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CCD Navigator

CCDNavigator is a powerful tool that helps you select interesting targets and create an optimal multi-target session plan that can be executed by automatic image acquistion software, such as CCDAutoPilot3, for any given night.

- CCDNavigator uses "*The Advanced Imager Catalog*" which consists of objects imaged by some of the world's best imagers and includes a thumbnail of each object. Thus, you can see in advance if an object will make an interesting photo. In addition. a second catalog, "*The Deep Sky Explorer Catalog*" which combines numerous astronomical catalogs including a thumbnail of each object, can be used for target selection. This allows you to easily hunt down and image little known objects. Also, images of targets at your exact position and camera angle can also be retrieved with a single click from the NASA Deep Sky Survey (DSS) database allowing you to see what your photo will look like before ever taking it. And scientific information about the object can be retrieved using the SIMBAD button.

- Target Criteria controls are provided so you can manage the session date plus the availability, elevation, size, and brightness of objects selected from the catalog. This allows you to focus on objects that "fit" your system and to plan automated all-night imaging runs of multiple targets.

- All useful details about the session date are displayed including Sun rise and set, start and end of darkness, the maximum length of the session in hours & minutes, plus information about the Lunar dark cycle and possible interference by the Moon.

- Objects in the catalog meeting your target criteria that are available for imaging on the session date are displayed for possible target selection . All potential targets are ordered by the priority of their availability for imaging and can be browsed sequentially or in a list. Technical data and a possible LRGBH allocation and order are given for each target. The LRGBH plan is easily modified and separate binning control for L, RGB and H as well as exposure duration for each filter is also provided. Two methods of acquiring the frames are provided - "Staircase" sequencing which schedules the frames based on the elevation of the object to maximize resolution while minimizing blue extinction and "Shuffle" sequencing which cycles between the filters to ensure getting some frames through each filter. Up to ten filters can be specified with any five of them being used for imaging a target.

- A graph displays the starting time, ending time and transit time for each target being considered as well as times when it is behind an obstruction at your local horizon.

- The "EZ-Guide" feature lets you position targets for autoguiding with a guidescope, internal guidechip or off-axis guider using only three clicks. Using CCDNavigator's link to TheSky6, the "Semi-Automatic" mode positions the autoguider on your chosen guidestar and will calculate guidestar exposures for each filter used based on two guidestar reference exposures. The camera angle, revised position (RA and DEC) and guidestar exposures are exported to CCDAutoPilot3 through a session plan. Also, users have the option of slewing their telescope to the target immediately.

- The ″In FOV″ feature lets you find out what other objects will be captured in your camera's field-of-view when you image a target. Clicking on a thumbnail will provide a list of all objects within your camera's field-of-view (including camera angle). This feature uses "*The Deep Sky Explorer Catalog*" which contains over 23,000 objects.

- When objects are selected for imaging, a session plan for the combined set of targets is created that can be imported into automated acquisition software such as CCDAutoPilot3. Information about the session plan are displayed including its start and end times, duration, time remaining, targets that will be imaged. Details of the session plan including the LRGBH sequencing can be viewed. The session plan contains the best possible ordering of the targets to maximize your time for imaging them and it conveys the target's co-ordinates and rotation angle for the camera so an autoguider will be properly positioned. Full session sequences can be exported to CCDAutoPilot3 and Astronomer's Control Panel while single target sequences can be exported to MaxImDL and CCDSoft.

- If invoked during the hours of darkness, CCDNavigator will create a "Just-In-Time" session plan that best utilizes the available time. This can help you salvage a late start for an imaging session by quickly and easily creating a plan for whatever is left of the night.

- The user can maintain a personal list of targets ("MyTargets") which is checked by CCDNavigator. If a target on the *MyTargets* list is available for imaging, the user is alerted. There are easy controls for adding targets and editing the list.

- When the catalogs are viewed, you can see all the technical data for each object including the best month for imaging it from your location. This, along with the dark cycle and other session information, allows you to make long term plans for imaging sessions for any future date. Catalogs can be sorted by any criteria allowing easy grouping of like objects.

- Your site location and system information can be saved into settings files and later retrieved so you can easily switch between different locations and equipment configurations.

🌟 CCDNavigator

The Advanced Imager Catalog v4.3

Session

Session Date	2/27/2007
Maximum Session Duration	09:46

Sun

Sunset Today	17:49
Darkness Begins Today	19:22
Darkness Ends Tomorrow	05:06
Sunrise Tomorrow	06:39

Moon

Waxing Moon Always Visible	
Moon's Illumination	80%
Dark Cycle	3/15/2007 - 3/19/2007

Target Selection

Object	M81	19 of 42 — List
Names	Bode's Nebula; NGC3031;	
Type	Sb	

Image courtesy of Rob Gendler

		RA DEC PA
Size	24.9	
Magnitude	7.0	09:55:20
Transit	23:32	+69:08:42
Available From	19:21	345.4
Available Until	05:07	EZ-Guide
Duration	06:36	DSS — ☑ Add to Plan — First
Frames	33	SIMBAD — In FOV — Next

L R G B H
18 5 5 5 0

Previous
Last

Target Transit and Availability

T

19:22	21:48	00:14	02:40	05:06

Moon

Session Plan

M81 NGC4631

Session Start	19:22	Session Duration	09:36
Session End	04:58	Time Remaining	00:08

Save Plan — Clear Plan — View Plan — Next Target

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Getting Started

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This section will acquaint you with CCDNavigator and take you on a quick tour.

Once installed, simply double click on the "CCDNavigator" icon to launch the application. You will see a window similar to this with no targets added to the plan:
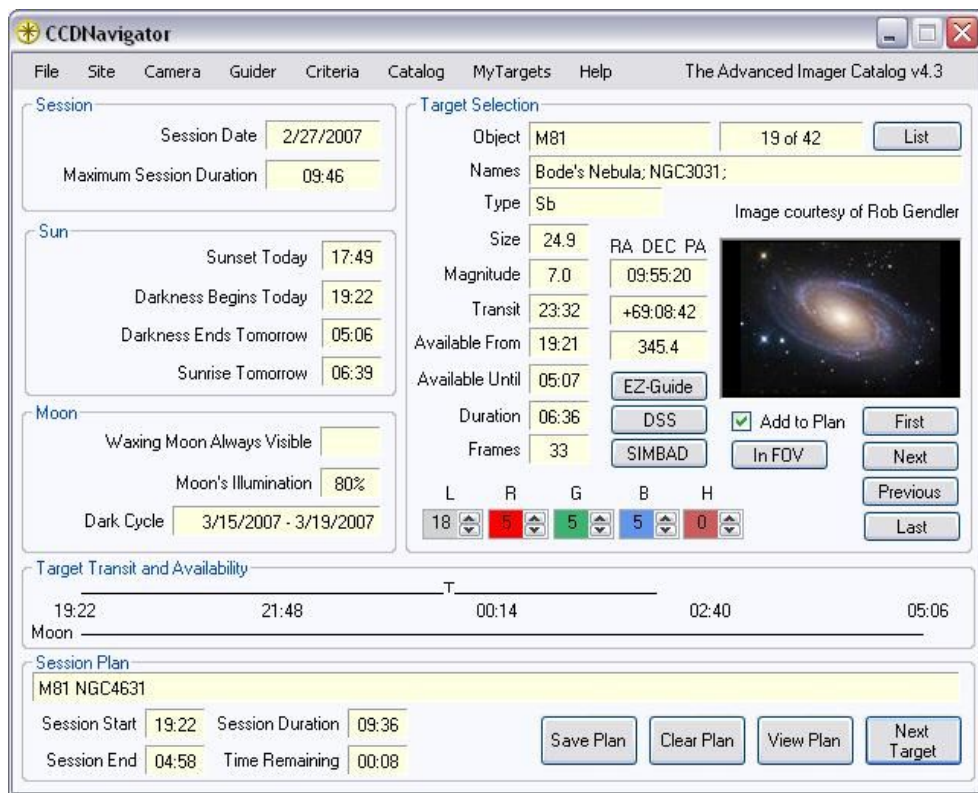
Menu Bar

The menu bar holds eight options and tells you which catalog is in use.

- **File** - This item lets you load or save the settings as files, set the path for saving the session plan and exit the application. These **settings files** are saved in the CCDNavigator folder "My Documents\CCDWare\CCDNavigator\Settings". A special settings file, "Profile", saves the parameters for the next time CCDNavigator is used and is kept current by the software. The current settings can be saved as a particular file name using "Save Settings As". The user can also select a folder for saving the **session plans**. The session plan path defaults to "My Documents\CCDWare\CCDNavigator\Session Plans". If you are using CCDAutoPilot3, setting the path to "My Documents\CCDWare\CCDAutoPilot3\Target Lists", or wherever your target lists are maintained, will make it easy to load the session plans into CCDAP3.

  - Site **-** Click here to set up your site parameters including latitude, longitude, timezone, local horizon, etc.
  - Camera **-** Click to set up your camera parameters including filter choices, LRGBH exposure intervals, binning options and field-of-view size. On first use, you should set up the Site and Camera parameters as well as the path to the session plan so CCDNavigator has your correct location and equipment configuration.
  - Guider - Click to control autoguider exposure settings and to preview the autoguider exposure calculations.
  - Criteria - This brings up a window that lets you control the various criteria that objects must satisfy to be listed as potential targets. This includes the date, minimum availability, smallest and largest size and brightness.
  - Catalog - CCDNavigator contains two catalog systems, click this menu item to either view or select catalogs. At the very end of the menu bar is a display showing which of the two catalog systems is in use and its version number.
  - MyTargets - This feature lets you save, retrieve and edit a list of objects that you want to image at a future session.
  - **Help -** Invokes this helpfile. It also allows the user to see the CCDNavigator version number.

The upper left hand panels displayed in the CCDNavigator window are:

- **Session Information** - Three panels display critical information about the session date as well as sun & moon set and rise.
- **Target Selection** - Displays thumbnails and technical information for each candidate, allows you to set LRGBH allocations and select targets for imaging.
- **Target Transit and Availability** - This graph extends from the start of darkness to the end of darkness and shows the displayed candidate's availability and transit time. The letter "T" denotes the transit time which can be before, after or during the darkness interval. The graph changes when the displayed object has been selected as a target, it then shows the actual interval allocated for imaging according to the LRGBH controls. An "X" in the graph denotes a time when the target is behind an obstruction in the local horizon.
- **Session Plan** - Displays information about the Session Plan and the list of targets selected for imaging.

CCDNavigator creates an optimal Session Plan which is kept up-to-date as the user selects and deletes targets or changes parameters that effect the imaging session. The Session Plan can be imported into acquisition software such as CCDAutoPilot3 for automated acquisition of the images. It also features EZ-Guide which lets you position an OAG or guidescope for image acquisition and calculates autoguider exposures for guidestars.

# Quick Start

Now, let's try a few features. A key menu item where you will make adjustments, is the "Target Criteria" panel. These parameters determine what date you will be imaging and lets you control how many candidates will be displayed as candidate targets. When started, CCDNavigator adjusts the Availability parameter to a value that will provide 20 targets. If you want to see more targets, reduce Minimum Availability to a smaller value. This will allow more objects to be listed as candidates. Two other useful controls are the Smallest Size parameter and the Largest Size parameter. These parameters establish upper and lower limits on the sizes of targets that will be listed. Decreasing the Smallest Size parameter or increasing the Largest Size parameter will produce more targets. Changing the Lowest Elevation parameter to a lower value will also produce more targets and if you're interested in objects that have very low declinations, lowering this parameter is essential.

For now, you can leave these controls at their default settings but later, you will definitely want to adjust the values in the "Target Criteria" panel.

You can also wait until later to change the Site and Camera properties but click on them now to see how they're set up.
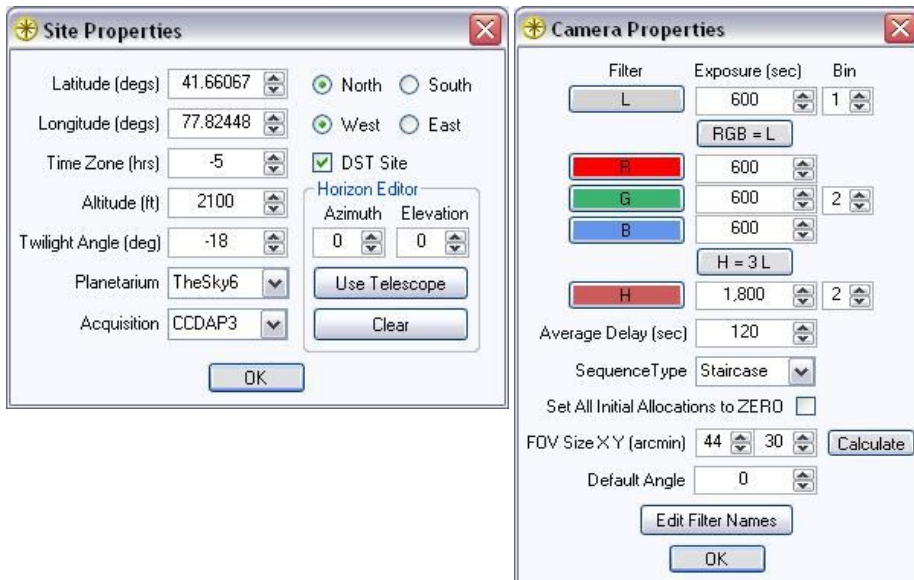
Now look at the "Settings" menu item. It lets you load and save all the parameters from the Site, Camera and Target Criteria panels which lets you have different values for different locations/camera systems. It also lets you set the path you want CCDNavigator to use for saving session plans. If you're using CCDAP3, set this to "My Documents\CCDWare\CCDAP3\Target Lists" as this is a convenient location for importing the plans into CCDAP3.

Next, examine the Session Information displayed for the selected date. This includes sunset, sunrise, the beginning and ending of astronomical darkness, the next dark cycle of the moon and, most importantly, how much time is available for imaging during the session.

Moon
Waning Moon Rises Tomorrow	01:49
Moon's Illumination	48%
Dark Cycle	10/20/2006 - 10/25/2006

In the "Target Selection" panel, you can step through the candidates by clicking the "Next", "Previous", etc. buttons until you see an object that interests you. All the technical parameters for the candidate such as the duration for imaging and its transit time are displayed. If no image is displayed and you are on the Internet, you can retrieve an image from the Deep Sky Survey by clicking the DSS button. SIMBAD will retrieve various technical/scientific information about the target from NASA's databases.

Target Selection

Object	M31		5 of 30	List
Names	Andromeda Galaxy; NGC224;			
Type	Sb			Image courtesy of Rob Gendler
Size	189.1	RA DEC PA		
Magnitude	3.5	00:42:44		
Transit	21:14	+41:16:08		
Available From	18:30	0.0		
Available Until	02:53	EZ-Guide		
Duration	08:12	DSS	☑ Add to Plan	First
Frames	41	SIMBAD	In FOV	Next
				Previous
				Last

L R G B H
20 7 7 7 0

You can view all the candidates at once by clicking on "List" and scrolling through all the possible choices. The list can be sorted by any of the columns such as "SIZE", "AVAILABILITY" and so forth by just clicking on the column header. Also you can search for a particular object and if found, the "List" window will close and the main menu will be displaying that candidate. If you see a candidate that interests you, simply double click on any field in that row (the thumbnail is easy to hit), click "OK" and the "Target Selection" panel will display the data and thumbnail for that candidate.

Target List

42 targets for 2/27/2007   [Find]

| TARGET	STATUS	IMAGE	ID	AVAILABILITY	TRANSIT	SIZE	MAG	NAMES	TY
16	Ineligible		ABELL671	07:48	22:05	28.1	14.9		G-
17	Ineligible		NGC2903	08:24	23:08	12.6	8.8		
18	Ineligible		NGC2403	09:09	21:13	23.4	8.2		
19	In Plan		M81	06:36	23:32	24.9	7.0	Bode's Nebula; NGC3031;	
20			M82	09:46	23:32	11.2	8.6	Cigar Galaxy; NGC3034; ARP337;	
21			M106	09:04	01:59	18.6	8.3	NGC4258;	

Now let's set a target up for guiding. First, launch TheSky6 and activate a Field-Of-View-Indicator (FOVI) that models your system. These are found in TheSky6 under the "View" menu, "Field of View Indicator" drop down. Then, in CCDNavigator, click on the "EZ-Guide" button and watch as TheSky6 is launched. The first time this is done, CCDNavigator will lead you through a calibration procedure for your particular FOVI so follow the instructions that pop up on your monitor. After

this is completed and CCDNavigator is ready to setup the target for guiding, you'll see the target you've selected centered in your Field-Of-View Indicator in TheSky6. Simply right click on whatever guidestar you want to use and select "Center" in the popup that appears (or double click on the guidestar and click on the center icon), then return to the CCDNavigator pop-up and click "OK". CCDNavigator will calculate the position angle and new coordinates and will manipulate TheSky6 to show the guiding window with the guidestar centered in the guidebox and the camera rotated. It will also display the guidestar catalog ID plus its magnitude and spectral classification and it will calculate autoguider exposures. If you want, you can slew your telescope to this position immediately but for now, just click on "No". To see the autoguider exposures calculated by CCDNavigator, click on "Filters" and see them in the Preview column.

If you've already selected this target for imaging and run EZ-Guide, the session plan will automatically be updated with the new camera angle, coordinates and autoguider exposures and you will notice the "Save Session Plan" button is enabled to remind you that the session plan has not been stored. To see all the objects that fall within the Field-Of-View of your camera (including camera rotation), just click on "In FOV" and a list will be displayed. This is useful if you want to capture multiple objects in a single image since you can be certain they are all included in your camera's FOV.

If you wish, multiple targets can be selected for an imaging session, just select the candidates that appeal to you but notice when they transit in the Target Transit and Availability graph so that the LRGBH frames can be taken while the target it near its highest elevation. As targets are added to the plan, CCDNavigator will automatically adjust the LRGBH frame count number to an initial value that will fit the target into the plan based on its availability. You can change the setup for each target by clicking the Session Plan panel's "Next Target" button and adjusting the target's associated LRGBH allocation. CCDNavigator will not allow these allocations to exceed the time available for imaging each target and if you change the allocation of any target, the later target's LRGBH counts will be re-initialized if they do not fit the target's availability.

To indicate when a target transits and when it's availability starts & ends, a graph is included called the "Target Transit and Availabilty" graph. This graph is associated with both Target Selection and with the Session Plan and shows the time interval from the beginning of darkness to the end of darkness. Before a target is selected for imaging, it shows the availablilty and transit time for the displayed object. From this graph, we can see that this object is available nearly all night long and that it transits (the "T" character) just before the middle of the night. At the lower part of the graph, the interval in which the Moon can be seen is displayed allowing you to decide if any adjustments should be made to the exposure due to the Moon's presence.
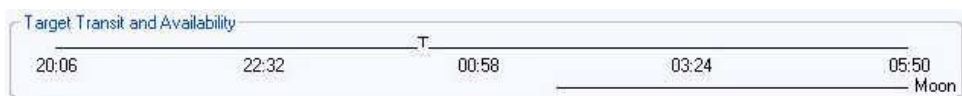
When a candidate is selected as a target by clicking the "Add to Plan" checkbox, the Target Transit and Availability graph will then show the actual time planned for imaging the target based on its availability and the target's starting time in the session plan. The LRGBH frame counters will be set to values that fit the target into the plan. If you wish to image multiple targets, you may need to reduce the LRGBH allocation so there will be some time available for imaging the other targets. To change the LRGBH allocation, simply change the frame counters with the up/down arrows next to each filter. These values can only be changed after selecting the target for a session plan. CCDNavigator will not allow you to exceed the maximum number of frames that fit the available time for a target. For example, the graph above is changed to the one below after adding the target to the session plan and reducing the LRGBH frame counts.

For example, a second target selected for a plan might have an availability that looks like the graph below. This target will be imaged during moonlight so possibly we should either wait for another night or pick a target where narrowband imaging can be done.

After multiple targets are selected for a plan, you can step sequentially through them by clicking on the "Next Target" button which will cause the display to show the next target. When this is done, the graph will display the planned allocation for that object. This allows you to easily see how the session will run and when the objects transit relative to their imaging intervals.

CCDNavigator creates a session plan for imaging all the targets you've selected. Within it, targets are ordered optimally for imaging regardless of the order in which they were selected. You can examine the session plan contents by clicking on "View Plan" in the "Session Plan" panel. Besides the target order, notice that the LRGBH sequence has been created optimally (if you have selected "Staircase" sequencing) so that the L frames are taken at the highest elevation, B frames at the next highest and so on. If "Shuffle" sequencing has been selected, the sequence will be a repeated cycle of LRGB frames. By default, the session plan is saved in the "My Documents\CCDWare\CCDNavigator\Session Plans" folder and is named by the session date as Year-Month-Day (for example "CCDN-2006-10-17") . It can be imported into acquisition software such as CCDAutoPilot3 for execution. If this is done frequently, you should go to the "Settings" menu item and use the "Set Plan Folder" to be the "Target List" folder in CCDAP3.

If you want to see the entire "*Advanced Imager Catalog*" just click on "View" in the "Catalog" menu drop down. If you want to switch to the "*Deep Sky Explorer Catalog*", click on "Select" in this dropdown. A new window will be displayed that allows you to select either catalog and, for the Deep Sky Explorer, which sub-catalogs are to be imported to the target selection process..

Try clicking on "The Deep Sky Explorer Catalog", select one or two catalog options and press "Ok" (be patient, this can take a while depending on how many objects are in the catalogs selected). After loading the catalog(s), the target list will be made up of all the objects in the catalog options you selected that meet your selection criteria. If a target has a thumbnail in the Advanced Imagers Catalog, it will be displayed and all of the 23,000+ targets have black and white thumbnails. Also, use the DSS button to retrieve an image from NASA's Deep Sky Survey database. The image will be scaled to the size of your field-of-view as set in the "Camera" menu and placed at the exact RA, DC and Position Angle seen in the target information. Incidentally, choosing some of the less familiar catalogs and stepping through them is a great way to spend time on cloudy nights.

I hope this quick tour gets you on a fast track to using CCDNavigator! Good luck imaging!

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Site Properties

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This panel holds the various parameters associated with your location. When the "OK" button is clicked, CCDNavigator will clear the target selections and session plan so be sure these parameters are set correctly before proceeding with target selection.

These parameters are:

- **Latitude** - This should be set to the latitude of your site and you must also select either "North" or "South" according to your position relative to the equator. The up/down buttons change the latitude parameter in steps of whole degrees. To modify the fractional part, simply highlight it (or the entire set of digits) and type in the desired value. The site must be below the Arctic circle and above the Antarctic circle so the latitude can range from 65 degrees North to 65 degrees South. Above or below these values, there are days when the sun neither rises nor sets leading to impossible calculations for the solar, lunar and session times.
- **Longitude** - This parameter should be set to your site's longitude and you must select either "West" or "East" according to your position relative to Greenwich. US longitudes are west of Greenwich. Setting the longitude also sets a range of time zones that can be selected.
- **Altitude** - This parameter should be set to your site's altitude above sea level and should be given in feet.
- **Time Zone** - This parameter gives the offset in hours from UTC to your local time. It is negative for locations west of Greenwich and positive for locations east of Greenwich. For example, the offset for the US Eastern Time Zone is -5, Central is -6, Mountain is -7 and Pacific is -8. This offset should be for standard time time, eg. EST, not when DST is in effect. When longitude is set, the time zone is set to a value central to that position on earth and can be adjusted plus or minus 1 zone from this position.
- **DST Site** - If your location uses Daylight Savings Time during the summer months, check this box. The check box simply tells CCDNavigator to use DST whenever DST is in effect (US rules are followed). CCDNavigator checks the session's calendar date and makes the switch if DST is actually in effect on that date. DST is currently programmed with the US definition.
- **Twilight Angle** - This parameter tells CCDNavigator how far below the horizon the Sun must be before imaging can commence and is used to calculate the times when darkness begins and ends. The default value is -18 degrees which is the normal definition of Astronomical Twilight. Standard definitions for the start and end of twilight are "Civil Twilight" which is 6 degrees below the horizon (-6), "Nautical Twilight" which is12 degrees below (-12) and "Astronomical Twilight " which is 18 degrees below (-18). If the user wishes to modify their session start and end times, this value can be changed to values between -6 and -30 but be careful that the Sun does not interfere with your imaging.
- **Planetarium** - This parameter tells CCDNavigator which planetarium program you are using. The planetarium is used for framing objects and selecting guidestars with EZ-Guide. At present, CCDNavigator only supports TheSky6 by Software Bisque. If you do not use TheSky6 select "None" - you will not be able to position guidestars with EZ-Guide but all other features will work normally. Future versions of CCDNavigator may support other planetarium programs.
- **Acquisition** - This parameter tells CCDNavigator which image acquisition / camera control program will be used to execute the session plans. At present, CCDAP3, ACP, MaxImDL and CCDSoft are supported. In the case of MaxImDL, multiple sequence files are generated when the "Save Plan" is pressed, one for each target in a multi-target plan. For CCDSoft, pressing "Save Plan" will launch CCDSoft and lets the user select which target is to be placed in CCDSoft's color series sequence. CCDSoft can only support "Shuffle" style sequences (see "Optimal Scheduling").
- **Horizon Editor** - You can trace out your local horizon so CCDNavigator will indicate when a target is behind an obstacle such as a house or trees. This is indicated in the "Target Transit and Availability Graph", see the discussion in "Target Selection". Here we are concerned with creating the horizon in CCDNavigator.

The horizon data can be generated in two ways.

- One way is to simply step the azimuth value from 0 to 360 degrees and set the elevation that is possible at each position. At any time, you can leave the "Site" menu and return later to continue editing. Don't forget to hit "Ok" when leaving the "Site" menu or your edits will not be saved. While this method will work and is practical for minor adjustments to the horizon, it is time consuming and tedious.

- If the user has TheSky6 as their planetarium, a second method can be used that reads the azimuth and elevation of the telescope. To use this method, simply click on the "Use Telescope" button to start recording. If the telescope is not already connected, you will be prompted to "Connect". Then, simply slew your telescope in azimuth and elevation to clear obstacles using a moderate slewing speed. This will trace out your

local horizon which CCDNavigator will record. As you are slewing, the azimuth and elevation of the telescope will be displayed in the up/down numeric values in the Horizon Editor panel. It is normal for these to change by more than one unit while slewing but all values in between will be initialized. If you make an error while slewing, simply backup and do it again - the old data will be overwritten - it is not necessary to restart the horizon editor. To terminate the horizon editor, simply disconnect from the telescope. While using this method, do NOT slew through the southern meridian (180 degrees azimuth) with a German Equatorial mount as this will cause incorrect values to be saved while the scope is "flipping" to the other side. Also do NOT slew through the northern meridian (0 degrees azimuth) with any type of mount as this will confuse the Horizon Editor. These small regions can be filled out using the manual editor.

At any time, the "Clear" button can be pressed to erase the Local Horizon dataset. Before this is done, the user will be prompted to ensure that clearing is a desired operation.

Note: Azimuth is measured from the north in the range from 0 degrees to 360 degrees. East has an azimuth of 90 degrees, south is 180 degrees and west is 270 degrees.
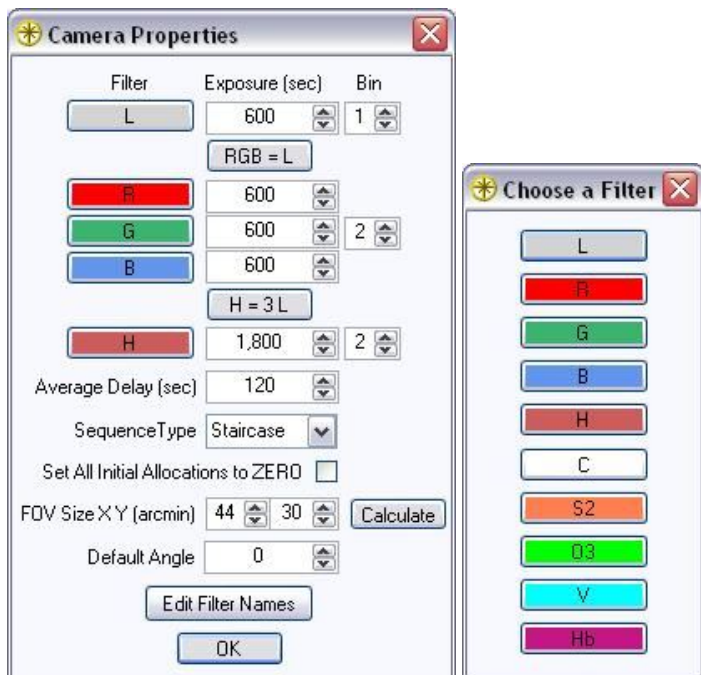
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Camera Properties

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This panel holds the various parameters associated with the camera. The camera parameters can be changed while planning a session. If this is done, the old parameters will be preserved for any targets already present in the session plan but all unselected objects will utilize the new parameters.


The camera parameters are:

- **Filter Name -** Up to five filters can be used for each target imaged during a session. To select filters, click on the filter to be changed and a new window will appear showing the ten available filters. To select one, click on it and it will replace the original filter. CCDNavigator must know the names of the filters used in your camera control software in order to create a Session Plan that can be utilized by your acquisition software (CCDAP3, ACP, MaxImDL or CCDSoft). When the session plan is executed, these names will be passed to your camera control program so you must use names that it will recognize. The default names are "L", "R", "G", "B" and "H" but these can be changed by clicking "Edit Filter Names
- **Exposure** - These parameters provide CCDNavigator with the length of time for each filter used to image frames with your CCD camera and is given in seconds. It should not include lost time to download frames, focus, slew or any other system delays as these are accounted for elsewhere. The values entered set the actual imaging times for each filter used by the camera in the exported session plans.
- **Bin** - These three parameters set the binning mode for each of the filters when acquiring images and can be set to 1x1, 2x2 or 3x3 binning for the L, RGB and H filters (the same binning mode is used for the R, G and B filter positions).
- **RGB = L** - Click this button to set the R, G and B exposures to be equal to the luminance frame exposure.
- **H = 3 L** - Click this button to set the H-alpha exposure to three times the luminance frame exposure.
- **Average Delay** - This parameter models the various delays that occur when an imaging session executes. These include downloads from the camera, precision slewing of the telescope with plate solves and settling delays, slewing to/from a focus star and focusing, guidestar acquistion with dithering delays, and meridian flips. As a first order approximation, this value can be set to the download times for 1x1 frames until a better estimate can be acquired. A better estimate can be calculated by timing a session from start of imaging to the end of imaging with all the normal operations taking place, subtracting the amount of time actually spent exposing the frames (number of resulting frames times the exposure used for each frame) and dividing the remaining time by the number of resulting frames. This can most easily be done by examining the log of CCDAutoPilot3 and doing this calculation. This parameter, along with the exposure durations for the filters used, is used to calculate how many frames can be taking during any given interval of time and estimating the starting time for each target.
- **Sequence Type** - This dropdown window lets you choose between "Staircase" sequencing and "Shuffle" sequence. Staircase sequencing captures frames in an order such that L frames are taken at the highest possible elevation, B frames at the next highest, G frames at the next highest, R frames next highest and H frames at the next highest elevation. An example staircase sequence where the target transits in the middle of the sequence is RRGGBBLLLLLLBBGGRR. This method tends to maximize resolution in the L frames and avoids extinction in the B frames. Shuffle sequencing takes the frames in a repeated cycle of L, R, G, B, H where a specific number of L, R, G, B and H frames are taken during each cycle. A common shuffle sequence is LRGBLRGBLRGB but a more general case is LLLLRRGGGBLLLLRRGGGB which takes four L frames, two R frames and three G frames per cycle. The shuffle method attempts to balance the acquisition of data so that if a session must be terminated, there is a chance of having enough data for an image. For more information, see the section on Optimal Scheduling.
- **Set All Initial Allocations to ZERO** - This option, when checked, will cause CCDNavigator to force LRGBH frame counts initially to ZERO whenever a taret is selected for the session plan or when it must be reinitialized while in the plan.
- **FOV Size X Y** - These parameters hold the size, in arcminutes, of the camera's field-of-view where the first parameter is the X (width) of the camera and the second parameter is the Y (height) of the camera. For example, 44 x 30 means that the camera/telescope combination covers a 44 arcminute by 30 arcminute field. This value is used when the user clicks on the "In-FOV" button which produces a list of all objects within the Field-Of-View. It also sets the FOV size of the Deep Sky Survey image retrieval feature.

- **Calculate** - This button launches a window that will help you calculate your Field-Of-View. Clicking "OK" will transfer these values to the main camera menu screen.
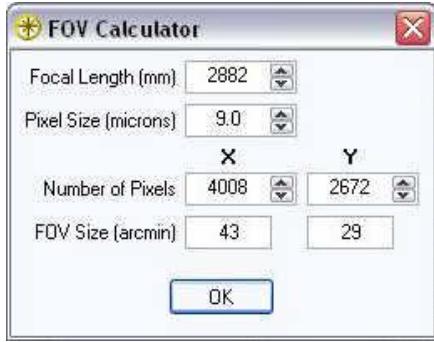
- **Default Angle** - This parameter establishes the default angle of the camera. When changed, all objects in the catalgs that have not been selected for a session plan will assume this value for their angle.

- **Edit Filter Names** - Launches a window in which the filter names can be changed. To change a name, simply highlight it with your cursor and retype the name. If a filter name is set to empty, then the filter's slot will not appear in the Filter Chooser dialog (shown above) or the Guider dialog.

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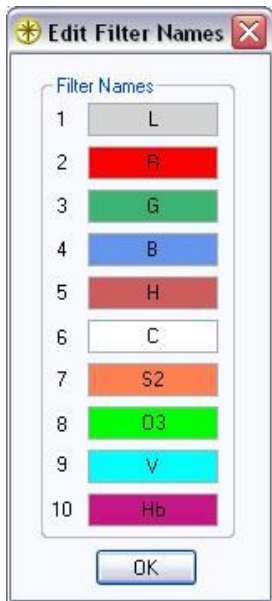
Target Criteria

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The parameters within the "Criteria" menu item are used to manage the listing of candidate targets including the planned date of your imaging session and other aspects of the candidate targets that CCDNavigator displays. When the "OK" button is clicked, CCDNavigator will recalculate the target selections and session plan so be sure these parameters are set correctly before proceeding with target selection. An exception to this is the "Override Plan Start" checkbox and the associated time to the right. If these are the only parameters that change, the target list will not be recomputed and the session plan will remain intact. In any case, the target currently being viewed on the main screen will remain provided it meets the revised criteria.

The target criteria parameters are:

- **Session Date** - This sets the date for the session and defaults to the current date in your computer. Click on the down arrow to view a calendar and select a different date.
- **Minimum Availability** - Only objects having available imaging times greater than or equal to this parameter (given in hours) will be listed as candidates in the Target Selection panel. If the available time for imaging an object is less than the Minimum Availability value, the object will not be listed as a candidate. When you close the target criteria window and have also changed the date, this value will be adjusted by CCDNavigator to a value that will provide at least 20 targets. It is important to remember that objects that set early or do not rise until late in the session as well as objects with low declinations will have short availabilities. If you want to consider these objects, set the Availability to a low value, as low as 0, so they will be listed. The maximum value for the Minimum Availability parameter is the Session Duration (length of darkness) rounded down to the nearest hour. You can set Minimum Availability to any value but if fewer than 20 targets are listed, CCDNavigator will reduce it until at least 20 targets are listed.
- **Smallest Size** - This parameter determines the size of the smallest objects that will be listed in the Target Selection panel. It is given in arcminutes and has a default value of 5 arcminutes. You can select this parameter according to the field-of-view of your imaging system and what size objects are appropriate for it. If you use a wide field system, you may wish to set this to a larger value since small objects will have very small scale in your images. You can set Size to zero to see all the objects having availability but this may give you a very large number of objects to consider depending on your catalog choices. Size is useful in controlling the number of target candidates since there are more and more targets of decreasing size.
- **Largest Size** - This parameter determines the size of the largest objects that will be listed in the Target Selection panel. It is given in arcminutes and has a default value of 999 arcminutes. You can select this parameter according to the field-of-view of your imaging system and what size objects are appropriate for it. This parameter and the "Smallest Size" parameter are linked to maintain consistency.
- **Lowest Elevation** - This parameter sets the minimum altitude that objects must reach in the night sky to be listed as candidates and it defaults to 30 degrees. Whenever possible, most imagers prefer not to image objects close to the horizon because of low resolution due to seeing and blue extinction. The Lowest Elevation parameter lets you control that aspect of the objects that will be listed as targets. But remember, if an object never reaches this elevation it will not be listed as a target candidate so don't forget to set it to a low value if you are interested in objects that are at low declinations. Depending on the target's position and other factors such as the start and end of darkness, this parameter will also effect the starting and ending times of availblility for imaging a target as shown in the Target Selection panel. The maximum value possible for this field is your latitude plus 90 degrees.
- **Faintest Brightness** - This parameter determines the faintest objects that will be listed in the Target Selection panel. Only objects meeting or exceeding this parameter will be listed as candidates. It defaults to magnitude 99 which will reveal all objects meeting the other control parameters.
- **Override Plan Start** - Check this box if you want to start at a time other than the beginning of darkness using the up/down control to the right. The override time is limited to being within the hours of darkness. This control can be used to allow a session to begin with a particular target or to generate a plan after the hours of darkness have begun.

If any of these parameters are set to unusual values (such as a super large Smallest Size and a very high Lowest Elevation), there may be no objects in the catalog that satisfy all of the criteria. In this case, all data in the Target Selection panel will be blank since there are no candidates to display.

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Target Selection

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This panel allows you to view targets that meet your Target Criteria and select them for session plans.

The information displayed is:

- **Object** - This is the catalog and number, such as M31, by which the target is known.
- **X of Y** - This simply indicates which candidate target is being displayed and the total number of candidates. Candidates are sorted according to the precedence of their availabilty for imaging.. Candidates whose availabilty ends earliest (the "Available Until" time) are listed first. If two or more candidates become unavailable at the same "Available Until" time, then candidates that become available earlier (the "Available From" time) are listed first. And if both the "Available From" and "Available Until" times match, candidates that transit earlier are listed first. Thus, candidates earlier in the list should be imaged before candidates later in the list to take advantage of their availability.
- **List** - Click this to see a tabular list of all candidate targets accompanied by thumbnails. This list is ordered by the precedences described previously. While the list is displayed, double clicking on a target image will set the **X of Y** field to the target selected so when you close the list display, that Target Selection panel will display that object. The list can be sorted by any of the header values and the direction of sorting (ascending or descending) alternates with each click of the header box.

- **Names** - Any common names, such as "Andromeda Galaxy; NGC224;", by which this object is known will be shown here. Also any other catalog identifiers, such as NGC numbers, that reference the same object will be listed.
- **Type** - This describes the object using notation that comes from various astronomical catalogs and some are rather cryptic. See the Helpfile on Classification Systems for details in understanding these shorthand descriptions.
- **Size** - The size, in arcminutes, of the object if known. Some objects in available catalogs have not been sized and these are listed as "0".
- **Magnitude** - The best estimate of the brightness of the object, sometimes as a visual magnitude, found in astronomical catalogs. Many objects have never been classified as to brightness (magnitude) or, as in the case of dark nebula, cannot be classified. For example the Sharpless, LBN and Barnard catalogs have no brightness values given. For these objects, the magnitudes will appear as mag 30 for dim HII regions and mag 99 for dark nebula.
- **Transit** - Local time when the target crosses the meridian (due south) which is the point of it's highest elevation.
- **Available From** - The local time when the target is available to begin imaging. At this time, the target meets all the Target Critera including the required minimum elevation or was already above the minimum elevation when darkness began. In the latter case, the "Available From" time will be equal to the onset of darkness.
- **Available Until** - Local time when the target no longer meets the minimum elevation criteria or when darkness has ended, whichever occurs first.
- **Duration** - Total time in hours and minutes used to image the target. This is calculated from the total LRGBH frame count shown just below.
- **Frames** - These LRGBH colored boxes are initially set to the maximum number of frames available to image the target based on the Exposure duration values for each filter and Avg Delay parameters found in the Camera panel. They are initialized according to the sequencing pattern selected ("Shuffle" or "Staircase" sequencing). Staircase allocation will have roughly 50% of the time allocated to Luminance frames and Shuffle sequencing will have all frame counts initialized to "1" (except H which is set to "0") but any of the allocations can be changed (unless the "Set All Initial Allocations to ZERO" has been selected in the camera dialog).. If any are changed, "Frames" and "Duration" are updated however CCDNavigator will not allow the total time of all frames to exceed the available time for imaging ("Available From" to "Available Until"). The filter names are displayed above each counter box. The frame counters cannot be changed until the candidate has been selected as a target for the session plan by clicking the "Add to Plan" checkbox. Also, the Repeat counter is not enabled unless "Shuffle" sequencing is selected in the "Camera" menu item.

- **RA DEC PA** - Right Ascension, Declination and Position Angle of the target are displayed next to the thumbnail. All of these values may change when guidestar selection using "EZ-Guide" is completed since it may be necessary to reposition the camera to align with a guidestar.
- **EZ-Guide** - Clicking this button will cause TheSky6 to display the target with an appropriate scale and in polar format. After calibration has been performed and an operation mode (Semi-Automatic or Manual) is chosen, a popup will appear with instructions for the user. When these have been completed, CCDNavigator will calculate the proper co-ordinates and rotation angle for the OAG to place the guidestar on the autoguider or to adjust the position and angle for a guidescope. Afterwards, TheSky6 will show the new position and rotation angle for your approval. If you prefer a different orientation, simply repeat the operation, CCDNavigator will reset the coordinates to their original values and clear the rotation angle so you are back to the original starting point. EZ-Guide will perform a calibration sequence whenever the active FOVI changes and will request the user to activate only one if either none or multiple FOVI are active. Lastly, if a telecope is connected, EZ-Guide will ask you to disconnect it to avoid any possible damage to the telescope while positioning the target. When complete, EZ-Guide will place the FOVI used back into its previous reference frame, angle and offset state and offer a choice of slewing the telescope to the target immediately. If the Semi-Automatic operation is used, EZ-Guide also calculates exposures to use for the autoguider based on the selected guidestar.
- **DSS** - Click here to retrieve a DSS image of the target that exactly matches the your Field-Of-View and camera angle using NASA's "SkyView" capability at Goddard Space Flight Center. The image is centered on the coordinates and position angle seen in the target selection panel (which may have been modified by EZ-Guide) so you can see exactly what you will be imaging. So if you re-center or rotate the target using EZ-Guide and want to see how it will be placed on your camera, click DSS after using EZ-Guide. The DSS window includes a button for saving the image to the DSS Cache folder as a ".gif" file. This button will only be available if there is not already a ".gif" file stored for the object.
- **SIMBAD** - This button will access the NASA database and present scientific articles relating to the object.
- **In FOV** - Clicking on this button will produce a list of all objects inside your camera's Field-Of-View as set in the Camera window. The RA/DEC shown for the target is used as the center of the field-of-view. When computing what objects are inside the field-of-view, the position angle of the camera is included. This feature is very useful for checking the framing for images meant to include (or exclude) multiple objects.

- **Thumbnail and Credit** - Just above the thumbnail of the object is a credit line to the imager who provided the thumbnail. For more detail on these imagers, see the Acknowledgements section.
- **Add to Plan** - This check box selects a target for inclusion in the Session Plan and updates the Session Plan. When this is done, the LRGBH counters will change to the maximum number of frames possible based on the target's availability. The session plan will take the number of frames commanded for each filter and it will contain a sequence for taking them based on the user's selected sequencing algorithm ("Staircase" or "Shuffle"). All frames taken use the exposure parameters for each filter, filter names and binning controls as specified using the "Camera" button. Session plans can contain multiple objects which will be ordered for getting the best acquisition results and will include each object's name, start time, position, angle and a sequence plan for shooting the LRGB frames as well as guidestar exposures if available. If multiple targets are selected, CCDNavigator will create an LRGBH sequence plan for each target. If the "Add to Plan" checkbox has been replaced by "Ineligible", the candidate target cannot be added to the session plan either because it would be imaged prior to its availability or its availabilty ends prior to the end of the plan. This can occur if the target would be added to the plan prior to it's availabile start time or if its availability has ended prior to the time when it would be added. To understand what is going on, look at the "Plan End" time and the candidate target's "Available From" and "Available Until" times which, along with the Session Start time when the target would be added, are highlighted in red. Also, if you change the LRGBH frame counts or any other parameter than will cause this condition to not be satisfied, any targets already in the plan that now fit in this situation will be deselected. To save the session plan, click on the "Save Plan" button in the Session Plan panel.

- **L R G B H and Repeat** - At the bottom left of the panel, there are five colored boxes showing a proposed allocation of L, R, G, B and H frames and a sixth box for repeating the sequence. Ths "Repeat" box is only enabled if "Shuffle"sequencing is selected in the "Camera" menu item. The user's chosen filter names are displayed above each counter box. These LRGBH colored boxes and the Repeat count are initially set to the maximum number of frames available to image the target assuming the Exposure duration values for each filter and Avg Delay parameters from the Camera panel. They are initialized according to the sequencing pattern selected ("Shuffle" or "Staircase" sequencing). Staircase allocation will have roughly 50% of the time allocated to Luminance frames and Shuffle sequencing will have all frame counts initialized to ONE. H frames (H-alpha) are given an initial allocation of zero for either sequencing scheme. These values can be modified but the total amount of time cannot exceed the available time from "Available From" to "Available Until" for the object. When this value is reached, CCDNavigator will not increment the counters further. The counters cannot be changed until the candidate has been selected as a target for the session plan by clicking the "Add to Plan" checkbox.
- **First, Last, Next and Previous** - At the lower right of the Target Selection panel, there are four navigation buttons that allow you to step through the targets to choose the ones you want to include in the Session Plan. Remember that targets earlier in the list will be imaged prior to later ones if selected for a session.

Although not part of the Target Selection panel, the "Target Transit and Availability" graph just below it conveys critical information about the displayed target. The graph extends from the start of darkness until the end of darkness and the line shows when the target displayed in the Target Selection panel begins and ends its availabilty. The letter "T" denotes the time when the target transits the meridian which can occur before the start of darkness, during the darkness interval, or after tne end of darkness. This information is critical when selecting targets for a session, see the section on "Optimal Scheduling" for more information. In addition, "X" values

will be displayed if the target is behind an obstruction in your local horizon, a data set that can be created in the menu. If desired, the user can either modify the number of LRGBH frames taken or change the starting time for imaging the target to avoid obstacles ("X"s).

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Session Information

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In the "Session Information" panel, CCDNavigator displays all the relevant information about the session for the selected date. All times are in local time with DST applied if appropriate.

The information shown is:

- **Session Date** - This gives the month, day and year chosen for the session in the Criteria menu item.
- **Maximum Session Duration** - This gives the length of darkness in hours and minutes and represents the longest time that can be used for imaging on the chosen date. The definition of darkness can be modified by the "Twilight Angle" in the "Site" menu item which can lengthen or shorten the session duration if desired.

- **Sunset Today** - The local time of Sunset on the evening of the session date.
- **Darkness Begins Today** - The local time on the session date when the setting Sun has reached the Twilight Angle relative to the horizon and imaging can begin. The Twilight angle is found in the Site parameter window can be changed if you want to start either earlier or later.
- **Darkness Ends Tomorrow** - The local time on the morning after the session when the rising Sun reaches the Twilight Angle relative to the horizon and the session should terminate.
- **Sunrise Tomorrow** - The local time of Sunrise on the morning after the session concludes.

- **Moon Rise or Set Time** - This panel tells you what the Moon is doing during the session. It indicates if the moon is waxing or waning, so for example, if the waxing Moon rises late in the session then "Waxing Moon Rises Tomorrow" will be displayed and the local time of Moonrise will be given. Likewise, if it sets during the session, it will give the setting time and day (tonight or tomorrow). On some evenings, the Moon neither rises nor sets but can either be visible continuously or not seen at all during the session. Since some imaging (narrowband especially) can be performed even during bright moonlight, CCDNavigator does not use the moon information to determine starting or ending times for either the session or target availability. The user must take this into consideration when selecting targets so that session plan does not run into bright moonlight.The interval when the moon can be seen during darkness is displayed on the Target Transit and Availability graph. This allows you to easily see if the moon might interfere with the imaging plan.
- **Moon's Illumination** - This shows the percent of the lunar disc that is illuminated so you can estimate how much it might interfere with an imaging session.
- **Dark Cycle** - This shows the set of dates when the moon is not visible at all for either the current or the next dark cycle.

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Session Plan

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In the "Session Plan" panel, CCDNavigator displays all the relevant information about the session plan based on the targets choosen using the Target Selection panel. Session plans are optimal with regard to the order in which targets are imaged and frame acqusition will use either Staircase or Shuffle scheduling. All times are in local time with DST applied if the site uses DST and the session date is one during which DST is in force.

The information shown is:

- **Target List** - At the top of the Session Plan panel, the list of targets included in the plan is displayed in the order that they will be imaged.
- **Session Start** - This gives the time of day when the session plan will begin. Normally this is the beginning of darkness but the starting time can be set in the "Criteria" window by using the "Override Start Time" option. Times are given in local time and Daylight Savings Time will be included if it is in effect. If darkness has already fallen and the session plan start time has already passed, this field will be colored orange.
- **Session End** - This is the approximate time of day when the session will conclude. Because of variation in session execution due to various factors such as slewing delays, focusing, target acquisition, etc. that can only be estimated, the sesson may actually end a bit earlier or later according to how closely the selected Average Delay parameter models the real delays encountered.
- **Session Duration** - This gives the time in hours and minutes of the duration of the session plan and is based on the total time for acquiring the frames specified for each filter plus overhead delays.
- **Time Remaining** - This readout shows the amount of time left over that can be added to the session. CCDNavigator will not allow too many frames to be taken so there is normally a little time left over that cannot be utilized because adding one more frame will exceed the available time for the session.
- **Save Plan** - This button is only enabled when the session plan has changed needs to be saved. If clicked, it will save the session plan in the folder specified under the settings menu item and will be named by the year, month and day it was created, for example, "CCDN-2006-11-15". A log file is also created in this same folder that contains the same information seen by the "View Plan" button described below. This can be used later to see what was planned for the session such as the number of frames, their sequencing and guidestar exposures.
- **Clear Plan** - This button will erase the current session plan after verifying with the user that this is not an accidental command.
- **View Plan** - This will display the session plan so the user can examine the sequence of targets, the order of the LRGB frames that will be taken by the imaging program, the catalog number and magnitude of the chosen guidestar and the autoguider exposures calculated for it.
- **Next Target**- This button will step the Target Selection panel to the next target that has been selected for the session plan so the user can see the technical data for the target and it's Target Availability and Transit graph.

Below is an example session plan. Since Semi-Automatic operation was used with EZ-Guide, each target shows the guidestar catalog number, its magnitude and spectral class. The guiding exposure for each filter has been calculated based on the reference guidestar information in the "Filters" window. Also notice that the estimated starting time for each target is also given as well as its camera angle and the LRGBH frame acquisition plan.
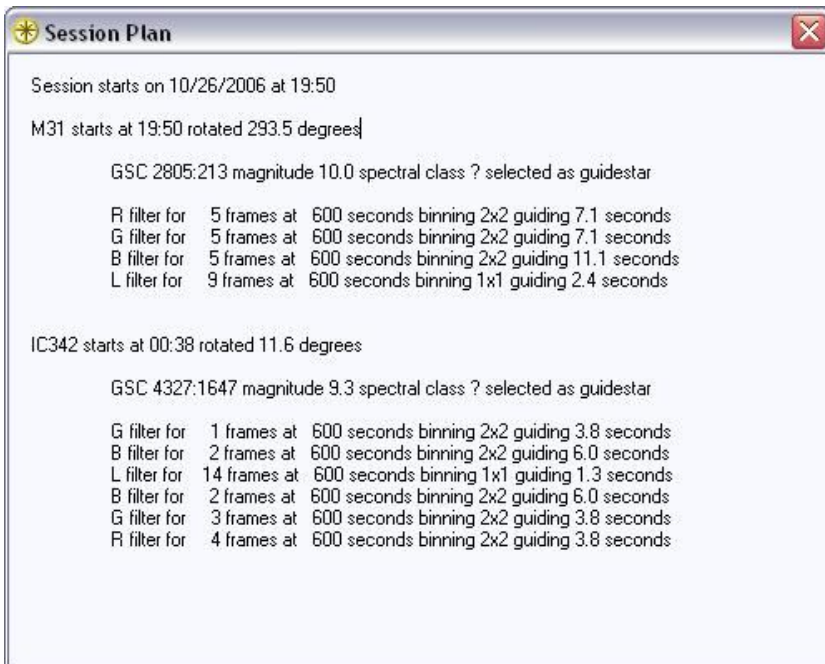
In CCDAutoPilot3, a session plan can be imported by clicking on "Target List", and selecting "Import" and then selecting "Plan". Then browse to "My Documents\CCDWare\CCDNavigator\Session Plans" folder and select the plan to import. The path in CCDNavigator for saving session plans can be

set to the CCDAutoPilot3 "Target List" folder, or where ever your target lists are maintained, to make this importing easier. The session plans are named by the date (Year-Month-Day) for which they were created. CCDAutoPilot3 will accept and run a session plan created for an earlier date but the LRGBH allocations will not be optimal for the new date. It is best to always create a fresh session plan for each session. Session plans created for CCDAP3 are formatted in XML while plans for ACP use the ACP Planner text format. A sequence file can be created for MaxImDL but it is limited to sequencing a single target at a time and CCDSoft accepts a single target sequence pushed to it's Color Series panel. You can choose your preferred acquisition program in the "Site" menu item.
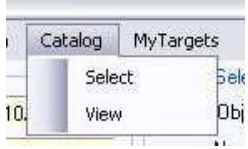
Catalog

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The "Catalog" menu item allows the user to "View" the current catalog" or to Select" alternate catalogs. *The Advanced Imager Catalog* presently has over 500 objects with thumbnails taken by some top imagers while *The Deep Sky Explorer Catalog* contains 18 astronomical catalogs with over 23,000 objects including a thumbnail of each. When the "View" menu item is selected, the object ID, nicknames, size, brightness, type, coordinates and the best month for imaging the object are displayed for the entire catalog. This allows you to do advanced planning for imaging particular targets
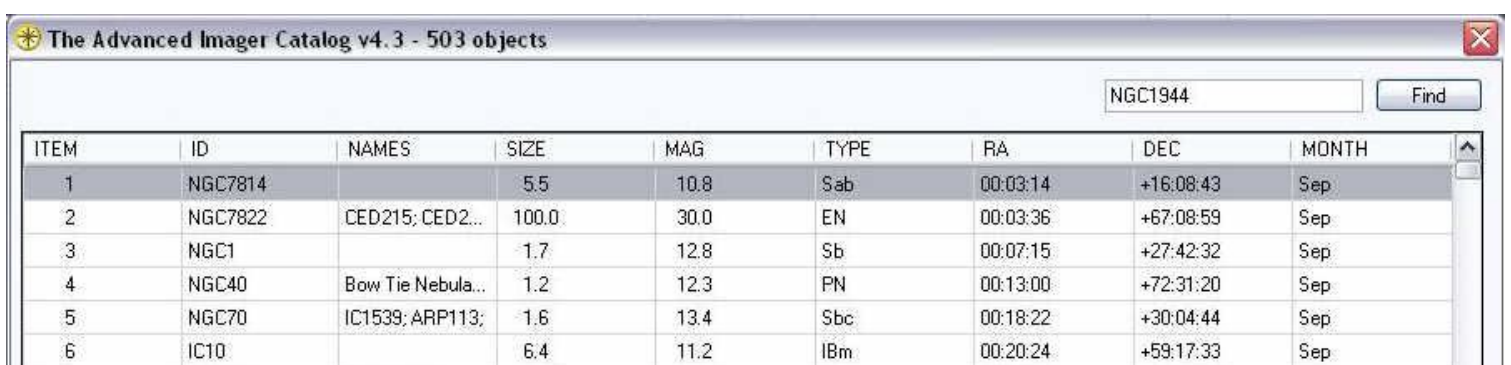

A second catalog, *The Deep Sky Explorer Catalog,* allows the user to choose from 18 astronomical catalogs. Using "Select" in the "Catalog" menu brings up a window which allows you to choose either *The Deep Sky Explorer Catalog* or *The Advanced Imager Catalog*. This catalog can also be used for selecting targets and it is also used to display lists of objects inside the field-of-view of the camera.
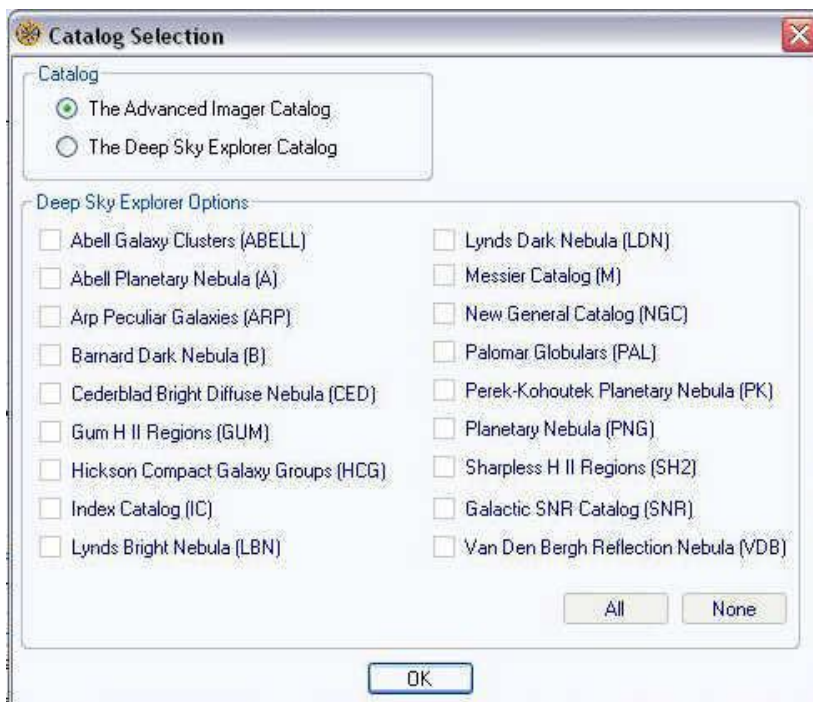
When *The Deep Sky Explorer Catalog* is selected, a lower panel will activate ("Deep Sky Explorer Options") where you can choose which astronomical catalogs will be used for target selection. You can use "All" or "None" to initialize the selection checkboxes. Then check off the ones you wish to either remove or add to your choices. Note that these filters only apply to *The Deep Sky Explorer Catalog*. Once you've made your choices, simply close this window and CCDNavigator will load your choices for use in target selection.. If all astronomical catalogs are included, loading will take about 25 seconds and viewing it can take up to 30 seconds so it is best to limit the number of catalogs that are being examined.

Using the Deep Sky Explorer catalog is a great way to check out potential imaging targets for future sessions letting you "Boldly go where no imager has gone before"! The catalog selection and options are saved between runs of CCDNavigator so you can resume from where you left off exploring.

While viewing a catalog, a search feature is available that will display the item number of any object if it exists in the catalog. Also while viewing the catalog, double clicking on a header will sort the catalog by that field and double clicking on a row will close the dialog and place the main menu on that target provided it is available as a target.

The Advanced Imager Catalog v4.3 - 503 objects

ITEM	ID	NAMES	SIZE	MAG	TYPE	RA	DEC	MONTH
1	NGC7814		5.5	10.8	Sab	00:03:14	+16:08:43	Sep
2	NGC7822	CED215; CED2...	100.0	30.0	EN	00:03:36	+67:08:59	Sep
3	NGC1		1.7	12.8	Sb	00:07:15	+27:42:32	Sep
4	NGC40	Bow Tie Nebula...	1.2	12.3	PN	00:13:00	+72:31:20	Sep
5	NGC70	IC1539; ARP113;	1.6	13.4	Sbc	00:18:22	+30:04:44	Sep
6	IC10		6.4	11.2	IBm	00:20:24	+59:17:33	Sep

Get Involved

If you want to see *your* initials & images popping up in CCDNavigator and you have a quality image that is not already in *"The Advanced Imager Catalog"*, send me an email:

1. The email "subject" should be "OBJECT by YOUR_NAME" (for example NGC1234 by Steve Walters).
2. A URL that goes directly to the full scale image so its quality can be reviewed. Please do not make me find it in your website.
3. Attach a 150 pixel wide x 100 pixel tall JPEG thumbnail named "OBJECT.jpg" (eg. NGC1499.jpg) with a file size 12 KB or less. No spaces between the catalog and number please.
4. Your name written exactly as you want it listed.
5. Your website URL so users can visit your website and see your images. This, along with your name and initials, will be used in the catalog.
6. Your email address (this is only for me to communicate with you, no other use is made of email addresses)
7. A brief note describing anything unusual about the object. Please do NOT include technical info about your equipment or how you imaged it.

Here are some guidelines for catalog submissions. Please follow them, they're not much trouble for you but will make my processing of submission far easier.

- Please do not send objects that are already listed in the catalog and be careful about submitting catalog names that identify an object already listed by another catalog name. For example, M42 and NGC1976 are the same object. Do a little research before submitting please
- Also think about the quality of your image before you submit it. While I am primarily interested in expanding the catalog with new objects, I also don't want to include sloppy work nor should you want your name associated with bad results.
- Color images are preferred but B&W images are perfectly acceptable.
- Please submit only one image per email, this will greatly facilitate my handling of submissions.
- I will try to respond to every submission but if your object is already in the catalog and I am swamped, please accept my appologies if there is no reply. I mean no disrespect and genuinely appreciate your submissions.

Good shooting!

Steve...

astrophoto (at) comcast (dot) net

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Acknowledgements

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I would like to express my deepest appreciation to the following deep sky imagers for allowing the use of their thumbnails in *The Advanced Imager Catalog*. For years, I have been inspired by their results and, thanks to their generosity, I have been permitted to include their thumbnails within CCDNavigator. Without their hard work and leadership in capturing these images, this catalog would not be possible. In alphabetical order by their last names, they are:

- Ken Crawford
- Russ Croman
- R. Jay GaBany
- Rob Gendler
- William McLaughlin
- Dean Salman
- Johannes Schedler
- Star Shadows Remote Observatory
- Kitt Peak Visitor Center

Ken Crawford images from his observatory, Rancho Del Sol, in California. His work has been published in magazines, books and on the Internet and several of his images have appeared on "Astronomy Picture Of the Day" (APOD). Ken's imaging craftsmanship is highly respected by all those who know him. Within *The Advanced Imager Catalog*, Ken's thumbnails are labeled with his name and his website is **www.rdelsol.com**.

Russell Croman has been widely recognized for his superb images. After imaging from his backyard in Texas for several years, he established a remotely operated observatory in New Mexico during 2005. His images have been published in numerous national magazines. Russ is well known for his generous sharing of technical knowledge and skills. Within *The Advanced Imager Catalog*, Russ's thumbnails are credited with his name and his website is **www.rc-astro.com**.

R Jay GaBany images from his home in San Jose, California and with remote observatories in New Mexico. He has also imaged from Kitt Peak, Arizona. Besides being a skilled imager, Jay shows exceptional wit in his titles and the written descriptions of his images. His writing skills can be enjoyed at "Universe Today", an Internet newsletter for space enthusiasts and his personal enthusiasm for astronomy seems boundless. Within *The Advanced Imager Catalog*, Jay's thumbnails are labeled with his name and his website is **www.cosmotography.com**

Robert Gendler is legendary for his images of the night sky. He imaged for years from his driveway in Connecticut but now has a remote observatory in New Mexico. He has produced stunningly beautiful images achieving world-wide accolades from both locations. Rob's finest images are contained in his upcoming book "*A Year in the Life of the Universe*". Within *The Advanced Imager Catalog*, Rob's thumbnails are labeled with his name and his website is **www.robgendlerastropics.com**

William McLaughlin images the Oregon night sky from his Raptor Ridge Observatory and previously from the ARGO Observatory of which he was a founder. Bill has produced many wonderful images from both these locations and I personally believe his planetary nebula images are among the finest ever recorded. His images have been published in numerous magazines around the world and he has generously shared his knowledge through lectures and articles. Within *The Advanced Imager Catalog*, Bill's thumbnails are labeled with his name and his website is **www.nightskypictures.com**.

Dean Salman images the Sharpless catalog and other deep sky objects from his observatory near Tuscon, AZ. His photos have been published in Astronomy magazine and Sky & Telescope magazine. Currently Dean uses an AP1200GTO with an Epsilon 180 and an SBIG ST-10 equipped with Astrodon filters, an excellent system for capturing the wide-field Sharpless objects in which he specializes. Dean also offers a free software package, CCD Explorer, for managing images that you've taken. Dean's images are labeled with his name and you can visit his website at **www.ccdimages.com**.

Johannes Schedler images from Panther Observatory in the southeastern part of Austria. His images have been published in a variety of international magazines, books and on the Internet. Johannes readily shares his knowledge of image processing with others and presented on this topic at the Advanced Imaging Conference in 2005. Within *The Advanced Imager Catalog*, Johannes's thumbnails are labeled with his name and his website is **www.panther-observatory.com**.

Star Shadows Remote Observatory (SSRO) in New Mexico is a cooperative venture owned and operated by Jack Harvey, Rick Gilbert, Jim Thibert and Steve Menaker. Their images have been selected for Astronomy Photo Of the Day (APOD), SETI Explorer and Sky & Telescope Magazine. Within *The Advanced Imager Catalog*, their thumbnails are labeled with the name **SSRO Team** and their website is **www.starshadows.com**.

Kitt Peak Visitor Center, an office of NOAO/AURA/NSF (National Optical Astronomy Observatory / Association of Universities for Research in Astronomy / National Science Foundation), has enriched the lives of the general public and many amateurs (myself included) with their Nightly Observer Program (NOP) and Advanced Observer Program (AOP). These public outreach programs make an unparalleled astronomy experience possible for anyone. Furthermore, the images taken by amateurs in the AOP represent a prolific selection of high quality images of deep sky objects. Within *The Advanced Imager Catalog*, these thumbnails are credited as **Kitt Peak AOP** and their website is **www.noao.edu/outreach/aop/observers/bestof.html**. The name of the individual who took the image is embedded in the file names there. For example, the file "M13bash2.jpg" was taken by "Bash".

In addition, I acknowledge the use of NASA's *SkyView* facility (**http://skyview.gsfc.nasa.gov**) located at NASA Goddard Space Flight Center. The ability to retrieve the Deep Sky Survey (DSS) images through the *SkyView* website is a tremendous resource for amateur astronomers.

Steve...

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EZ-Guide Positioning

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This feature allows users with either off-axis guiders (OAG), internal guidechips or guidescopes to easily select and center a guidestar and have an autoguider exposure calculated for its particular magnitude. For those using an OAG or internal guidechip, EZ-Guide will automatically center the user selected guidestar on the guider, position the telescope so the target is as close as possible to the center of the camera's Field-Of-View (FOV), and calculate an appropriate guiding exposure for it. For those using a guidescope, it allows repositioning of the object to a point other than the center of the field including rotating the camera for a specific artistic composition followed by the optional selection of a guidestar and calculation of a guiding exposure. EZ-Guide is only available if the user's planetarium program is "TheSky6". Otherwise, it is disabled.

To work properly, **EZ-Guide** requires a Field-Of-View-Indicator (FOVI) in TheSky6 that matches your camera/telescope combination. If a telescope is connected, **EZ-Guide** will instruct you to disconnect it in TheSky6 to avoid possible accidents with the telescope. After positioning the target, **EZ-Guide** offers an option of connecting and slewing the telescope to the target. For those using OAG or internal guidechips, the FOVI should be accurate with regard to the position of the guiding window relative to the camera window. For those using guidescopes, the FOVI should indicate the coverage of the guidescope as well as the camera so the inclusion of a good guidestar can be made when composing for the imaging camera.

To begin using EZ-Guide, first be sure you have only one FOVI(s) active in TheSky6 that accurately represents your camera configuration. Whenever no FOVI are active in TheSky6 or if multiple FOVI are active, CCDNavigator will instruct the user to activate the one that matches their system. After this is done, you will be prompted to select either "Semi-Automatic" positioning or "Manual" positioning. Users with an OAG or internal guiding chip can use either mode but they may prefer the semi-automatic mode since it will position their chosen guidestar with less effort. User's with guidescopes should use the manual operation mode. There is a special help button on the mode selection window that explains Semi-Automatic and Manual operation.

After choosing the operation mode, EZ-Guide will function as follows:

In Semi-Automatic operation mode, CCDNavigator will display the active FOVI in TheSky6 over the target and then prompt the user to select and center a guidestar. Once this is done, CCDNavigator will then adjust the camera's position and rotation angle so the guidestar is centered in the guiding box. When semi-automatic operation is first selected, a simple calibration procedure is performed that displays the FOVI and asks the user to click and center the midpoint of the guiding box. This allows EZ-Guide to know the distance and angle to the guiding box. When choosing guidestars in the Semi-Automatic operation mode, it is best to choose one at a distance that is close to the radius of the guide box since this keeps the target reasonably centered in the camera. However, EZ-Guide will use any guidestar you select, even those outside or inside the guidebox circles. Also, because CCDNavigator knows what guidestar was chosen, it can display the star's catalog number, magnitude, spectral class and will compute guider exposures for each filter and place these results in the Session Plan for exportation.

In manual operation, the user can rotate and center the FOVI as desired to either place a guidestar on the guiding box or to achieve a specific artistic composition. Here, the FOVI will be displayed over the target in TheSky6 and the user prompted to adjust the position and angle of the FOVI. EZ-Guide will then prompt the user to select a guidestar. If no guiding is needed, simply close this window. Otherwise, select and center a guidestar and click "Continue". EZ-Guide will then calculate the exposure for the guider and display the object in its selected position.

For either positioning mode, if the chosen guidestar is brighter than the Bright Reference magnitude, the exposure will be set to the Bright Secs value. If the chosen guidestar is fainter than the Faint Reference.And if no guidestar is selected, then no guiding exposure will be exported, an action indicated by question marks in the final guidestar information window at the end of the EZ-Guide operation..

If you are dissatisfied with the positioning after EZ-Guide completes or wish to choose a different guidestar, simply click EZ-Guide again to reposition the camera on the target.

If you wish to switch operating modes between "Semi-Automatic" and "Manual" or recalibrate EZ-Guide due to changes in your guiding configuration, simply click on the "Re-Calibrate" button in the initial EZ-Guide setup window and the mode selection window will be invoked followed by the re-calibration window (if Semi-Automatic operation is selected).

The **EZ-Guide** button is located in the Target Selection panel at the bottom left of the thumbnail image.
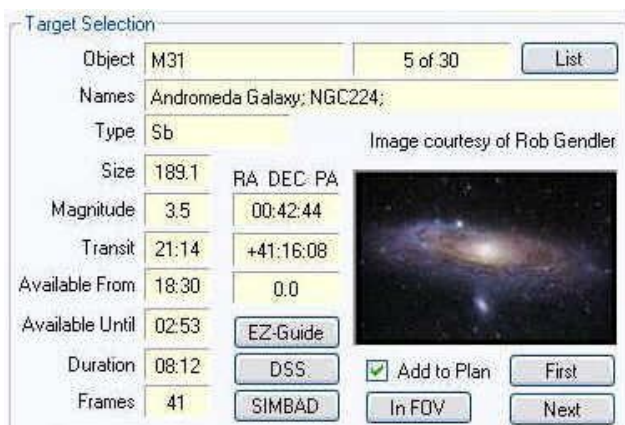
- **EZ-Guide** - Clicking this button will cause TheSky6 to display the target with a scale appropriate for your camera's FOV and in polar format. If you are not using "TheSky6", EZ-Guide will not be enabled. A popup will appear with instructions as follows:
  - If in **Manual** operation mode, the popup will instruct you to center whatever point you wish in TheSky6 and rotate the FOVI to any desired angle, then return to the popup and click "Continue". In this way, a specific composition can be created for the target. After the composition is designed, EZ-Guide will prompt the user to select a guidestar. If no guiding is desired, simply close this window. Otherwise, follow the instructions to select and center a guidestar so EZ-Guide can determine a guiding exposure.Once the Manual EZ-Guide operation is complete, the guidestar exposures for each filter can be seen by clicking "Guider" in the main menu.
  - If in **Semi-Automatic** operation mode, the popup will instruct you to select a guidestar, center it in TheSky6, then return to the popup and click "Ok". EZ-Guide will automatically calculate the proper co-ordinates and rotation angle for the camera to place the guidestar on the autoguider while keeping the target as near as possible to the center of the field. This mode will also record the catalog number, magnitude and spectral class of the guidestar and will place a guiding exposure in the Session Plan based on the reference guidestar exposures found in the "Guider" menu. For more information, see "Autoguiding". Once the Semi-Automatic EZ-Guide operation is complete, the guidestar exposures for each filter can be seen by clicking "Guider" in the main menu.
  - Afterwards, CCDNavigator will show the new co-ordinates and rotation angle for the target and guidestar name, magnitude and spectral class in the final EZ-Guide window. It will leave the FOVI activated until you acknowledge the EZ-Guide completion prompt which gives the user the option of slewing their telescope to the target. This allows users who are not using automated acquisition software such as CCDAP3 to immediately position their telescopes on the target and rotate their cameras to the guidestar either by hand or by using a motorized rotator.
  - If you wish to change the positioning or guidestar selection, simply repeat the operation by clicking "EZ-Guide" again. CCDNavigator will reset the coordinates to their original values and clear the rotation angle so the target is back to its original starting point. After running "EZ-Guide", clicking the DSS button will retrieve (from NASA SkyView) an image centered on the RA, DEC and rotated to the Position Angle (PA) so you can see the exact framing of the target.

Note: All Right Ascension and Declination values in CCDNavigator are displayed and exported using the J2000 epoch. This is needed for planetarium software such as TheSky6 and for acquisition software such as CCDAutoPilot3. However, when slewing the telescope to targets, the RA and DEC are adjusted for Precession, Nutation and Abberation of Light to the current epoch.

Note: For centering an object or star in TheSky6, CCDNavigator asks you to right click on the object and then click "Center" in the subsequent Sky6 menu but it is also possible to use a normal double click (left mouse button) on a star if you wish to see its information box. This can be useful when selecting guidestars since their magnitude can be considered.

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Optimal Scheduling

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When imaging multiple targets, we should consider the order in which targets will be imaged and in what order to acquire the LRGBH frames for each.

Target Precedence

To get the best results, we should order targets according to when they become available and when they are no longer available. A target becomes "available" whenever darkness is reached and it satisfies all the Target Criteria. In CCDNavigator, this is called the "**Available From**" point and it is shown in the Target Selection panel. This point is determined by the object's coordinates and the elevation critia you have selected. Suppose for example, that the Lowest Elevation is 30 degees. So, if an object rises at 5 pm, darkness falls at 7 pm, and the object reaches 30 degrees at 7:30 pm, then the "Available From" point is 7:30 pm. But if it were already above the mandatory 30 degrees at 7 pm, then the Available From point would be 7 pm. The "**Available Until**" point is the time when the object no longer satisfies all of your target criteria and is therefore no longer available. Continuing the example, if darkness ends at 4 am but the object passes below our choosen 30 degree elevation at 3:15 am, then the "Available Until" point will be 3:15 am. But if it didn't drop below 30 degrees until 4:30 am, then the Available Until opint would be 4 am. Based on these times, the object's availability duration is calculated by CCDNavigator. If an object exceeds the required Minimum Availability criteria, it will be listed as a candidate target.

Once CCDNavigator has calculated the "Available From" and "Available Until" points plus the object's transit time, it orders them for imaging using a precedence rule. The precedence is:

1. Objects with the earliest "Available From" times should be imaged first since we can start imaging them before the others.
2. If two or more objects have the same "Available From" times, then those with the earliest "Available Until" times should be imaged first since we can complete imaging them sooner and have some time available for the others.
3. If two objects have the same "Available From" and "Available Until" times, we should image the ones with the earliest Transit time since this allows us to image them at their highest elevation before starting the next target.

The target list created by CCDNavigator is ordered by this precedence rule and gives us the best chance of getting good data for each target imaged. If, for example, there are 12 targets in the Target Selection panel, the earlier ones listed have the highest priority and will be imaged first in a session. Targets later in the list can be imaged later in the session or, for targets near the end of the list, even the following month. Targets that transit around the middle of the night can be identified by looking at the Target Transit and Availabilty graph.

Whatever targets are selected, CCDNavigator will create a session plan in which targets listed earlier in the list will be imaged before targets that are listed later.

LRGBH Acquisition

Next, we must consider a plan for the acquisition of LRGBH (Luminance, Red, Green, Blue, H-alpha) frames for each target. CCDNavigator provides two methods for doing this, "Staircase" and "Shuffle" sequencing. "Staircase" scheduling attempts to obtain the best resolution by acquiring frames at an appropriate elevation as the target moves through the night sky. "Shuffle" scheduling attempts to ensure that some data for each filter will be acquired even if the session is cut short.

The method is chosen by a drop-down control in the "Camera" menu item.

Staircase Sequencing

To achieve the best resolution in our data, we should image the L frames when the target is at its highest possible elevation because this is where seeing has the least effect on resolution. The B frames should then be acquired at the next highest possible elevation because of increased blue extinction that occurs at lower elevations. These can be followed by the G frames, the R frames and finally the H-alpha frames. This does not mean that the order should be LBGRH however because we must consider the elevation of the target as it moves during the session.

Suppose for example that we plan to image M42 from 10:00 pm until 2:00 am on a given night and that M42 transits at midnight. In this case, the transit will occur exactly in the middle of the session. If we are taking 10-minute frames during this 4 hour interval, we can take a total of 24 frames during the session (we're ignoring download and other lost time for this example but CCDNavigator includes these times in its calculations) so we might choose to take a total of 12 L, 4 R, 4 G and 4 B frames. To optimize resolution, we should image in order 2 R, 2 G, 2 B, 12 L, 2 B, 2 G and 2 R frames. If this sequence is considered, it can be seen that the L frames are centered on the transit time and the B, G and R frames are split on either side of the L frames so each set will be at the highest available elevation for the given filter. This is an optimal staircase sequence for this imaging situation and it acquires exactly the number of frames for each channel as planned.

Now suppose that we are imaging M42 on the same night but we choose to image it from 8 pm until midnight. Now, the transit occurs at the end of the imaging session. We can still take 12 L, 4 R, 4 G and 4 B frames during the allotted time but in this situation, the optimal staircase sequence would be 4 R, 4 G, 4 B, 12 L since this places the L frames at the highest available elevation, the B frames at the next highest point and so on. While this is the best we can do, it is not as good as the previous example because even though the frames are taken at the highest possible elevations, these are lower elevations than the previous example. Also notice that if we imaged from midnight until 4 am, the staircase sequence would be reversed, ie. 12 L, 4 B, 4 G, 4R.

As a last example, suppose we decide to image M42 on the same night but we want to image it from 9:10 pm until 1:10 am. So the transit occurs 1 hour and 10 minutes (7 frames) before we have to stop imaging. We still can take the same number of LRGB frames as before but now we should choose 3 R, 3G, 2 B, 12 L, 1 B. This sequence centers the L frames on the transit time (6 on either side of the transit) and splits the B frames on each side of the L frames so they are that the next highest possible elevation. Since there is only time for 1 B frame after the L frames are completed, we must take the other 2 B frames just before the L frames start. If we further delayed our start time until 9:20 pm, then the optimal sequence would be 3 R, 3 G, 1 B, 12 L and 2 B. In this case, a second B frame is placed after the L frames to optimize the elevation of all the frames.

While this is not rocket science, this calculation relies on knowing the transit time of the target, it's times of availability, the time when we start imaging the target, how many frames we plan to take and the duration of each frame including overhead such as downloads, focusing, slewing and target acquisition. When multiple targets are to be imaged on the same night, this makes the calculations even more complex since we have to consider which target will be imaged first, when we can start and end imaging it, the different exposures for each filter, and we must make an optimal plan for each target. And the order in which we image the targets should be chosen to optimize the elevation for each. With the clock ticking, we have to quickly determine a plan or we will loose valuable time under a clear sky. It is nearly impossible for an unassisted human to figure out an optimal sequence in the field in a timely manner.

Fortunately, this is exactly the kind of problem that is easily solved by computer. CCDNavigator first selects the order to image multiple objects so as to maximize their availability during the session based on the precedence rule described earlier. It then constructs an optimal staircase sequence for the user's allocation of frame counts for each target and it will prevent the total exposure duration from exceeding the availability of the target.

What is meant by "Optimal"? This is a good question and it is possible to have different definitions of what constitutes "optimal". It must be remembered that the user can define a set of targets and numbers of LRGBH frames that are a poor choice for a session. For example, suppose two objects that both transit at midnight are selected for imaging but the 1st object is imaged for nearly the entire session. This means that the 2nd target will have all its frames acquired at low elevations. CCDNavigator will create an "optimal" plan for this situation in the sense that it will select the best target to image first and will create a staircase sequence acquisition plan that best acquires the frames for each target's location and transit times. This is an optimal plan for doing what the user has ordered and CCDNavigator will generate the best possible plan given the user's choice of targets. But it would be better to image these two targets on different nights.

This means that the user still needs to make intelligent choices. So, if you plan to image two targets, it is best to notice the transit times of targets on the Target Transit and Availability graph and pick one target that transits during the first half of the session and a second one that transits during the second half of the session. If we divide the available session time between them, we can capture all the frames at high elevations. The graph can help you make these choices and by choosing targets that transit during the interval available for imaging them, CCDNavigator can create a good LRGBH allocation.

Shuffle Sequencing

An alternative to staircase sequencing is "shuffle" sequencing. This mode will repeatedly acquire the L, R, G, B and H frames in a cycle. The particular cycle depends on the number of frames to be taken for each filter but the frame counts default to "1" for each filter (except H which defaults to "0"). For example, a shuffle sequence could be LRGB repeated 11 times.. This sequence has several properties. For one, if clouds roll in early but some frames have been acquired, there is a chance of having enough data to create an image. If the clouds stay away a bit longer, more frames will be acquired which will improve image quality. As more and more time passes during the session, more and more data is acquired thereby improving the final image quality. This strategy is most useful when inclimate weather threatens to terminate a session early.

CCDNavigator allows a generalized shuffle in that it allows the user to set the number of LRGBH frames to be acquired during each cycle. In addition, the user can set the number of cycles to control the overall total number of frames acquired. For example, it would be possible to use a sequence of LLLRGB repeated 5 times. Or RRRGBBH repeated 4 times by setting the frame counts for each filter and the cycle count however you wish.

Saving and Viewing the Plan

You can examine the Session Plan file using the "View Plan" button in the Session Plan panel. Or, even better, import the Session Plan into CCDAutoPilot3 and look at the "Light Frames" panel to see the ordering of the LRGBH sequence and allocation. Plans can be saved using the "Save Plan" button. The "Save Plan" becomes enabled whenever a change is made in the session plan. Session Plans are named for the session date and, by default, are stored in the "My Documents\CCDWare\CCDNavigator\Session Plans" folder but this can be changed by the user. Also, a log of the session plan is created using the same name and is placed in the same folder. This can be viewed after CCDNavigator has been closed.

If CCDNavigator is invoked during the hours of darkness for a session, it will enter "Just-In-Time Scheduling" mode and will create a plan that fits the available time for the session rather than planning from the start of astronomical darkness.

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Just-In-Time Scheduling

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If the user starts CCDNavigator any time during the hours of darkness of the selected session date (including the morning hours on the day following) and the session Start Time has already passed, CCDNavigator will alert you to this fact by coloring the Session Start Time in orange. This means that a different session plan must be computed that starts later than the end of astronomical twilight because targets that might have been available earlier in the evening may not be available now.

To accomodate this, simply click on "Criteria" and check the "Override Plan Start" box. This will set the start time to the current time rounded upwards to the nearest five minutes. You can further adjust the time to any value during the darkness hours with the up/down buttons. Then, when you close the Camera window, a new target list will be constructed and CCDNavigator will display targets that are available during the truncated session.

Any targets that have already been selected for the session plan will be retained so long as they are still available.

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MyTargets

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You can establish a reminder list of potential targets and later utilize them as targets through the MyTargets feature. MyTargets is simply an ordinary text file named "MyTargets.txt" located in "My Documents\CCDWare\CCDNavigator\Session Plans" folder. CCDNavigator examines this file each time it runs and any time the date is changed in the Criteria window. If any of the objects in MyTargets list will transit during the session's interval of darkness, a popup will appear that lists those objects. This serves as a reminder to the user that the special targets that they want to image are available during the session. Even though announced targets will be transiting during the session, they may not appear in the target list if the catalog selections and elevation criteria settings do not cause it to be presented. So it may be necessary for the user to select the specific catalog that the object is in from the Deep Sky Explorer Catalog and to set the elevation and other criteria to values that will include them.

There are three menu items associated with the MyTargets feature:

The first menu item, "Add Current Target" allows you to place the ID of the object currently being shown in the Target Selection panel into the MyTargets list. This is an easy way to add an object to the reminder list. If the object is already included, it will not be added a second time.

The second menu item, "Edit MyTargets", will display a new window in which a user can directly add, delete or change object ID values. If you choose to manually enter objects in "MyTargets.txt" remember that they MUST be specified using a catalog code having no spaces. For example, "NGC1499" or "ngc1499" or "NgC1499" are all ok but specifications such as "ngc 1499" or "Ngc-1499" will not be recognized (due to the spaces and dashes). Also common names cannot be used (such as "California Nebula") and only objects listed in one of the "Deep Sky Explorer Catalog" option catalogs will be recognized. Simply make whatever changes you wish and hit "OK". To delete an object, simply highlight it and hit "Delete" or backspace on your keyboard. If you wish to discard your changes without saving, hit "Cancel".
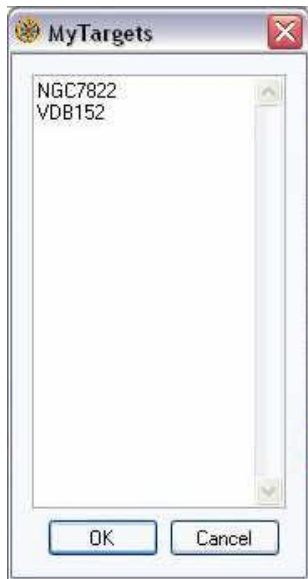
The third menu item, "Load Mytargets", retrieves all MyTarget objects from the active catalog that meet the "Lowest Elevation" criteria and makes them the only objects in the target list. If an object is listed in MyTargets but is not represented in the set of catalogs loaded at that time, it will not be retrieved. Only the "Lowest Elevation" criteria must be met by the MyTargets objects, the other parameters (Minimum Duration, Brightness, Smallest Size, Largest Size, Minimum Brightness) are ignored for this operation. Any targets previously added to the session plan will be removed.

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Classification Systems

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Dreyer Classification

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The Dreyer classification notation is given below:

- Ab..............about
- n..............north
- alm.............almost
- neb...........nebula
- am..............among
- nf............north following
- app.............appended
- np............north preceding
- att............attached
- nr............near
- b..............brighter
- N.............Nucleus, or to a Nucleus
- be.............between
- p..............pretty (before F,B,L,S)
- biN............binuclear
- p.............preceding
- bn.............brightest towards
- pg.............pretty gradually the north side
- pm............pretty much
- bs.............brightest towards
- ps............pretty suddenly the south side
- P.............poor
- bp.............brightest towards
- quad..........quadrilateral the preceding side
- quar..........quartile
- bf.............brightest towards
- r.............resolvable the following side (mottled,not resolved)
- B..............bright
- rr............partially relolved,
- c..............considerably some stars seen
- ch.............chevelure
- rrr...........well resolved, clearly
- co.............coarse, coarsely consisting of stars
- com............cometic
- R.............round
- cont...........in contact
- RR............exactly round
- C..............compressed
- Ri............rich
- C.G.H..........Cape of Good Hope
- s.............suddenly
- Cl.............cluster
- s.............south
- d.............diameter
- sp............south preceding
- def...........defined
- sf............south following
- dif...........diffused
- sc............scattered
- diffic.........difficult
- st...........stars
- dist...........distance or sev...........several distant
- susp..........suspected
- D..............double

- sh.............shaped
- e...............extremely,
- stell..........stellar excessively
- S..............small
- ee..............most extremely
- sm.............smaller
- er..............easily resolvable
- triN...........trinuclear
- exc.............excentric
- trap...........trapezium
- E...............extended
- v..............very
- f..............following
- vv.............very, very
- F...............faint
- var............variable
- g...............gradually
- *..............a star
- *10, a star of 10th magnitude
- gr.............group
- i..............irregular
- **.............double star
- inv.............involved,involving
- ***............triple star
- iF.............irregular figure
- !..............remarkable
- l..............little,long
- !!............very remarkable
- L...............large
- !!!...........a magnificent or
- m..............much otherwise interesting
- mm.............mixed magnitudes object
- mn.............milky nebulosity
- st 9...........stars from the 9th
- M..............middle,or in the magnitude downwards middle
- st 9 13........stars from the 9th to 13th magnitude

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Galaxy Classification

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Astronomers classify galaxies based on their overall shape (elliptical, spiral or barred spiral) and further by the specific properties of the individual galaxy (for example degree of ellipse, number of spirals or definition of bar). The system of galaxy classification is called the Hubble "tuning fork" diagram, and is the Hubble sequence.

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Hubble Galaxy Classification

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Tuning-fork style diagram of the Hubble sequence is shown below. The Hubble "tuning fork" diagram starts from the left with elliptical galaxies as its base. Elliptical galaxies can be named from E0 to E7. E stands for elliptical while the number indicates how oval-shaped the ellipse is with 0 being ball shape (in other words, a giant globular cluster) to 7 being discus shape. Technically speaking, the number is ten times the eccentricity. For example, an E7 galaxy has an eccentricity of 0.7.

/ - Sa - Sb - Sc - Sd

E0 - E1 - E2 - E3 - E4 - E5 - E6 - S0

\ - SBa - SBb - SBc

After the elliptical galaxies the diagram splits into two branches. The upper branch covers spiral galaxies also called lenticular galaxies. It starts off with S0. The "S" means lenticular, the "0" means no arms, and the subscript number indicates how heavily a stripe is absorbed out of the image of the galaxy by dust in the galactic disc. On the same branch are the next 3 types which all have spiral arms. The "S" here also means lenticular, but the lower case

letter after it tell how wound up the arms are. They range from "a" to "d" having the following meanings: Sa - tightly-wound, smooth arms, and a bright central disc, Sb - better defined spiral arms than Sa, Sc - much more loosely wound spiral arms than Sb, Sd - very loose arms, most of the luminosity is in the arms and not the disc. The lower branch of the diagram covers barred spiral galaxies given the symbol "SB". This branch starts with SBO galaxies which is followed by a subscript number that indicates how heavily defined the bar is. After that the branch continues with the SB galaxies which have lower case letters after them that indicates how heavily defined the bar is. They range from "a" to "c" having the following meanings: SBa - a bright center and tight spirals SBb - better defined arms than SBa galaxy and are more loosely wound SBc - even looser arms, and a much dimmer central portion of the galaxy The Milky Way Galaxy is now believed to be an SBb galaxy; previously, it was thought to be Sb like its giant companion, the Andromeda Galaxy.

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The De Vaucouleurs System

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There is an extension to the Hubble sequence that is in wide use; the de Vaucouleurs extensions. The distinction between the de Vaucouleurs and Hubble classification systems lies primarily with spiral galaxies. While the Hubble type describes spiral galaxies based upon the two criteria of tightness of spiral and barredness, de Vaucouleurs adds a third descriptor, internal ring. Spiralness: galaxies range from E, through S0, through the other spirals, to Im. Barredness: galaxies are described as being A (ordinary), B (barred), or AB (intermediate). Ringedness: galaxies are described as being s-shaped (no ring), r-shaped (ring), or sr (intermediate). Therefore, a galaxy may be described as being SAB(rs)c - Sc spiral, between barred and ordinary, and between ringed and no ring. Visually, the de Vaucouleurs system is often represented in three dimensions, with spiralness on the x-axis, barredness on the y-axis, and ringedness on the z-axis. A cross-section of one spiralness (eg: Sb) will yield a representation in two dimensions with ringedness on the x-axis and barredness on the y-axis. Pictures are available here.

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Installation and Updates

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Be sure you have the .NET platform version 2.0 installed on your computer. This is a free download from Microsoft and is available here.

To install or update CCDNavigator:

1. Save the CCDNavigator ZIP file anywhere in your system.
2. If you received CCDNavigator through email, you must then right click on the ZIP file, select "Properties", and click "Unblock".
3. Next double click on the ZIP file and then click "Install". If you prefer, you can "Extract" the installation files to a convenient folder and then double click on "Setup".
4. After some prompts, your ZIP installer will extract CCDNavigator and install it on your system.

Follow these same directons for either a new installation or updating an existing installation.

On very rare occasion, it may be necessary to uninstall CCDNavigator and to remove all its files. This will be required if significant changes are made the the program's structure or file content. In this case, older files may cause the system to crash so they must be removed. You will be informed if this is necessary in the installation instructions.

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Release Notes

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Version 1.20.4

1. Corrected a bug that crashed the program when more than 100 frames on any filter was displayed. This could occur if the camera is using very short exposures.
2. Revised the EZ-Guide logic so CCDNavigator's main window does not cover up the Sky6 window during EZ-Guide operation but is restored when completed.

Version 1.20.3

1. Corrected a bug that caused autoguider reference exposures to be truncated.
2. Added Dean Salman's Sharpless thumbnails to the Advanced Imager Catalog image set. Thanks Dean!
3. Repaired a bug associated with MaxImDL target sequence files.

Version 1.20.2

1. Added a "Default Angle" parameter to the camera menu. This allows the user to select a default angle for viewing DSS images and for the initial angle used in EZ-Guide.
2. Revised EZ-Guide so that the user is prompted to select a guidestar in "Manual" positioning mode. For both "Manual" and "Semi-Automatic" positioning modes, no guiding exposure is exported if no guidestar is selected.

Version 1.20.1

1. Modified the object handling so that EZ-Guide will recreate the TheSky6 object if you close TheSky6 after using EZ-Guide. Previously, doing this would cause an exception to be thrown. However, if you quickly close TheSky6 after finishing an EZ-Guide operation, it is possible to still cause an exception due to timing. There is no avoiding this (just as there is no hope if you close TheSky6 before EZ-Guide is completed) so don't rush to close TheSky6. Iit's best to just leave it open while planning sessions and only close if after closing CCDNavigator.
2. Repaired a bug that prevented the camera state for an object from being updated when removed from plan. As a result, the original camera state would be retained.
3. Changed the attribution credit lines for user saved DSS cache images so the user can tell if it's their version ("Your SkyView DSS image") or the default DSS thumbnai ("NASA SkyView DSS image").

Version 1.20.0

1. Worked with NASA to add "Rotation" capability to SkyView. DSS retrieval now displays the exact field-of-view for the RA, DEC and camera angle of a target.
2. Created a DSS Cache download (52MB) that contains a thumbnail of all 23,000 objects in the catalogs. Every thumbnail covers a 45' x 30' field-of-view
3. Increased the size of the DSS image retrieved..
4. Placed an "Add to Cache" button on the DSS window. This makes it easy to save custom DSS image retrievals in the DSS Cache folder. These images replace the download cache images and cover whatever field-of-view is set in the Camera menu as well as the camera angle.
5. Revised the "Guider" menu so each filter has separate controls for the guiding exposure on the bright and faint references. This makes it unnecessary to calculate any scale factors and provides added flexibility.
6. Added "Best Month" to the "List" display of the targets. Repaired a bug in the best month calculation.
7. Fixed a bug with the Horizon feature so that Daylight Savings time is used in the calculation. This resulted in targets encountering horizon obstacles incorrectly.
8. Modified logic so targets that are already in the session plan remain there even if the catalog is changed. This allows session plans to be built using targets from different catalogs.
9. Modified logic so that the Minimum Availability criteria is only reduced when no targets at all meet that criteria. Also modified for 15 minute instead of 1 hour increments.
10. Repaired a bug in the EZ-Guide manual positioning mode.

Version 1.10.0

1. Revised the logic so overriding the session plan or changing the override time does not recompute the target list.
2. Revised the logic so when targets meet the user criteria but cannot be added at the current time in the session plan, the "Add to Plan" checkbox is replaced with an "Ineligible" checkbox. Also, the Session End time which is when a target will be added is highlighted and either the target's "From" or "Until" time will also be highlighted. This allows the user to determine what action to take such as overridding the session plan start time or adjusting the LRGBH frame allocations of an earlier target already in the plan to make the target eligible.
3. Revised the logic so the currently viewed target will still be viewed when criteria are changed provided the target meets the new criteria. This allows the user to change any criteria and still be "on" their target of choice.
4. Added a "Horizon" capability where users can record their local horizon in the "Site" menu by scanning the horizon with their telescope or by sequentially entering the azimuth/altitude values that define the horizon. Once this is done, CCDNavigator will mark the "Target Transit and

Availability" graph with "X"s at times when the target is behind an obstruction such as trees or houses.

5. Revised the "Site" menu so the timezone is set based on the user's longitude but can be further adjusted plus or minus one hour. This should prevent illogical settings of the timezone value.
6. Added a "Guider" menu item where guiding exposure calculations for each filter based on a set of reference exposures. These are exported to CCDAutoPilot3 when a guidestar is selected using EZ-Guide's "Semi-Automatic" method.. See the "Autoguiding" helpfile for more information on how to use this capability and the "Guider" menu helpfile item.
7. Added a "Largest Size" parameter to the "Criteria" menu. This, in conjunction with the "Smallest Size", allows the user to specify a range for the sizes of targets.
8. Revised the location of the Settings and Session plan folders for Microsoft Vista compatability. As a result, users who wish to retain data in their existing profiles will have to copy the profiles from the old Program Files \ CCDWare \ CCDNavigator location to the new locations. After copying them to the new folder, use CCDNavigator to "Load" them and then use "Save As" to add all new data and update the old profiles.
   o Under WinXP, these are now located in My Documents\ CCDWare \ CCDNavigator \
   o Under Vista they are located in Documents \ CCDWare \ CCDNavigator \
9. Added a splash screen while loading database and setting up.
10. Repaired a bug associated with high latitude site locations.
11. Repaired a bug that started Daylight Savings Time a day late.
12. A folder named "DSS Cache" is checked for any targets not having an image. If a ".gif" file is found there, it is displayed for the target's thumbnail. These can be collected using the "DSS" button, after a DSS image is retrieved, right click on it, use "Save As" and name the file for the target ID (exactly).
13. Updated the "Help" files.

Version 1.00.7

1. Repaired the DSS retrieval and some profile formats to work with European numbering formats.
2. Repaired a bug introduced that caused site altitude and other saved settings to not be restored.
3. Modified color scheme in "List" for better readability.

Version 1.00.6

1. Revised the "Site" "Time Zone" parameter so it is independent of longitude and can vary from -12 to +12 hours.
2. Added a menu item under "MyTargets" called "Load MyTargets" that revises the target list to be only targets available from the MyTarget set for the session date. The objects in MyTargets must be in the current set of loaded catalogs to be listed and they must satisfy the "Criteria" "Minimum Elevation" parameter.
3. Added a session "log" file. This contains all the information seen in "View Plan" and is stored in a file at the same location as the session plans.
4. Revised color scheme to work with the Windows 2000 operating system.
5. Revised the Helpfiles and made minor cosmetic adjustments to the displays.

Version 1.00.5

1. Revised the "Set Session Plan Folder" logic so it starts at the user's Desktop. This allows saving session plans to networked systems.
2. Modified the logic so non-US environments will work correctly.
3. Added logic that will restore, if possible, any targets already selected for a session plan when the user changes criteria settings, switches catalogs or loads a settings profile. Targets that cannot be restored due to non-availability under the new criteria and catalog will be removed from the session plan with a popup notice. This can occur if the new catalog set does not contain the target as either ID or cross-reference or if the availability has changed such that it no longer meets the user's criteria.

Version 1.00.4

1. Added a reference guidestar exposure and magnitude to the "Camera" dialog which is used to calculate an equivalent filtered exposure for guidestars. If Semi-Automatic guidestar selection is used in EZ-Guide, the selected guidestar name, magnitude and recommended exposure are displayed in the "View Plan" window.
2. Added a FOV calculator to the Camera dialog.
3. Revised "Save Plan" to support CCDSoft by loading the LRGB sequence to CCDSoft's "Color" sequence. CCDSoft can only support the "Shuffle" style of sequencing.
4. Revised "Save Plan" for MaxImDL so that multiple sequence files are generated, one for each target, if multiple targets are selected.
5. Revised the "Just-In-Time" feature to be linked with the "Override Plan Start" capability. Now the override time setting is initialized with the current time if activated during a session. The session start time override in the "Criteria" window is now linked to the session date which limits the range of the override to be within the start and end of darkness for the particular date. In the main menu, the Plan Start box is colored orange if darkness has already fallen and the starting time has passed.
6. Improved useability of "Minimum Availability" inside the "Criteria" window, this now is linked to the session date and the maximum value is set whenever the date is changed. This allows both the date and the Minimum Availability to be set while in the Criteria window.
7. Added a"Find" function to the "List" target window. If the object is found, the "List" window closes and the main menu will display the object. If it is not found, a "Not Found" message is displayed and the "List" window remains open. Also, double clicking on a thumbnail while in the "List" target window will cause the window to close and the main menu to display the target. Since this replaces the "OK" function, the OK button has been eliminated. Single clicks on a header column will still sort the column.
8. Added a"Find" function to the "View" catalog window. If the object is found and is also in the target list for the session date, the "View" catalog window closes and the main menu will display the object. If the object is found but it is not in the target list for the session date, a popup displays the object's "Item" number and the "View" catalog window will remain open so you can scroll down to the object. If it is not found in the catalog, a "Not Found" message is displayed.

9. Double clicking on an object's row while in the catalog "View" window will, if the object is in the target list, close the window and place the main menu on the object. If it is not in the target list, the View catalog window simply remains open.
10. Repaired a bug associated with ZERO allocations
11. The starting time for each target is now shown when viewing the session plan.
12. Repaired a bug associated with circumpolar targets and transits close to midnight
13. Modified various cosmetic aspects such as dialog sizes, etc.

Version 1.00.3

1. The "Criteria" menu now includes a checkbox control to override starting at darkness and a numeric window to specify the session's override time
2. All parameters in the "Camera" menu can now be modified while planning a session so each target can use different camera filters, exposures, binning, sequence type, etc. There is a new dialog for naming up to ten filters
3. The "Camera" menu now includes a checkbox that will force all initial frame allocation counts to ZERO
4. Improved exception handling when TheSky6 is not installed
5. Repaired a bug associated with Transit time calculations

Version 1.00.2

1. Added a SIMBAD button that connects you to the NASA information center and retieves info and bibliographies on the target ID
2. Repaired a bug introduced in version 1.00.1 that would let the minimum availability become negative which would crash the program

Version 1.00.1

1. Revised resource folder binding so CCDNavigator can be installed anywhere. This was crashing some users installations.
2. Repaired bug in sidereal time calculation that caused small errors in transit time calculations
3. Revised "Site Properties" menu to use North/South and West/East for latitude and longitude respectively instead of signed values
4. "Site Properties" TimeZone value now assumes the same sign as longitude so user only needs to know the magnitude of their offset from UT
5. Doubleclicking a thumbnail while in the target selection's "List" display will return to the main menu with that object selected
6. Added units to all numeric controls (ie. arcmin, deg, etc)
7. Users can now add thumbnails for display. Simply make a 150 x 100 pixel JPG image and place it in the "Resources\Thumbnails" folder as "name.jpg" (for example, VDB151.jpg)

Version 1.00.0

1. The first release of CCDNavigator

Issues

- While not a bug, DST calculations are based on the US dates of starting and ending Daylight Savings Time. If this program proves to be popular elsewhere in the world, I will consider adding other DST rules. Please contact me if you desire this capability.

This list will be corrected in a future version. If you notice any bugs, please notify me at the CCDWare User Forum

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Guidestar Exposure Calculation

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This section explains CCDNavigator's approach to setting the exposure for an autoguider using reference values that establish guiding exposures for the brightest and faintest stellar magnitudes to be used.

How it works

The relative brightness of stars varies exponentially as shown in the figure to the right. If the figure's equation is considered, it can be seen that if two stars differ by 2.5 magnitudes, their brightness values differ by a factor of 10. Likewise if there is difference of 5 magnitudes between the stars, their brightness differs by a factor of 100. So, if a magnitude 5 star produces a particular guider ADU at an exposure of 0.3 seconds, then a magnitude 7.5 star would require a 3 second exposure and a 10th magnitude star would demand 30 seconds to produce a similar ADU level at the guider.

$$\frac{b2}{b1} = 10^{\frac{(m1-m2)}{2.5}}$$
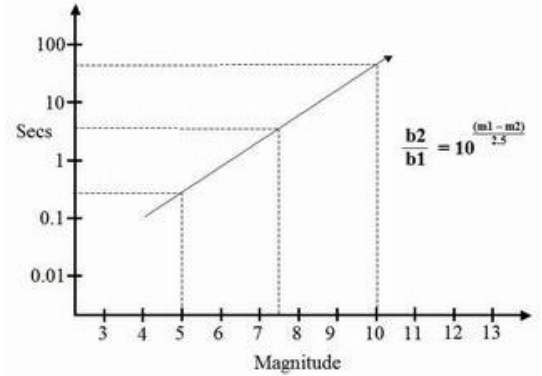
Experienced users know it is impractical to guide at the same ADU value for any guide star, especially when a wide range of magnitudes is considered. Instead, two reference points will be used, one for bright guide stars and a second reference for dim guide stars. This is considered in the graphs below.
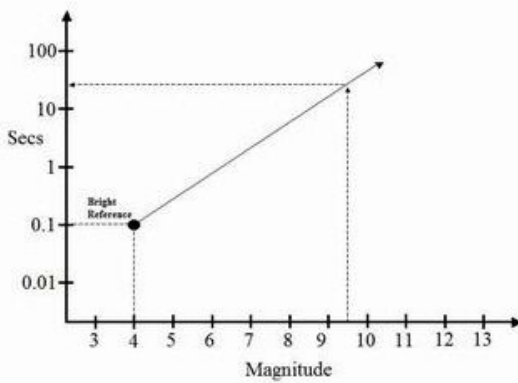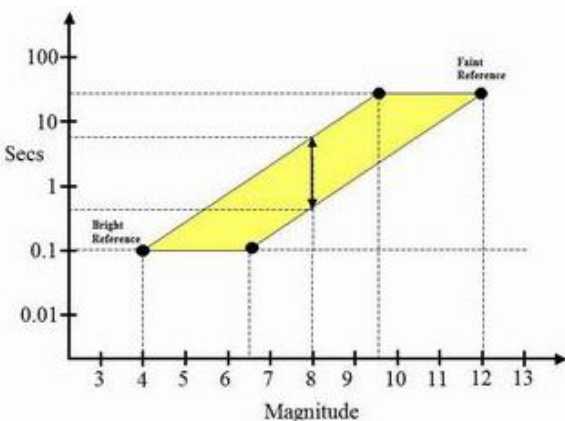

Suppose, for example, that we experimentally determine for a particular system that a bright 4th magnitude guide star requires a 0.1 second exposure for good guiding characteristics (left graph) and that a faint 12th magnitude star requires 15 seconds (right graph). These two reference points may have quite different ADU values at the autoguider but both operating points provide acceptable guiding. These reference points can be extrapolated to different magnitudes using the formula in the first figure.
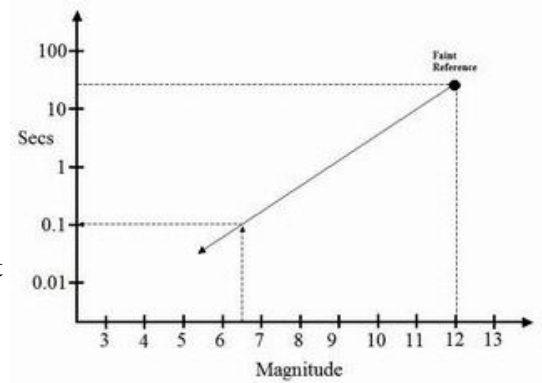
The table to the right shows the exposure for equivalent ADU counts using the formula from the first graph for the example bright and faint guidestar magnitudes just mentioned (mag 4.0 and mag 12.0 respectively). The column labeled Bright Reference begins at magnitude 4.0 and extrapolates down to magnitude 12.0 whereas the column titled Faint Reference begins at magnitude 12.0 and extrapolates up to magnitude 4.0. From the table, we can see that the bright reference exposure exceeds 15 seconds for stars fainter than magnitude 9.6 and that the faint reference exposure is less than 0.1 seconds at magnitude 6.4 and brighter. These values establish the limits beyond which the extrapolation for the particular reference exposure should not be used because the faint reference exposure will be unnecessarily short and the bright reference exposure will be unnecessarily long.

| Guidestar Mag	Bright Reference (Constant ADU/SNR)		Faint Reference (Constant ADU/SNR)	
4.0	0.1		0.01	Too Short
4.4	0.1		0.01	Too Short
4.8	0.2		0.02	Too Short
5.2	0.3		0.03	Too Short
5.6	0.4		0.04	Too Short
6.0	0.6		0.06	Too Short
6.4	0.9		0.09	Too Short
6.8	1.3		0.13	
7.2	1.9		0.18	
7.6	2.7		0.27	
8.0	3.9		0.38	
8.4	5.6		0.55	
8.8	8.1		0.80	
9.2	11.7		1.15	
9.6	16.9	Too long	1.66	
10.0	24.4	Too long	2.40	
10.4	35.3	Too long	3.46	
10.8	50.9	Too long	4.99	
11.2	73.4	Too long	7.21	
11.6	105.9	Too long	10.40	
12.0	152.8	Too long	15.00	

From these observations, we can establish a range of acceptable guiding exposures. The parallelogram seen in the figure to the left represents this region as bounded by the two reference points. If we consider an 8th magnitude star, the exposure could range from 0.38 to 3.9 seconds. If the exposure were set to 0.38 seconds, the guider's operation would be similar to the 12th magnitude faint reference star. But if set to 3.9 seconds, the operation would be similar to that of the 4th magnitude bright reference.

Based on this understanding, it is possible to define three strategies - short, medium and long - for exposure duration which are illustrated in the graph to the right. The green line provides the longest acceptable exposure while the red line provides the shortest acceptable exposure. It is

also possible to choose a value that is midway between the longest and shortest values as shown by the blue line. At the reference points, all three strategies converge to the same exposure value. Notice that for stellar magnitudes below 6.5, the exposure value is locked to that of the bright reference point and that for magnitudes greater than 9.5 it is locked to the faint reference point's exposure of 15 seconds.
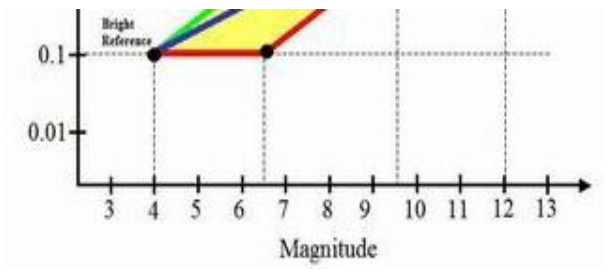
Depending on the user's equipment, one or the other of these strategies can be chosen. Users with Adaptive Optics (AO) will generally prefer shorter exposures since this provides the fastest AO update rate. However if the user is directly guiding their mount, longer exposures will reduce the effects of seeing more. CCDNavigator provides all three choices of these guide exposures.

To use this capability, the user must first choose the brightest and faintest magnitudes that will be used for guiding. They should then experimentally determine the exposure value for the bright and faint magnitude reference points for each filter. These values can be entered into CCDNavigator and when a guide star is selected, CCDNavigator will then calculate the exposure according to the user's preference of "Long", "Medium" or "Short" exposures.

For specfic instructions for using this capability, see the "Guider" help section.

Frequently Asked Questions

1. **When I launch CCDNavigator, it crashes.** Be sure you have the .NET platform version 2.0 installed on your computer. This is a free download from Microsoft and is available at http://www.microsoft.com/downloads under the .NET Framework Version Redistributable Package (x86).

2. **Sometimes "Add to Plan" is replaced with the phrase "Ineligible". When I click on the associated checkbox, nothing happens.** CCDNavigator establishes the "availability" of all targets listed for possible imaging. Sometimes, a target is available to be imaged in a session but cannot be the first target chosen for a session plan. For example, suppose that you requested 2 hours of minimum availability for a session starting at 8 pm. Some targets, say NGC1499, could be available for more than 2 hours but its availability may not begin until 10 pm. So it cannot be the first target in the plan. Once one or more targets have been added to the plan so that NGC1499's imaging run will begin after 10 pm, then the phrase "Ineligible" will be replaced with "Add to Plan" and NGC1499 can be added. A similar situation occurs for targets whose availability has already ended prior to the position where they would be added. For example, suppose that NGC891 was availble from 7 pm until 9 pm but another target has been selected for the session plan that is being imaged until 10 pm. In this case, NGC891 cannot be selected for the session plan. Whenever a target is "Ineligible", the "Session Start" time will be colored red and either the target's "From" or "Until" time will also be colored red. This highlights the reason that the target is ineligible so you can take the appropriate action such as overriding the session plan's start time or adjusting the LRGBH frame counts in earlier targets in the plan.

3. **Sometimes I set the "Minimum Availability" parameter in the "Criteria" properties section. After I close the window and then reopen it, the value has changed.** Ordinarily CCDNaviagator will not modify your chosen Minimum Availability. However, if the selected value produces fewer than 20 objects for consideration, CCDNavigator will reduce the Minimum Availability parameter until at least 20 targets are presented. Also note that changing the date will cause this parameter to be adjusted.

4. **Why is the Session Start time colored orange?** If the user starts CCDNavigator any time during the hours of darkness of the selected session date (including the morning hours on the day following), CCDNavigator will alert you to this fact by coloring the Session Start Time as orange. If you wish to construct a proper session for the current time, use the "Override Plan Start" feature in the "Criteria" menu.

5. **After I retrieve a DSS image and have saved it in the DSS Cache folder, how do I overwrite it?** Images retrieved from NASA SkyView are saved as ".gif" files. To over write these, it is necessary to delete the current copy so the "Save to DSS Cache" button will be enabled in the DSS screen. Simply navigate to My Documents / CCDWare / CCDNavigator / DSS Cache and delete whatever ".gif" file you wish to overwrite.
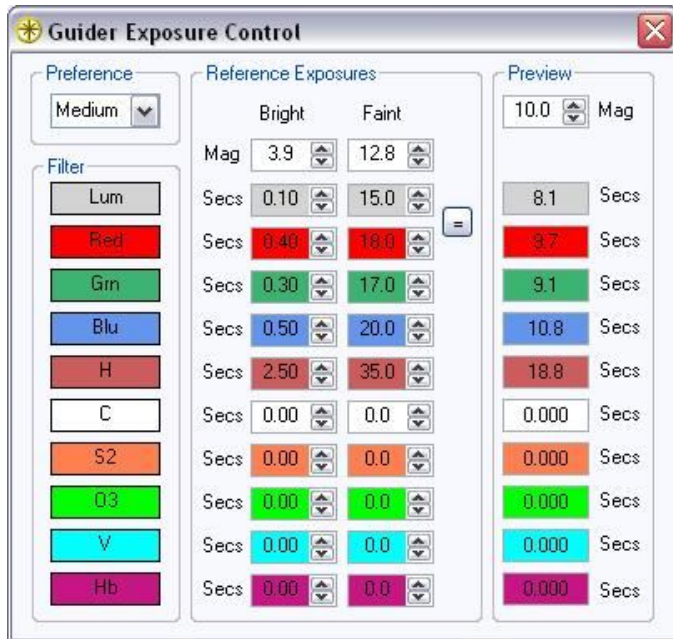
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Guider Menu

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This screen allows the user to control and preview the autoguider exposures for each filter. Note that at present, autoguider exposures can be calculated and exported only if the Semi-Automatic operation method is used in EZ-Guide. Also note that only CCDAutoPilot3 imports these values.

- **Preference** - There are three choices for this control: "Short", "Medium" or "Long". Users with Adaptive Optics (AO) systems should use either "Short" or "Medium" while users directly guiding their mounts should use either "Medium" or "Long". Short exposures will provide the fastest update rate to an AO system but are probably too fast for directly guiding mounts due to their inertia. Long exposures will better nullify seeing effects which is good for direct guiding but will slow the cycle rate for AO systems. "Medium" provides a value that is halfway between the "Long" and "Short" values. For more information on how these values are determined, see the "Autoguiding" help page.
- **Filter** - These simply show the filter names available. If a filter name has been set to empty in the "Edit Filter Names" window, that filter slot will not be shown.
- **Reference Exposures** - These parameters control the calculations of the exposure duration for the autoguider based on the magnitude of the choosen guidestar and the Bright and Faint reference magnitudes. There is a separate pair of reference exposures, Bright and Faint, for each filter.
  - **Bright and Faint Mag** - These two values should be set to the brightest and faintest stellar magnitudes to be used for autoguiding. If a guidestar is selected in EZ-Guide that is brighter than the Bright magnitude (or fainter than the Faint magnitude), the autoguider exposure will be set to the bright (or faint) value for each respective filter and a warning will be issued. Thus stars brighter than the Bright magnitude will be overexposed and stars fainter than the Faint magnitude will be underexposed.
  - **Bright and Faint Secs** - Each filter has a Bright and Faint Secs (seconds) parameter. These two values should be set to the exposure that gives good autoguiding at the Bright and Faint magnitude respectively and should be determined experimentally. The "Equal" button will copy the first filter position (normally Luminance) to all filter slots. This is useful if autoguiding is not effected by the filters, for example if an Off-Axis Guider pickoff feeds the guider from a point ahead of the filters.
- **Preview** - Set the Preview Magnitude to any stellar magnitude to see what autoguiding exposures will be used for each filter. These values are displayed in the preview column. When a guidestar is selected with EZ-Guide, this control is automatically set to the selected guidestar's magnitude so the exposure durations can be inspected following an EZ-Guide positioning operation by simply clicking "Guider" in the main menu. The "Session Plan" will also show the chosen values when it is viewed.

Setting the Parameters

1. First, decide what range of stellar magnitudes you wish to use for autoguiding. For most users, a range of 4th to 12th magnitude is reasonable but a wider or narrower range can be chosen.
2. Next, using your equipment on a night of normal seeing, locate a star with a stellar magnitude that closely matches your intended Bright Reference magnitude. Record the actual magnitude of the chosen guidestar as the Bright mag of the "Reference Exposures" and train your autoguider on this star using the Clear or Luminance filter. Experiment with the exposure duration until you are satisfied with the guiding, then record your preferred exposure duration for this filter in the Bright column of the "Reference Exposures" section (secs). Switch to a different filter and repeat until you have set the Reference Exposure secs for all of your filters.
3. Now, repeat step #2 with a star that closely matches the Faint Reference magnitude and record the "Mag" and "Secs" values in the "Faint" column of the "Exposure Preference" section. This must be done for all filters.
4. Lastly, locate a star having a stellar magnitude somewhere between the Bright and Faint reference magnitudes, perhaps an 10th magnitude or similar brightness star. Go to the "Guider" menu and load this star's magnitude into the "Preview Magnitude" control and select either the "Short", "Medium" or "Long" Exposure Preference. Now you can see what exposures will be calculated by CCDNavigator for each filter in the "Preview"

column. Set up your autoguider on the star and try the recommended value to see if you like the guiding it produces. Try all the options of "Short", "Medium" or "Long" to see which you prefer. Based on this experiment and your equipment setup (AO or non-AO), you can decide which exposure Preference you like.

Once these parameters are set,CCDNavigator can calculate and export a guiding exposure based on the magnitude of the guidestar. This is only done if a guidestar is selected in EZ-Guide from either "Manual" or "Semi-Automatic" positioning mode. After using EZ-Guide, the "Preview" magnitude control will be set to the guidestar's magnitude so you can click on "Guider" in the main menu to see what the guiding exposures will be for each filter. The guiding exposures can also be seen in the Session Plan when it is viewed.

Some general guidance on the Preference selection is as follows:

- "Short" preference - If you are using AO, the "Short" preference will give the fastest AO cycle rate. If you are not using AO, this preference may tend to "chase seeing" if your reference exposures are short so it is probably not the best choice. But if your mount has severe tracking problems, it may be better than letting the mount drift.
- "Medium" preference - This is probably the preferred mode for direct (non-AO) guiding for mounts of good quality especially if the reference exposures have high ADU counts. This mode will tend to average out seeing effects due to the longer guiding exposures.
- "Long" preference - Users very high quality mounts which are in excellent polar alignment may prefer this mode since it will do the most to average out seeing effects and will make the fewest corrections to the mount during tracking. This setting may also prove useful on nights of exceptionally bad seeing.
- In all cases, if a guidestar is chosen with the bright reference magnitude value (or brighter), the exposure will be the reference value no matter what preference is selected. Likewise, if the guidestar is used having the faint reference magnitude value (or fainter), the exposure will be set to the reference value irrespective of the preference.
- No matter what preference is used, the guiding will have an ADU count and SNR that is (approximately) at least as good as the faint reference point but no better than the bright reference point.
- Note that some variation in ADU and SNR will occur due to the spectral characteristics of the guidestar when guiding through different filters, especially narrowband ones. CCDNavigator does not make any compensation for this at present.