MAX earlier than V2.00 only, continue by entering the values "32768" for both resolution entries. This older version of the SGT-MAX automatically "scales" the encoder values up to 32768.

Alignment Stars

Alignment "stars" can be chosen from any object in ECU's databases. Usually stars are used to align the optical encoder system, however it is possible align the system using the Sun, Moon, and/or planets in the daytime, but if you do this, you have to select the Sun, Moon, and/or planets as alignment "stars" immediately before doing the alignment. This is because their positions are what are saved, and these positions change with time.

To select an alignment star, "click" on the desired object. While its **Identify Objects Box** is displayed, enter Encoder Settings... and select either the **Set First** or **Set Second** buttons.

For maximum accuracy, you should select alignment stars carefully by selecting stars that you can easily identify in the "real" sky and stars that cause both axis of the telescope to move significantly when you move the telescope between the stars. An example of this, for an altitude/azimuth mounted telescope such as a Dobsonian, would be to select one star low in the south and another high in the northeast.

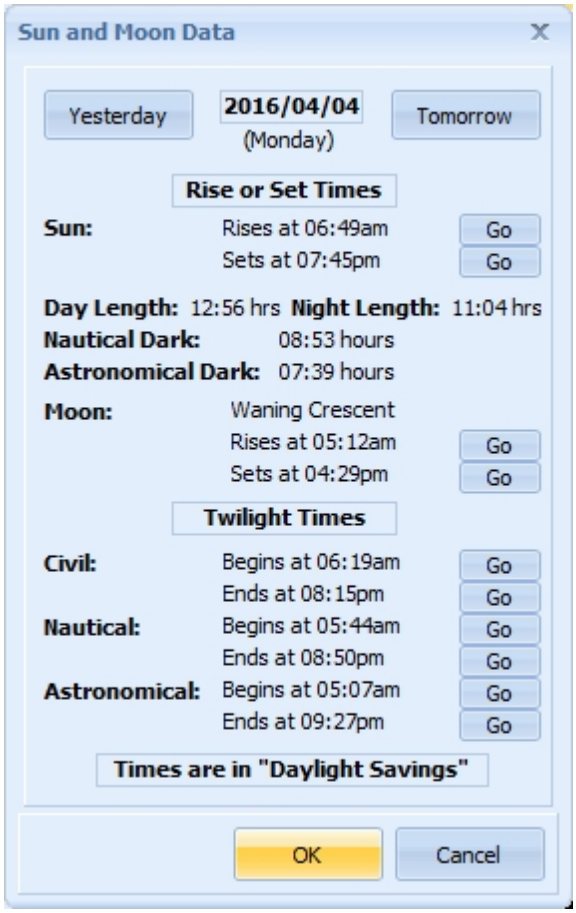
If the one-star alignment process is used, it is best select a star high in the sky (to reduce the effects of atmospheric refraction) and near the meridian.

Miscellaneous Menu

The **Miscellaneous** menu provides access to all of the functions which did not seem belong anywhere else! These include the display of Sun/Moon data and sidereal time and Julian date, various Internet functions, and the settings for various files and directories used by ECU.

Sun and Moon Data...

The **Sun and Moon Data...** menu selection shows a dialog box that displays various data for the Sun and Moon on the current date.



Civil, nautical, and astronomical twilight are defined as when the Sun is 6, 12, and 18 degrees below the geometric local horizon, respectively. These twilight times can be used to determine when it is dark enough to begin observing. Usually by the time of nautical twilight in the evening, it is dark enough to begin deep sky observing.

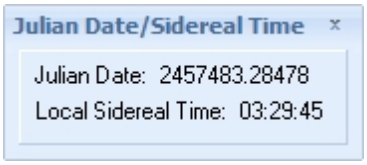
Note that the durations given for day/night length and astronomical/nautical dark are for the current day. For example, “Night Length” would be the number of hours between midnight and sunrise plus the number of hours between sunset and midnight on the same day.

The **GO** button to the right of each time causes that time to be set and the date shown and the **Sky Chart** redrawn.

The **Yesterday** and **Tomorrow** buttons cause the date to be changed to the previous or next day respectively.

Julian Date/Sidereal Time...

The **Julian Date/Sidereal Time...** menu selection causes a box to be shown that displays the current Julian Date and Local Sidereal Time. It is updated when ECU's date and time changes.



Retrieve Digitized Sky Survey Image...

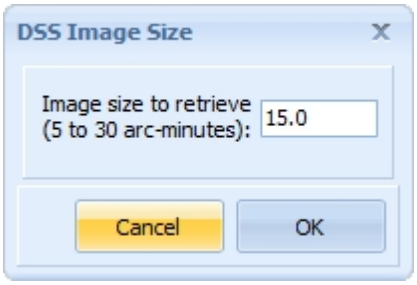
The **Retrieve Digitized Sky Survey Image...** menu selection retrieves an image of the sky located at the current center of the **Sky Chart**. The size of the image is set using the DSS Image Size... The image retrieved appears in a web browser window. You must be connected to the Internet for this feature to work.

The images originate from the Space Telescope Science Institute's Digitized Sky Survey service.

The web address used to retrieve the image is set in Directory/File/Web Setup... By default, the red DSS2 image is retrieved, since it seems to have more complete sky coverage, but the technical user could change the web address to retrieve other images.

DSS Image Size...

The **DSS Image Size...** menu selection shows a dialog box setting the size, in arc-minutes, of Digitized Sky Survey images retrieved from the Internet.



Retrieve Nearest Clear Sky Chart...

The **Retrieve Nearest Clear Sky Chart...** menu selection uses the current Geographic Location to access the nearest (within 50km by default) Clear Sky Chart — the data appears in a web browser window. You must be connected to the Internet for this feature to work.

The Clear Sky Chart (CSC) is a free service provided by Attilla Danko of Ottawa, Canada and the Canadian Atmospheric Environment Service. The CSC provides site specific predictions of cloud cover, transparency, seeing quality, darkness, wind speed, humidity and air temperature for North America. For information see:

cleardarksky.com/csk
www.weatheroffice.ec.gc.ca/astro/index_e.html

The web address used to retrieve the data is set inset in Directory/File/Web Setup…. By default, the search radius is 50km, but the technical user could change this value.

Retrieve Weather Information…

The **Retrieve Weather Information…** menu selection causes a web browser window to be displayed at the user's pre-set "favorite" weather website – the default page is the weather information for an observatory near ECU's author. You must be connected to the Internet for this feature to work. The web address used can be set in Directory/File/Web Setup….

A good website to use for obtaining weather information is: www.wunderground.com (the Weather Underground). The web site you could use to retrieve current weather for Bangor, Maine would be:

www.wunderground.com/cgi-bin/findweather/getForecast?query=Bangor%2C+ME

Run Image Viewer…

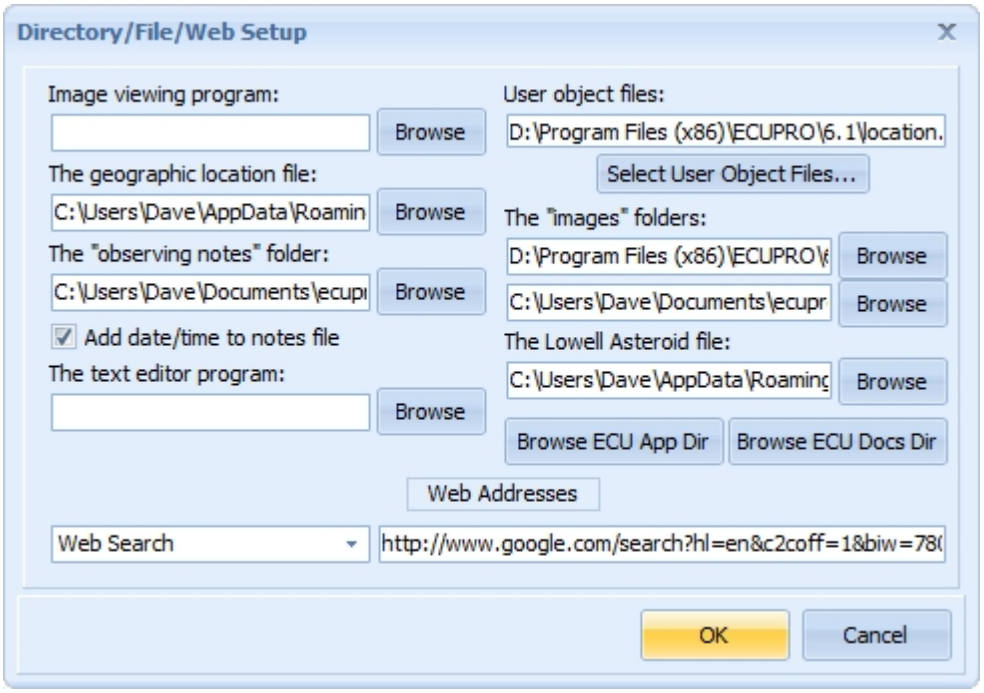
The **Run Image Viewer…** menu selection executes the image viewer program configured in Directory/File/Web Setup….

Run Text Editor…

The **Run Text Viewer…** menu selection executes the text editor program configured in Directory/File/Web Setup….

Directory/File/Web Setup…

The **Directory/File/Web Setup...** menu selection sets the location of several files, programs, and directories used by ECU. The items in this dialog box, except the user object filenames and "Add date/time to notes file" check box, are saved in the ecu.ini, not in the normal ECU configuration file.



The following items can be configured. In each case, the full directory (include drive letter) and filename should be entered or selected with the adjacent **Browse** button.

- **Image viewing program** — this field controls which program is used to display image files. This is used by the **Image** button in the Identify Objects Box. If it is left blank, the current default Windows image viewer is used. Note that with Windows Vista or Windows 7/8/10, the default image viewer will not work (this is because it is a DLL, not an EXE file). We recommend you download and install a free image viewer known as "Irfanview" (www.irfanview.com).
- **The geographic location file** — this field specifies the name of the text file used to store the geographic location database. The default file is "location.ecu".
- **The "observing notes" folder** — this field controls the directory used to store the observing notes files.
- **Add date/time to notes file** — a check box that controls whether or not the date and time are added to notes files.
- **The text editor program** — this item controls which program is used to display or edit text files. The observing **Notes** button in the **Identify Objects Box** uses this. If it is left blank, the current default Windows text editor is used (usually Notepad).
- **User object files —** this field specifies the name of up to five text files used to store User Objects. Each filename is entered separated by a semi-colon (;) character and should include the filename and drive/directory.
- **The "images" folders** — this field provides for the entry of two directories where ECU will search for image files.
- **The Master Asteroid file** — this field sets the orbit database used when searching orbits. This is usually either the Lowell Observatory or IAU Minor Planet Center asteroid database downloaded in Download Orbits....
- **Web Addresses** — this item includes a drop-down list of website addresses used by many of ECU's Internet features.

Help Menu

The **Help** menu provides access to this **User's Manual...**, various Nova Astronomics websites, and the **About ECU...** dialog box.

About ECU... shows ECU's version number, copyright notice, and how to contact the author. The **Willman-Bell Credits** tab indicates that ECU contains source code that is copyrighted by Jeffrey Sax. The source code referred to, provides high accuracy astronomical calculations based on the algorithms described in the book: **Astronomical Algorithms by Jean Meuss** (distributed by Willman-Bell).

And finally, the **Other Credits** tab recognizes the efforts of the many amateur and professional astronomers responsible for the preparation and maintenance of most of the databases used by ECU. It also acknowledges certain trademarks and copyrights.

Databases and Calculations

This section describes the built in astronomical databases and some details of the astronomical calculations used.

ECU includes many object databases. The databases covered in this section include the Stellar Databases, Deep Sky Databases, Variable Star Database, and Double Star Database.

You can also add objects to ECU's database:

- User Objects - you can add up to 50,000 non-moving objects
- Orbits - you can add up to 25,000 comets and asteroids. These can be easily downloaded from the internet OR selected, based on a number of criteria, from the Lowell Observatory asteroid database.

Calculations

ECU uses the algorithms from the following sources:

- "Astronomical Algorithms" by Jean Meuss (published by Willman-Bell, Inc.) for all of the solar system calculations and many other astronomical calculations as well. The Pascal source code included with the book and written by Jeffrey Sax are used.
- "Practical Astronomy with your Calculator" by Peter Duffett-Smith - used for various calculations.
- "Astronomy and the Limits of Vision" by Bradley Schaefer (Vista in Astronomy, Vol. 36, pp 311-361) - extinction calculation.
- "Observational Techniques and Data Reduction" by Andrew Young (Methods in Experimental Physics, 12A, 123, 1974) - air mass calculation.
- "Astronomical Computing" columns in Sky and Telescope - various calculations including precession and Moon rise and set.
- "Map Projections: A Working Manual" by John P. Snyder - the stereographic projection.

The positions of the planets and the Sun are derived from the planetary theory VSOP87 (see "Planetary theories in rectangular and spherical variables. VSOP solutions," by P. Bretagnon and G. Francou, Astronomy and Astrophysics 202, 309-315 (1988)). The time-span validity of these positions is about 2000BC to 6000AD. Beyond this time-span, positions may be unreliable.

The positions of the Moon are derived from Meuss' adaptation of the lunar theory ELP2000 (see "The lunar ephemeris ELP 2000," by M. Chapront-Touze and J Chapront, Astronomy and Astrophysics, 124, 50-62 (1983)). The time validity range is not given, so care should be given in using these positions far from the present time.

Stellar Databases

ECU includes four stellar databases: the Yale Bright Star Catalog (YBSC), the Smithsonian Astrophysical Observatory (SAO) Star Catalog, the Tycho-2 Star Catalog, and the Hubble Guide Star Catalog. The YBSC/SAO combination compliments the Tycho-2 Star Catalog. Each of these databases is described in detail below.

It also supports, but does not include, the US Naval Observatory's A-2.0 and SA-2.0 Star Catalogs.

Yale Bright Star Catalog

The Yale Bright Star Catalog (version 5 – 1982) contains 9110 stars to magnitude 6.5. It is contained in the files: YBSC1.ECU, YBSC2.ECU, and YBSC3.ECU. This catalog is designed to work in concert with the SAO Star Catalog (see next section). The following information is included for each star:

- Position (J2000.0 epoch)
- Visual Magnitude (nearest tenth)
- Proper Name (if available)
- Bayer and Flamsteed Designation (if available)
- HR Number
- Henry Draper Number
- SAO Number
- B-V Color
- Spectral Type
- Proper Motion

Smithsonian Astrophysical Observatory Star Catalog

The Smithsonian Astrophysical Observatory (SAO) Star Catalog contains some 259,000 stars. The Yale stars and those with the magnitude unknown were extracted leaving a database of 245,654 stars to about magnitude 9.5. It is contained in the files: SAO1.ECU and SAO2.ECU. This catalog is designed to work in concert with the Yale Bright Star Catalog since there are no duplicate stars. The following information is included for each star:

- Position (J2000.0 epoch – 10 arc-second resolution in declination, 20 arc-second resolution in right ascension)
- Magnitude (nearest tenth)
- SAO Number
- Spectral Type

Tycho-2 Star Catalog

The Tycho-2 Star Catalog is a production of the European Space Agency and is based on data acquired by the Hipparcos astrometric satellite. For detailed information about the catalog see www.astro.ku.dk/~erik/Tycho-2. This catalog can be optionally installed.

The base catalog contains about 2.5 million stars and contains stars as faint as magnitude 12-13. Since the base Tycho-2 Star Catalog is missing some stars, including many bright ones, the database used by ECU was supplemented with data from the Hipparcos Catalog and two supplement catalogs. A total of 2,436,615 stars are in the database that are contained in the files TYC1.ECU to TYC5.ECU. For efficiency reasons, the database was split into bright (magnitude 6.2 and brighter) and faint (fainter than magnitude 6.2) stars.

The following information is included for each star:

- Position (J2000.0 epoch)
- Magnitude (nearest tenth)
- Tycho Catalog Number
- Hipparcos Catalog Number (if available)
- Henry Draper Catalog Number (if available)
- Corrected V Magnitude (nearest hundredth, if available)
- Corrected B Magnitude (nearest hundredth, if available)
- Parallax (if available, distance is computed from the parallax by ECU)
- Parallax Error Estimate (if available)

- Proper Motion (if available)

Hubble Guide Star Catalog

The Hubble Guide Star Catalogue (called the GSC or HGSC) can be optionally installed when you install ECU. It is derived from a pair of CD-ROM disks published by *The Space Telescope Science Institute* and used by Nova Astronomics under license. These disks contain about 15,000,000 stars, with the faintest being about magnitude 15.5. **ECU** ignores the objects classified as non-stellar objects. This catalog or parts of it can be optionally installed.

The GSC was originally created to provide a selection of guide-stars in support of the *Hubble Space Telescope*. In dense regions of the Milky Way, the faintest stars are only about magnitude 13. This is because the goal in selecting stars was to have a nominal number of stars per square degree, thus in dense regions there were more bright stars to choose from. A large amount of information regarding the GSC is included in Appendix A of this manual (a requirement according to its license agreement).

The GSC provides the following information for each star:

- Position (J2000.0 epoch)
- Magnitude (nearest tenth)
- Position Error Estimate
- Magnitude Error Estimate
- Magnitude Band
- Plate ID

With today's large hard disks, it is recommended that you install the entire GSC to your hard disk. If used the GSC, be sure to enable the **Hubble Guide Star Catalog** check box in the Stars… item in the Chart menu (advanced tab).

US Naval Observatory Star Catalogs

In addition to the star catalogs included with ECU, two additional catalogs (not available from Nova Astronomics due to licensing issues) produced by the US Naval Observatory are supported. These two catalogs are (quoted from their website):

USNO-A2.0 — *contains entries for over a half billion stars (526,230,881, to be exact!) which were detected in the digitized images of three photographic sky surveys. For the entire northern sky and the southern sky down to declinations of -30°, all the photographic plates were part of the original Palomar Optical Sky Survey (POSS-I). Photographs were taken on blue- and red-sensitive emulsions. Only those stars that were detected in both colors were included in the USNO-A2.0 catalog. The rest of the southern sky was covered by the Science Research Council (SRC)-J survey and the European Southern Observatory (ESO)-R survey. Again, only stars appearing in both colors were accepted for the final catalogue.*

USNO-SA2.0 — *is a subset of USNO-A2.0 that is a lot easier to handle on a small computer because it contains only a tenth as many stars as the parent catalog (54,787,624 stars in all). The goal in creating this smaller catalog was to provide a spatially uniform distribution of stars in an intermediate range of magnitudes that would be useful as a ``reference grid'' for astrometric analysis.*

For details about these two catalogs see: http://ftp.nofs.navy.mil/projects/pmm/catalogs.html.

Both of these catalogs are incredible resources for deep sky observers and CCD imagers. The A-2.0 includes stars over **the entire sky down to fainter than 19th magnitude – truly incredible!** The SA-2.0 is less useful since, when plotted, it looks like the stars in the sky are laid down on a grid – not useful for creating a sky chart, but very useful for those doing astrometry (measuring accurate positions of objects).

These catalogs can be downloaded from the Internet using a high-speed connection and a great deal of patience.

Download information for the USNO A2.0: ftp.nofs.navy.mil/projects/pmm/a.response
Download information for the USNO SA2.0: ftp.nofs.navy.mil/projects/pmm/sa.response

The A2.0 is about 6.3 Gigabytes for the entire sky. The sky north of –45 degrees declination fits nicely on one recordable DVD.

Both catalogs are organized into declination zones 7.5 degrees high, each zone being comprised of an index file and a data file. The zones files are named 'zoneXXXX.acc' (index) and 'zoneXXXX.cat' (data) where XXXX is the number of degrees north of -90 degrees in declination — ranging from '0000' to '1725'. The '0000' file means data for stars from –90 to –82.5 degrees and the '1725' file means data for stars from +82.5 to +90 degrees. **ECU** can handle any fraction of the whole database, as long as both the index and data file for each zone is present.

To configure the use of the USNO star catalogs, see the Stars... item in the Chart menu (advanced tab).

Deep Sky Databases

ECU contains three deep sky databases. The first is a general database, containing all types of deep sky objects, called the Saguaro Astronomy Club database. The second is a specialized database containing only galaxies called the Principle Galaxy Catalog. The third is a specialized database containing only planetary nebulae called the Wallace-SEC Planetary Nebulae database.

Saguaro Astronomy Club Database

The Saguaro Astronomy Club database (files MESSIER.ECU, SAC1.ECU and SAC2.ECU) contains a complete database of 10,342 deep sky objects. The members of the Saguaro Astronomy Club (SAC) (pronounced sa-war-oh) of Phoenix, Arizona have provided much of the effort to compile this database (database version 8.1 – March 2010). The database includes the entire NGC catalog, the 110-object Messier Catalog, plus many other interesting deep sky objects. Selected fields of the SAC database were extracted for use in ECU. The object positions are stored in integer format obtaining a resolution of about 10 arc-seconds in Declination and 20 arc-seconds in Right Ascension at the celestial equator, however, the source database only reports positions to 1' in Declination and 0.1' in Right Ascension. These fields are described below:

a) **Object Name** — usually the NGC number, but for objects with no NGC value, other catalogs are used. The abbreviations listed below are used to represent the other catalogs.

Abell	George Abell (planetary nebulae and galaxy clusters)
ADS	Aitken Double Star catalog
AM	Arp-Madore (globular clusters)
Antalova	(open clusters)
Ap	Apriamasvili (planetary nebulae)
Arp	Halton Arp (interacting galaxies)
Bark	Barkhatova (open clusters)
B	Barnard (dark nebulae)
Basel	(open clusters)
BD	Bonner Durchmusterung (stars)
Berk	Berkeley (open clusters)
Be	Bernes (dark nebulae)
Biur	Biurakan (open clusters)
Blanco	(open clusters)
Bochum	(open clusters)
Ced	Cederblad (bright nebulae)
Cr	Collinder (open clusters)
Czernik	(open clusters)
DDO	David Dunlap Observatory (dwarf galaxies)
Do	Dolidze (open clusters)
DoDz	Dolidze-Dzimselejsvili (open clusters)
Dun	Dunlop (globular clusters)

Fein	Feinstein (open clusters)
Frolov	(open clusters)
Gum	(bright nebulae)
H	William Herschel (globular clusters)
Haffner	(open clusters)
Harvard	(open clusters)
He	Henize (planetary nebulae)
Hogg	(open clusters)
HP	Haute Provence (globular clusters)
Hu	Humason (planetary nebulae)
IC	1st and 2nd Index Catalogs to the NGC (All except dark nebulae)
Isk	Iskudarian (open clusters)
J	Jonckheere (planetary nebulae)
K	Kohoutek (planetary nebulae)
King	(open clusters)
Kr	Krasnogorskaja (planetary nebulae)
Lac	Lacaille (globular clusters)
Loden	(open clusters)
LDN	Lynds (dark nebulae)
Lynga	(open clusters)
M	Messier (all types of objects except dark nebula)
MCG	Morphological Catalog of Galaxies
Me	Merrill (plantary nebulae)
Mrk	Markarian (open clusters and galaxies)
Mel	Melotte (open clusters)
M1 thru M4	Minkowski (planetary nebulae)
NGC	New General Catalog of Nebulae & Clusters of Stars
Pal	Palomar (globular clusters)
PC	Peimbert and Costero (planetary nebulae)
Pismis	(open clusters)
PK	Perek & Kohoutek (planetary nebulae)
RCW	Rodgers, Campbell, & Whiteoak (bright nebulae)
Roslund	(open clusters)
Ru	Ruprecht (open clusters)
Sa	Sandqvist (dark nebulae)
Sher	(open clusters)
Sh	Sharpless (bright nebulae)
SL	Sandqvist & Lindroos (dark nebulae)
SL	Shapley & Lindsay (clusters in LMC)
Steph	Stephenson (open clusters)
Stock	(open clusters)
Ter	Terzan (globular clusters)
Tombaugh	(open clusters)
Ton	Tonantzintla (globular clusters)
Tr	Trumpler (open clusters)
UA	Catalog of selected Non-UGC galaxies
UGC	Uppsala General Catalog (galaxies)
UKS	United Kingdom Schmidt (globular clusters)
Upgren	(open clusters)
VV	Vorontsov-Velyaminov (interacting galaxies)
vdB	van den Bergh (open clusters, bright nebulae)
vdBH	van den Bergh & Herbst (bright nebulae)
vdB-Ha	van den Bergh-Hagen (open clusters)
Vy	Vyssotsky (planetary nebulae)
Waterloo	(open clusters)
Westr	Westerlund (open clusters)
Zw	Zwicky (galaxies)

b) **Other Name** — contains other catalog designations that the object is known by. The same abbreviations as in a) are used.

c) **Object Type** — the type of object from the list below.

Asterism	Bright Nebula

Quasar	Unverified Southern Object
Planetary Nebula	Cluster with Nebulosity in the SMC
Open cluster in the SMC	Supernova Remnant
Nonexistent in RNGC	Open Cluster
Multiple Star	
Globular Cluster in the LMC	Open cluster in the LMC
Globular Cluster in a Galaxy	Cluster with Nebulosity in a Galaxy
Globular Cluster	Diffuse Nebula in a Galaxy
Galaxy cluster	Galaxy
Diffuse Nebula in the SMC	Globular Cluster in the SMC
Cluster with Nebulosity in the LMC	Diffuse Nebula in the LMC
Cluster with Nebulosity	Dark Nebula

d) **Position** — the object's position, Right Ascension and Declination, in the J2000.0 epoch.
e) **Magnitude** — the object's brightness to the nearest tenth. There are many objects which have no published magnitude; they are listed as ??.?. Dark nebulae obviously have no magnitude, so they are also listed as ??.?.
f) **Position Angle (PA)** — for elongated objects, the position angle is given in degrees with north as zero degrees progressing clockwise.
g) **Description** — a visual description of the object. Most of these are from the NGC, some are from prominent amateurs. Back issues **of Deep Sky Magazine**, *Astronomy* magazine, *Sky and Telescope* magazine and *Burnham's Celestial Handbook* are used as a source of some of these descriptions. The descriptions use the abbreviations from the NGC and Burnham's. They are given below:

!	remarkable object	!!	very remarkable object
Am	Among	N	North
Att	Attached	N	Nucleus
Bet	Between	Neb	nebula, nebulosity
B	Bright	P w	paired with
B	Brighter	P	pretty (before F,B,L or S)
C	Compressed	P	Preceding
C	Considerably	P	Poor
Cl	Cluster	R	Round
D	Double	Ri	Rich
Def	Defined	R	not well resolved, mottled
Deg	Degrees	rr	partially resolved
Diam	Diameter	Rrr	well resolved
Dif	Diffuse	S	Small
E	Elongated	S	Suddenly
E	Extremely	S	South
Er	easily resolved	Sc	Scattered
F	Faint	Susp	Suspected
F	Following	St	star or stellar
G	Gradually	V	Very
IF	irregular figure	Var	Variable
Inv	Involved	Nf	north following
Irr	Irregular	Np	north preceding
L	Large	Sf	south following
l	Little	Sp	south preceding
Mag	Magnitude	11m	11th magnitude
M	Middle	8...	8th magnitude and fainter
M	Much	9...13	9th to 13th magnitude

If you have never dealt with the NGC abbreviations before, perhaps a few examples will help:

NGC Number	Description	Decoded Descriptions
214	pF, pS, lE, gvlbM	pretty faint, pretty small, little elongated gradually very little brighter in the middle
708	vF, vS, R	very faint, very small, round

891	B, vL, vmE	bright, very large, very much elongated
7009	!, vB, S	remarkable object, very bright, small
2099	! B, vRi, mC	remarkable object, bright, very rich, much compressed
6643	pB,pL,E50,2 st p	pretty bright, pretty large, elongated in position angle 50 degrees, two stars preceding

h) **Notes** — notes pertaining to the object. Much of this field came from UGC Notes provided by Jim Lucyk. Most of the abbreviations used by the Description field apply here also. Several other common names are included in this field. If there is a position angle (PA) here, that is providing a companion objects' angle in relation to the main object. Another abbreviation that is used often is P w N (paired with NGC ###) or P w U (paired with UGC ###). Most of the data on companions to an object have been marked to make recognition easier, but some did not fit into the 71 spaces allotted. So, the data is always in this order: distance in minutes from main object, PA from main object, then the size and magnitude of the companion. Example: P w N4566 @ 4.5,120,0.9X0.7 says that the main object is paired with NGC 4566 and is at 4.5', position angle 120 degrees and 0.9'X0.7'.

i) **Size** — the size of the object in minutes of arc (′), seconds of arc (″), and degrees. For objects that are elongated, often the dimensions of the long and short axis are listed.

j) **Class** — the class of the object. Several professional classification schemes are contained here.

Trumpler type for open clusters

Concentration

I. Detached, strong concentration toward the center
II. Detached, weak concentration toward the center
III. Detached, no concentration toward the center
IV. Not well detached from surrounding star field

Range in brightness

1. Small
2. Moderate range
3. Large range

Richness

p Poor (<50 stars)
m Moderately rich (50-100 stars)
r Rich (>100 stars)

An "n" following the Trumpler type denotes nebulosity in cluster

Shapley-Sawyer concentration rating for globular clusters

The values range from 1 to 12, smaller numbers are more concentrated clusters.

Vorontsov-Velyaminov type for planetary nebulae

1. Stellar
2. Smooth disk (a, brighter center; b, uniform brightness; c, traces of ring structure)
3. Irregular disk (a, very irregular brightness; b, traces of ring structure)
4. Ring structure
5. Irregular form similar to diffuse nebula
6. Anomalous form, no regular structure

Some very complex forms may combine two types.

Hubble type for galaxies

E elliptical, E0 is roundest to E7 is flattest subgroups; 'd' is dwarf, 'c' is supergiant, 'D' has diffuse halo
S Spiral, 'a' has tightly wound arms, 'b' has moderately wound arms and 'c' has loosely wound arms

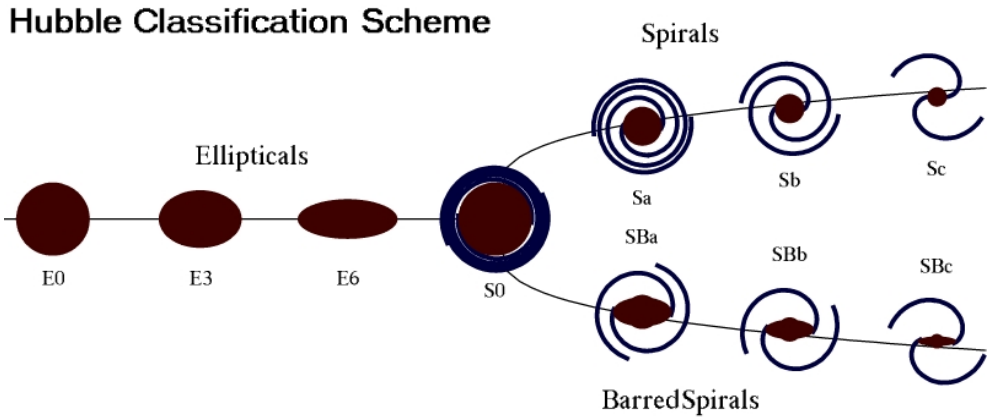
SB Spiral with central bar
Ir Irregular

Principle Galaxy Catalog

ECU includes the 2002 Edition of the Catalog of Principal Galaxies (PGC), which is a catalog containing 980,947 galaxies. It was compiled by a group of professional astronomers led by G. Paturel of France.

Selected fields from the original PGC database were extracted for use in ECU. These fields are described below:

- **Galaxy Names** — the PGC number is the primary name of each galaxy. Up to four other identifications are included. These are from the NGC, UGC, MCG, Messier, and IRAS catalogs and others.
- **Position** — the object's position, Right Ascension and Declination, in the J2000.0 epoch.
- **Magnitude** — the object's brightness to the nearest tenth. There are many galaxies with no published magnitude; they are listed as ??.?.
- **Size** — the size of the object in minutes and tenths of minutes of arc (′). For galaxies that are elongated, often the dimensions of the long and short axis are listed.
- **Class** — the class, or morphological type, of the galaxy coded according to the Hubble Classification Scheme (see below) with additions for unusual galaxies. For more information see: http://en.wikipedia.org/wiki/Hubble_sequence



- **Position Angle (PA)** — the position angle, if known, is given in degrees with north as zero degrees progressing clockwise.
- **Radial Velocity** — the radial velocity of the galaxy compared to the Sun. **ECU** also computes the implied distance to the galaxy using the Hubble relationship (assuming a Hubble constant of 75 km/s per megaparsec).
- **Status** — the status of the galaxy is identified as either a "Galaxy" or "Probable Galaxy".

The Wallace-SEC Catalog of Galactic Planetary Nebulae

ECU includes the Strasbourg-ESO Catalog of Galactic Planetary Nebulae with additional value added for the amateur observer by Kent Wallace based on his own observations and the observations of other experienced observers. Included is database version 7 (July 15, 2005) which includes 1143 objects.

Selected fields from the original Wallace-SEC database were extracted for use in ECU. These fields are described below:

- **PK Object Name** — the name of the object in the Perek & Kohoutek planetary nebulae catalog.
- **PNG Object Name** — the name of the object in the PNG planetary nebulae catalog.
- **Other Object Name** — the name of the object in other catalogs, usually the NGC or IC

catalogs.

- **Position** — the object's position, Right Ascension and Declination, in the J2000.0 epoch.
- **Magnitude** — the object's brightness to the nearest tenth, if known.
- **Size** — the size of the object in minutes and or seconds, if known. Some object sizes are just reported as "stellar".
- **Status** — the status of the object. Some objects are classified as possible planetary nebulae or misclassified as a planetary nebulae.

Variable Star Database

ECU includes the V5.1 (Mar 11, 2020 version) version of the General Catalog of Variable Stars (GCVS), which is a catalog containing 54,919 variable stars. It was compiled by a group of professional astronomers led by P. N. Kholopov at the Sternberg Astronomical Institute and the Institute of Astronomy, Moscow.

Selected fields from the original GCVS database were extracted for use in ECU. These fields are described below:

- **Variable Designation** — the name of the variable star in the standard format, which is comprised of two parts: the designation (usually one or two capital letters) followed by a three-letter constellation abbreviation.
- **Position** — the object's position, Right Ascension and Declination, in the J2000.0 epoch.
- **Maximum Magnitude** — the star's maximum magnitude to the nearest hundredth. Also included for most stars is the photometric system used, usually "V" for visual magnitude or "P" for photographic magnitude.
- **Minimum Magnitude** — the star's minimum magnitude (if known) to the nearest hundredth. In some cases, the amplitude of variability is given instead of the minimum magnitude.
- **Type of Variability** — a code describing the mechanism believed to cause the star to vary in brightness. See GCVS Variable Star Types for details.
- **Spectral Type** — the spectral type of the star, if known.
- **Period** — the period of variability of the star, if known.
- **Rising Time (or duration of eclipse)** — the rising time or during of eclipse, expressed as a percentage of the period.
- **Epoch** — the Julian Date of a previous maximum or minimum (in the case of eclipsing variables). ECU uses this date and the period to predict the date and time (UTC) of the next maximum or minimum. The computation is based solely on the data, which may result in inaccurate results. Your best source for update date information on variable stars is the American Association of Variable Stars (see www.aavso.org).

Double Star Database

ECU includes the 2016-March-25 edition of the Washington Visual Double Star (WVDS) Catalog, which is a catalog containing 135,098 pairs of double stars. It was compiled by a group of professional astronomers led by C. E. Worley at the United States Naval Observatory.

Selected fields from the original WVDS database were extracted for use in ECU. These fields are described below:

- **Discoverer Code and Number** — the name of the double star, which is comprised of two parts: the discoverer code (usually the initials of the discoverer) followed by a sequential number.
- **DM Name** — the stars Durchmusterung catalog number, if known.
- **Position** — the object's position, Right Ascension and Declination, in the J2000.0 epoch..
- **Component Identification** — when the group of stars has more than two stars, this identifies which pair of a larger grouping this is. For example, a grouping of four stars might have three

entries in the database with component identifications of "AB", "AC", and "AD", which in this case would mean that "B", "C", and "D" orbit star "A".

- **Magnitudes** — the magnitudes of the two components to the nearest hundredth.
- **Separations** — the separation of the pair of stars in arc-seconds at either one or two different years (usually year of discovery and the year of the last observation).
- **Position Angles** — the position angle, in degrees, of the pair of stars at either one or two different years (usually year of discovery and the year of the last observation).
- **Spectral Type** — the spectral type of one or both stars, if known.

User Objects

User Objects are a special type of object that provides the opportunity for the user to add new objects to ECU's object database. For example, you might want to add the position of a newly discovered Nova, the positions of a comet for which you don't have the orbital parameters, or include a database of objects not provided with ECU**.**

The positions, object type, magnitude, and a comment (usually the object's name) for up to 50,000 new objects can be provided in up to five ordinary "text" files that are specified by the user in the Directory/File/Web Setup... dialog box.

ECU is provided with a sample user object file called "nearby.ecu" (located in the directory where ECU is installed), which includes all stars within 25 parsecs (about 81 light years) of the Sun. By enabling this database and turning off the normal star database, the sky sure looks different! The first thing that becomes evident is that most of the nearby stars are quite faint and all but a few of the familiar constellations disappear.

To create your own user object file, use the following guidelines. The user object file can be created in any text editor, such as the Windows Notepad. Each object occupies one line in the file. Each line has 7 entries, each separated by a space, as follows:

- **Object Type** — this 1st field contains a number from 0 to 17 that defines the object type that ultimately controls the symbol used to display the object. The number "0" is a star, "1" is a galaxy, "2" is a globular cluster, "3" is an open cluster, "4" is a nebula, "5" is a planetary nebula, "6" is an "other" type of deep sky object, "7" is a solar system object, "8" is an animation trail, "9" is an open circle, "10" is an "X", "11" is an open square, "12" is star shaped, "13" is a double star, "14" is a variable star, "15" is an open triangle, "16" is an open diamond, and "17" is blank (no symbol).
- **Right Ascension (hours)** — this is the object's right ascension (hours) (epoch 2000.0). It can be an integer, if used with the minutes (see below) or can be the decimal hours, in which the minutes should be set to 0.
- **Right Ascension (minutes)** — this is the object's right ascension (minutes), which is used in conjunction with the hours (see above).
- **Declination (degrees)** — this is the object's declination (degrees) (epoch 2000.0). It can be an integer, if used with the minutes (see below) or can be the decimal hours, in which case the minutes should be set to 0.
- **Declination (minutes)** — this is the object's declination (minutes), which is used in conjunction with the degrees (see above).
- **Magnitude** — this field is the magnitude of the object.
- **Comment —** the last field is a text comment, which would usually be the name of the object, and can be up to 25 characters long.

To illustrate the text description of the file format, below is the first few lines of the sample nearby object database provided.

```
0 0.090153 0 -37.357363 0 8.6 HD225213 (14.5)
0 0.086399 0 45.786281 0 9.9 (34.7)
0 0.088117 0 -67.832194 0 8.4 HD55 (42.4)
```

```
0 0.094777 0 45.813201 0 8.9 HD38 (34.7)
0 0.094777 0 45.810673 0 9.0 (34.7)
0 0.104366 0 58.437145 0 6.0 HD123 (72.5)
0 0.104366 0 58.437145 0 6.0 HD123 (72.5)
```


Orbit Files

Orbital elements, which define the orbit of a comet or asteroid around the Sun, are used by ECU in four ways:

- Loaded into memory and in active use - ECU supports up to 25,000 comets and asteroids to be active at any one time.
- Saved as part of an ECU configuration file - ECU supports up to 25,000 comets and asteroids to be saved as part of a configuration file.
- Stored in an ECU Orbit File - these files have the extension ".orb" and their format is described below. Orbits for current comets and interesting asteroids can be downloaded from the Internet in ECU Orbit Format - see Download Orbits....
- Contained in the Master Orbit file - masterorbit.orb - this file contains all known asteroids and can be downloaded from the Internet in ECU Orbit Format - see Download Orbits.... The Search Orbits... feature can extract orbits for active use based on several parameters.

ECU Orbit File Format

ECU Orbit files are text files, thus can be altered by any text editor. There are two lines per orbit. The first line contains the name of the asteroid or comet (up to 40 characters). The second line contains the orbital elements separated by a space. By convention asteroid elements are defined a bit differently than comet elements so there are two formats:

Comet Format

The orbital element line contains 13 entries separated by a space in the following order: Enable (an 'E' if the comet is enabled, a 'D' if it is disabled), Orbit type (always a 'C' for a comet), Epoch, Year, Month, Date, Perihelion, Eccentricity, Argument of Perihelion, Longitude of Ascending Node, Inclination, Magnitude Parameter 'H', Magnitude Parameter 'G', and the Tail Length (optional). For a description of each entry, see Edit Orbits....

A sample comet entry is:

2P/Encke
E C 2000 2003.00000 12 29.8787 0.33846 0.8473400 186.49900 334.58730 11.76960 11.50 15.00

Asteroid Format

The orbital element line contains 14 entries separated by a space in the following order: Enable (an 'E' if the asteroid is enabled, a 'D' if it is disabled), Orbit type (always a 'A' for a asteroid), Epoch, Year, Month, Date, Mean Anomaly, Semi-Major Axis, Eccentricity, Argument of Perihelion, Longitude of Ascending Node, Inclination, Magnitude Parameter 'H', and Magnitude Parameter 'G'. For a description of each entry, see Edit Orbits....

A sample asteroid entry is:

(4544) Xanthus
E A 2000 2004.00000 7 14.0000 336.27920 1.04206 0.2503710 333.68280 24.09080 14.14730 17.10 0.15

Using the Telescope Interface

ECU provides extensive support for the control many different types of telescopes and focusers equipped with computer interfaces. Some of these are connected directly by built-in drivers, but many more are supported through drivers provided by the ASCOM Initiative. For the list of built in interfaces, see Primary Settings....

The astronomy software industry is now endorsing ASCOM drivers and ECU has supported them since nearly day-one. All built-in drivers remain included for the convenience of existing users, but except for the Encoder Interface type of telescope, **are no longer supported**. If they work, great. If not, then you will have to migrate to an ASCOM driver for your hardware.

Included in the list of supported interfaces are Nova Astronomics' own encoder interfaces: **The Micro-Guiders**. The Micro-Guider I and III and 5 are, unfortunately, no longer available for purchase.

Even though many of the menu selections and mouse/keyboard functions used by the telescope interface functions are shared among the many telescope interfaces, they do operate differently and thus each general type of telescope interface is separately described in the next few manual sections. See Primary Settings... to determine which section pertains to your telescope interface type.

Reference material is found in the Telescope menu section.

Using an ASCOM Telescope

The ASCOM (AStronomy Common Object Model) Platform is a set of technologies and drivers that form the basis for interoperability between ASCOM-based tools. Besides a set of utility objects and Microsoft-supplied scripting engines, the ASCOM Platform supports a variety of instrument types via standard drivers. For further information see www.ascom-standards.org.

These drivers allow ECU to access and control a large number of telescopes (and focusers) in a standard way without knowing anything about the actual telescope or the way it interfaces to the computer. The drivers are always being updated bugs are found or as new models of telescopes are introduced.

In order to use an ASCOM telescope or focuser the "ASCOM Platform" must be installed. The latest version is always available at http://www.ascom-standards.org/Downloads/Index.htm. After installing the platform, you have to download and install the drivers for your specific telescope. Be sure to re-boot your computer before attempting to use them.

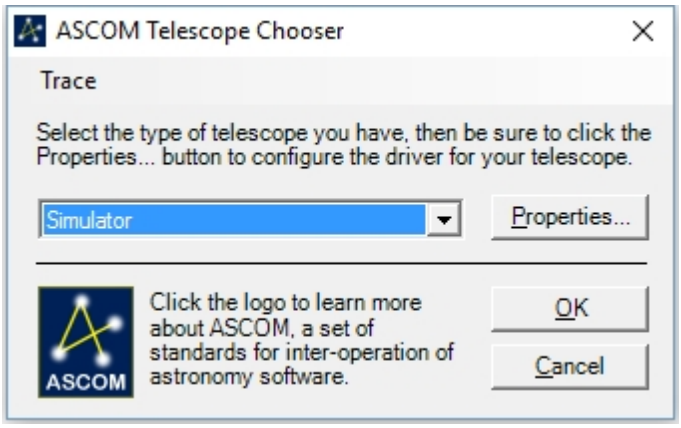
Initial Set Up

The first time you use an ASCOM-controller telescope or focuser you will have to make some adjustments to ECU's settings. However, as mentioned in the previous section, the "ASCOM Platform" (the drivers) must have previously installed.

Select Primary Settings... from the **Telescope** menu. Select the "Telescope Interface Type" to the "ASCOM-Controlled Telescope" (the currently selected driver is also displayed). When selecting the telescope interface type, the "update delay" is automatically set to a suitable value. Under normal circumstances, you should not have to change the "update delay", however, if your PC or telescope operates slowly when the telescope interface is enabled, try using a higher "update delay".

Select the **ASCOM Settings** tab and press the **Select Telescope Driver** button. Use the drop down list to select the driver applicable to your telescope or computerized mount, then press the **Properties...** button to appropriately configure the driver (every driver is different, so you are on your own to figure it out). If you are

using an ASCOM telescope driver for the first time, it is recommended that you select the "Simulator" driver, which is just that — a virtual telescope.



If you intend on using an electric focuser, activate the check box **Use ASCOM Focuser** and press the **Select Focuser Driver** button. Use the drop down list to select a focuser driver, then press the **Properties...** button to appropriately configure the driver (every driver is different, so you are on your own to figure it out). If you are using an ASCOM focuser driver for the first time, it is recommended that you select the "Simulator" driver, which is just that — a virtual focuser.

Press the **OK** button to save these settings, then make them permanent by using the **File** ⇒ **Save** or **File** ⇒ **Save As...** menu selections.

Enabling the Telescope Interface

Prior to enabling the ASCOM telescope interface, a number of steps must be completed as listed below:

- Connect the telescope to your computer (usually via an RS232 or USB cable).
- Turn the telescope on.
- Align the telescope following the procedure outlined in its instruction manual.
- Some telescopes require their computer interfaces to be enabled before they will respond to commands from the ASCOM driver.
- Enable the telescope interface by selecting the Enable Telescope Interface menu selection or press its button on the **Tool Bar**.
- If no error messages were displayed, the telescope interface should be functional.

If an error occurs, either when enabling the telescope interface or in subsequent operations, an "ECU Status" window will appear providing a detailed error message provided by the driver. If you cannot solve ASCOM-related problems yourself, first ensure that everything works properly using the telescope (or focuser) simulator drivers. If they work fine, then join the ASCOM group on the Internet (see groups.yahoo.com/group/ASCOM-Talk) to resolve what is most likely a driver issue. If the simulators don't work properly, then contact *Nova Astronomics* for assistance.

To disable the telescope interface, just select the Enable Telescope Interface menu selection again or press its **Tool Bar** button.

Using the Telescope Interface

Once enabled, the telescope interface is quite easy to use. The capabilities of each telescope, focuser, and its associated driver determine which telescope functions described below are available to you.

- **Position Display** — if the check box **Show Position** (see Miscellaneous Settings... for this and other telescope interface options) is enabled, an indicator will be drawn on the **Sky Chart** at the position which the telescope is pointed to and will follow it in real-time. If the check box **Track Telescope** is enabled, and the telescope position moves out of the current **Sky Chart**, it

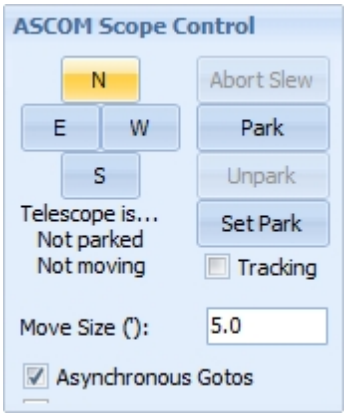
will be re-drawn with the current telescope position at the new center. You should also read about the **Auto Track Telescope** feature. The type of indicator displayed depends on the state of the **Use Default Chart Target** setting. If enabled, the position display will be the programmable field circles (or rectangle) as described in Targets... If not enabled or you **Sky Chart** is sufficiently zoomed out, a fixed size cross-hair is used.

- **Coordinate Display** — if **Show Coordinates** is enabled, a box will be visible which displays the real time equatorial coordinates of the telescope in equatorial and local horizon coordinates.

- **Manual Telescope Control** — if your telescope is "goto" capable, and **Telescope Control Box** is enabled, a box will be visible which allows manual control of the telescope motions, focus, and other functions.

  To manually move the telescope, first ensure that **Focus Mode** is not checked, then enter a "Move Size" in arc-minutes, then press the desired motion direction button.

  Several other functions are also supported in the control window. The **Park** button usually moves the telescope to its "park" location and turns off the RA drive. The **Unpark** button usually just turns on the RA drive, but does not move the telescope. The **Set Park** button, with some telescopes, sets the location that subsequent "Park" commands move the telescope to.



  The **Telescope** check box allows the equatorial tracking to be turned off or on. The **Asynchronous Gotos** check box determines how telescope "goto" commands work. If checked, when "goto" commands are given, the telescope will start to move and control is returned almost immediately. If not-checked, when "goto" commands are given, ECU waits (with an hour-glass style mouse cursor) until the "goto" operation is complete before returning control to the user.

  Focus Mode is entered when its check box is checked. The **N** and **S** buttons change to **F+** and **F-** meaning focus plus and focus minus. To move the focuser, enter the "Focus Step" size and press either the **F+** or **F-** button. The **Focus Temp. Comp.** button enables or disables temperature compensation for focusers that support this feature. Note that when temperature compensation is on focus motions are not allowed.

- **Goto Object** — the user can instruct the telescope to automatically slew to an object in the sky by first selecting the object from the **Sky Chart** (with the left mouse button) and then pressing the **Move Scope to Object** button from the Identify Objects Box. Some telescopes will not move if the object is below the local horizon or a limit imposed by the telescope and an error message will be displayed, otherwise the telescope will slew to the object. You can also limit the motions of telescope using user-defined Goto Limits... You can also slew to the

position occupied by the center of the **Sky Chart** by using the menu selection Move Telescope to Chart Center.

- **Synchronize Telescope** — the user can instruct the telescope to re-synchronize its current coordinates to known coordinates. This improves the pointing accuracy of the telescope. The usual procedure is to first use the Goto Object function to find an object. Due to various errors, the object will not likely be in the exact center of the field of view of the telescope. Use the telescope's manual controls to position the object in the center of the field of view. Then, finally, select the same object again with the left mouse button and press the **Sync Scope** button from the **Identify Objects Box**. You can also synchronize the telescope to the position occupied by the center of the **Sky Chart** by using the menu selection Sync Telescope to Chart Center. Depending on the **Confirm Syncs** setting, the user may be prompted to confirm a sync operation. Note that not all telescopes support the "syncing" feature.

Using a "GOTO" Type Telescope

To use a "GOTO" type telescope, you will need an RS232 cable to connect your telescope to your computer. This cable is available from your telescope retailer or telescope manufacturer or you can often make one yourself according to the instructions in your telescope instruction manual. Be careful in doing so, however, since the vast majority of problems that users report are directly attributable to incorrectly made cables.

Before attempting to use ECU with your telescope, you should have read your telescope instruction manual thoroughly and be able to confidently use it "stand-alone" without the aid of a computer.

Initial Set Up

You will need to install the Nova Astronomics COMPort driver - a link to this download is included in the email sent when you purchased ECU. The installer file is named **NovaAstroCOMPortInstaller.exe**.

The first time you use the "GOTO" telescope interface, you will have to make some adjustments to ECU's settings. Select Primary Settings... from the **Telescope** menu. Select the "Telescope Interface Type" to match your telescope type. Select the communications port that is used to connect the telescope to the computer. When selecting a telescope interface type, the "update delay" and "baud rate" are automatically set to suitable values. Under normal circumstances, you should not have to change these parameters, however, if your PC or telescope operates slowly when the telescope interface is enabled, try using a higher "update delay".

Press the **OK** button to save these settings, then make them permanent by using the **File** ⇒ **Save** or **File** ⇒ **Save As...** menu selections.

Enabling the Telescope Interface

Prior to enabling the telescope interface, a number of steps must be completed as listed below:

- Connect the RS232 cable between the telescope and your computer.
- Turn the telescope on.
- Align the telescope following the procedure outlined in its instruction manual.
- Some telescopes, such as the Celestron NexStars, require their RS232 interfaces to be enabled before they will respond to commands.
- Enable the telescope interface by selecting the Enable Telescope Interface menu selection or press its button on the **Tool Bar**.
- If no error messages were displayed, the telescope interface should be functional.
- If desired, you can use the **Set Telescope Time...** and **Set Telescope Geog Location...** buttons in Miscellaneous Settings... for Meade LX200 and other similar telescopes. Note that with the Astro-Physics GTO mount, the initialization procedure sets both the time and location,

so it's important that ECU's location and your computer's time are both set correctly.

To disable the telescope interface, just select the **Enable Telescope Interface** menu selection again or press its **Tool Bar** button.

Using the Telescope Interface

Once enabled, the telescope interface is quite easy to use. Several functions are provided; each is described below.

- **Position Display** — if the check box **Show Position** (see Miscellaneous Settings...for this and other telescope interface options) is enabled, an indicator will be drawn on the **Sky Chart** at the position which the telescope is pointed to and will follow it in real-time. If the check box **Track Telescope** is enabled, and the telescope position moves out of the current **Sky Chart**, it will be re-drawn with the current telescope position at the new center of the **Sky Chart**. You should also read about the **Auto Track Telescope** feature. The type of indicator displayed depends on the state of the **Use Default Chart Target** setting. If enabled, the position display will be the programmable field circles (or rectangle) as described in Targets... If not enabled or you **Sky Chart** is sufficiently zoomed out, a fixed size cross-hair is used.

- **Coordinate Display** — if **Show Coordinates** is enabled, a box will be visible which displays the real time equatorial coordinates of the telescope in equatorial and local horizon coordinates.

- **Manual Telescope Control** — if your telescope supports manual control and the check box **Telescope Control Box** is enabled, a box will be visible which allows manual control of the telescope motions and focus.

- **Goto Object** — the user can instruct the telescope to automatically slew to an object in the sky by first selecting the object from the **Sky Chart** (with the left mouse button) and then pressing the **Move Scope to Object** button from the Identify Objects Box. Some telescopes will not move if the object is below the local horizon or a limit imposed by the telescope and an error message will be displayed, otherwise the telescope will slew to the object. You can also limit the motions of telescope using user-defined Goto Limits... You can also slew to the position occupied by the center of the **Sky Chart** by using the menu selection Move Telescope to Chart Center.

- **Synchronize Telescope** — the user can instruct the telescope to re-synchronize its current coordinates to known coordinates. This improves the pointing accuracy of the telescope. The usual procedure is to first use the Goto Object function to find an object. Due to various errors, the object will not likely be in the exact center of the field of view of the telescope. Use the telescope's manual controls to position the object in the center of the field of view. Then, finally, select the same object again with the left mouse button and press the **Sync Scope** button from the **Identify Objects Box**. You can also synchronize the telescope to the position occupied by the center of the **Sky Chart** by using the menu selection Sync Telescope to Chart Center. Depending on the **Confirm Syncs** setting, the user may be prompted to confirm a sync operation. Note that not all telescopes support the "syncing" feature.

Using an Encoder Interface

To use an encoder interface, you will need, as a minimum, the following components:

1. Optical encoders mounted on both axis of your telescope.
2. An interface box (called the encoder interface) to translate the encoder signals into RS232 format.
3. An RS232 cable to connect the interface box to your computer.

There are many encoder interfaces on the market available from several suppliers. Not all of these have the required RS232 interface. Many of these units are manufactured by the same company (Tangent

Instruments), but marketed by many companies under different brand names, and are compatible with each other and thus also with ECU.

Some of these encoder interfaces are self-contained (that is, they can operate by themselves using their own integral display without the need for a separate computer), others are simpler, relying on a computer running a program such as ECU. These instructions will assume that you are using the simpler type, such as the Micro-Guider 5 or the JMI SGT-MAX.

Initial Set Up

You will need to install the Nova Astronomics COMPort driver - a link to this download is included in the email sent when you purchased ECU. The installer file is named **NovaAstroCOMPortInstaller.exe**.

The first time you use the encoder interface system, you will have to make some adjustments to ECU's settings to match your specific telescope and encoder interface.

Select Primary Settings... from the **Telescope** menu. Select the "Telescope Interface Type" to the one that most closely matches your encoder interface. Select the communications port that is used to connect the telescope to the computer. Initially select the "update delay" to 0.1 seconds (this is the default). If your PC operates slowly when the telescope interface is enabled, try using a higher "update delay". The baud rate for all supported encoder interfaces is 9600 baud and ECU automatically sets that default baud rate for you. Under normal circumstances, you should not have to change these parameters, however, if your PC or encoder interface operates slowly when the telescope interface is enabled, try using a higher "update delay".

Select the **Encoder Settings** tab. Enter your optical encoder resolutions and other settings according to the instructions outlined in Encoder Settings....

The **Reverse Direction** check boxes are necessary because of the various ways that encoders are installed on different models of telescopes. ECU provides a **Test Mode** (activated by the its check box) that can be used to experimentally determine if the direction of each encoder needs to be reversed.

Connect the RS232 cable between the telescope and your computer and turn on the encoder interface. After you have enabled the "Test Mode", select the Enable Telescope Interface menu selection. When the "Align Altitude Encoder" box is displayed, press the **1 Star** button.

As you move your telescope, its Azimuth (Azim) and Altitude (Alt) will be displayed in a small window in real-time. The Azimuth angle (or the RA angle for an equatorially-mounted telescope) should increase as the telescope is moved counter-clockwise, as viewed from above. The Altitude angle (or Declination angle for an equatorially-mounted telescope) should increase as the telescope is moved up (or to the north). If either of these motions is incorrect, reverse the corresponding **Reverse Direction** check box and test it again.

The "Test Mode" can also test the encoder resolution settings. Verify that the azimuth readings move smoothly from 0º through 360º for one complete rotation of the telescope and that the altitude readings move through a span of 90º as the telescope is moved one quarter of a turn. When finished with the "Test Mode", be sure to disable it.

Press the **OK** button to save these settings, then make them permanent by using the **File** ⇒ **Save** or **File** ⇒ **Save As...** menu selections.

Enabling the Encoder Interface

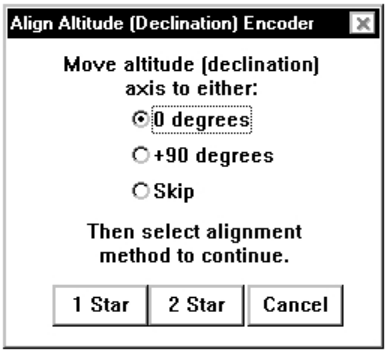
Prior to enabling the encoder interface you must first connect the RS232 cable between the telescope and the computer and turn on the encoder interface.

The encoder interface must be aligned using either one or two stars in the sky. ECU uses these stars as reference points when translating the optical encoder readings into right ascension and declination. The one-star alignment process can only be used for equatorially-mounted telescopes that are known to be accurately aligned on the celestial pole. Otherwise, the two star alignment process should be used.

Carefully select and enter your alignment star(s) into ECU according to the instructions in Encoder Settings...

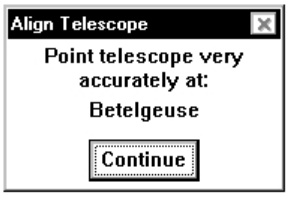
Select the Enable Telescope Interface menu or press its **Tool Bar** button. If you have aligned the encoder interface previously since running ECU, you will be presented with a message box containing the question: "Encoder Interface has already been aligned - use current alignment?". You can press the **Yes** button if you have not moved your telescope mounting or turned off your encoder interface, otherwise press the **No** button.

Next, the box similar to that below will be displayed. The telescope's altitude (or declination) axis must be aligned to either 0º or +90º (whichever is convenient) and the appropriate "radio" button pressed. If you have performed this step since turning on your encoder interface, you can press "skip" to ignore this step.



Press either the **1 Star** or **2 Star** button, or **Cancel** to abort the alignment process.

The **Sky Chart** will re-draw with the first alignment star positioned at the center of the chart and a message similar to that below will be displayed. Point the telescope exactly at the first alignment star and press the "Continue" button.



If you are performing a two-star alignment, the **Sky Chart** will re-draw with the second alignment star positioned at the center of the chart with another message displayed. Point the telescope exactly at the second alignment star and press the "Continue" button.

The alignment process completes by calculating and displaying the estimated error of the alignment. Ideally this value (in degrees) would be zero, but an error of last than 1 or 2 degrees usually produces a good alignment. Press the **Yes** button to accept the alignment or the **No** button to reject it.

Selecting the Enable Telescope Interface menu selection again will disable the encoder interface.

Using the Encoder Interface

Once enabled and aligned, the encoder interface is quite easy to use. Several functions are provided; each is described below.

- **Position Display** — if the check box **Show Position** (see Miscellaneous Settings... for this and other telescope interface options) is enabled, an indicator will be drawn on the **Sky Chart** at the position which the telescope is pointed to and will follow it in real-time. If the check box **Track Telescope** is enabled, and the telescope position moves out of the current **Sky Chart**, it will be re-drawn with the current telescope position at the new center of the **Sky Chart**. You should also read about the **Auto Track Telescope** feature. The type of indicator displayed depends on the state of the **Use Default Chart Target** setting. If enabled, the position display

will be the programmable field circles (or rectangle) as described in Targets... If not enabled or you **Sky Chart** is sufficiently zoomed out, a fixed size cross-hair is used.

- **Coordinate Display** — if **Show Coordinates** is enabled, a box will be visible which displays the real time equatorial coordinates of the telescope in equatorial and local horizon coordinates.

- **Find an Object** — to locate an object in the sky, select the object in the **Sky Chart** with the left mouse button and press the **Move Scope to Object** button. This will cause a window (shown below) to appear on the screen. Depending on the **Large Center Scope Box** setting, a large version of this window may also appear, making it easier to see the read the coordinates when you are a large distance from the screen.

  Move the telescope until both the coordinates displayed read zero (or nearly so). To make this process easier, when the telescope is closer than 2 degrees from the object in either axis, a "beeping" sound will be heard (if enabled — see section 3.8.16). This feature eliminates the necessity of looking at the computer screen while moving the telescope, except for the final positioning. To silence the "beeping" sound, press the ***** button or the "B" key on the keyboard.

  The best method to find objects is to move each axis of the telescope separately. Move the first axis until the "beeping" sound is heard. Silence the sound. Move the second axis until the "beeping" sound is heard again. Silence the sound. Zero in on the object by fine adjusting the telescope position until the coordinates display reads zero. End the process by pressing the **OK** button. You can also use the menu selection Move Telescope to Chart Center.

- **Synchronize Telescope** — re-synchronizes the current telescope coordinates to known coordinates. This improves the pointing accuracy of the telescope. The usual procedure is to center a known object in the exact center of the telescope's field of view. Then, select the same object from the **Sky Chart** with the left mouse button and press the **Sync Scope** button from the **Identify Objects Box**. If you aligned using the two-star method, ECU re-aligns using the current object and the better of the two original alignment stars. If ECU determines that the alignment will be of low accuracy, it presents a warning dialog box to user. You can also synchronize to the position occupied by the center of the **Sky Chart** by using the menu selection Sync Telescope to Chart Center. Depending on the **Confirm Syncs** setting, the user may be prompted to confirm a sync operation.

Using an "RA/Dec" Type Telescope

To use an "RA/Dec" type telescope interface, you will need an RS232 cable to connect your telescope interface to your computer. Before attempting to use ECU with your telescope, you should be able to confidently use computerized telescope "stand-alone" without the aid of a computer.

Initial Set Up

You will need to install the Nova Astronomics COMPort driver - a link to this download is included in the email sent when you purchased ECU. The installer file is named **NovaAstroCOMPortInstaller.exe**.

The first time you use the RA/Dec type telescope interface, you will have to make some adjustments to ECU's settings. Select Primary Settings... from the **Telescope** menu. Select the "Telescope Interface Type" to match your telescope type. Select the communications port that is used to connect the telescope to the computer. When selecting a telescope interface type, the "update delay" and "baud rate" are automatically set to suitable values. Under normal circumstances, you should not have to change these parameters, however, if your PC or telescope operates slowly when the telescope interface is enabled, try using a higher "update delay".

The "update delay" is automatically set to an appropriate value for the selected interface. If your PC or the telescope interface operates slowly when the telescope interface is enabled, try using a higher "update delay". If you use a Sky Commander or Losmandy DSC, set the "update delay" to 0.5 seconds. Speeds faster than this may cause the telescope interface to malfunction or become slow to operate.

The baud rate used by the Sky Commander or Losmandy DSC could be either 2400 baud or 9600 baud — newer units are set to 9600, older units are set to 2400 — you may have to try both speeds until it works properly. Its serial interface must also be enabled to work.

The baud rate used by the Magellan I is 1200 baud and the Magellan II is 300 baud and their serial interface must be enabled.

Press the **OK** button to save these settings, then make them permanent by using the **File** ⇒ **Save** or **File** ⇒ **Save As...** menu selections.

Enabling the Telescope Interface

Prior to enabling the telescope interface, a number of steps must be completed as listed below:

- Connect the RS232 cable between the telescope and your computer.
- Turn the telescope on.
- Align the telescope interface following the procedure outlined in its instruction manual. Enable the serial interface.
- Enable the telescope interface by selecting the Enable Telescope Interface menu selection or pressing the **Tool Bar** button.
- If no error messages were displayed, the telescope interface should be functional.

To disable the telescope interface, just select the **Enable Telescope Interface** menu selection again or press the **Tool Bar** button.

Using the Telescope Interface

Once enabled the telescope interface is quite easy to use. Several functions are provided; each is described below.

- **Position Display** — if the check box **Show Position** (see Miscellaneous Settings...for this and other telescope interface options) is enabled, an indicator will be drawn on the **Sky Chart** at the position which the telescope is pointed to and will follow it in real-time. If the check box **Track Telescope** is enabled, and the telescope position moves out of the current **Sky Chart**, it will be re-drawn with the current telescope position at the new center of the **Sky Chart**. You should also read about the **Auto Track Telescope** feature. The type of indicator displayed depends on the state of the **Use Default Chart Target** setting. If enabled, the position display will be the programmable field circles (or rectangle) as described in Targets... If not enabled or you **Sky Chart** is sufficiently zoomed out, a fixed size cross-hair is used.

- **Coordinate Display** — if the check box **Show Coordinates** is enabled, a window will be visible which displays the real time equatorial coordinates of the telescope.

- **Find an Object** — to locate an object in the sky, select the object in the **Sky Chart** with the left mouse button and press the **Center Scope** button. This will cause a box (shown below) to appear on the screen. Depending on the **Large Center Scope Box** check box setting, a large version of this window may also appear, making it easier to see the read the coordinates when you are a large distance from the screen.

  Move the telescope manually until both the coordinates displayed read zero (or nearly so). To make this process easier, when the telescope is closer than 2 degrees from the object in either axis, a "beeping" sound will be heard (if enabled). This feature eliminates the necessity of looking at the computer screen while moving the telescope, except for the final positioning. To

silence the "beeping" sound, press the ***** button or the "B" key on the keyboard.

The best method to find objects is to move each axis of the telescope separately. Move the first axis until the "beeping" sound is heard. Silence the sound. Move the second axis until the "beeping" sound is heard again. Silence the sound. Zero in on the object by fine adjusting the telescope position until the coordinates display reads zero. End the process by pressing the **OK** button. You can also use the menu selection Move Telescope to Chart Center.

Note that, unlike some other telescope interfaces, the Magellan and Sky Commander/Losmandy DSC do not support "syncing," via the serial interface, on an object to improve pointing accuracy, but may support "syncing" using their built-in keypad.

Automation Interface

ECU provides an ActiveX automation interface for scripting and externally accessing some of ECU's capabilities from other programs. This interface is new as of V6.1. It was developed mainly to provide access to ECU's database and its solar system and orbit calculations for the Abbey Ridge and Burke-Gaffney automated observatories.

The available methods and properties are limited at present. If you need access to features not available, let me know, and they will be considered in future versions.

ActiveX automation can be used from many scripting or programming languages, including VBScript, JScript, Java, Visual Basic, Delphi, etc. The easiest language to use is VBScript.

Here is an example VBScript script to connect to ECU, set the window size and position and load a configuration file.

```
' create ECU object
set ECU=createobject("ECU.ECUCOM")

ECU.WindowSize 700, 900
ECU.WindowPosition 50, 50
ECU.OpenCFG "c:\users\dave\documents\ecu\test.cfg"       ' use a fully
qualified filename
ECU=nil

' exit successfully
WScript.Quit(0)
```

To execute the script from a windows command prompt, save it as 'test.vbs' type:

```
cscript test.vbs
```


Properties

This section contains a reference for the properties exposed by the `ECU.ECUCOM` object:

AppendNewOrbits

Property

AppendNewOrbits

Description

This read-write property of type "VARIANT_BOOL" determines whether the LoadOrbits method replaces current orbits (false) or appends the loaded orbits (true) to currently loaded orbits.

Connections

Property

Connections

Description

This read-only property of type "int" returns the current number of automation clients presently connected.

Locked

Property

Locked

Description

This read-write property of type "VARIANT_BOOL" returns "true" if another automation client has "locked" access to the automation interface.

If this property is set to "true", it is requesting exclusive access. If it was already "true", an exception is raised - this indicates that another client has access. Be sure to set property to "false" when exclusive access is done.

The intent of this property is to allow one automation client to get exclusive access.

Methods

This section contains a reference for the methods exposed by the `ECU.ECUCOM` object:

CenterAzAlt

Method

CenterAzAlt AZ , ALT

Description

This centers ECU's **Sky Chart** to azimuth AZ and altitude ALT given the current date, time, and geographic location. AZ and ALT are of type "double".

An exception is raised if AZ or ALT are out of range.

CenterRADec

Method

CenterRADec RA , DEC

Description

This centers ECU's **Sky Chart** to right ascension RA and declination DEC. RA and DEC are of type "double".

An exception is raised if RA or DEC are out of range.

CenterTelescope

Method

CenterTelescope

Description

This moves the telescope to the ECU's current chart center. If the telescope is not enabled, this method does nothing.

ClearOrbits

Method

ClearOrbits

Description

This clears ECU's loaded minor planet and comet orbits.

FieldSize

Method

FieldSize SIZE

Description

This sets ECU's chart size to SIZE degrees. SIZE is of type "double".

ForwardOneStep

Method

ForwardOneStep

Description

This sets ECU's date and time forward by the current animation time step.

Hide

Method

Hide

Description

This hides the ECU window to the Windows system tray.

LoadOrbits

Method

LoadOrbits filename.orb

Description

This loads the ECU asteroid and comet orbit file "filename.orb". The filename must be fully-qualified with the drive and directory.

An exception is raised the orbit file is not found or could not be loaded.

LoadUsers

Method

LoadUsers

Description

This causes the current User Object files to be reloaded. An exception is raised if an error occurs.

OpenCFG

Method

OpenCFG "c:\users\dave\documents\ecu\filename.cfg"

Description

This loads the ECU configuration file "filename.cfg". The filename must be fully-qualified with the drive and directory.

An exception is raised the configuration file is not found or could not be loaded.

ReverseOneStep

Method

ReverseOneStep

Description

This sets ECU's date and time backward by the current animation time step.

SaveCFG

Method

SaveCFG "c:\users\dave\documents\ecu\filename.cfg"

Description

This save the ECU configuration file "filename.cfg". The filename must be fully-qualified with the drive and directory.

An exception is raised if the configuration file could not be saved.

SaveOrbits

Method

SaveOrbits "c:\users\dave\documents\ecu\filename.cfg"

Description

This save the ECU asteroid and comet orbit file "filename.orb". The filename must be fully-qualified with the drive and directory.

An exception is raised if the orbit file could not be saved.

Search

Method

Search "OBJECTNAME", RA , DEC, MAGNITUDE, OBJECTTYPE, CATALOG, MOVINGOBJECT, PRIMARYNAME

Description

This searches ECU's databases for object OBJECTNAME and returns:

- RA - the right ascension of the object (as type "double")
- DEC - the declination of the object (as type "double")
- MAGNITUDE - the magnitude of the object (as type "double"). If unknown, it's set to -20.
- OBJECTTYPE - the type of the object as follows (as type "int"):
  - STAR=0
  - GALAXY=1
  - GLOBULARCLUSTER=2
  - OPENCLUSTER=3
  - NEBULA=4
  - PLANETARYNEBULA=5
  - OTHERDEEPSKY=6
  - DOUBLESTAR=13
  - VARIABLESTAR=14
  - SUN=18
  - MOON=19
  - PLANET=20
  - COMET=21
  - ASTEROID=22
  - UNKNOWN=23
  - ASTERISM=24
  - DARKNEBULA=25
  - GALAXYCLUSTER=26
  - CLUSTERNEB=27
  - QUASAR=28
  - MULTIPLESTAR=29
  - CLUSTERINGALAXY=30
  - NEBULAINGALAXY=31

        - SNR=32
        - CONSTELLATION=33
    - CATALOG - the name of the source catalog for the object (as type "BSTR")
    - MOVINGOBJECT - this is true of the object is a solar system object and false if its a fixed object (as type "VARIANT_BOOL")
    - PRIMARYNAME - the primary name of the object found. For example if one searches for NGC2168, its primary name would be M35.

If the object is found, the **Sky Chart** is also redrawn at the object's location. An exception is raised if the object was not found.

SetAnimStep

Method

SetAnimStep HOURS

Description

This sets ECU's animation time step in hours. The smallest value allowed is 1 second and the largest is one year. HOURS is of type "double". An exception is raised if HOURS is out of range.

SetLocalTime

Method

SetLocalTime YEAR, MONTH, DATE, HOUR, MINUTE, SECOND

Description

This sets ECU's local date and time. All parameters are of type "int". An exception is raised if any parameters are out of range.

TrackTelescope

Method

TrackTelescope ENABLE

Description

If the parameter is "true", the Track Telescope feature is enabled otherwise is it disabled. When enabled it causes ECU's **Sky Chart** to be redrawn if the telescope's position goes off the chart. ENABLE is a "VARIANT_BOOL".

SetUTCTime

Method

SetUTCTime YEAR, MONTH, DATE, HOUR, MINUTE, SECOND

Description

This sets ECU's Universal date and time (UTC). All parameters are of type "int". An exception is raised if any parameters are out of range.

Show

Method

Show

Description

This shows the ECU window (restores it from the Windows system tray).

TelescopeOff

Method

TelescopeOff

Description

This disables ECU's telescope interface. An exception is raised if the telescope could not be disabled.

TelescopeOn

Method

TelescopeOn

Description

This enables ECU's telescope interface. An exception is raised the telescope could not be enabled.

TimetoClock

Method

TimetoClock

Description

This sets ECU's date and time to the current time (from the PCs clock) and enables auto-updates each minute.

TimetoJD

Method

TimetoJD JD

Description

This sets ECU's date and time Julian Date JD. JD is of type "double". This is the same as Julian Date....

TimetoNow

Method

TimetoNow

Description

This sets ECU's date and time to the current time (from the PC's clock). It does not enable auto-updates.

WindowSize

Method

WindowSize X , Y

Description

This sets the size of ECU's main form to X (width) and Y (height). X and Y are of type "int".

WindowPosition

Method

WindowPosition X , Y

Description

This sets the position of the top left corner of ECU's main form to X (left) and Y (top). X and Y are of type "int".

Exceptions

This section contains the list of possible exception messages and error numbers. The error message is prefixed by the method or property that reported the error.

Error Code (hexadecimal)	Error Message
201	Failed: Error loading config file
202	Failed: Error saving config file
203	Failed: Error enabling telescope
204	Failed: Error disabling telescope
205	Failed: Object not found
206	Failed: Julian Date is invalid
207	Failed: Time step invalid (1 sec to 1 yr in hours)
208	Failed: Azimuth is out of range
209	Failed: Altitude is out of range
210	Failed: RA is out of range
211	Failed: Dec is out of range

212	Failed: Object not found
213	Failed: Invalid date or time
214	Failed: Error loading user files
215	Failed: Cannot set "Locked" state - already locked
216	Failed: Error loading orbit file
217	Failed: Error saving orbit file

Appendices

The Appendix includes:

- About the Author - biographical information about ECU's author
- Guide Star Catalog Info
- GCVS Variable Star Types
- What's New - detailed lists of what has changed in the last few releases of ECU.

About the Author

I (Dave Lane) have been an active amateur astronomer since the early 1980s, am a life member of the Royal Astronomical Society of Canada (RASC), and am a past-president of the Halifax Chapter and of the national Society. Since 1992, I have been employed as the Astronomy Technician (now Observatory Director) and Systems Administrator at the Department of Astronomy and Physics at Saint Mary's University (Halifax, Nova Scotia, Canada) where I am responsible for the Burke-Gaffney Observatory and the department's computing infrastructure. Prior to working at SMU, I developed instrumentation systems for oceanography and meteorology and led the "hardware group" at Seimac Limited (later Cobham Tracking & Locating - now no longer in business).

My primary astronomical interests are observatory automation, public outreach, contributing to amateur astronomical science projects (such as variable star observing), deep sky observing, and astrocomputing.

I also operate the very-part-time business, **Nova Astronomics**, whose primary work involves the development and distribution of this software.

I also hold the distinction, along with Paul Gray of being the first and second Canadians to discover any supernovae (1995F in NGC 2726 and 2005B in UGC11066) from within Canada.

Outside of work and astronomy, I am a sailor that races and cruises a 30-foot C&C 30-2 sailboat. I also volunteer in several capacities at the St Margaret Sailing Club.

Notable Awards and Recognition

- From the RASC
  - Chant Medal (1996) - the highest award for amateur contributions to astronomy in Canada.
  - Ken Chilton Prize (1995 and 2010) - awarded annually to an amateur astronomer resident in Canada, in recognition of a significant piece of astronomical work carried out or published recently.
  - Service Award (1998) - recognizes the contributions of members who, at either the National or Centre levels, have made a significant contribution to the life and vitality of the Society.
  - President's Award (2013) - given at the President's discretion to a member who has made an important contribution to the Society.
  - Fellowship Award (2015) - acknowledges the work of long-serving members. It recognizes those outstanding members who have made extraordinary contributions to the Society over the long term, much of which service has been rendered at the national level.
- From Saint Mary's University
  - The President's Award for Exemplary Service (2008)
- From the Discovery Centre
  - Science Champion (2007) - awarded to a working scientist, technology professional, full-time science teacher/professor, journalist, radio or TV personality who devotes time to the promotion of science and technology to the public.
- From the IAU
  - Asteriod (117032) Davidlane was named after me - the citation reads: *David Lane (b. 1963) is the author of The Earth Centered Universe, a brilliantly easy-to-use planetarium and telescope-control program. With Paul Gray, Lane has discovered three supernovae--- SN1995F, 2005B and 2005ea. He is scheduled to assume the presidency of the Royal Astronomical Society of Canada in June 2008.*

Guide Star Catalog Info

Note for Earth Centered Universe Users

Nova Astronomics has obtained a license from the Space Telescope Science Institute to reproduce data from the Guide Star Catalog. As a requirement of the agreement, Nova Astronomics is required to provide this reproduction of the original printed booklet included with the original CD-ROM set. Several changes have been made to the Guide Star Catalog (GSC) Version 1.1 to produce the "Earth Centered Universe" version of the GSC that may make some information in this booklet slightly incorrect. Details of these changes and other important information regarding the Guide Star Catalog are included in the text file: "README.GSC" located in the GSC directory of your ECU installation.

THE GUIDE STAR CATALOG VERSION 1.1

An all-sky astrometric and photometric catalog to support
the operation of the Hubble Space Telescope

This set of two CD-ROMs in the ISO 9660 format contains the Guide Star Catalog — Version 1.1, with an issue date of 1 August 1992. The Guide Star Catalog (GSC) was prepared by the Space Telescope Science Institute (ST ScI), 3700 San Martin Drive, Baltimore, MD 21218, USA. ST ScI is operated by the Association of Universities for Research in Astronomy, Inc. (AURA), under contract with the National Aeronautics and Space Administration (NASA).

1. INTRODUCTION

The Guide Star Catalog (GSC), which has been constructed to support the operational need of the Hubble Space Telescope (HST) for off-axis guide stars, contains nearly 19 million objects brighter than sixteenth magnitude, of which more than 15 million are classified as stars.

The original version of this catalog, GSC 1.0, is described in a series of papers: Lasker et al. (1990); Russell et al. (1990); and Jenkner et al. (1990); hereafter referred to as Papers I, II, and III. Additions and corrections made in GSC 1.1 addressincompleteness, misnomers, artifacts, and other errors due to the overexposure of the brighter stars on the Schmidt plates, the identification of blends likely to have been incorrectly resolved, the incorporation of errata reported by the user-community or identified by the analysis of HST operational problems.

Among the primary authors of the GSC 1.0 and the associated systems, the scientific responsibilities were divided as follows: Helmut Jenkner, system coordination and overall design; Barry M. Lasker, astrophysics and photometry; Brian J. McLean, algorithmic analysis and systems development; Jane L. Russell, astrometry; Michael M. Shara, system management; and Conrad R. Sturch, production management and quality control. GSC 1.1 analysis and production were performed primarily by Jesse B. Doggett, Daniel Egret, Brian J. McLean, and Conrad R. Sturch.

Helmut Jenkner is on assignment from the European Space Agency; Jane L. Russell is currently affiliated with the Applied Research Corporation, Landover, MD; and Conrad R. Sturch is with the Astronomy Programs, Computer Sciences Corporation at Space Telescope Science Institute. Daniel Egret is affiliated with Observatoire de Strasbourg, France.

2. DISCUSSION OF THE GSC 1.0 PROJECT

Astronomical and Algorithmic Foundation

As described in Paper I, the GSC is primarily based on an all-sky, single epoch, single passband collection of Schmidt plates. For centers at +6 degrees and north, a 1982 epoch "Quick V" survey was obtained by the Palomar Observatory, while for southern fields, materials from the UK SERC J survey (epoch approximately 1975) and its equatorial extension (epoch approximately 1982) were used. In addition, over

100 short-exposure plates were taken with the Palomar Oschin and UK Schmidt telescopes to cover complex regions including the southern Milky Way, the Magellanic Clouds, and M31. These northern, southern, and supplemental plates hereafter are referred to as N, S, and X plates, respectively. The plates were digitized into 14000-square rasters at 25 um sample intervals using modified PDS microdensitometers.

The sky-background was modeled with a bi-dimensional cubic spline approximation to the modal level. Then an object finder, based on locating connected pixels at a certain threshold above the background, was used to obtain, for each plate, a list of positions, sizes, intensities, and related descriptive parameters. Images with multiple peaks were deblended by an algorithm based on correlations against a library of stellar images.

The identified objects were classified as stars or non-stars by an interactive multivariate Bayesian classifier that used image features from the object-detection steps and was started from a small set of objects visually identified on each plate. Comparison of classifications from multiply cataloged objects in the plate overlap areas shows that the purity of objects classified as stars is typically 97 percent.

Photometric and Astrometric Calibrations

The GSC calibrations were obtained on a plate-by-plate basis by polynomial modeling against the photometric and astrometric reference catalogs.

Photometry is available in the natural systems defined by the individual plates in the GSC collection (generally J or V), and the calibrations are done using B, V standards from the Guide Star Photometric Catalog (Lasker, Sturch, et al. 1988).

In Paper II the overall quality of the photometry near the standard stars was estimated from the fits and other tests to be 0.15 mag (one sigma, averaged over all plates), while the quality far from the sequences was estimated from the all-sky plate-to-plate agreement and from comparisons with independent photometric surveys to be about 0.3 mag (one sigma), with about 10% of the errors being greater than 0.5 mag. Additionally, Ratnatunga's (1990) comparison of the GSC against totally independent J-band photographic photometry for three southern fields (20 sq deg area) for $12.5 < J < 15.5$ shows agreement at the 0.1-0.2 mag level.

Astrometry, at equinox J2000, is available at the epochs of the individual plates used in the GSC; and the reductions to the reference catalogs (AGK3, SAOC, or CPC, depending on the declination zone) use third order expansions of the modeled plate and telescope effects. The fits to the reference catalogs lie in the range 0.5" to 0.9", and most of this is attributable to errors in the reference catalogs, to centroiding errors on the relatively large images of the reference stars, and to unmodeled astrometric effects.

Paper II reported estimates of the overall external astrometric error, produced by comparisons of independently measured positions, in the range 0.2" to 0.8" (per coordinate), depending on the areas of the plate and the sky. Then from a more extensive analysis against the Carlsberg Automatic Meridian Circle data, Taff et al. (1990) found that GSC absolute positional errors from plate center to edge vary from 0.5" to 1.1" in the north and from 1.0" to 1.6" in the south, and that relative errors at half-degree separations range from 0.33" to 0.76" depending upon hemisphere and magnitude.

Production, Database Organization, and Population Statistics

Paper III describes the software system used to produce the GSC. It consisted of a set of (primarily non-interactive) image-processing and calibration programs interconnected by a set of pipeline files and supported by databases organized on a plate-by-plate basis. A set of utility programs was also provided to support quality control and to correct operational problems.

Object names are of the form GSC rrrrr nnnnn, where the first field specifies an internal region number and the second is an ordinal within it. For objects cataloged from more than one photographic plate, an entry was made from each image; and all entries for the same object were given the same unique name.

Paper III also reviews the database for compiling statistics of objects with multiple entries and the details of the organization and structure of the GSC, including the provisions for assigning unique names, for cataloging objects lying in the plate overlap regions, for rapidly indexing positions against regions, and for recovering the original plate measurements. The separate count statistics for stellar and non-stellar objects on a plate-by-plate basis are provided in the supporting tables.

User Interfaces, Utilities, and Astronomical Applications

The all-sky collection of Schmidt plates that were digitized, archived to optical disc, and processed to generate the Guide Star Catalog (GSC) constitute a general image resource for astronomical research.

This data set, combined with the computing environment provided by the Guide Star Astrometric Support Package (GASP), major elements of which are exported within the Space Telescope Science Data Analysis System, provides random access to a digital image in any part of the sky. The GASP environment also supports access to the GSC and to other major astronomical catalogs.

3. REVISIONS IN GSC 1.1

The GSC 1.1 activities performed to address a number of known problems in GSC 1.0 are summarized here and described in detail in the text file for this revision, `REV_1_1.TBL;1`.

Two concerns related to the brighter stars arise from the heavily overexposed images on the Schmidt plates used in the GSC, namely an incompleteness and a reduced precision. Both are addressed in the domain V < 7.5 by the use of data from the INCA Data Base (Turon et al. 1992; Jahreiss et al. 1992; Grenon et al. 1992) in the Tycho Input Catalog (TIC; Egret et al. 1992). Such entries are designated by the plate identifier +056 in GSC 1.1. The limit of V < 7.5 preserves the original GSC data for objects that were used in the GSC 1.0 astrometric calibration.

Naming errors occur when objects catalogued from more than one photographic plate have positional errors sufficiently large that crossmatching of the overlapping plate areas is done incorrectly. The most significant known instances of this in GSC 1.0 were associated with overexposed (and therefore badly centroided) images of the brighter stars. A search around the positions of the INCA stars facilitated the identification of these naming errors, which were then removed in GSC 1.1.

GSC 1.0 contains many pairs of objects (from single plates) with separations significantly smaller than the expected resolution of the catalog, which Garnavich (1991), based on a study of four northern plates, estimates at ~ 10" for 8.0 < V < 14.0. Visual inspection shows that these are generally blends that have been properly resolved, but then affected by a centroider defect that made the separations artificially small. Such components of blends with incorrect separations are given a classification of 2 (blend; cf. the text file for a full listing of the codes).

For stars with V < 8, image-processing artifacts near the diffraction spikes exist in GSC 1.0. In GSC 1.1, potential artifacts were identified by use of a purely geometrical criterion (proximity of the object to the spike), and were assigned a classification of 5.

Small areas around southern stars brighter than V ~ 3 are not processed from the Schmidt plates and were left blank in GSC 1.0. For these, GSC 1.1 contains entries from supplemental astrograph plates taken with the GPO (Gran Prisma Objectif) telescope on La Silla, and the astrograph at the Black Birch Observatory (BBO) in Blenheim, New Zealand. Because of their smaller fields, the photometric and astrometric calibrations of data from most GPO and a few BBO plates were performed against nearby GSC entries based on the Schmidt plates.

A number of specific errors in GSC 1.0 have been identified by the user-community and by analyses of HST operational problems. These generally involve naming errors, plate flaws, misclassifications, and multiple stars; most are individually corrected in GSC 1.1. Also, the photometric error parameter in GSC 1.1 is now correctly described by equation (3) in Paper II; i.e., the erratum of footnote 5 therein is no longer pertinent

Plans for GSC maintenance beyond version 1.1 include an astrometric recalibration (cf. Taff, Lattanzi, and Bucciarelli 1990), and investigation of erroneous double entries that may exist for V > 7.5.

4. ORGANIZATION OF THE DATA FILES

The Guide Star Catalog is subdivided into regions that are bounded by small circles of right ascension and great circles of declination, and that are numbered consecutively from 0001 to 9537. Data for each region are stored as separate files; these files are contained in directories, each of which subtends a 7.5 degree zone of declination.

The Guide Star Catalog is distributed as a two CD-ROM set, divided at a declination of -7.5 degrees. An introductory file (`README.TXT;1`) and the supporting tables are duplicated on both discs.

All data files (i.e., with the exception of the file `README.TXT;1` and the directory files) are in FITS (Flexible Image Transport System; Greisen et al. 1981; Wells et al. 1981; Grosbol et al. 1988; and Jahreiss et al. 1992) table format.

The root directory contains the following files:

`README.TXT;1`	- Introduction.
`GSC`	- Directory for GSC region files.
`TABLES`	- Directory for GSC supporting tables.

Directory GSC contains directories for the 7.5 degree zones in declination; these directories in turn contain the GSC region files in FITS format for the respective zone, with file identifiers of the form nnnn.GSC;1, where nnnn is the 4-digit decimal region number, with leading zeroes used as required to fill the field. The directories are named as follows:

Directory	Declination		Regions		Disc
	From	To	From	To	
N0000	+00D 00'	+07D 30'	0001	0593	1
N0730	+07D 30'	+15D 00'	0594	1177	1
N1500	+15D 00'	+22D 30'	1178	1728	1
N2230	+22D 30'	+30D 00'	1729	2258	1
N3000	+30D 00'	+37D 30'	2259	2780	1
N3730	+37D 30'	+45D 00'	2781	3245	1
N4500	+45D 00'	+52D 30'	3246	3651	1
N5230	+52D 30'	+60D 00'	3652	4013	1
N6000	+60D 00'	+67D 30'	4014	4293	1
N6730	+67D 30'	+75D 00'	4294	4491	1
N7500	+75D 00'	+82D 30'	4492	4614	1
N8230	+82D 30'	+90D 00'	4615	4662	1
S0000	-00D 00'	-07D 30'	4663	5259	2
S0730	-07D 30'	-15D 00'	5260	5837	2
S1500	-15D 00'	-22D 30'	5838	6411	2
S2230	-22D 30'	-30D 00'	6412	6988	2
S3000	-30D 00'	-37D 30'	6989	7522	2
S3730	-37D 30'	-45D 00'	7523	8021	2
S4500	-45D 00'	-52D 30'	8022	8463	2
S5230	-52D 30'	-60D 00'	8464	8839	2
S6000	-60D 00'	-67D 30'	8840	9133	2
S6730	-67D 30'	-75D 00'	9134	9345	2
S7500	-75D 00'	-82D 30'	9346	9489	2
S8230	-82D 30'	-90D 00'	9490	9537	2

Directory TABLES contains the following supporting files for the GSC, written in FITS table format:

COMMENTS.TBL;1	- Introduction and general comments.
REV_1_1.TBL;1	- Comments on GSC 1.1 revisions.
PLATES.TBL;1	- Information on the plates used in the GSC.
PROCESS.TBL;1	- Image processing parameters.
ASTR_CAL.TBL;1	- Parameters of astrometric calibrations.
PHOT_CAL.TBL;1	- Parameters of photometric calibrations.
C_UP_POP.TBL;1	- Catalog update population statistics.
ST_POP.TBL;1	- Population statistics for stars.
NS_POP.TBL;1	- Population statistics for non-stars.
REGIONS.TBL;1	- Boundaries of GSC regions.
C_RE_POP.TBL;1	- GSC region population statistics.
LG_REG_X.TBL;1	- Index to large regions.
SM_REG_X.TBL;1	- Index to small regions.
XREF_P2R.TBL;1	- Cross-reference table, plates to regions.
XREF_R2P.TBL;1	- Cross-reference table, regions to plates.

5. ACKNOWLEDGEMENTS

The primary authors would like to thank the large number of persons who have participated in the Guide Star Selection System and the Guide Star Catalog developments over the past years. In addition to the many people previously acknowledged, we would like to thank the following who made contributions in GSC 1.1:

* by collaboration in merging INCA data into GSC 1.1: Daniel Egret and the HIPPARCOS INCA and Tycho groups;
* for providing astrograph plates for southern bright stars: Geoffrey Douglass, Robert Harrington, G. Monderen, and Otto Richter;
* by contributing to the GSC 1.0 error discussion or by reporting specific errors in GSC 1.0: Batrice Bucciarelli, Daniel Egret, Holland Ford, Peter Garnavich, Roberto Gilmozzi, Roberta Humphreys, Mario

Lattanzi, William Owen, Barry Rappaport, Kavan Ratnatunga, Larry Taff, Patrick Wallace, Fred Walter, and Archibald Warnock;
* for pre-mastering the CD-ROMs: Ian Evans;
* and by making essential contributions to the project's infrastructure: Marian Iannuzzi, Greg McLeskey, Dave Paradise, Don Stevens-Rayburn, and Patty Trovinger.

Finally, special thanks are due to Riccardo Giacconi, Director of the Space Telescope Science Institute, for his vision and continuing support of this project.

The Guide Star Catalog is partially based on data obtained at Palomar Observatory, operated by the California Institute of Technology; at the UK Schmidt Telescope, operated by the UK Science and Engineering Research Council and by the Anglo-Australian Observatory; at the Cerro Tololo Inter-American Observatory and the Sacramento Peak Observatory, both operated by the Association of Universities for Research in Astronomy, Inc., under contract to the National Science Foundation; and at the Mount Lemmon Observatory, operated by the University of Arizona.

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GCVS Variable Star Types

Note

The information below is included as part of the General Catalog of Variable stars - the source infomation is here.

An improved system of variability classification is used in the fourth edition of the GCVS, based on recent developments in classification principles and taking into account the suggestions of a number of specialists. Variability types are grouped according to the major astrophysical reasons for variability, viz.,

1. eruptive (FU, GCAS, I, IA, IB, IN, INA, INB, INT, IT, IN(YY), IS, ISA, ISB, RCB, RS, SDOR, UV, UVN, WR),

2. pulsating (ACYG, BCEP, BCEPS, CEP, CEP(B), CW, CWA, CWB, DCEP, DCEPS, DSCT, DSCTC, GDOR, L, LB, LC, M, PVTEL, RPHS, RR, RR(B), RRAB, RRC, RV, RVA, RVB, SR, SRA, SRB, SRC, SRD, SXPHE, ZZ, ZZA, ZZB),

3. rotating (ACV, ACVO, BY, ELL, FKCOM, PSR, SXARI),

4. cataclysmic (explosive and novalike) variables (N, NA, NB, NC, NL, NR, SN, SNI, SNII, UG, UGSS, UGSU, UGZ, ZAND),

5. eclipsing binary systems (E, EA, EB, EW, GS, PN, RS, WD, WR, AR, D, DM, DS, DW, K, KE, KW, SD),

6. intense variable X-ray sources (X, XB, XF, XI, XJ, XND, XNG, XP, XPR, XPRM, XM),

7. other symbols (BLLAC, CST, GAL, L:, QSO, S, *, +, :).

8. the new variability types (ZZO, AM, R, BE, LBV, BLBOO, EP, SRS, LPB)

All of these classes include objects of a dissimilar nature that belong to different types of light variability. On the other hand, an object may be variable because of almost all of the possible reasons or because of any combination of them. If a variable belongs to several types of variability, the types are joined in the data field by a "+" sign, e.g., E+UG, UV+BY.

Despite considerable success in understanding stellar variability pro- cesses, the classification adopted in the Catalogue is far from perfect. This is especially the case for explosive, symbiotic and novalike variables; X-ray sources; and peculiar objects.

The new variability types (ZZO, AM, R, BE, LBV, BLBOO, EP, SRS, LPB) have been added in the Name-Lists 67- 77 and in the GCVS vol.V.

ZZO ZZ Cet type variables of the DO spectral type showing HeII and and CIV absorpion lines in their spectra.

AM AM Her type variables; close binary systems consisting of a dK-dM type dwarf and of a compact object with strong magnetic field, characterized by variable linear and circular polarization of light. The total range of light variations may reach 4-5 mag V.

R Close binary systems characterized by the presence of strong reflection (re-radiation) of the light of the hot star illuminating the surface of the cooler companion. Light curves are sinusoidal with the period equal to Porb, maximum brightness coinciding with the passage of the hot star in front of the companion. The eclipse may be absent. The range of light variation is about 0.5-1.0mag V (KV Vel).

BE It becomes more and more clear that, although the majority of Be stars are photometrically variable, not all of them could be properly called GCAS variables. Quite a number of them show small-scale variations not necessarily related to shell events; in some cases the variations are quasi-periodic. By now we are not able to present an elaborated system of classification for Be variables, but we adopt a decision that in the cases when a Be variable cannot be readily described as a GCAS star we give simply BE for the type of variability.

EP Stars showing eclipses by their planets. Prototype: V0376 Peg.

SRS Semiregular pulsating red giants with short period (several days to a month), probably high-overtone pulsators. Prototype: AU Ari.

GDOR Gamma Doradus stars. Early type F dwarfs showing (multiple) periods from several tenths of a day to slightly in excess of one day. Amplitudes usually do not exceed 0.1 mag. Presumably low degree g-mode non-radial pulsators. Prototype: gamma Dor.

RPHS Very rapidly pulsating hot (subdwarf B) stars. Typical periods are hundreds of seconds, amplitudes are within several hundredths of a magnitude. Prototype: V361 Hya = EC 14026-2647.

LPB The comparatively long-period pulsating B stars (periods exceeding (LBV) one day).

BLBOO The so-called "anomalous Cepheids", i.e. stars with periods characteristic of comparatively long-period RRAB variables, but considerably brighter by luminosity (BL Boo = NGC 5466 V19).

1. Eruptive Variable Stars

Eruptive variables are stars varying in brightness because of violent processes and flares occurring in their chromospheres and coronae. The light changes are usually accompanied by shell events or mass outflow in the form of stellar winds of variable intensity and/or by interaction with the surrounding interstellar medium. This class includes the following types:

FU Orion variables of the FU Orionis type. Characterized by gradual increases in brightness by about 6 mag in several months, followed by either almost complete constancy at maximum that is sustained for long periods of time or slow decline by 1-2 mag. Spectral types at maximum are in the range Ae(alpha) - Gpe(alpha). After an outburst, a gradual development of an emission spectrum is observed and the spectral type becomes later. These variables probably mark one of the evolutionary stages of T Tauri-type Orion variables (INT), as evidenced by an outburst of one member, V1057 Cyg, but its decline (2.5 mag in 11 years) commenced immediately after maximum brightness was attained. All presently known FU Ori variables are coupled with reflecting cometary nebulae.

GCAS Eruptive irregular variables of the Gamma Cas type. These are rapidly rotating B III-IVe stars with mass outflow from their equatorial zones. The formation of equatorial rings or disks is often accompanied by temporary fading. Light amplitudes may reach 1.5 mag in V.

I Poorly studied irregular variables with unknown features of light variations and spectral types. This is a very inhomogeneous group of objects.

IA Poorly studied irregular variables of early (O-A) spectral type.

IB Poorly studied irregular variables of intermediate (F-G) to late (K-M) spectral type.

IN Orion variables. Irregular, eruptive variables connected with bright or dark diffuse nebulae or observed in the regions of these nebulae. Some of them may show cyclic light variations caused by axial rotation. In the Spectrum-Luminosity diagram, they are found in the area of the main sequence and subgiants. They are probably young objects that, during the course of further evolution, will become light-constant stars on the zero-age main sequence (ZAMS). The range of brightness variations may reach several magnitudes. In the case of rapid light variations having been observed (up to 1 mag in 1-10 days), the letter "S" is added to the symbol for the type (INS). This type may be divided into the following subtypes:

INA Orion variables of early spectral types (B-A or Ae). They are often characterized by occasional abrupt Algol-like fadings (T Ori);

INB Orion variables of intermediate and late spectral types, F-M or Fe-Me (BH Cep, AH Ori). F-type stars may show Algol-like fadings similar to those of many INA stars; K-M stars may produce flares along with irregular light variations;

INT,IT Orion variables of the T Tauri type. Stars are assigned to this type on the basis of the following (purely spectroscopic) criteria: spectral types are in the range Fe-Me. The spectra of most typical stars resemble the spectrum of the solar chromosphere. The feature specific to the type is the presence of the flourescent emission lines Fe II 4046, 4132 A (anomalously intense in the spectra of these stars), emission lines [Si II] and [O I], as well as the absorption line Li I 6707 A. These variables are usually observed only in diffuse nebulae. If it is not apparent that the star is associated with a nebula, the letter "N" in the symbol for the type may be omitted, e.g., IT (RW AUR);

IN(YY) Some Orion variables (YY Ori) show the presence of absorption components on the redward sides of emission lines, indicating the infall of matter toward the stars' surfaces. In such cases, the symbol for the type may be accompanied by the symbol "YY".

IS Rapid irregular variables having no apparent connection with diffuse nebulae and showing light changes of about 0.5 - 1.0 mag within several hours or days. There is no strict boundary between rapid irregular and Orion variables. If a rapid irregular star is observed in the region of a diffuse nebula, it is considered an Orion variable and designated by the symbol INS. To attribute a variable to the IS type, it is necessary to take much care to be certain that its light changes are really not periodic. Quite a number of the stars assigned to this type in the third edition of the GCVS turned out to be eclipsing binary systems, RR Lyrae variables, and even extragalactic BL Lac objects.

ISA Rapid irregular variables of the early spectral types, B-A or Ae;

ISB Rapid irregular variables of the intermediate and late spectral types, F-M and Fe-Me.

RCB Variables of the R Coronae Borealis type. These are hydrogen-poor, carbon- and helium-rich, high-luminosity stars belonging to the spectral types Bpe-R, which are simultaneously eruptive and pulsating variables. They show slow nonperiodic fadings by 1-9 mag in V lasting from a month or more to several hundred days. These changes are superposed on cyclic pulsations with amplitudes up to several tenths of a magnitude and periods in the range 30-100 days.

RS Eruptive variables of the RS Canum Venaticorum type. This type is ascribed to close binary systems with spectra showing Ca II H and K in emission, their components having enhanced chromospheric activity that causes quasi-periodic light variability. The period of variation is close to the orbital one, and the variability amplitude is usually as great as 0.2 mag in V (UX Ari). They are X-ray sources and rotating variables. RS CVn itself is also an eclipsing system (see below).

SDOR Variables of the S Doradus type. These are eruptive, high-luminosity Bpec-Fpec stars showing irregular (sometimes cyclic) light changes with amplitudes in the range 1-7 mag in V. They belong to the brightest blue stars of their parent galaxies. As a rule, these stars are connected with diffuse nebulae and surrounded by expanding envelopes (P Cyg, Eta Car).

UV Eruptive variables of the UV Ceti type, these are K Ve-M Ve stars sometimes displaying flare activity with amplitudes from several tenths of a magnitude up to 6 mag in V. The amplitude is considerably greater in the ultraviolet spectral region. Maximum light is attained in several seconds or dozens of seconds after the beginning of a flare; the star returns to its normal brightness in several minutes or dozens of minutes.

UVN Flaring Orion variables of spectral types Ke-Me. These are phenomenologically almost identical to UV Cet variables observed in the solar neighborhood. In addition to being related to nebulae, they are normally characterized by being of earlier spectral type and greater luminosity, with slower development of flares (V389 Ori). They are possibly a specific subgroup of INB variables with irregular variations superimposed by flares.

WR Eruptive Wolf-Rayet variables. Stars with broad emission features of He I and He II as well as C II-C IV,

O II-O IV, and N III-N V. They display irregular light changes with amplitudes up to 0.1 mag in V, which are probably caused by physical processes, in particular, by nonstable mass outflow from their atmospheres.

2. Pulsating Variable Stars

Pulsating variables are stars showing periodic expansion and contraction of their surface layers. The pulsations may be radial or nonradial. A radially pulsating star remains spherical in shape, while in the case of nonradial pulsations the star's shape periodically deviates from a sphere, and even neighboring zones of its surface may have opposite pulsation phases.

Depending on the period value, on the mass and evolutionary status of the star, and on the scale of pulsational phenomena, the following types of pulsating variables may be distinguished:

ACYG Variables of the Alpha Cygni type, which are nonradially pulsating supergiants of Bep-Aepla spectral types. The light changes with amplitudes of the order of 0.1 mag often seem irregular, being caused by the superposition of many oscillations with close periods. Cycles from several days to several weeks are observed.

BCEP Variables of the Beta Cephei type (Beta Cep, Beta CMa), which are pulsating O8-B6 I-V stars with periods of light and radial-velocity variations in the range of 0.1 - 0.6 days and light amplitudes from 0.01 to 0.3 mag in V. The light curves are similar in shape to average radial-velocity curves but lag in phase by a quarter of the period, so that maximum brightness corresponds to maximum contraction, i.e., to minimum stellar radius. The majority of these stars probably show radial pulsations, but some (V469 Per) display nonradial pulsations; multiperiodicity is characteristic of many of these stars.

BCEPS A short-period group of Beta Cep variables. The spectral types are B2-B3 IV-V; periods and light amplitudes are in the ranges 0.02 - 0.04 days and 0.015 - 0.025 days, respectively, i.e., an order of magnitude smaller than the normally observed ones.

CEP Cepheids. Radially pulsating, high luminosity (classes Ib-II) vari- ables with periods in the range of 1-135 days and amplitudes from several hundredths to 2 mag in V (in the B band, the amplitudes are greater). Spectral type at maximum light is F; at minimum, the types are G-K. The longer the period of light variation, the later is the spectral type. The maximum of the surface-layer expansion velocity almost coinciding with maximum light.

CEP(B) Cepheids (TU Cas, V 367 Sct) displaying the presence of two or more simultaneously operating pulsation modes (usually the fundamental tone with the period P0 and the first overtone P1). The periods P0 are in the range from 2 to 7 days, with the ratio P1/P0 approx. 0.71.

CW Variables of the W Virginis type. These are pulsating variables of the galactic spherical component (old disk) population with periods of approximately 0.8 to 35 days and amplitudes from 0.3 to 1.2 mag in V. They obey a period-luminosity relation different from that for Delta Cep variables (see DCEP). For an equal period value, the W Vir variables are fainter than the Delta Cep stars by 0.7 - 2 mag. The light curves of W Vir variables for some period intervals differ from those of Delta Cep variables for corresponding periods either by amplitudes or by the presence of humps on their descending branches, sometimes turning into broad flat maxima. W Vir variables are present in globular clusters and at high galactic latitudes. They may be separated into the following subtypes:

CWA W Vir variables with periods longer than 8 days (W Vir);

CWB W Vir variables with periods shorter than 8 days (BL Her).

DCEP These are the classical cepheids, or Delta Cep-type variables. Com- paratively young objects that have left the main sequence and evolved into the instability strip of the Hertzsprung-Russell (H-R) diagram, they obey the well-known Cepheid period-luminosity relation and belong to the young disk population. DCEP stars are present in open clusters. They display a certain relation between the shapes of their light curves and their periods.

DCEPS These are Delta Cep variables having light amplitudes <0.5 mag in V (<0.7 mag in B) and almost symmetrical light curves (M-m approx. 0.4 - 0.5 periods); as a rule, their periods do not exceed 7 days.

They are probably first-overtone pulsators and/or are in the first transition across the instability strip after leaving the main sequence (SU Cas). Traditionally, both Delta Cep and W Vir stars are quite often called Cepheids because it is often impossible to discriminate between them on the basis of the light curves for periods in the range 3 - 10 days. However, these are distinct groups of entirely different objects in different evolutionary stages. One of the significant spectral differences between W Vir stars and Cepheids is the presence, during a certain phase interval, of hydrogen-line emission in the former and of Ca II H and K emission in the latter.

DSCT Variables of the Delta Scuti type. These are pulsating variables of spectral types A0-F5 III-V displaying light amplitudes from 0.003 to 0.9 mag in V (usually several hundredths of a magnitude) and periods from 0.01 to 0.2 days. The shapes of the light curves, periods, and amplitudes usually vary greatly. Radial as well as nonradial pulsations are observed. The variability of some members of this type appears sporadically and sometimes completely ceases, this being a consequence of strong amplitude modulation with the lower value of the amplitude not exceeding 0.001 mag in some cases. The maximum of the surface layer expansion does not lag behind the maximum light for more than 0.1 periods. DSCT stars are representatives of the galactic disk (flat component) and are phenomenologically close to the SX Phe variables.

DSCTC Low amplitude group of Delta Sct variables (light amplitude <0.1 mag in V). The majority of this type's representatives are stars of luminosity class V; objects of this subtype generally are representative of the Delta Sct variables in open clusters.

L Slow irregular variables. The light variations of these stars show no evidence of periodicity, or any periodicity present is very poorly defined and appears only occasionally. Like for the type I, stars are often attributed to this type because of being insufficiently studied. Many type L variables are really semiregulars or belong to other types.

LB Slow irregular variables of late spectral types (K, M, C, S); as a rule, they are giants (CO Cyg). This type is also ascribed, in the GCVS, to slow red irregular variables in the case of unknown spectral types and luminosities.

LC Irregular variable supergiants of late spectral types having amplitudes of about 1 mag in V (TZ Cas).

M Mira (Omicron) Ceti-type variables. These are long-period variable giants with characteristic late-type emission spectra (Me, Ce, Se) and light amplitudes from 2.5 to 11 mag in V. Their periodicity is well pronounced, and the periods lie in the range between 80 and 1000 days. Infrared amplitudes are usually less than in the visible and may be <2.5 mag. For example, in the K band they usually do not exceed 0.9 mag. If the amplitudes exceed 1 - 1.5 mag , but it is not certain that the true light amplitude exceeds 2.5 mag, the symbol "M" is followed by a colon, or the star is attributed to the semiregular class with a colon following the symbol for that type (SR).

PVTEL Variables of the PV Telescopii type. These are helium supergiant Bp stars with weak hydrogen lines and enhanced lines of He and C. They pulsate with periods of approximately 0.1 to 1 days, or vary in brightness with an amplitude of 0.1 mag in V during a time interval of about a year.

RR Variables of the RR Lyrae type, which are radially-pulsating giant A-F stars having amplitudes from 0.2 to 2 mag in V. Cases of variable light-curve shapes as well as variable periods are known. If these changes are periodic, they are called the "Blazhko effect." Traditionally, RR Lyrae stars are sometimes called short-period Cepheids or cluster-type variables. The majority of these stars belong to the spherical component of the Galaxy; they are present, sometimes in large numbers, in some globular clusters, where they are known as pulsating horizontal-branch stars. Like Cepheids, maximum expansion velocities of surface layers for these stars practically coincide with maximum light.

RR(B) RR Lyrae variables showing two simultaneously operating pulsation modes, the fundamental tone with the period P0 and the first overtone, P1 (AQ Leo). The ratio P1/P0 is approximately 0.745;

RRAB RR Lyrae variables with asymmetric light curves (steep ascending branches), periods from 0.3 to 1.2 days, and amplitudes from 0.5 to 2 mag in V;

RRC RR Lyrae variables with nearly symmetric, sometimes sinusoidal, light curves, periods from 0.2 to 0.5

days, and amplitudes not greater than 0.8 mag in V (SX UMa).

RV Variables of the RV Tauri type. These are radially pulsating supergiants having spectral types F-G at maximum light and K-M at minimum. The light curves are characterized by the presence of double waves with alternating primary and secondary minima that can vary in depth so that primary minima may become secondary and vice versa. The complete light amplitude may reach 3-4 mag in V. Periods between two adjacent primary minima (usually called formal periods) lie in the range 30-150 days (these are the periods appearing in the Catalogue). Two subtypes, RVA and RVB, are recognized:

RVA RV Tauri variables that do not vary in mean magnitude (AC Her);

RVB RV Tauri variables that periodically (with periods from 600 to 1500 days and amplitudes up to 2 mag in V) vary in mean magnitude (DF Cyg, RV Tau).

SR Semiregular variables, which are giants or supergiants of intermediate and late spectral types showing noticeable periodicity in their light changes, accompanied or sometimes interrupted by various irregularities. Periods lie in the range from 20 to >2000 days, while the shapes of the light curves are rather different and variable, and the amplitudes may be from several hundredths to several magnitudes (usually 1-2 mag in V).

SRA Semiregular late-type (M, C, S or Me, Ce, Se) giants displaying persistent periodicity and usually small (<2.5 mag in V) light amplitudes (Z Aqr). Amplitudes and light-curve shapes generally vary and periods are in the range of 35-1200 days. Many of these stars differ from Miras only by showing smaller light amplitudes;

SRB Semiregular late-type (M, C, S or Me, Ce, Se) giants with poorly defined periodicity (mean cycles in the range of 20 to 2300 days) or with alternating intervals of periodic and slow irregular changes, and even with light constancy intervals (RR CrB, AF Cyg). Every star of this type may usually be assigned a certain mean period (cycle), which is the value given in the Catalogue. In a number of cases, the simultaneous presence of two or more periods of light variation is observed;

SRC Semiregular late-type (M, C, S or Me, Ce, Se) supergiants (Mu Cep) with amplitudes of about 1 mag and periods of light variation from 30 days to several thousand days;

SRD Semiregular variable giants and supergiants of F, G, or K spectral types, sometimes with emission lines in their spectra. Amplitudes of light variation are in the range from 0.1 to 4 mag, and the range of periods is from 30 to 1100 days (SX Her, SV UMa).

SXPHE Phenomenologically, these resemble DSCT (Delta Sct) variables and are pulsating subdwarfs of the spherical component, or old disk galactic population, with spectral types in the range A2-F5. They may show several simultaneous periods of oscillation, generally in the range 0.04-0.08 days, with variable-amplitude light changes that may reach 0.7 mag in V. These stars are present in globular clusters.

ZZ ZZ Ceti variables. These are nonradially pulsating white dwarfs that change their brightnesses with periods from 30 s to 25 min and amplitudes from 0.001 to 0.2 mag in V. They usually show several close period values. Flares of 1 mag are sometimes observed; however, these may be explained by the presence of close UV Ceti companions. These variables are divided into the following subtypes:

ZZA ZZ Cet-type variables of DA spectral type (ZZ Cet) having only hydrogen absorption lines in their spectra;

ZZB ZZ Cet-type variables of DB spectral type having only helium absorption lines in their spectra.

3. Rotating Variable Stars

Variable stars with nonuniform surface brightness and/or ellipsoidal shapes, whose variability is caused by axial rotation with respect to the observer. The nonuniformity of surface brightness distributions may be caused by the presence of spots or by some thermal or chemical inhomogeneity of the atmosphere caused by a magnetic field whose axis is not coincident with the rotation axis. These stars are subdivided into the following types:

ACV Alpha2 Canum Venaticorum variables. These are main-sequence stars with spectral types B8p-A7p and displaying strong magnetic fields. Spectra show abnormally strong lines of Si, Sr, Cr, and rare earths whose intensities vary with rotation. They exhibit magnetic field and brightness changes (periods of 0.5-160 days or more). The amplitudes of the brightness changes are usually withine 0.01-0.1 mag in V.

ACVO Rapidly oscillating Alpha2 CVn variables. These are nonradially pulsating, rotating magnetic variables of Ap spectral type (DO Eri). Pulsation periods are in the range of 6-12 mmag (0.004-0.01 days), while amplitudes of light variation caused by the pulsation are about 0.01 mag in V. The pulsational variations are superposed on those caused by rotation.

BY BY Draconis-type variables, which are emission-line dwarfs of dKe-dMe spectral type showing quasiperiodic light changes with periods from a fraction of a day to 120 days and amplitudes from several hundredths to 0.5 mag in V. The light variability is caused by axial rotation of a star with a variable degree of nonuniformity of the surface brightness (spots) and chromospheric activity. Some of these stars also show flares similar to those of UV Cet stars, and in those cases they also belong to the latter type and are simultaneously considered eruptive variables.

ELL Rotating ellipsoidal variables (b Per, Alpha Vir). These are close binary systems with ellipsoidal components, which change combined brightnesses with periods equal to those of orbital motion because of changes in emitting areas toward an observer, but showing no eclipses. Light amplitudes do not exceed 0.1 mag in V.

FKCOM FK Comae Berenices-type variables. These are rapidly rotating giants with nonuniform surface brightnesses, which have G-K spectral types with broad H and K Ca II emission and sometimes Halpha. They may also be spectroscopic binary systems. Periods of light variation (up to several days) are equal to rotational periods, and amplitudes are several tenths of a magnitude. It is not excluded that these objects are the product of further evolution of EW (W UMa) close binary systems (see below).

PSR Optically variable pulsars (CM Tau), which are rapidly rotating neutron stars with strong magnetic fields, radiating in the radio, optical, and X-ray regions. Pulsars emit narrow beams of radiation, and periods of their light changes coincide with rotational periods (from 0.004 to 4 s), while amplitudes of the light pulses reach 0.8 mag.

SXARI SX Arietis-type variables. These are main-sequence B0p-B9p stars with variable-intensity He I and Si III lines and magnetic fields. They are sometimes called helium variables. Periods of light and magnetic field changes (about 1 day) coincide with rotational periods, while amplitudes are approximately 0.1 mag in V. These stars are high-temperature analogs of the ACV variables.

4. Cataclysmic (Explosive and Novalike) Variables

These are variable stars showing outbursts caused by thermonuclear burst processes in their surface layers (novae) or deep in their interiors (supernovae). We use the term "novalike" for variables that show novalike outbursts caused by rapid energy release in the surrounding space (UG-type stars - see below) and also for objects not displaying outbursts but resembling explosive variables at minimum light by their spectral (or other) characteristics. The majority of explosive and novalike variables are close binary systems, their components having strong mutual influence on the evolution of each star. It is often observed that the hot dwarf component of the system is surrounded by an accretion disk formed by matter lost by the other, cooler, and more extended component. This category is subdivided into the following types:

N Novae. Close binary systems with orbital periods from 0.05 to 230 days. One of the components of these systems is a hot dwarf star that suddenly, during a time interval from one to several dozen or several hundred days, increases its brightness by 7-19 mag in V, then returns gradually to its former brightness over several months, years, or decades. Small changes at minimum light may be present. Cool components may be giants, subgiants, or dwarfs of K-M type. The spectra of novae near maximum light resemble A-F absorption spectra of luminous stars at first. Then broad emission lines (bands) of hydrogen, helium, and other elements with absorption components indicating the presence of a rapidly expanding envelope appear in the spectrum. As the light decreases, the composite spectrum begins to show forbidden lines characteristic of the spectra of gas nebulae excited by hot stars. At minimum light, the spectra of novae are generally continuous or resemble the spectra of Wolf-Rayet stars. Only spectra of the most massive systems show traces of cool components. Some novae reveal pulsations of hot components with periods of

approximately 100 s and amplitudes of about 0.05 mag in V after an outburst. Some novae eventually turn out to be eclipsing systems. According to the features of their light variations, novae are subdivided into fast (NA), slow (NB), very slow (NC), and recurrent (NR) categories.

NA Fast novae displaying rapid light increases and then, having achieved maximum light, fading by 3 mag in 100 or fewer days (GK Per);

NB Slow novae that fade after maximum light by 3 mag in >= 150 days (RR Pic). Here the presence of the well-known "dip" in the light curves of novae similar to T Aur and DQ Her is not taken into account: The rate of fading is estimated on the basis of a smooth curve, its parts before and after the "dip" being a direct continuation of one another;

NC Novae with a very slow development and remaining at maximum light for more than a decade, then fading very slowly. Before an outburst these objects may show long-period light changes with amplitudes of 1-2 mag in V (RR Tel); cool components of these systems are probably giants or supergiants, sometimes semiregular variables, and even Mira variables. Outburst amplitudes may reach 10 mag. High excitation emission spectra resemble those of planetary nebulae, Wolf-Rayet stars, and symbiotic variables. The possibility that these objects are planetary nebulae in the process of formation is not excluded;

NL Novalike variables, which are insufficiently studied objects resembling novae by the characteristics of their light changes or by spectral features. This type includes, in addition to variables showing novalike outbursts, objects with no bursts ever observed; the spectra of novalike variables resemble those of old novae, and small light changes resemble those typical for old novae at minimum light. However, quite often a detailed investigation makes it possible to reclassify some representatives of this highly inhomogeneous group of objects into other types;

NR Recurrent novae, which differ from typical novae by the fact that two or more outbursts (instead of a single one) separated by 10-80 years have been observed (T CrB).

SN Supernovae (B Cas, CM Tau). Stars that increase, as a result of an outburst, their brightnesses by 20 mag and more, then fade slowly. The spectrum during an outburst is characterized by the presence of very broad emission bands, their widths being several times greater than those of the bright bands observed in the spectra of novae. The expansion velocities of SN envelopes are in the thousands of km/s. The structure of a star after outburst alters completely. An expanding emission nebula results and a (not always observable) pulsar remains at the position of the original star. According to the light curve shape and the spectral features, supernovae are subdivided into types I and II.

SNI Type I supernovae. Absorption lines of Ca II, Si, etc., but no hydrogen lines are present in the spectra. The expanding envelope almost lacks hydrogen. During 20-30 days following maximum light, the brightness decreases by approximately 0.1 mag per day, then the rate of fading slows and reaches a constant value of 0.014/day;

SNII Type II supernovae. Lines of hydrogen and other elements are apparent in their spectra. The expanding envelope consists mainly of H and He. Light curves show greater diversity than those of type I supernovae. Usually after 40-100 days since maximum light, the rate of fading is 0.1 mag per day.

UG U Geminorum-type variables, quite often called dwarf novae. They are close binary systems consisting of a dwarf or subgiant K-M star that fills the volume of its inner Roche lobe and a white dwarf surrounded by an accretion disk. Orbital periods are in the range 0.05-0.5 days. Usually only small, in some cases rapid, light fluctuations are observed, but from time to time the brightness of a system increases rapidly by several magnitudes and, after an interval of from several days to a month or more, returns to the original state. Intervals between two consecutive outbursts for a given star may vary greatly, but every star is characterized by a certain mean value of these intervals, i.e., a mean cycle that corresponds to the mean light amplitude. The longer the cycle, the greater the amplitude. These systems are frequently sources of X-ray emission. The spectrum of a system at minimum is continuous, with broad H and He emission lines. At maximum these lines almost disappear or become shallow absorption lines. Some of these systems are eclipsing, possibly indicating that the primary minimum is caused by the eclipse of a hot spot that originates in the accretion disk from the infall of a gaseous stream from the K-M star. According to the characteristics of the light changes, U Gem variables may be subdivided into three types: SS Cyg, SU UMa, and Z Cam.

UGSS SS Cygni-type variables (SS Cyg, U Gem). They increase in brightness by 2-6 mag in V in 1-2 days and in several subsequent days return to their original brightnesses. The values of the cycle are in the range 10 days to several thousand;

UGSU SU Ursae Majoris-type variables. These are characterized by the presence of two types of outbursts called "normal" and "supermaxima". Normal, short outbursts are similar to those of UGSS stars, while supermaxima are brighter by 2 mag, are more than five times longer (wider), and occur several times less frequently. During supermaxima the light curves show superposed periodic oscillations (superhumps), their periods being close to the orbital ones and amplitudes being about 0.2-0.3 mag in V. Orbital periods are shorter than 0.1 days; companions are of dM spectral type;

UGZ Z Camelopardalis-type stars. These also show cyclic outbursts, differing from UGSS variables by the fact that sometimes after an outburst they do not return to the original brightness, but during several cycles retain a magnitude between maximum and minimum. The values of cycles are from 10 to 40 days, while light amplitudes are from 2 to 5 mag in V.

ZAND Symbiotic variables of the Z Andromedae type. They are close binaries consisting of a hot star, a star of late type, and an extended envelope excited by the hot star's radiation. The combined brightness displays irregular variations with amplitudes up to 4 mag in V. A very inhomogeneous group of objects.

5. Close Binary Eclipsing Systems

We adopt a triple system of classifying eclipsing binary systems: according to the shape of the combined light curve, as well as to physical and evolutionary characteristics of their components. The classification based on light curves is simple, traditional, and suits the observers; the second and third classification methods take into account positions of the binary-system components in the (MV ,B-V) diagram and the degree of inner Roche lobe filling. Estimates are made by applying the simple criteria proposed by Svechnikov and Istomin (1979). The symbols for the types of eclipsing binary systems that we use are given below.

a) Classification based on the shape of the light curve

E Eclipsing binary systems. These are binary systems with orbital planes so close to the observer's line of sight (the inclination i of the orbital plane to the plane orthogonal to the line of sight is close to 90 deg) that the components periodically eclipse each other. Consequently, the observer finds changes of the apparent combined brightness of the system with the period coincident with that of the components' orbital motion.

EA Algol (Beta Persei)-type eclipsing systems. Binaries with spherical or slightly ellipsoidal components. It is possible to specify, for their light curves, the moments of the beginning and end of the eclipses. Between eclipses the light remains almost constant or varies insignificantly because of reflection effects, slight ellipsoidality of components, or physical variations. Secondary minima may be absent. An extremely wide range of periods is observed, from 0.2 to >= 10000 days. Light amplitudes are also quite different and may reach several magnitudes.

EB Beta Lyrae-type eclipsing systems. These are eclipsing systems having ellipsoidal components and light curves for which it is impossible to specify the exact times of onset and end of eclipses because of a continuous change of a system's apparent combined brightness between eclipses; secondary minimum is observed in all cases, its depth usually being considerably smaller than that of the primary minimum; periods are mainly longer than 1 day. The components generally belong to early spectral types (B-A). Light amplitudes are usually <2 mag in V.

EW W Ursae Majoris-type eclipsing variables. These are eclipsers with periods shorter than 1 days, consisting of ellipsoidal components almost in contact and having light curves for which it is impossible to specify the exact times of onset and end of eclipses. The depths of the primary and secondary minima are almost equal or differ insignificantly. Light amplitudes are usually <0.8 mag in V. The components generally belong to spectral types F-G and later.

b) Classification according to the components' physical characteristics

GS Systems with one or both giant and supergiant components; one of the components may be a main

sequence star.

PN Systems having, among their components, nuclei of planetary nebulae (UU Sge).

RS RS Canum Venaticorum-type systems. A significant property of these systems is the presence in their spectra of strong Ca II H and K emission lines of variable intensity, indicating increased chromospheric activity of the solar type. These systems are also characterized by the presence of radio and X-ray emission. Some have light curves that exhibit quasi sine waves outside eclipses, with amplitudes and positions changing slowly with time. The presence of this wave (often called a distortion wave) is explained by differential rotation of the star, its surface being covered with groups of spots; the period of the rotation of a spot group is usually close to the period of orbital motion (period of eclipses) but still differs from it, which is the reason for the slow change (migration) of the phases of the distortion wave minimum and maximum in the mean light curve. The variability of the wave's amplitude (which may be up to 0.2 mag in V) is explained by the existence of a long-period stellar activity cycle similar to the 11-year solar activity cycle, during which the number and total area of spots on the star's surface vary.

WD Systems with white-dwarf components.

WR Systems having Wolf-Rayet stars among their components (V 444 Cyg).

c) Classification based on the degree of filling of inner Roche lobes

AR Detached systems of the AR Lacertae type. Both components are subgiants not filling their inner equipotential surfaces.

D Detached systems, with components not filling their inner Roche lobes.

DM Detached main-sequence systems. Both components are main-sequence stars and do not fill their inner Roche lobes.

DS Detached systems with a subgiant. The subgiant also does not fill its inner critical surface.

DW Systems similar to W UMa systems in physical properties (KW, see below), but not in contact.

K Contact systems, both components filling their inner critical surfaces.

KE Contact systems of early (O-A) spectral type, both components being close in size to their inner critical surfaces.

KW Contact systems of the W UMa type, with ellipsoidal components of F0-K spectral type. Primary components are main-sequence stars and secondaries lie below and to the left of the main sequence in the (MV,B-V) diagram.

SD Semidetached systems in which the surface of the less massive com- ponent is close to its inner Roche lobe. The combination of the above three classification systems for eclipsers results in the assignment of multiple classifications for object types. These are separated by a solidus ("/") in the data field. Examples are: E/DM, EA/DS/RS, EB/WR, EW/KW, etc.

6. Optically Variable Close Binary Sources of Strong, Variable X-ray Radiation (X-ray Sources)

X Close binary systems that are sources of strong, variable X-ray emis- sion and which do not belong to or are not yet attributed to any of the above types of variable stars. One of the components of the system is a hot compact object (white dwarf, neutron star, or possibly a black hole). X-ray emission originates from the infall of matter onto the compact object or onto an accretion disk surrounding the compact object. In turn, the X-ray emission is incident upon the atmosphere of the cooler companion of the compact object and is reradiated in the form of optical high-temperature radiation (reflection effect), thus making that area of the cooler companion's surface an earlier spectral type. These effects lead to quite a peculiar complex character of optical variability in such systems. These objects may be subdivided into the following types:

XB X-ray bursters. Close binary systems showing X-ray and optical bursts, their duration being from several

seconds to ten minutes, with amplitudes of about 0.1 mag in V (V 801 Ara, V 926 Sco);

XF Fluctuating X-ray systems showing rapid variations of X-ray (Cygnus X-1 = V1357 Cyg) and optical (V821 Ara) radiation on time scales of dozens of milliseconds;

XI X-ray irregulars. Close binary systems consisting of a hot compact object surrounded by an accretion disk and a dA - dM-type dwarf. These display irregular light changes on time scales of minutes and hours, and amplitudes of about 1 mag in V. Superposition of a periodic variation because of orbital motion is possible (V818 Sco);

XJ X-ray binaries characterized by the presence of relativistic jets evident at X-ray and radio wavelengths, as well as in the optical spectrum in the form of emission components showing periodic displacements with relativistic velocities (V1343 Aql);

XND X-ray, novalike (transient) systems containing, along with a hot compact object, a dwarf or subgiant of G-M spectral type. These systems occasionally rapidly increase in brightness by 4-9 mag in V, in the visible simultaneously with the X-ray range, with no envelope ejected. The duration of the outburst may be up to several months (V616 Mon);

XNG X-ray, novalike (transient) systems with an early-type supergiant or giant primary component and a hot compact object as a companion. Following the main component's outburst, the material ejected by it falls onto the compact object and causes, with a significant delay, the appearance of X rays. The amplitudes are about 1-2 mag in V (V725 Tau);

XP X-ray pulsar systems. The primary component is usually an ellipsoidal early-type supergiant. The reflection effect is very small and light variability is mainly caused by the ellipsoidal primary component's rotation. Periods of light changes are between 1 and 10 days; the period of the pulsar in the system is from 1 s to 100 min. Light amplitudes usually do not exceed several tenths of a magnitude (Vela X-1 = GP Vel);

XPR X-ray pulsar systems featuring the presence of the reflection effect. They consist of a dB-dF-type primary and an X-ray pulsar, which may also be an optical pulsar. The mean light of the system is brightest when the primary component is irradiated by X rays; it is faintest during a low state of the X-ray source. The total light amplitude may reach 2-3 mag in V (HZ Her);

XPRM, X-ray systems consisting of a late-type dwarf (dK-dM) and a pulsar

XM with a strong magnetic field. Matter accretion on the compact object's magnetic poles is accompanied by the appearance of variable linear and circular polarization; hence, these systems are sometimes known as "polars". The amplitudes of the light changes are usually about 1 mag in V but, provided that the primary component is irradiated by X rays, the mean brightness of a system may increase by 3 mag in V. The total light amplitude may reach 4-5 mag in V (AM Her, AN UMa). If the beam of X-ray emission originating at the magnetic poles of the rotating hot compact object does not pass through the observer's position and the system is not observed as a pulsar, the letter "P" in the above symbols for X-ray- system types is not used. If an X-ray system is also an eclipsing or an ellipsoidal variable, the X-ray symbol is preceded by "E" or "ELL" joined with the X-ray symbol by a "+" sign (e.g., E+X, ELL+X).

7. Other Symbols

In addition to the variable-star types described above, certain other symbols that need to be explained will be found in the Type data field:

BLLAC Extragalactic BL Lacertae-type objects. These are compact quasistellar objects showing almost continuous spectra with weak emission and absorption lines and relatively rapid irregular light changes with amplitudes up to 3 mag in V or more. Sources of strong X-ray radiation and radio waves, their emission displays strong and variable linear polarization in the visible and infrared spectral regions. Some objects of this type, considered erroneously to be variable stars and designated in the GCVS system, will probably sometimes be included in the main table of the Catalogue in the future, too.

CST Nonvariable stars, formerly suspected to be variable and hastily designated. Further observations have not confirmed their variability.

GAL Optically variable quasistellar extragalactic objects (active galactic nuclei [AGNs]) considered to be variable stars by mistake.

L: Unstudied variable stars with slow light changes.

QSO Optically variable quasistellar extragalactic sources (quasars) that earlier were erroneously considered to be variable stars.

S Unstudied variable stars with rapid light changes.

* Unique variable stars outside the range of the classifications de- scribed above. These probably represent either short stages of transition from one variability type to another or the earliest and latest evolutionary stages of these types, or they are insufficiently studied members of future new types of variables.

+ If a variable star belongs to several types of light variability simultaneously, the types are joined in the Type field by a "+" sign (e.g., E+UG, UV+BY).

: Uncertainty flag on Type of Variability

(End) N.N. Samus [Moscow Inst. Astron.], O.V. Durlevich [Sternberg Astron. Inst., Moscow] 18-June-2015

This appendix contains detailed lists of what has changed in the last few releases of ECU:

V6.1 to V6.1F Changes

Sky Chart/Print Features

- The split chart now has separate settings for horizontal and vertical flips.
- The number of objects that can be plotted on-screen has been increased to 30,000.

Databases

- The General Catalog of Variable Stars database has been updated to the current (V5.1) version, and it now contains 54,919 stars.
- The number of comet/asteroid orbits that can be active at any given time has been increased to 25,000.
- Added download of and full support for the IAU Minor Planet Center's asteroid orbit database.
- Added support for download of the MPCs bright minor planets at opposition list.
- The master orbit file is now called 'masterorbit.orb'.

Searching

- You can now search for a specific equatorial position as an RA in hours and minutes OR hours and minutes and seconds and a Dec in degrees and minutes OR degrees and minutes and seconds.

Automation Interface

- The Search method now returns the found object's primary object name.
- Added the ClearOrbits, LoadOrbits, SaveOrbits methods.

Miscellaneous

- Updated the URL for General Catalog of Variable Stars web searches.
- Orbits now accept eccentricities up to 5 (for the new class of interstellar asteroids).
- Better error handling in the loading of orbit files.
- The angular separation calculation uses a more accurate "haversine" algorithm.
- Telescope serial interface routines now use an external COM Port Driver (developed by Nova Astronomics).

Bug Fixes

- Some problems with dialog box sizing on some computers has been resolved.
- Broader ASCOM exception handling was added.
- Some mathematical overflows and other problems were fixed there were caused by the new "interstellar" asteroids and orbits with hyberbolic orbits.
- Add better error handling for parallax calculations.
- Improved program shutdown if started by the automation interface.
- Fix bug where sky was not redrawn on alignment stars during encoder interface alignments.
- Fix bug where telescope interface was sometimes causing an error when disabling it.
- Fix bug where alignment star names were not shown during encoder interface alignments.

V6.0L to V6.1 Changes

Updated User Interface

ECU is one of the oldest planetarium and telescope control programs still in active development - first out in March of 1992!

- The former (pdf) User's Manual has been replaced with context-aware on-line help (a pdf version is available on the website for those who want to print it)
- The User's Manual has also been expanded in several areas and improved.
- This release **simplifies the user interface greatly** by reducing the number of menu items and dialog boxes (no significant functionality is lost!)
- Most dialog boxes are now "tabbed", keeping similar settings and functionality together (eg. all time and settings are now in one dialog)
  - These changes are numerous, so are not individually listed below
- All dialog boxes are now re-styled with a more modern look and feel
- Some important dialog boxes - Object Search and Animation - are no longer "modal" so can be left open while doing other things
- Many dialog boxes now have "Apply" buttons so changes to settings can be made without closing them
- The entire application can be set to one of 36 new "styles" in addition to the default "Windows" styles. These styles affect the appearance, fonts and colors.

Compatibility

ECU is compatible with:

- Windows XP
- Windows Vista (32 and 64-bit)
- Windows 7 (32 and 64-bit)
- Windows 8 and 8.1 (32 and 64-bit)
- Windows 10

Sky Chart/Print Features

- The map projection used to draw the sky has been completely revamped. It how uses the much better **Stereographic Projection**. It now better represents object shapes in large chart sizes, but distorts the scale (everything is a compromise!)
- Added the anti-zenth point (Nadir)
- When showing the magnitude of User Objects, the decimal point is now included
- The Sun symbol is more distinctive

Databases

- The General Catalog of Variable Stars database has been updated to the current (September 2015) version, and it now contains 52,011 stars. It's stored resolution has also been increased
- The Washington Visual Double Star database has been updated to the 2016Mar25 version, and it now contains 135,098 pairs of double stars
- User Objects are now stored and plotted at higher resolution

Object Searching

- Object searching and the Object List functions are now unified into a single tabbed dialog box

- You can now search for common object names such as "Ring Nebula"
- Searching for asteroids and comets is easier - you can now find minor planets by name, by number (eg. "(xxxx)") and comets by designation (eg. "C/2005B1" or "194P")

Automation Interface

ECU now includes a Windows COM object interface (similar to the way ASCOM drivers work) that allows access to and control of ECU by external programs. This functionality is limited at present and was developed mainly to provide access to ECU's built in object databases and some of its astronomical calculations by external programs. It presently has about 30 properties and methods available - see the manual for details.

New Miscellaneous Features

- Configuration files from versions 3.0, 3.1, 3.2, 4.0, 5.0, and 6.0 of ECU are automatically read and converted to V6.1 format. This operation is totally transparent
- Settings for Atmospheric Pressure and Temperature have been added - they affect the refraction calculation
- The Geographic Location dialog box can
  - show the current location on a Google Map
  - allow entering of latitude and longitude by either decimal degrees or degrees and minutes
- Some repetitive calculations have been parallelized so will take advantage of multiple or multi-core processors
- The system colours (used for the night vision mode) can no longer be changed - newer versions of windows do not allow it
- The colours of the lines and text on the Status Line can now be set
- The day of the week is now displayed in the Sun and Moon Data dialog box
- The Directory/File/Web Setup dialog box:
  - Browse buttons were added to make the setting of files and directories much easier
  - now has buttons to show ECU's Documents and AppData directories (where it stores files)
  - User object files are now separated by a semi-colon and are easily selected using a file browser
- In the Identify Object dialog box, the object's Hour Angle is now displayed
- The Field menu is now called the Chart menu
- Field Targets are now called Chart Targets
- Changes have been made to some of the keyboard short-cuts
- Left clicking on the Status Line now enables/disables the scroll bars (instead of showing/hiding the Status box)
- Loading a new configuration file (for ASCOM type telescopes) no longer disables the telescope interface
- Features related to loading/removing the Hubble Guide Star catalog are removed - now handled by the program installer
- The Hubble constant, used to estimate galaxy distances, has been reduced to 70.
- In the Enter Time dialog box the Sun and Moon rise and set buttons now use the date specified rather than only the current date.

Bug Fixes

- SEC planetary nebulae were drawn when "Only Messiers" was enabled
- Fixed a bug related to saving orbit files
- It now does more database checks on start up and if problems are detected more useful error messages are displayed
- fix Hipparcos star searching - the last star in each block was missed

- fix formatting of variable star data in Identify Dialog and Object Reports
- Correct messaging for maximum and minimum brightness of variable star predictions (previously it reported maximum when eclipsing binaries were actually minimums)
- fix Track Telescope bug
- fix/improve telescope field-of-view plotting
- fix the missing default Chart Target rectangles

V5.0 to V6.0L Changes

Future Proofing

- ECU is one of the oldest planetarium and telescope control programs in existance - first out in March of 1992! However, this means the dvelopment environment was old too (Borland Pascal 6, also from 1992). It could only develop 16-bit code meaning ECU V5 would not run on 64-bit versions of Windows and the memory limitations of 16-bit code made to very difficult to implement new features in ECU. Therefore:
- ECU V6 was ported and converted to a brand new development environment called Delphi that will help ensure ECU has a long life.
- This upgrade is not about many new features, but there are some as can be seen below and a by-product is that its faster than ECU 5 (not that any version of ECU has even been slow!).
- It is about putting ECU back on the main sequence (to use an astronomy analogy), otherwise it would have quickly become a white dwarf!

Compatibility

ECU is now compatible with:

- Windows 2000
- Windows XP
- Windows Vista (32 and 64-bit)
- Windows 7 (32 and 64-bit)
- Windows 8 (32 and 64-bit)
- Linux using the free "Wine" windows emulator (some functions such as scope control don't work).
- Mac OS/X under the free "Wine" windows emulator (some functions such as scope control don't work).

Sky Display/Print Features

- A new local horizon grid can now be shown on the sky display and on printed charts. This plots the lines of azimuth and altitude.
- Setting of the Custom Horizon feature is now accomplished by dragging the mouse to create the horizon shape, rather than having to adjust 36 scroll bars!
- Changed custom horizons so that alt/az is displayed as you move the mouse (V6.0F).
- Changed custom horizons so that the size of the image box is 1.5 times bigger (V6.0F)
- The number of objects that can be kept track of on screen at the same time is now 20,000 (was 4,600).
- You can now copy the Sky Display to the clipboard (Edit->Copy Chart to Clipboard) (V6.0C).

Animation

- Time Animation is much faster than with earlier versions - at movie like speeds on current hardware.
- The maximum number of animation trails is now 500 (was 200) and the first 1,000 orbits are

trailed (was 500).
- The speed of animation can be more finely adjusted to any interval from 0 to 60 seconds (it used to be only settable in seconds to the nearest integer).
- You can now easily set a time step using a pop-up menu displayed by right-clicking on the "Step" Status Line item.(V6.0A).
- Animation time step resolution is now 1 second (instead of 1 minute). Fixed time steps of 15, 30, and 45 seconds have also been added. There is an explicit "Manual Time Step" check box to make it easier to switch back and forth between the fixed and manual time steps (V6.0A).
- A new special time step called "Same Sun Altitude" has been added. It steps to the next or previous day when the Sun is at the same altitude. This is handy for simulating events that take place near the time of sunrise/set (V6.0A).

Identify Object Box

- Added the altitude at the transit time for non Solar System objects - hover over transit time is view (V6.0A).
- The Identify Object box now stays up until closed by the user (V6.0C).
- The name for USNO A2 stars is now 'USNOA2 ZZZZ SSSSS' (Z is zone, S is star number) (V6.0D).
- You can now change where the dialog box is displayed (See Edit->Identify Box in Opposing Corner setting), either in the opposite corner from the object clicked on was or initially in the screen center but thereafter wherever the user left it (V6.0D).
- The rates of motion of the moon, sun, and planets were added (V6.0H).
- The layout of the box has been changed (V6.0K).
- The text for the "Center Scope" button has changed to "Move Scope to Object" (V6.0K).
- Add heliocentric ecliptic coordinates for the planets and orbits (V6.0L).
- Add heliocentric ecliptic coordinates for the Earth (click on the Sun to get it) (V6.0L).

Usability

- A new Drag the Sky naviation feature was added. Just hold down the "shift" key (or left mouse button) and move the mouse and you can drag the sky around.
- You can swap the function of the shift key and left mouse button to your preference (V6.0C).
- A Faster Drags function improves the dragging speed by automatically disabling grids, most labels, and object animation trails.
- You can now zoom in and out using the Mouse scroller wheel (laptop users can usually slide your finger along the right side of the touch pad). The step size is 10% of the current field of view (V6.0A).
- If you right click on the Field Size display on the Status Line or the Field Size tool bar button, a popup menu allows you to easily zoom to several preset field sizes (V6.0A).
- If you right click on the delete field target tool bar button, it (after confirmationj) deletes all the field targets (V6.0A).
- Added a Clear Nearest Field Target feature that deletes the field target closest to the center of the chart (V6.0C).
- Changed the shortcut key for Edit->Undo to Control-Z (which is more commonly used) (V6.0C).
- You can now filter which planetary nebulae are shown by size (in the Deep Sky… dialog box) (V6.0D).
- If the time was set to "Use System Time" it now stays in that mode in the time dialog boxes until that setting is unchecked (V6.0D).
- There is now a setting that automatically sets Daylight Saving Time. This is designed to work for USA and Canada and Europe (the correct mode is set based on the longitude setting). If you are not observing from these locations or in a location that does not use daylight savings (eg. Saskatchewan, Canada), disable this mode (V6.0D).
- Added a select dialog box to make it easier to select the User Object files (V6.0K)
- Add drag and drop support for ECU config files (V6.0L).

Databases

- The General Catalog of Variable Stars database has been updated to the current (June 2013) version, and it now contains 47,968 stars.
- The Washington Visual Double Star database has been updated to the 2013Oct20 version, and it now contains 127,620 pairs of double stars.
- The Saguerro Astronomy Club deep sky database has been updated to V8.1 (March 2010 version).
- The maximum number of User Objects has been increased to 50,000 (from 10,000).
- The maximum amount of memory that can be used to cache Hubble Guide Star Catalog stars has been increased to 128 blocks - was 32 (will make plotting quicker).
- The maximum amount of memory that can be used to cache US Naval Observatory A2 stars has been increased to 255 blocks - was 128 (will make plotting quicker).

Solar System

- The maximum number of Comets and Asteriods that can be handled at the same time is now 5,000 (used to be 1,000).
- Added Delete Disabled Orbits function which deletes and orbits that are currently disabled.
- Planets are now drawn such that if they pass in front of the Sun, that can be seen (V6.0C).
- Added the Convert Lowell File... menu item. It converts a raw file of orbits downloaded from Lowell to be converted to ECU format (V6.0F).
- Updated magnitude calculations for Venus and Mercury (V6.0H).
- Added observer's parallax calculation to comet and asteroid orbits (V6.0H).

Telescope

- You can now control whether or not coordinates are sent and received to the telescope in the epoch of current date or J2000.0.
- Added ASCOM offset tracking rates support and dialog (for those scopes that support it) (V6.0H)
- Added second serial port module (set in telescope General Settings...) for better compatibility with the variety of serial port adapters out there (V6.0H).
- Increased the displayed resolution of some scope type's RA to tenths of seconds (V6.0H).
- Enable ASCOM tracking before initiating a goto (V6.0L).
- Add ASCOM slew abort button and slew/park status displays (V6.0L).
- Add azimuth and altitude coordinate display for ASCOM scopes (V6.0L).
- Add 'side of pier' status display (V6.0L).

New Miscellaneous Features

- Configuration files from versions 3.0, 3.1, 3.2, 4.0, and 5.0 of ECU are automatically read and converted to V6.0F format. This operation is totally transparent. Remember, however, that files written by V6.0C cannot be read by earlier versions.
- The Simple Cursors function (Edit menu) has been removed (no longer needed).
- The Continuous Drawing mode has been removed (no longer needed).
- Added Julian Date and Local Sidereal Time to the large Status Box and Julian Date to the small Status Box (V6.0A).
- The Julian Date/Sideral Time dialog box can now be left up and it updates automatically as the time changes (V6.0A). Also, if you click the left mouse button over the sidereal time display on Status Line, it now displays the JD/ST box (V6.0A).
- In the Custom Horizon dialog box, if you hold down the control key as you drag it draws a flat horizon (V6.0A).
- The time resolution (not necessarily accuracy!) is now 1 second throughout (instead of 1

minute) including all places where times are set or displayed (not including rise/set/transit times) (V6.0A).
- When you Center on North, South, etc., the horizon is now along the bottom of sky display instead of the center of the chart (6.0C).
- The day of the week is now displayed on the Status Line (V6.0D).
- The fractional UT date is displayed when the mouse is hovered over UTC in the large status box (V6.0D).
- All stars are now clickable even with the automatic star magnitude limit disabled (V6.0D).
- You can now filter which planetary nebulae are shown by size (in the Deep Sky... dialog box) (V6.0D).
- Changed so that ini file and all user modified files are now in userprofiles\ecu (V6.0F).
- Added dialog to Center on an Hour Angle and Declination (V6.0L).
- Added Hour Angle display to large status box (V6.0L).

Bug Fixes

- Fixed several minor bugs that were noticed when porting the code from Borland Pascal 6 to Delphi XE.
- Changed animation step for "1 year" to match that used for the manual time forward/reverse buttons (that is 365.25 years) (V6.0A).
- Fixed a bug that occasionally happened when animation stepped earlier than the 4712 BC limit V6.0A).
- Fix the problem that displayed a hint on the Status Line each time a Tool Bar button was pressed (V6.0A).
- Changed the serial port code to fix a problem where "real" serial ports did not work (V6.0A).
- Fixed a but where the solar system extended label check boxes in the Labels dialog box were mixed up (V6.0A).
- Fixed a bug where image filenames were truncated because the string was not large enough (V6.0A).
- Fixed a bug in the Time Step dialog box where the list box not cleared each time it was displayed (V6.0A).
- Fixed a bug whereby the fill colours for variable and double stars was wrong (V6.0B).
- Fixed a bug related to upgrading the time in config files from earlier versions (V6.0B).
- Fixed a bug whereby the logic of the "Search Only Enabled Databases" menu item was reversed (V6.0B).
- Fixed a bug that caused missing stars in USNO catalog. (V6.0C).
- Fixed a bug whereby the second telescope alignment star was showing the star 1 name instead of the star 2 name (V6.0C).
- Fixed a bug which caused a range check error when Orbit selection dialog box was closed without an orbit being selected (V6.0C).
- The default aspect ratio of the ECU window is better and error checking has been added on the ECU window's position, including a minimum window size of 300x300 pixels (V6.0D).
- Fixed the CheckViewer routine for Win 7 security (V6.0F)
- Fixed a bug where number 2, 3, 4 custom horizons could not be selected (V6.0F).
- Fixed bug where the image search url was being clobbered (V6.0F).
- Fixed a bug related to the loading of web ini items (V6.0F).
- Chart printing was broken in V6.0H, now fixed (V6.0I).
- Fix Precess button bug in IdentifyDialog (V6.0L)
- Fix overflow problem when zooming in and out (V6.0L)
- Fix bug wehre Orbit Search parameters were not being saved (V6.0L).

V4.0 to V5.0 Changes

Sky Display/Print Features

- The galactic equator line can now be shown on the sky display and on printed charts.
- The north and south galactic pole points can now be shown on the sky display and on printed charts.
- Stars can now be drawn in (exagerated) color based on either their spectral type or B-V color. This feature works for Yale Bright Stars, SAO Stars, and Hipparcos/Tycho stars.
- The sky can now be rotated to any arbitrary angle specified by the user.
- The anti-Sun point can now be shown on the display and on printed charts.

Object Identify Dialog Box

- The Right Ascension and Declination coordinates are now also displayed in decimal hours and decimal degrees.
- The galactic coordinates of each object is now included.
- The rates of motion, in multiple formats, are displayed for comets, asteroids and planets.
- A "copy" button has been added used to copy the contents of the Object Identify dialog box to the clipboard.

Internet Features

- Advanced web searching has been added to the Database Search dialog. The user can do a traditional web search such as with Google, search for images using Google, search the AAVSO's variable star database, and search professional databases such as GCVS, NED or SIMBAD.
- Advanced web searching has been added to the Identify Object dialog box. The user can do a traditional web search such as with Google, search for images using Google, search the AAVSO's variable star database, and search professional databases such as GCVS, NED or SIMBAD. You can also automatically bring up an image of the selected object from the 48" Schmidt-based Digitized Sky Survey.
- A new feature has been added to automatically bring up an image, centered at the current sky display center, from the 48" Schmidt-based Digitized Sky Survey.
- A new feature has been added to automatically bring up your favourite weather web page.
- A new feature has been added to automatically find the nearest Clear Sky Clock web page based on your current Geographic Location (north america only - see cleardarksky.com/csc).
- New menu items in the Help menu to bring up the Nova Astronomic's website, ECU's support web page, and a page that checks for the availability of new versions of ECU.

Object Search Features

- The last 10 search strings are now saved and you can select one of these in the Database Search dialog box. These searches are automatically saved between ECU sessions.
- Database searches can now include, just the enabled databases and object types or all of the object databases.
- If a search fails when all of the object databases were not searched, the user is reminded about the above feature.
- The Database Search dialog box now includes internet searching - see Internet Features section above.

Usability

- The current daylight savings status is now included in the Sun and Moon Data dialog box.
- The length of the day and night and the amount of time of astronomical and nautical darkness are now included in the Sun and Moon Data dialog box.
- Descriptive "hints" are now displayed on the status line when the mouse hovers over toolbar and status line buttons.
- The rates of motion for comets, asteroids, and planets are now included in the object reports.
- A new Autowrap Toolbar feature has been added to enable/disable the wrapping of the toobar to two lines (this is handy for small screens).
- Right-clicking the mouse on the n,s,e, and w toolbar buttons re-centers the sky by 10 degrees or 1 hour in the cooresponding direction.
- The User's Manual can now be displayed from the Help... menu.
- The Angular Separation dialog box now includes the position angle between to the two measured points.
- When "clicking" on objects on the sky display, it is now much easier to select large objects because the search area is much larger than before. Searching occurs beginning at the mouse cursor and then outwards in larger and larger rings.
- When saving the 'default.cfg' configuration file (used by Set Defaults) the web address settings are also saved in 'defaults.ini'.
- The Set Defaults menu item now looks for the file 'default.ini' and uses this file to load the web address default settings.
- Local Sidereal Time can now be displayed on the Status Line.

Databases

- The Principal Galaxy Catalog database has been updated to the 2002 version, which now contains 980,947 galaxies - about 10 times more galaxies than the previous version!
- A new dedicated planetary nebulae database has been added. This database, version 7 of the Wallace-SEC galactic planetary nebula database, contains 1143 planetary nebulae. It is maintained by planetary nebulae observer Kent Wallace and is based on the Strasbourg - ESO Catalogue of Galactic Planetary Nebulae.
- The General Catalog of Variable Stars database has been updated to V4.2 (2004 version), and it now contains 34,111 stars.
- The Washington Visual Double Star database has been updated to the 2005Jul08 version, and it now contains 102082 pairs of double stars.
- The Saguerro Astronomy Club deep sky database has been updated to V7.70.
- The stored resolution of the Washington Visual Double Star database has been increased, meaning they will plot more accurately.
- The "U" hotkey scans for changes to the USNO catalog (eg. a CD change) - this is also done whenever the "Stars..." dialog box is terminated (V4.0A).
- More Named Objects have been added.
- Many more object images have been added, thanks to ECU user Walter MacDonald.

Telescope Control

- Support has been added for the Orion Intelliscope digital setting circle device (V4.0A).
- The user is now optionally prompted to confirm telescope sync operations.
- The order of the telescope types has been re-ordered in the General Settings dialog box - more common telescopes are now near the top of the list.
- Native support for Celestron NexStar telescopes has been removed - please use the Celestron ASCOM driver instead (there is a way to re-enable these telescopes if necessary - contact the author for info.
- The east/west and/or north/south telescope motion buttons can be swapped.

- If the telescope stops responding (10 consecutive errors reading the telescope's position), the telescope interface can be optionally disabled.
- The menu item Center -> On Telescope Position has been added to center the sky display at the current telescope position. The T key is now assigned to this menu item.

Solar System

- The planet magnitute calculations have been adjusted slightly so that they exactly match the US Naval Observatory's Astronomical Almanac.
- A "sort" button has been added to the Center on Orbits... dialog box used to sort the orbit names into alphabetical order.
- The Animation and Center "On Comet/Asteroid... menu items have been moved up to the main level.

New Miscellaneous Features

- Configuration files from versions 3.0, 3.1, 3.2, and 4.0 of ECU are automatically read and converted to V5.0 format. This operation is totally transparent. Remember, however, that files written by V5.0 cannot be read by earlier versions.
- By default, galaxies are now plotted by their outlines (i.e. not filled).
- When querying a GPS receiver, ECU will now wait a user-specified time-out instead of waiting only five seconds for a valid position.
- The Flip Horizonal and Flip Vertical menu items have been moved to the Field -> Chart Mode menu.
- Added a Center -> On Solar System -> Anti-Sun menu item.
- Clicking the right mouse button on the geographic location display on the status line or on the geographic location toolbar button now brings up the GPS dialog box.
- Clicking the right mouse button on the UTC display on the status line now brings up the Julian Date/Sidereal Time dialog box.
- Right-clicking the mouse on the "grid" toolbar button now brings up the Custom Horizons... dialog box.
- A brief wait, with a mouse cursor change, was added to the Save, Save As..., Save Report File..., and Increase and Decrease animation step functions. These functions happened so quickly, it was hard to tell if the cooresponding toolbar button was actually pressed.
- A "splash" window is now displayed when ECU starts up which includes registration information.
- ECU now requires to be "registered" with a valid registration code before it will run.
- Some users running ECU on Apple Macs (in a Windows emulator) are reporting problems with their mouse cursors, so a mode was added that does not change the mouse cursor from its default arrow.

Bug Fixes

- Fixed a bug which caused the Angular Separation dialog to report small errors for small angles.
- Fixed a bug which made it not possible to display User Objects which had negative magnitudes.
- Fixed a bug which made ECU excessively picky about denying access to 32-bit functions when running multiple copies of ECU.
- Fixed a bug which made auto updates (when the time was set to "Use System Time" mode) stop at midnight if the clock mode was set to UTC.
- Fixed a bug which caused non-enabled deep sky object types to be searched.