Overview

CCDAutoPilot Version 4
Basic and Professional
Software Documentation

Thanks to Matt and Steve Bisque, Ken Crawford, Doug George, Stan Moore, Ray Gralak, Don Goldman, Andrew Read, Steve Walters and Rick Bennion for invaluable assistance. Special thanks to Sandy Barnes, Emmanuel Schalit, Wes Stauffer and all the beta testers.

Dedication

CCDAutoPilot continues to be dedicated to my astro-wife, Diane, for putting up with my countless hours writing and testing this code. It would have been impossible without her continuous generous and loving support.

CCDAutoPilot is technically an executive program that will command other programs, such as your camera control program, telescope control program and other programs used in operating your imaging system. If you were operating the system manually, you would have to take certain actions with one or more programs at certain times to achieve a successful imaging run. With CCDAutoPilot, you can set up the activities during the day or whenever convenient and CCDAutoPilot will execute those activities at the appropriate time and take appropriate corrective action if things don't go as planned.

Successful use requires an initialization whereby CCDAutoPilot extracts key parameters about your system. Once initialized, you can select a target anywhere in the sky and CCDAutoPilot will slew to that point within a few arc-sec. tolerance regardless of your mount tolerance, automatically calibrate your guider and guide exposure and take the series of sub-exposures you desire for one or more targets. It will also take any calibration frames you desire, either before or after your light frames and even take twilight flats at dawn or dusk. If appropriate for you system, it will monitor the weather conditions, open and close your dome and even send you an email or text message concerning significant events. CCDAutoPilot can inter-operate with other observatory control systems, either commercial or of your design by a powerful control file facility. Some of these features are not available in the Basic Edition.

Given the level of complexity of these systems, initialization and configuration setup is essential for successful operation. Through this help file and other instructional material, I hope to make the transition from manual to automatic imaging as painless and enjoyable as possible. Once you successfully make this transition, you will have a reliable protocol to operate your system to its greatest capability and get to sleep while all this is going on as a bonus!

See Getting Started to begin using CCDAutoPilot.

Features

Continuing to add features while improving ease of use, this version of CCDAutoPilot represents the seventh generation of automated image acquisition software. Originally intended to allow the computer to do the acquisition work while the operator was otherwise engaged (or asleep!), CCDAutoPilot has evolved into a tool to maximize your image acquisition quality by supporting a repeatable and reliable protocol. The feature set has been considerably enhanced to support unattended local or remote imaging and for the first time, comes with a complete tool set to help characterize your system for optimal results.

The user simply goes down the buttons on the left side to set up your unattended run literally from sunset to sunrise. A new status window reports on all activities as they occur in an easy to understand report. Of course, more detail is available if needed. A new Preferences page is added to the menu to set infrequently-changed items.

CCDAutoPilot comes in two versions - Basic and Professional. The Professional version provides unlimited multitarget imaging with the same easy-to-understand point-and-click user interface that CCDAutoPilot users have come to expect. It also includes remote reporting via text messaging or email of critical session events, as desired. The Professional version has the ability to interact with other programs via a platform-independent single line file structure so that other supervisory programs can access and control its function. The Basic version is limited to a single target and has none of the remote imaging and support tools of the Professional version..

CCDAutoPilot is a multi-threaded application. What this means is that instead of plodding from step to step, key events and activities can be monitored independently of the main session thread, allowing appropriate action such to be taken immediately instead of waiting to be asked.

Key Features

- **Enhanced User Interface:** Sporting a completely revised user interface, version 4 puts everything you need to easily set up your unattended run. A set of major functions is accessed via the buttons from Settings to set up your equipment to Run Session to review and execute your run. Reference links are provided that are germane to each function. New data entry controls minimize the occurrence of locale-specific issues and reduce incorrect entries. The various entry fields have been simplified and rearranged for a more intuitive look and feel. The system profile is now "associated" with CCDAutoPilot such that double-clicking on a given system profile will launch CCDAutoPilot with that profile loaded.

- **Application Flexibility:** Supports all popular camera control programs (CCDSoft and Maxim), telescope control programs (TheSky6 and ASCOM), focus control programs (FocusMax and @Focus2), rotators (RCOS PIR, Optec Pyxis and Astrodon TAKometer) and dome control programs (AutomaDome, ASCOM, Digital DomeWorks). When AutomaDome is used, a separate, high performance thread is used to keep the dome slot aligned during long exposures, eliminating the need to resource-hogging scripts. A required technology is plate solving and either PinPoint (full version), or the combination of CCDSoft and TheSky6 can be used. Integrated Flip-Flat support for artificial light source flat generation at the end of a session. Support for the Boltwood Cloud Sensor and other compatible weather stations is seamlessly integrated into operations via a high performance separate monitoring thread (Professional Version).

- **One Step Setup:** For a given equipment arrangement, hitting the Initialize button calibrates your entire system, including your guider. You can then slew all over the sky with high accuracy, select a target and begin guiding *without guider calibration*. Just enter RA, Dec and PA and you will be right on the target. If you use TheSky6 (recommended!) you can position TheSky6's FOV Indicator as desired and begin accurate guiding, thanks to CCDAutoPilot's powerful internal algorithms for guider calibration.

- **Enhanced Target Selection:** After a one-time imager and guider initialization, you can point to literally any point in the sky and the telescope will accurately point there. Additionally if there is a guide star in the FOV, your guider will be calibrated not based on a simple and somewhat inaccurate guider calibration routine, but instead based on an accurate algorithm for enhanced guiding. CCDAutoPilot works entirely from RA, Dec. and PA (Position Angle) to point the scope and rotator (if installed) to the desired target. There is no need to be aware or rotator position - it is handled "under the hood" by CCDAutoPilot. Convenient reference information for sun, moon and target rise and set information is available. A programmable target midpoint altitude is provided to define your preferred lower altitude limit and when it occurs.

- **MultiTarget Acquisition:** Incorporating the ease-of-use CCDAutoPilot customers have come to expect, the Professional version provides a number of ways to acquire multiple targets. One can simply select the target by placing the FOVI (Field Of View Indicator) in TheSky6 as desired and hit a single button to get the coordinates. For mosaics, the user simply creates the Mosaic in TheSky6 and hits a single button to get the coordinates for all the mosaic sub-frames. There are also a number of importers. Plans created in CCDNavigator are easily imported. A plan from Starry Night Pro can be imported as well as the essentials of one from ACP. A user can also import a CSV (Comma Spaced Variables) file. Finally, target information can be entered manually via an edit window. Multiple target data can be acquired either with a common set of light frame data for all targets or individual sets, called profiles, for each target. The user has nearly unlimited flexibility.

- **Focusing:** In addition to a generous selection of alternatives for focusing, filter offsets, starting focus exposure time and focusing using a user-specified filter (For those with parfocal filters) are provided. Focusing can be either temperature or time dependent as desired.

as desired.

- **Tracking and Guiding:** Depending on whether your are doing guided or unguided imaging a number of options are provided. You can dither to the desired amount with either technique. You can image through the meridian, depending on your equipment capability to go through minimal atmosphere for those all-important clear or luminance frames. A number of options and alternatives are provided to support your specific equipment complement. If unguided, your scope will be realigned periodically to take out any cumulative drift. If guided, you can use the new auto-exposure capability to adjust your guide exposure to meet a defined level or program your guide exposure as a function of filter chosen and enable the Automatic Guide Star Recovery feature. With AGRS, CCDAutoPilot will wait until the guide error is within a specified accuracy within a specified number of attempts. If it isn't, AGRS will attempt to reacquire the guide star and change guide star exposures to continue guiding.

- **Slewing:** Precision slewing can now be repeated to get pointing within a user-specified accuracy. A Double Slew capability is provided for those mounts that would benefit from such a feature. Keep-out regions can be defined to prevent your OTA from coming too close to the pier.

- **Guider Calibration:** For the first time anywhere, CCDAutoPilot brings a new and powerful approach to guider calibration. Instead of relying on a single guider calibration, and perhaps modifying that calibration result as the camera is rotated or the sky position changes as other products do, a completely new approach is used. Based on a system calibration via CCDAutoPilot's new Initialize function, guiding is optimally determined by analytical prediction and ***replaces*** guider calibration in the camera control program by these optimal vectors. No longer are multiple calibrations required to get good guider performance. And once initialized, this optimum guider performance is achieved no matter where in the sky the system is pointed, no matter how the camera is rotated, manually or automatically.

- **AutoLevel Guide Exposure:** For guided operation, CCDAutoPilot will automatically adjust your guide exposure within user-specified limits to the target signal level you specify.

- **Light Frames:** Using a simple point-and-click user interface, CCDAutoPilot adds some editing aids to make data entry easier. You can also elect to focus on the first exposure of a series or not. From the same page, you can edit the target exposure settings (target profiles) for every target on your list.

- **Dark and Bias Frames:** You can easily select specific dark and bias frames to be acquired either before the light frames while waiting for the target to rise, or afterward, when the light frames are complete, or both. Or, you can acquire these calibration frames immediately. You can optionally flush the imager before any frames are acquired.

- **Flat Frames:** Flat frames can be acquired from either TheSky or a light box. Additionally, you can specify a position angle for the flat to match key target data, a direct rotator angle or no rotation. Automatic exposure dawn and dusk sky flats are supported with either tracking off or tracking on and dithered, depending on your preferences. If you desire a specific alt/az location for flats, it can be entered by the user. Flats can be taken either in a best effort order or in a user defined order to tune your flat acquisition strategy for best efficiency.

- **Session Tasks:** More automation tasks are provided including opening your dome and starting your cooler at a specified time. After your light frames you can park your scope and optionally close your dome. If you elect dawn flats, you can leave the dome open and at the appropriate time, the telescope will unpark, take dawn flats, re park the scope and warm up the cooler. At key points in the evening's activities, user developed applications or scripts can be run for maximum flexibility. To aid in data management, folders for the evenings activities can be automatically generated if desired, giving a readily recognizable folder name as to date and target.

- **Run Session:** Here the equipment setup can be reviewed as well as the session plan. Warning messages are provided to make sure nothing has been overlooked. Once satisfied, hitting the Run Session button minimizes the main window and opens the status window, enabling the user to track session progress to the degree desired. Of course the ability to pause and resume a run, as well as abort one, is provided.

- **Professional Support:** Stand FITS keywords, spectroscopy binning and inserting of World Coordinate System data in the FITS header is provided for professional users.

- **Smart Sub-framing:** With the advent of larger imaging sensors, many optical systems prevent full illumination of the sensors. Smart Sub-framing allows only useful data, as defined by the user, to be taken and downloaded. Once the user has defined the sub-frame size to be used, it is applied equally to light, dark, bias and flat frames. Any slew adjustments are then made to the center of the sub-frame.

- **Tools:** A number of tools are provided to make imaging easier and more efficient. Provisions are included for inputting min./max. move and aggressiveness to your CCDSoft or Maxim guide routines. Automatic guide exposure makes guessing at guide star exposures unnecessary. A single button push will suggest a dither value that is optimal for your system. After framing an appropriate G2V star, a single button push measures that star through each of your filters and develops your color combine ratio, automatically compensating for atmospheric extinction. A single button push will characterize your camera's gain and read noise. Following that, another button push and you can determine your sky glow, which enables setting your ideal sub-

exposure, based on your selected image sensor. Finally recommendations are made for camera operating temperature and even the number of dark frames you will need. Improved run time estimation is achieved via heuristic modeling of the various times involved in the system. Over a number of runs, estimates for download times, focusing times, and other key time variables are learned and adjusted to make the run time estimates even more accurate.

- **Remote Control (Professional Version):** CCDAutoPilot can be controlled by an external text file to start a run, pause and restart it and report problems via a text message or email. At the conclusion of a session, an email notification with the log file can be optionally sent. Whether sent by email or not, CCDAutoPilot will aggregate all color exposures taken for a given target and, noting the altitude of each exposure, will calculate and log an extinction-corrected color combine ratio. A Boltwood Cloud Sensor or compatible weather/control system can be monitored and a session aborted upon a user-defined wind speed or humidity being exceeded, in the event of rain or very cloudy weather.

What's New

Here's a partial list of what's new in version 4.

Functionality
Automatic RGB Measurement, sometimes called G2V calibration
Automatic guide star exposure
Automatic measurement of camera gain, read noise and sky glow
Sub-Exposure Calculator
Heuristic (Learning) system for time variable events
Tools added for better run time estimates and planning of light frames and dark frames.
Improved sky flat acquisition efficiency
Automatic dome flats at park
Support for Maxim's MicroGuide
Automatic AO bump calibration in Maxim, both self-guided and off-axis guided
Selectable tolerance for pointing corrections
Temperature sensitive focusing control
Suggested dither amounts based on system settings
Network support for Cloud Sensors
From FIT function uses FITS data if present

User Interface
Target list now contains calibration frame programming
System profile now contains all system settings
Double-click on system profile to launch CCDAutoPilot
On-the-fly editing of data acquisition settings while run is in progress
More robust user interface and fault tolerant code to prevent bad entries
Greatly expanded help system with Imaging Strategies section

Professional Edition Features
Color combine ratio calculations per target
Input file for controlling CCDAutoPilot by external programs
Email/SMS notification of key session and weather events

Edition Differences

Professional Edition
The Professional Edition supports all features, tools and capabilities described in this help file.

Basic Edition
The basic edition is limited to a single target per session. Additionally, it does not support the control file for customization, it does not send email/text messages for key events and does not calculate the extinction-corrected RGB combine ratio for a given target session.

Other than that, all features, tools and capabilities described in this help file are fully operational.

Application Requirements

The following software components and versions are the minimum necessary for successful operation with CCDAutoPilot. CCDAutoPilot will simply **not work** with older versions or without the specified components properly installed. Version checking is incorporated to prevent operation with applications whose versions do not meet these minimums. In most cases, updates are freely available from the software publisher and must be implemented for successful CCDAutoPilot operation.

- Net Framework (version 2.0) Usually a part of an updated Windows system, it is **essential** to operation and may be downloaded here

One of the following camera control programs:

- CCDSoft version 5.00.192 or later
- MaxImDL/CCD version 4.54 or later Version 4.54 is required for AO support and direct guider programming for min/max move and aggressiveness.

One of the following telescope control programs:

- TheSky **Professional Edition**, version 6.0.0.56 or later
- TheSkyX Professional Edition, Build 3952 or later
- ASCOM platform 4.1 or later, the NOVAS-COM Vector Astrometry Engine, v2.1 or later and The Kepler Orbit Engine v1.0a

Filter offset programming and Focusing:

- FocusMax 3.3.29 or later. The basic installer for version 3.2.1 and a patch file to the latest version
- TheSky6, 6.0.0.56 or later for the Sky Star focusing method. See the Focusing section.
- ASCOM platform 4.1 or later
- PinPoint (Required for plate solving with Maxim alone and Acquire Star function only, see the Setup section info for details)
- For @Focus2, TheSky6 and CCDSoft are required.

One of the following rotator control programs:

- RCOS TCC software, version 1.5.23 or later
- Native support included for the Optec Pyxis rotator.
- AstroDon TAKometer Control, version 0.0.1 or later

One of the following dome control :

- AutomaDome version 1.00.011 or later
- ASCOM platform 4.1 or later
- Technical Innovation's Digital Dome Works

For the Boltwood Cloud Sensor:
The single line data facility must be configured and located in a folder accessible to CCDAutoPilot. The Clarity software is not required.

Version History

4.22.1 July 13, 2010
- Bug fix: Correct Win 7 update bug (dang!)

4.22.0 July 11, 2010
- Enhancement: Added support for TheSkyX Professional. See Software Settings for **important** information. before using TheSkyX. You will need TheSkyX Pro Build 3952 or later, which should be in the next Software Bisque maintenance release as v 10.1.9, to park after light frames and park again after dawn flats. To use an earlier build, turn off Revision Checking, avoid using Park While Waiting, use Turn off Tracking instead and only park at the end of the session. Also, see Plate Solving to take advantage of the greatly improved CCDSoft/TheSky plate solving capability.
- Enhancement: Added UCAC3 catalog support for PinPoint. Requires PinPoint version 5.1 or later.
- Bug fix: Fixes early trial period termination for trial users.
- Bug fix: Correct CCDNavigator plan import with no filter wheel.
- Bug fix: Enhanced version checking to recognize more versioning variations.

4.21.9 June 10, 2010
- Bug fix: Unable to start CCDAutoPilot under some circumstances.
- Enhancement: Bad weather abort will now stop an exposure in progress.

4.21.8 May 27, 2010
- Bug fix: Correct internal build error.

4.21.7 May 26, 2010
- Bug fix: Enhanced version reporting under 64-bit OS.
- Bug fix: Flat readout modes with Maxim not being properly set.

4.21.6 May 13, 2010
- Bug fix: CCDNavigator session plan file filter broadened to select all xml files.

4.21.5 May 11, 2010
- Bug fix: Abort exposure in process of control file calls for a session abort.

4.21.4 April 29, 2010
- Enhancement: Add ability to turn off plate solving for CCDSoft and shutterless cameras. See Plate Solving

4.21.3 April 20, 2010
- Enhancement: Add with sync option to precision slew to focus star
- Bug fix: Prevent SkyStar warning in Review Setup when ASCOM/TheSky6 is selected.

4.21.2 April 5, 2010
- Bug fix: @Focus2 not being allowed when it should have been
- Bug fix: Show sun ephemeris data.

4.21.1 April 1, 2010
- Bug fix: ASCOM rotator not reporting position, correct error message

4.21.0 March 31, 2010
- Bug fix: Allow @Focus2 with ASCOM/TheSky6 during session run
- Bug fix: Prevent slew abort during weather event.

4.20.9 March 27, 2010
- Bug fix: ASCOM/TheSky6 doesn't need Kepler/NOVAS
- Bug fix: Allow @Focus2 for ASCOM/TheSky6

4.20.8 March 20, 2010
- Enhancement: Added a Telescope Control option to combine ASCOM telescope control with TheSky. See Telescope
- Enhancement: Increased max flat ADU target to 60,000.
- Enhancement: Minimum number of stars for an acceptable plate solution is now adjustable. See Plate Solving
- Enhancement: Dawn flats will abort if sun is 10 degrees above the dusk altitude specified on the Preferences page. See SkyFlat Settings

- Enhancement: Import and Export of text files changed to handle ',' as decimal character. See Targets Menu
- Bug fix: Improved accuracy of moon rise and set times.
- Bug fix: Corrected read noise measurement for binned imagers. See Sub-Exposure Calculator
- Bug fix: Setting guide exposure to 0 on lights page will now properly result in series being unguided. Requires CCDSoft 5.00.192 or later.
- Bug fix: Shouldn't require PinPoint or Flip-Flat, if selected, be installed for Planing mode. Fixed.

4.20.7 February 18, 2010
- Enhancement: Accommodate new Maxim 5.08 guide speed scaling. Earlier versions of Maxim still supported.

4.20.6 February 15, 2010
- Bug fix: Correct CCDN filter name mismatch trapping logic

4.20.5 February 15, 2010
- Bug fix: Prevent spurous plate solve attempt when changing to Run Session page under some circumstances

4.20.4 February 4, 2010
- Enhancement: Add confirmation dialog on Apply To All button on Targets page.
- Enhancement: Add cooler temperature and power percentage to log where supported by camera control program.
- Enhancement: Add warning for filter name mismatch on CCDNavigator import.
- Enhancement: Flip-Flat now closes immediately aftere lights run and before park.
- Enhancement: Add KAF8300 to sensor list on Tools page. Use sensor maximum values where specified by vendor.
- Bug fix: Correct number of darks calculation based in master darks being correlated. See Sub-Exposure Calculator.

4.20.3 January 18, 2010
- Enhancement: Show solar altitude in log for all successfully acquired sky flats. See Sun Altitude.
- Bug fix: email not being sent on guide star failure

4.20.2 December 28, 2009
- Enhancement: Prevent entering anything other than 8 or 16 for Guider A/D bits/pixel

4.20.1 December 15, 2009
- Enhancement: Added code to prevent FocusMax corrupting Maxim exposure settings
- Bug fix: Prevent exception if Focus Before Target Start is checked without a filter wheel

4.20.0 December 9, 2009
- Enhancement: Use J2000 coordinates for RA, Dec kewords in FITS header
- Enhancement: Do precision slew if user specified Focus at Series Start and doesn't connect a focuser
- Enhancement: Revised AO calibration routine when used with ST-4000
- Enhancement: ASCOM sends telescope coordinates in mount-specified equinox if supported in driver
- Enhancement: Now requires NOVAS-COM 2.1. Users should upgrade if necessary. See Software Requirements
- Enhancement: Updates now downloads a complete installer to update an installation. Required for Windows 7. See Updates
- Enhancement: Precision slew is now used to improve return to target accuracy when Focuser Program Picks Star is used (e.g. AcquireStar).
- Bug fix: Fixed issues with ASCOM telescope slew

4.16.0 October 25, 2009
- Bug fix: Remove Map entry on Options page. Remove spurious log entry if Map Pixels is not checked.
- Bug fix: Correct ReverseX guiding error when no rotator is used
- Bug fix: Correct error when loading a new system profile from other than the settings page.

4.15.9 October 10, 2009
- Enhancement: autodarks are now used during RGB (G2V) target star selection
- Enhancement: If Flats at park position is checked, park after target run will automatically be checked
- Enhancement: Added support for Maxim's Remove Bad Pixels during image acquisition. See Customizations.
- Bug fix: Resolved PinPoint plate solving errors with non-US versions of Windows

4.15.8 September 22, 2009
- Enhancement: Account for long exposure and long focus time when approaching meridian flip time
- Enhancement: Use Equipment Settings FL is imager FL is not entered in camera control program setup
- Enhancement: Maxim 5.07 appropriated FOCUSPOS keyword. CCDAP will now use FOCUSER.

- Enhancement: Added global error handling facility
- Enhancement: Allow ":" in manually entered RA and Dec coordinates
- Enhancement: If with sync is checked on the Targets page, a sync will be performed when returning to the target from a SkyStar focusing run.
- Enhancement: Allow darks to proceed after a cloud abort.
- Enhancement: Warm up cooler at the conclusion of the session after a cloud abort.
- Enhancement: Skip plate solve before focusing if SkyStar is used and the first active series contains a focus at series start
- Enhancement: Add option to stop mount tracking while waiting for clouds to clear. See Preferences.
- Enhancement: Always use specifed coordinates for target coordinates. Saves a plate solve.
- Enhancement: When autoguide exposure is used, it now starts at the minimum user-specified exposure.
- Enhancement: Added customization options for simple file names and cooler set point recovery. See Customization.
- Enhancement: Initialization enhanced for increased reliability. Cardinal point warning added for CCDSoft initialization.
- Enhancement: Plate solving reports number of stars used in solution and rejects solutions with insufficient number of stars.
- Enhancement: Plate Solving Notes topic added to the help file
- Bug fix: Corrected unhandled exception errors in 4.15.5 and 4.15.6
- Bug fix: Default folder names - all calibration frames are now stored in a calibration folder whose date stamp agrees with the date stamp of the target (data) folder, regardless when the calibration frames were taken in the course of the evening.

4.15.7 July 23, 2009
- 4.15.5 and 4.15.6 changes removed pending further testing.

4.15.6 July 9, 2009
- Bug fix: Corrected focus deferral near meridian calculation.

4.15.5 July 6, 2009
- Enhancement: Added protection against long focus times impacting meridian flip
- Bug fix: Default folder names - all calibration frames are now stored in a calibration folder whose date stamp agrees with the date stamp of the target (data) folder, regardless when the calibration frames were taken in the course of the evening.

4.15.4 June 16, 2009
- Enhancement: Added log parser utility. This requires downloading the utility from the CCDAutoPilot4 support forum (search for Log Parser) or downloading the latest build from http://www.ccdware.com/downloads/
- Enhancement: ResetAO is performed prior to precision slew
- Bug fix: Exposure delay wasn't being set properly if automatic guide star exposure was used.

4.15.3 May 29, 2009
- Bug fix: Average altitude and extinction coefficients being improperly calculated under some conditions

4.15.2 May 16, 2009
- Changed Maxim guide error reporting to accommodate differences between Maxim v4.xx and v5.xx

4.15.1 May 9, 2009
- Enhancement: Sky flats can now be taken automatically at dawn in reverse order from dusk with an optional 180 degree rotation. See Dusk Order in the Flat Frames command summary. The flat measurement technique has changed.
- Enhancement: Sky flat measurements now taken at the center of the sensor. Improvements in efficiency as well.
- Enhancement: Automatic guide star measurement now starts at minimum specified exposure time.
- Bug fix: Corrected plan estimate to count focus at series start properly.
- Bug fix: Mount tracking was not turning off at some points.
- Bug fix: Maxim guide error measurement not reporting corrected. Added check and log entry for guide star fade. Also, see Maxim v5.05/5.06 note for important Maxim information.

4.15.0 April 11, 2009
- Enhancement: Integrated support added for the Flip-Flat, a programmable artificial light source for flat field generation.
- Bug fix: Fixed turning on tracking for sky flats
- Bug fix: Eliminated sunrise testing for artificial flats
- Bug fix: Eliminated slewing to sky flats when artificial flats is selected

4.13.3 March 25, 2009
- Ehnancement: Arguments for applications to be run at specified times is now supported. See Options
- Bug fix: Allow artifical flats when sun is in the west.
- Bug fix: Tracking on/off now works properly.

- Bug fix: If dusk flats tracking off and neither park while waiting nor tracking off while waiting is selected, tracking will be turned on.

4.13.2 March 9, 2009
- Enhancement: Preserve non-sidereal tracking rate when manually set in ThsSky at the start of the run. This is useful for Paramount users imaging non-sidereal objects such as comets, asteroids and the like.
- Enhancement: Accommodate non-square imager pixels for faster plate solving with PinPoint
- Enhancement: Increased Pyxis timeout from 5 to 10 sec. to respond to a command.
- Bug fix: Correct field used for RDNOISE keyword. Now uses the correct Read Noise entry on the Tools Page

4.13.1 February 15, 2009
- Bug fix: Exception when starting with default profile.

4.13.0 February 14, 2009
- Enhancement: Reset times now closes gaps while optionally preserving first target start time. See Reset Times
- Enhancement: Attempts to load an invalid target file are now trapped.
- Enhancement: Keywords for read noise (RDNOISE) and gain (GAIN) added to FITS header for light frames. See FITS keywords
- Enhancement: Improved Vista 64-bit compatability.
- Enhancement: Improved guide star detection for 8-bit guide cameras. See Guider Settings
- Enhancement: Allow optional guide star selection by Maxim. See Guided Operation
- Bug fix: Min. W Altitude limit now properly impacts west of meridian only at target start.

4.12.9 February 1, 2009
- Enhancement: Improved guide star detection and exposure setting. See Guided Operation
- Enhancement: G2V measurement accuracy improved. Focus star centering now used for precision slews
- Enhancement: Trap and exit 0,0 guide errors when reported by Maxim.

4.12.8 January 26, 2009
- Enhancement: Added disk drive space (with low space warning) to setup review
- Bug fix: Resolved Maxim guider start problem for some users

4.12.7 January 20, 2009
- Enhancement: Added support for ASCOM rotators
- Enhancement: Added focus star centering tolerance for SkyStar
- Enhancement: User interface changes to show/hide certain options depending on Software Settings
- Enhancement: Eliminate extra target precision slew for initial focusing. Increased precision slew tolerance limit
- Enhancement: Eliminate DDWCP dome home on Connect
- Bug fix: Focus time and temperature initialization changed from per target to per session
- Bug fix: Flat readout mode default file name (Maxim only) fixed.
- Bug fix: Dome not closing under certain circumstances fixed.
- Bug fix: Overhead percentage now properly calculated.

4.12.6 January 9, 2009
- Bug fix: PinPoint catalog selection is back to being persistent
- Bug fix: Accommodate Maxim 5's 32 pixel forbidden region in guider FOV

4.12.5 January 3, 2009
- Enhancement: Dec. Axis Release option added which replaces and enhances the "rc-astro" hidden option. See Mount Settings,
- Bug fix: Improved reporting of guide errors when using Maxim.

4.12.4 December 30, 2008
- Enhancement: Complete support for Maxim version 5 Readout Mode added. See Readout Modes and Data Organization.
- Enhancement: Added PinPoint selection for USNO NOMAD catalog. Requires an internet connection and PinPoint version 5 or greater.
- Bug fix: Stop removing the domain name from the user name for SMTP servers that may require it.
- Bug fix: Insure auto-detect guide star in Maxim v5.

4.12.3 December 23, 2008
- Bug fix: Apparent Maxim 5.03 internal change caused guide error readout to be 0. Fixed.
- Bug fix: Maxim doesn't report initial readout mode state for FLI cameras. CCDAP defaults to Normal (RBI Flushing)

4.12.2 December 11, 2008
- Enhancement: Support fast readout mode (Maxim only) for certain Apogee and FLI cameras.
- Enhancement: Overhead per frame is calculated for improved CCDNavigator planning accuracy.
- Bug fix: Prevent multiple emails and notices on run abort via control file

4.12.1 December 4, 2008
- Bug fix: Remove test code, which prevented guide errors from being reported with CCDSoft.

4.12.0 December 3, 2008
- Enhancement: Increased post-focus offset and dusk flat elevation ranges
- Enhancement: Prevent exceptions on some user input errors
- Bug fix: Changed fast readout mode (Maxim) version detection

4.11.9 November 18, 2008
- Enhancement: Abort will now stop slews in progress as part of the abort process
- Enhancement: ASCOM dome open implements home before trying to open
- Enhancement: ASCOM telescope is disconnected when CCDAP is disconnected or closed
- Enhancement: Test buttons enhanced and now require connection to operate
- Enhancement: Prevent confusion from "Sun" showing up in TheSky's Object Information window
- Bug fix: ASCOM chooser cancel exception eliminated
- Bug fix: Duplicate FOVI names are flagged only if the duplicate name is active

4.11.8 October 26, 2008
- Enhancement: Added support for CloudWatcher and WeatherWatcher
- Enhancement: FOCALLEN keyword will be written to all FITS headers, based on Settings page entry
- Bug fix: Cloudy weather condition will not abort darks in progress

4.11.7 October 15, 2008
- Enhancement: Fast readout mode enabled for some FLI cameras (Maxim only)
- Enhancement: Revised recommended dither values
- Enhancement: Improved Precision Slew efficiency
- Bug fix: CCDSoft initialization near a cardinal point improved
- Bug fix: Automatic AOL bump calibration now works properly with Maxim v4.54 to 4.62. Maxim 5 not recommended yet.

4.11.6 September 27, 2008
- Enhancement: Guide Star Selection Algorithm improved to reject overly bright guide stars
- Bug fix: Pyxis COM port setting and Center Focus Star setting now persistent
- Bug fix: Corrected spurious "IsReady" error.

4.11.5 September 12, 2008
- Enhancement: Off-target unguided focusing now returns to target coordinates
- Enhancement: Focus Now now returns to exact starting point via precision slew
- Enhancement: Added Secure Sockets Layer (SSL) to Email setup
- Bug fix: Upper limit of sky flux increased to 999
- Bug fix: Periodic focus had required a filter wheel - corrected.
- Bug fix: Correct RA wraparound error
- Bug fix: Exposure time not being imported from CCDNavigator or ACP Planner - corrected.

4.11.4 September 3, 2008
- Bug fix: Insure termination of CCDAutoPilot.exe process after exit

4.11.3 August 30, 2008
- Enhancement: null point Az and Alt is now persistent
- Bug fix: Periodic realign only happens with unguided imaging as intended
- Bug fix: Maxim version checking corrected

4.11.2 August 21, 2008
- Enhancement: Added Plate Solve Exposure info in help file
- Enhancement: Increased AGSR maximum allowable correcting slew to 4 degrees
- Enhancement: New method to write FITS header information

- Bug fix: Improved Maxim exposure fail-to-start retry logic.

4.11.1 August 15, 2008
- Enhancement: Workaround for CCDSoft not reporting certain FITS key/value required pairs with some cameras
- Enhancement: Trap some erroneous user inputs
- Bug fix: Corrected keep-out altitude processing

4.11.0 August 8, 2008
- Enhancement: Added a Suggest function for guider move calculator
- Enhancement: Increased pixel size precision to .01
- Bug fix: Dome now closes properly on weather abort
- Bug fix: Guide calculator corrected

4.10.9 July 31, 2008
- Bug fix: Correct bad registration info display in Settings Utility Window
- Bug fix: Correct dust donut calculator accuracy
- Bug fix: Correct CCDSoft predictive guiding near cardinal points

4.10.8 July 24, 2008
- Enhancement: Interaction of Maxim Lossless Compression with Insert WCS clarified
- Bug fix: Defaulted Max E Altitude and Max W Altitude to 90 when using a profile created by versions prior to 4.10.7.

4.10.7 July 23, 2008
- Enhancement: Added additional steps when a weather event is triggerred. Details here.
- Enhancement: Added Run Abort and Shutdowm option to Control File.
- Enhancement: Changed sensor.ini structure. See Camera Notes
- Enhancement: Added optional Maxim lossless file compression capability.
- Bug fix: Precision slew with tolerance now applied on retrun slew from off-target focus star.
- Bug fix: Changed event order in Options/Data Acquisition to reflect actual sequence.
- Bug fix: Added Max E Altitude and Max W Altitude to profile.

4.10.6 July 19, 2006
- Bug fix: Corrected Boltwood data reporting error

4.10.5 July 13, 2008
- Enhancement: Color combine ratio calculation will now be reported even if run aborts for clouds or dawn
- Enhancement: Plate solve time estimate now includes plate solve exposure times for increased session accuracy. Your existing time estimate for plate solve will adjust (increase) as additional sessions are executed.
- Bug fix: Boltwood data wasn't being reported

4.10.4 July 10, 2008
- Corrected focuser temperature reporting
- Corrected flip time with ngative PMTrack values
- Change email for data acquisition start to email for "Starting image data acquisition"
- Dawn flats will not be attempted if very cloudy events triggered
- Improved accuracy of E/W light frame file naming
- Keywords for XPIXSZ, YPIXSZ and FOCALLEN written in proper numeric format
- Workaround for CCDSoft RGH black hole incorporated.
- Internal data synchronization improved.

4.10.3 July 3, 2008
- Change dawn abort to before estimated dawn flat start.
- Added more time for CCDSoft to report guide errors when short guide exposures are used.
- Minimum auto exposure time reduced to 0.01 sec.

4.10.2 July 1, 2008
- Unchecking Dawn Abort now works properly
- Kepler and NOVAS download links updated in Application Requirements

4.10.1 June 30, 2008

- Corrected inability to start with default profile

4.10.0 June 29, 2008
- Decrease min. guide exposure to 100 ADU
- Advance revision to prevent spurious updates

4.00.0 June 27, 2008
- Initial release

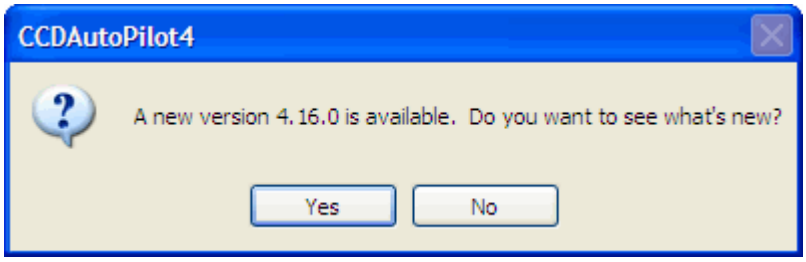
Updates

CCDAutoPilot has the ability to check for program updates automatically from the Internet. There are two menu items under Help that apply to this feature.

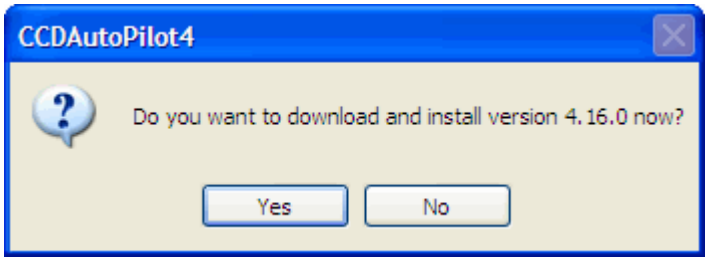
- **Get Updates from Web:** When checked, the first time CCDAutoPilot is loaded each day it will check for program updates via the Internet. If not checked, this checking will not take place.
- **Update Now:** When this menu item is selected, CCDAutoPilot will immediately check for updates.

Updates Available

If there are updates available, you will be presented with an opportunity to get more information about the update.



Selecting Yes will open the Version History page in your default browser. Selecting No will skip displaying the Version History. You will next be given an opportunity to download and install the new version.



Selecting Yes will display a progress window as the new version installer downloads to
(My) Documents/CCDWare/CCDAutoPilot4/Updates/
Once downloaded, the installer will begin. Follow the prompts and CCDAutoPilot will automatically launch at the end of the installation process with the new version. It is that easy!

Update Options

As described above, you can disable the daily update checking. This is handy if you are on a slow internet connection or do not have internet access. This condition can be changed at any time by checking the "Get Updates from Web" menu entry. Merely opening it changes the presence or absence of a check mark to the opposite state.

Regardless of the checked state of "Get Updates from Web", you can always immediately check for updates by selecting the Updates Now menu item.

No Internet Connection at the Observatory

In this case, you should install CCDAutoPilot on your home or office PC so that you can check for updates. Note which modules are replaced and in what folder they are located. Copy those files to an appropriate media (flash drive, CD-ROM), and copy those to the appropriate folder, usually
C:\Program Files\CCDWare\CCDAutoPilot4, overwriting those that already exist.

License

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If you do not accept the terms and conditions of the License Agreement, you are to promptly delete each and any copy of the Software from your computer(s).
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The Licensor reserves the right to charge an upgrade fee in the case of major new enhancements or additions to the Software. This major new version will then start a new version line that will use version numbers clearly distinguishable from the old version line. The Licensee has no obligation to upgrade to the new version line and the Licensor will continue to make the latest version of the previous version line available for download to Licensee.
You must not attempt to reverse compile, modify, translate or disassemble the Software in whole or in part. You must not run the Software under a debugger or similar tool allowing you to inspect the inner workings of the Software.
The Software remains the exclusive property of the Licensor. Any Licensee who fully complies with the terms in this license agreement may use it according to the terms of this license agreement. You must not give copies of the Software or your license key to other persons or entities. You must not transfer the Software or your license key to another person or entity. You must also take reasonable steps to prevent any third party from copying the software from one of your machines without your permission.
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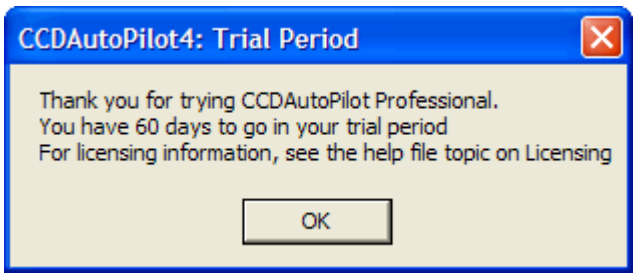
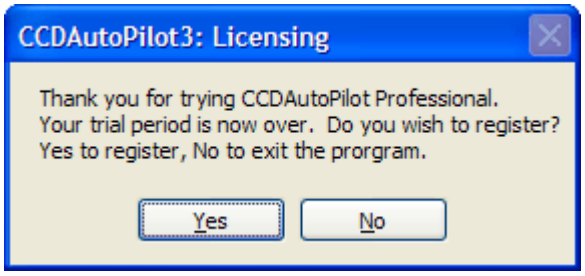
Entering Registration Key

Trial Period

CCDAutoPilot begins with a trial license to the Professional (full-function) Edition that allows you to see how it works with your particular system before you must purchase a license. The trial period is 60 days and 15 uses. This means you can use it as often as you wish in the first 60 days but if you don't use it at all in that period, you still have 15 trial starts regardless of how long after that you load the program. While you are in the trial period, an opening screen tells you how many days you have left in the trial.



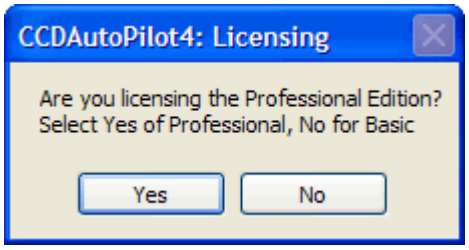
In this example, there are 60 days remaining in the trial period. This screen is no longer displayed when the product is licensed. If the trial period is expired, you will see this screen:



If you hit the No button, the program will exit. The Yes button will take you to the licensing dialog.

License Selection

Licensing can be accessed at any time from the Help | Register menu. From here, you can enter a registration key for either the Basic or Professional Edition. To upgrade a Basic Edition to a Professional Edition, see below.

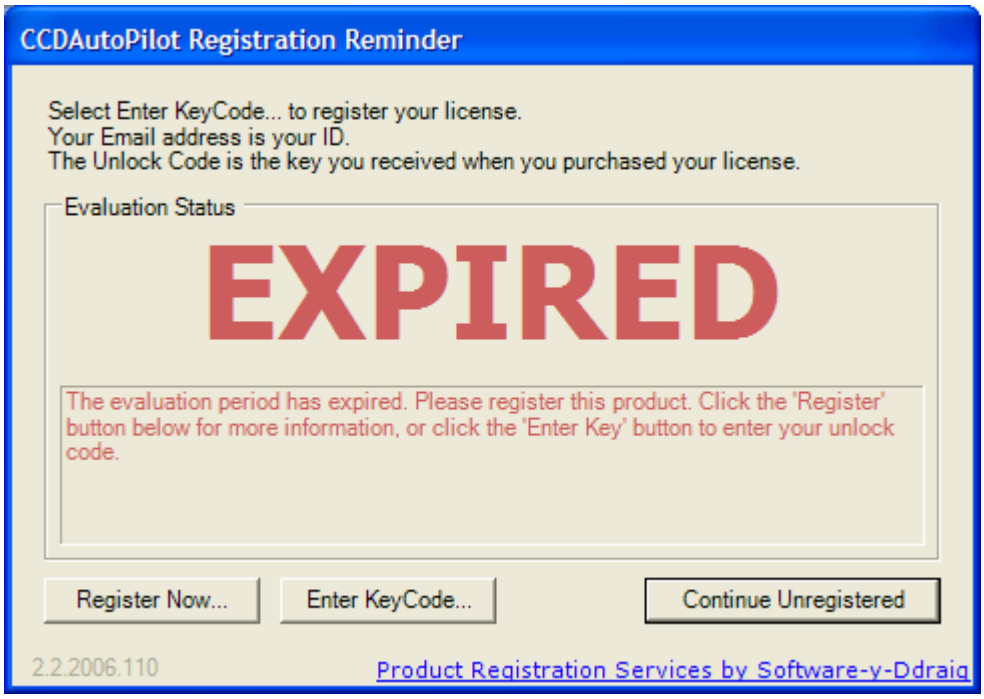


After making your choice on whether to license the Professional Edition (hit Yes) or the Basic Edition (hit No), you will see one of the following windows, depending on your choice:

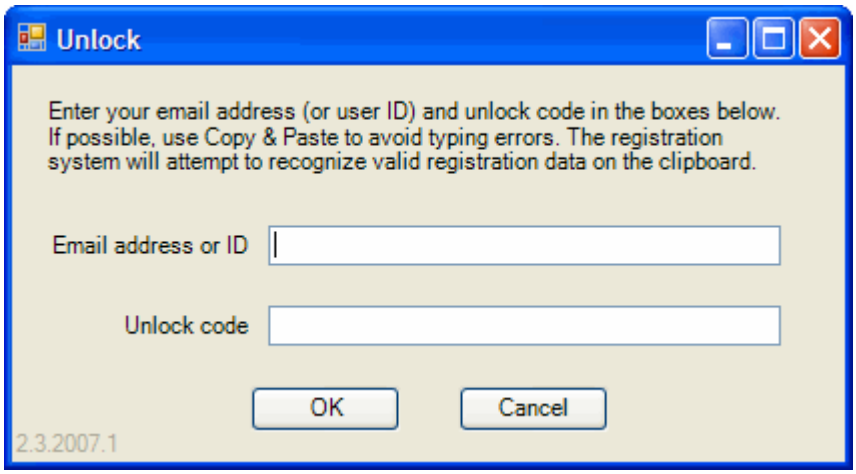
or

Entering the license info

From this point, you will get an information screen and finally the registration screen, as shown below:



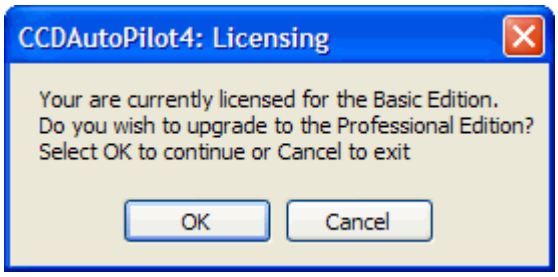
In the above example, the Trial Period is expired. If you are entering your license information before trial expiration, you will still see a similar screen, without the "Expired" statement. Hit the EnterKeyCode... button and you will see this final screen:



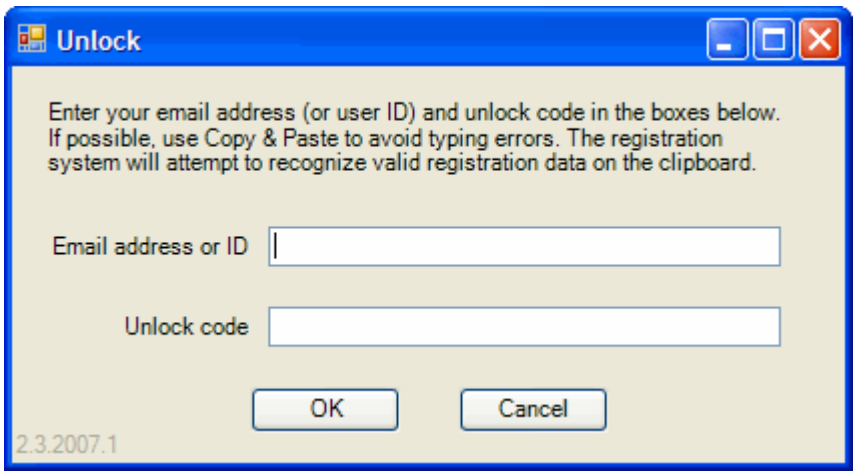
Registration information consists of an Email/Key pair. These are directly related and the email address must be that used when you purchased the registration key. Enter the email address your ID and the corresponding key you received as the Unlock code. Hit OK and you will be registered. You may confirm your successful registration by selecting the Help | About menu item.

Upgrading from Basic to Professional

If you have a Basic Edition license, you can upgrade to the Professional Edition license by purchasing an upgrade license. Go to the Help|Register menu. If you have the Basic Edition licensed, you will see:



If you hit the Yes button, you will get an information screen and finally the registration screen, as shown below:



Registration information consists of an Email/Key pair. These are directly related and the email address must be that used when you purchased the registration key. Enter the email address your ID and the corresponding key you received as the Unlock code. Hit OK and you will be registered. You may confirm your successful registration by selecting the Help | About menu item.

Help File Organization

This help file is organized into five main topics:

- **Introduction:** Which you are reading now.
- **Imaging Strategies:** This section discusses strategies for key functions and activities surrounding image acquisition. Using the tools provided in CCDAutoPilot, along with some scientifically-based recommendations, you will be able to achieve optimum results.
- **Command Summary:** This section describes all the commands available for the menu bar and the commands and settings on the individual pages that are accessed by the buttons down the left side of the main window. Hitting the F1 key will bring up the help topic for the specific page you are viewing.
- **Other Applications:** This section discusses additional included applications to assist in troubleshooting and configuring your system.
- **Troubleshooting:** Given the number of possible interactions among CCDAutoPilot, the applications it controls and the hardware these applications subsequently control, it is possible during the learning curve to run into unexpected actions and consequences. This section will help you through those unintended consequences.

Getting Started

It is recommended that you read the imaging strategies topic first. Then peruse the command summary to see how these strategies may best be implemented, given the characteristics of your specific system. It is **essential** that your other software be properly configured and at the minimum or higher version for successful operation. For successful operation, CCDAutoPilot needs to know about your imager, guider, mount. Once these settings are completed, your system **must** be initialized for successful operation.

After you are successfully imaging with CCDAutoPilot and are posting your results to your web site, you are welcome to use the little web bug, credit.gif, located in the CCDAutoPilot4 program folder. typically C:\Program Files\CCDWare\CCDAutoPilot4. And, thanks!

Overview

There is a significant amount of technology in image acquisition with CCD cameras but with an understanding of some of the underlying concepts, best use can be made of the available time. This section will hopefully provide some "getting started" concepts. As your skills and understanding develop, you may delve more into the underlying details to further optimize your data acquisition.

One of the first questions asked is how long should my sub-exposures be? This simple question can take an "urban legend" kind of answer - as long as possible, go deep, "10 minutes is what I use", etc. But there is some underlying science that can be applied to make sense of all this and determine what is best for your telescope, camera and sky conditions

Imaging is all about Signal-to-Noise-Ratio (SNR). Noise is that grainy background that we see in the faint areas of the target after our exposure is complete. There are multiple sources of noise - the camera electronics and the camera sensor (read noise) and even noise from the sky itself, in the form of sky glow. The goal is to minimize the impact of the things we can control. How we deal with these issues is a function of whether we are doing narrow band imagine (H alpha is one example, along with Sulfer II and Oxygen III) and broad band (Luminance or clear filter along with RGB typically) is another.

Broad Band imaging
With broadband imaging, the sky glow forms an appreciable illumination component. Like most light sources, there is a noise component, technically called Poisson arrival statistics, that contributes uncertainty (noise) to the value (signal) of the sky glow. Since sky glow is a uniform component of the signal, it can be effectively subtracted from the data but the noise can not. Noise sources combine like the Pythagorean theorem - the square root of the sum of the squares. So, given the noise in sky glow, we make our sub-exposures long enough so that the sky glow noise is the major noise component and overwhelms read noise. A typical strategy is to make the sub-exposure time long enough so that read noise contributes 5% of the total noise. The sub-exposure calculator provides a convenient way to measure camera gain, read noise and sky glow for popular camera sensors so that you can arrive at a suitable minimum sub-exposure time. It should be noted that the luminance component carries the resolution and color information is generally blurred so the noise in the color channels is not as important as the read noise.

Once we have a sub-exposure time determined, we can look at dark current. Every sensor has dark current, which is another signal that can be subtracted from the data but again it has a noise component that can not. Here, cooling the sensor reduces the dark current typically by one-half for every 6 degrees C. We can use a similar strategy to determine how much we want to allow the dark current to contribute to the total noise. Since dark frames are easy to come by on cloudy nights, we can set experiment with the sub-exposure calculator to determine camera operating temperature and number of dark frames we need. In many cases, a surprising camera operating temperature for a given dark noise contribution results. For example, with a KAF16803 sensor and my suburban skies, a 600 sec. sub-exposure is sufficient so that read noise contributes 2.5% to the total noise and to have the dark current contribute 0.5% to the total, I need only 6 dark frames and can run the sensor at -15 degrees C. Again, once your gain, read noise and sky glow is known, you can experiment with sub-exposure calculator settings to see the effect of cooler temperatures on the dark noise contribution and number of dark frames needed.

(It should be mentioned that there is another quasi-noise source called pattern noise. This is pixel-to-pixel differences in dark current for each sensor. Technically, this also represents noise but dithering and subsequent registration and statistical rejection combining minimizes this contribution for aesthetic imaging. The order of magnitude of this pattern noise is approximately equal to the dark signal. For precision photometry, the temperature should be reduced approximately another 7 degrees C from that calculated above to reduce the pattern noise. The number of dark frames calculated above should also be doubled.)

Narrow Band Imaging
With Ha, OII, SIII and similar narrow band filters, the sky glow is essentially negligible. Here, the noise sources are primarily read noise and secondarily dark signal noise. Read noise is relatively insensitive to temperature. Since exposure times are generally long, the number of dark frames should be calculated after inputting your exposure time and camera operating temperature. If your imaging scale is sufficient, binning can reduce the effective read noise. For example, binning 2x2 means 4 pixels are read with one read cycle. If your read noise is 10e for example, then that will be applied to 4 pixels. and your effective SNR will be increased by approximately 4.

The above discussion barely scratches the surface of SNR. Interested readers are referred to available texts on this issue.

Subsequent chapters in this topic will explore key contributors to overall data quality.

Focusing Techniques

Keeping your system in focus is, as might be expected, of critical importance in achieving high data quality. Not only does excellent focus give smallest stars and highest resolution but it also gives higher signal. So focusing and maintaining focus is very important.

Focusing Programs
There are two focusing methodologies supported in CCDAutoPilot - FocusMax and @Focus2. When properly initialized or calibrated, both will do an excellent job of achieving critical focus.

FocusMax is a free program put in the public domain by Steve Brady and Larry Weber. It supports a wide range of focusers and is widely used and respected. It works with both CCDsoft and Maxim. It requires an initial calibration routine that might take 30 minutes or so but once done, will never need to be revisited unless you change cameras or the imaging telescope's focal length, by a focal reducer for example. Consult the FocusMax help file for more details.

@Focus2 is a unique technology to Software Bisque and is incorporated in CCDSoft. It supports most popular focusers. Initial calibration requires determining the exposure time for a given magnitude star that results in a peak count of 25,000. This must be done for each filter and can take 10-15 minutes or so for 5 filters. Once done, it will not need changing unless the camera of imaging telescope's focal length is changed. Consult the CCDSoft help file for more information.

The Problem
For each optical system, focusing must be maintained within the Critical Focus Zone (CFZ). This may be considered as the best focus, limited to the wavelength of the incoming light and the size of the AIry disk, which is primarily a function of the imaging telescope's aperture. Even assuming an accurate initial focus, the focus can change over the course of the imaging run due to a number of sources.

- **Filters:** Different filters may have different optical thicknesses, resulting in a change in focus as different filters are used. Even parfocal filters, filters which have the same optical thickness, may not result in the same focus point if the imaging telescope has significant refractive elements. The best corrected APO refractors will still show a focus difference between red and blue filters for example. Reflective telescopes typically do not show this problem.
- **Temperature:** Aluminum is a component in most telescopes and is subject to contraction as temperature decreases. This usually results in a focus change, unless mechanically compensated. And some lower cost telescopes might have optical elements made from non-zero temperature coefficient glass, leading to a potential change in focus.
- **Mirror Flop:** This is an issue primarily with lower cost SCT's, where the mirror moves due to change in OTA attitude. This issue may also be exacerbated by the meridian crossing "flip" with an equatorial mount. In flipping from east to west, the OTA effectively rotates by 180 degrees!

Solutions
From the above it is clear that there is a need to focus during the course of the evening. CCDAutoPilot provides a number of techniques to focus and has the ability to characterize your system. You can characterize your system during moon time by a couple of techniques.

Filter Effect: Set up a session that takes a single short exposure through each filter. Each series should have a Focus At Series Start and use a different filter. Use 5-7 sets. Set up SkyStar focusing with Center Focus Star checked to insure you focus close to the center of the optical field. At the completion of the session, examine the session log and note the focus positions for each filter. Use the clear or luminance filter as a reference and determine the filter offsets, plus or minus, from that reference position for each filter. If the difference is within the CFZ (Use the calculator in the left pane of the focus page to determine CFZ), then you can use the same filter for focusing. Because a color filter has a narrower band pass than a clear filter, you will probably get a more precise focus. Green is suggested as a mid-band filter range. Even if there are significant offsets, you can program in those offsets on the Focus page so that they will be added or subtracted as necessary to achieve excellent focus.

Temperature Effect: This will probably take a full evening's run again during moon time. You will need a method of recording temperature over the evening. CCDAutoPilot can acquire temperature from a number of sources. Set up a number of focus stars that will be within 20 - 30 degrees of the meridian over the course of the evening. (This requires the Professional edition, since each focus star is a target. For the basic edition, you will have to set up individual sessions.) Unless you know you don't have a mirror flop issue, you should keep to one side of the meridian. Set up SkyStar with Center Focus Star checked. Do 5 series of a short exposure with the same filter. At the conclusion of the evening's run, you can assess how much focus changes with temperature and how much temperature change causes you to exceed the CFZ. You can then program CCDAutoPilot to focus on a temperature change that corresponds to 1/3 of the CFZ for example.

Mirror Flop: Set up a number of series with the same filter and select focus at series start. Choose a suitable value for the number of sets to insure the imaging time carries through a meridian flip. Select Focus At Star Center with Center Focus Star checked. For meridian flip settings, check Focus On Flip as an additional data point. At the end of the session, examine the log to see how much the focus point changes across the meridian flip. If you see a significant change, be sure to always use the focus after meridian flip option.

Unknowns: The above covers what we know but other things can happen that we don't know about. For example, a passing cloud

can obscure the focus star and you may get a bad focus reference. Periodic focusing, focus at series start even with focus offsets set up, can help catch and correct for those events. See the Focusing topic in the Command Summary for details on the many focusing tools provided in CCDAutoPilot.

Guiding & Tracking Techniques

Guided Imaging

Long exposures generally consist of a number of shorter sub-exposures and because of that, the telescope must be kept accurately pointing to the target during the course of the sub-exposures. A very precise mount may be able to track accurately enough for the sub-exposure duration but most do not. That is where guided imaging comes in. A guide star is selected and its centroid calculated with every exposure. As the centroid moves from the starting position, commands are sent to the telescope to bring the centroid back to its original position. However, the guiding routine is always acting after the error has occurred so there is an inherent delay in this correction. By the time the correction has been sent to the telescope has been sent, there might be a different and even opposite correction required. A number of guide parameters can be adjusted to minimize this effect.

However, recall the discussion about pattern noise. That can be minimized by dithering (intentionally moving the guide star position between sub-exposures). When the resultant sub-exposures are aligned, any pattern noise will not be reinforced by alignment but sky details will. If a subsequent statistical combining method is applied to the aligned, dithered images, the pattern noise will be greatly reduced. Of course dithering must be such that the same location is not duplicated and CCDAutoPilot provides such a capability with its Enhanced Dithering option.

There are a number of parameters that must be properly set to achieve successful guiding.

- **Minimum Move Time:** This is the time (or movement) that must be exceeded by the guiding algorithm to cause the telescope to move. This must be set to avoid "chasing the seeing" and causing frequent but unnecessary movement of the telescope. In other words, set this value so that only those corrections that will impact the image will be sent to the telescope.
- **Maximum Move Time:** This is the maximum time (or movement) that will be sent by the guiding algorithm to the telescope. It must be set high enough to have a reasonable correction response time but not so long that an occasional cosmic ray or other effect can cause the telescope to move too far so that it has to come back on the next correction.
- **Aggressiveness:** This is a measure of how much of the calculated correction is actually sent to the telescope. At first blush, one might be tempted to send the complete correction but recall there is a lag from the time the error is calculated until the telescope is moved. So my sending less than 100% of the correction, the tendency to overshoot is minimized. On the other hand, setting it too low may mean the telescope never catches up to the starting guide star position.
- **Guide Exposure:** During the guide star exposure, the guide star position is essentially being averaged for the duration of the guide exposure. If the guide exposure is set too short, the telescope won't have time to respond, there will always be a lag and we will be chasing the seeing again. Set it too long and the corrections will be delayed too much to properly correct for mount tracking and elongated stars will result. On the other hand, the guide exposure has to be long enough to get an adequate SNR for the guide routine to be able to accurately calculate the star's centroid. (Note: there is a type of guiding called AO for Adaptive Optics, in which a mirror or piece of glass is moved. As such it can be moved more quickly due to its lower mass, compared to a telescope. In this case, shorter exposures are desirable since the lag is greatly reduced because of this lower mass.)
- **Dithering:** How much dithering is enough? Too little and the pattern noise will not be shifted enough from frame to frame so that it won't be removed in stacking; too much and the guider will spend a lot of time recovering from the dither, reducing data gathering efficiency.
- **Guide Star Selection Algorithm:** Normally for guided imaging, you want the brightest guide star you can find for best guiding performance. With narrow field imaging and guiding, getting a sufficiently bright guide star is generally a challenge. However, when using a wide-field guide scope, you may accidentally find a guide star in the FOV that is too bright (saturated). As you might expect, guiding accuracy is impacted if this saturated star, being the brightest in the FOV, were chosen to guide on. CCDAutoPilot will reject any guide star whose peak value exceeds 55,000 ADU to avoid this problem. It will choose a star whose peak value is less than 55,000 ADU automatically.

CCDAutoPilot has tools to enable efficient starting point settings for these variables. The Guide Calculator on the Tools page suggests minimum and maximum moves. The Suggest button on the Tracking & Guiding page recommends a Maximum Dither that is appropriate for your system, based on your entries in the Settings page. For non-AO operation, I suggest a minimum guide exposure of 3 sec. The maximum guide exposure depends on how well your mount tracks. Longer gives more averaging of the guide star's position. There is an Auto Guide Exposure facility that allows you to set the minimum and maximum guide exposure so that your Target Guide ADU can be achieved by automatically setting the guide exposure between those two limits.

Finally, CCDAutoPilot has a number of recovery options in case the guide star is temporarily lost. See the Tracking & Guiding topic for more details.

Guiding with Adaptive Optics (AO)

AO guiding consists of using an additional optical element, either a mirror or a piece of glass, in the optical path. This element is driven to correct for positional errors in the guide star due to seeing (to a first order), mount and other sources of error. Instead of moving the entire telescope, as is the case with conventional guiding, only the optical element, which is a much lower mass than the mount is moved. This has the benefit of being able to move much faster than is possible with a mount and can correct for some seeing issues.

The optical element has limited travel and at some point, it will run out of range. This limitation is resolved by moving the mount when the AO gets near its maximum movement. This is causes "bumping" the mount. The mount is moved while the AO is guiding so the AO effectively corrects for any disturbance induced by the mount bumping.

There are therefore two calibrations that are required - mount bumping and AO. AO calibration is done once (manually) and mount bumping normally has to be done at every sky location. CCDAutoPilot will properly provide the calibration for mount bumping once initialized. Thus, all you need to do is calibrate the AO using your camera control program, initialize CCDAutoPilot and you won't ever have to worry about any calibration for your AO system unless you change something in your physical camera arrangement.

Unguided Imaging

If a mount tracks well enough for a sub-exposure duration, then unguided imaging is a much simpler operation. Of course, one should dither for the same reasons one dithers with guided imaging.to mitigate pattern noise. However, even the best mounts will slowly drift off target over a time if a substantial number of sub-exposures are taken. CCDAutoPilot has the ability to correct pointing to the target periodically. Use the Realign scope every xx minutes feature. Set xx to whatever value you find you need. 30 minutes might be a good starting point.

Meridian Crossing with a German Equatorial Mount

For best quality imaging, it is always desirable to collect data through the least amount of atmosphere and this means around the meridian. Unfortunately most German equatorial mounts (GEM) can't track indefinitely through the meridian. CCDAutoPilot provides automatic meridian crossing detection and supports a number of setup options to maximize imaging near and through the meridian so that as little time is lost as possible.

Target Selection

If you are imaging a single target per night, it is best to time your data so that important data occurs near the meridian since you look through the lowest air mass and atmospheric stability will have the least impact on resolution. One way to assess seeing, the stability of the atmosphere is to visually look at stars from the zenith to lower in altitude. If you have a reasonably good night, you will see minimal twinkling at the zenith but as you go lower in altitude, the twinkling will begin to appear. A good night might show twinkling at 45° or so. If you see twinkling at the zenith, you have a poor night and that might make a good night for acquiring binned data.

Multiple Targets

One way to minimize atmospherics is to take multiple targets with differing transit times over multiple nights. Using this approach, you can time each target's data to be close to the meridian crossing. Of course, this requires a reasonable run of clear nights and may not be appropriate for all locations.

Target Location

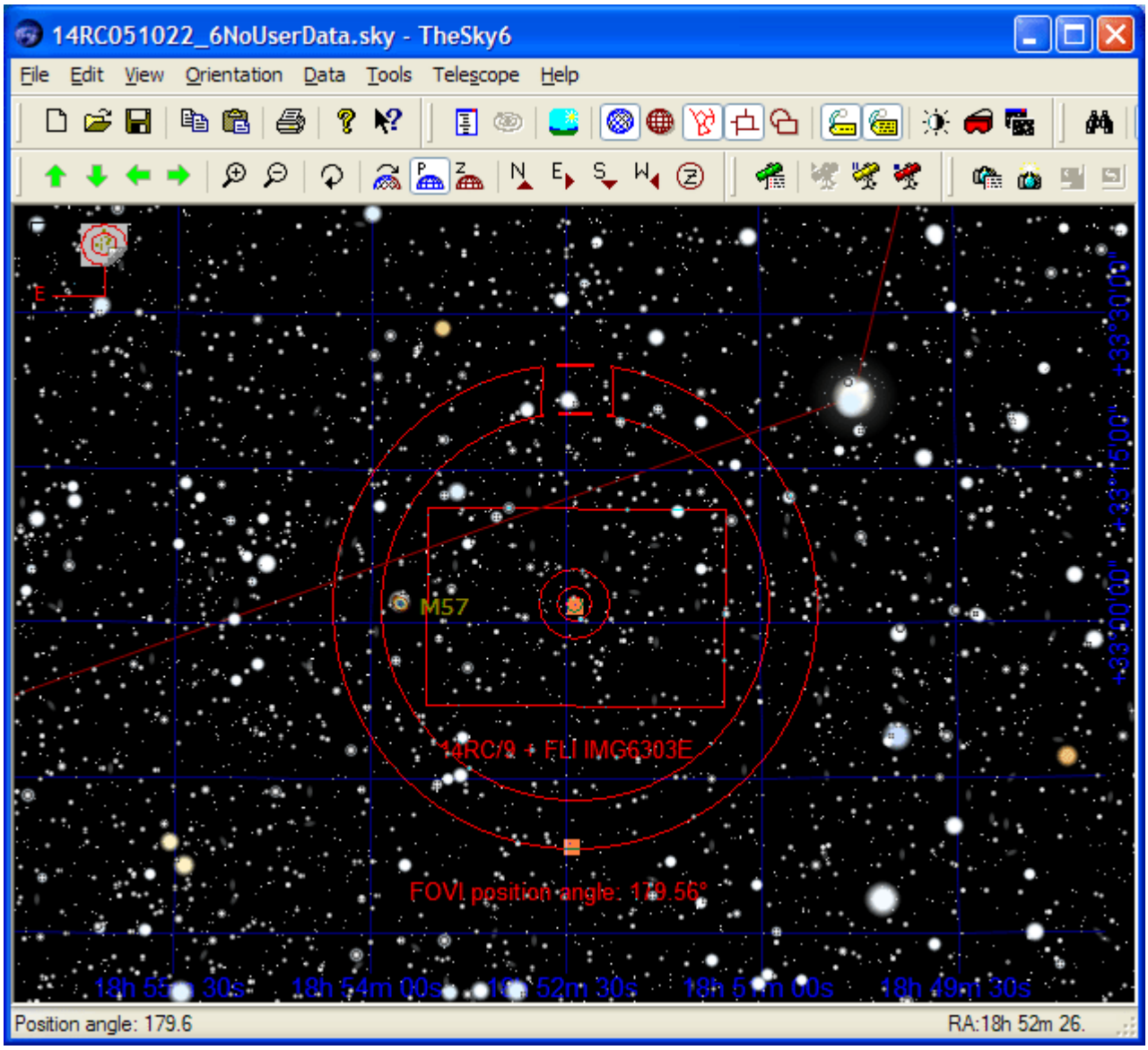
Ultimately, target location has to consist of Right Ascension (RA), Declination (Dec) and Position Angle (PA). This defines a position in the sky and a rotation of the camera. RA and Dec are to be given in J2000 equinox data for consistency. Any precession to the current equinox is handled by CCDAutoPilot. Once the target coordinates are defined, they can be entered into CCDAutoPilot via a number of techniques. See the Targets page command summary for details.

If you have TheSky6, a nice way to enter target coordinates is via the Field of View Indicator (FOVI). Here are the steps to do that.

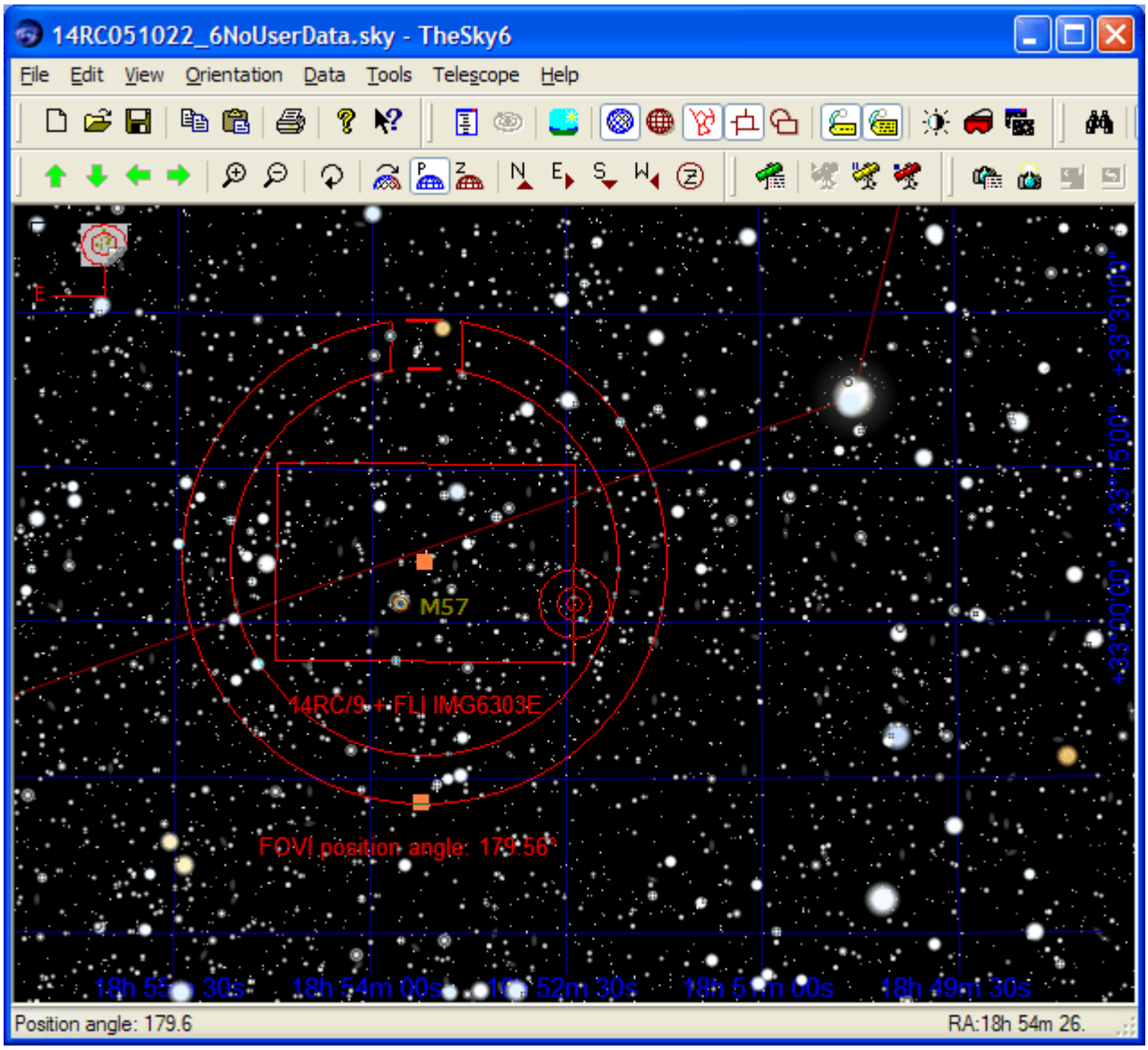
Target Selection via TheSky6

By combining the power of CCDAutoPilot and TheSky6, target planning an acquisition becomes immensely easier. No more image links or plate solving or trial and error. All that is required is TheSky6 and an accurate Field Of View Indicator (FOVI). All that is needed is to orient the FOVI appropriate to your situation and use a precision slew to target as part of your session. The coordinates will be precisely arrived at by the mount and, if you have a rotator, it will rotate to the appropriate position angle (PA) automatically. Here is an example.

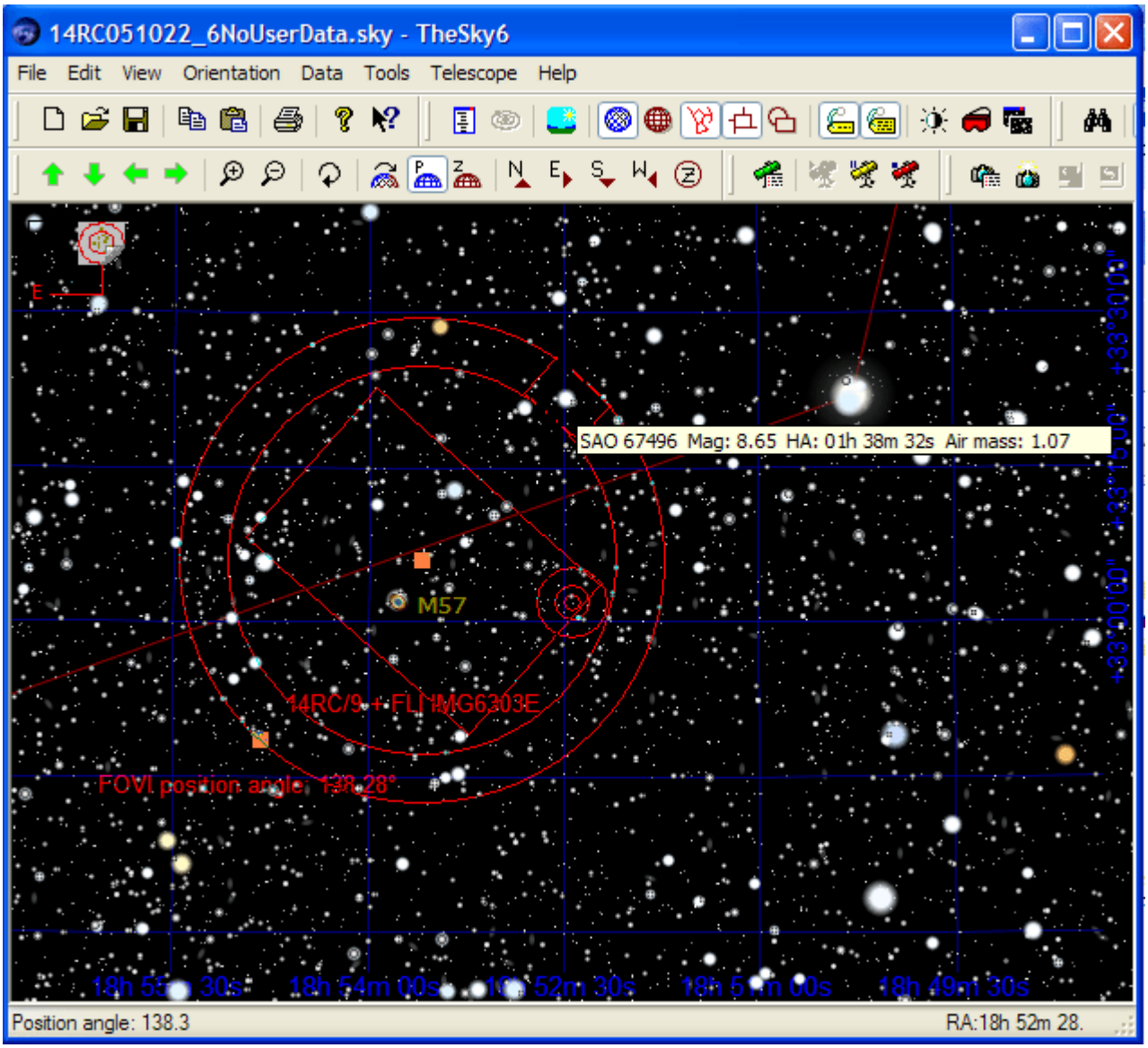
Assume you want to image M57. Here is what you might see in TheSky6



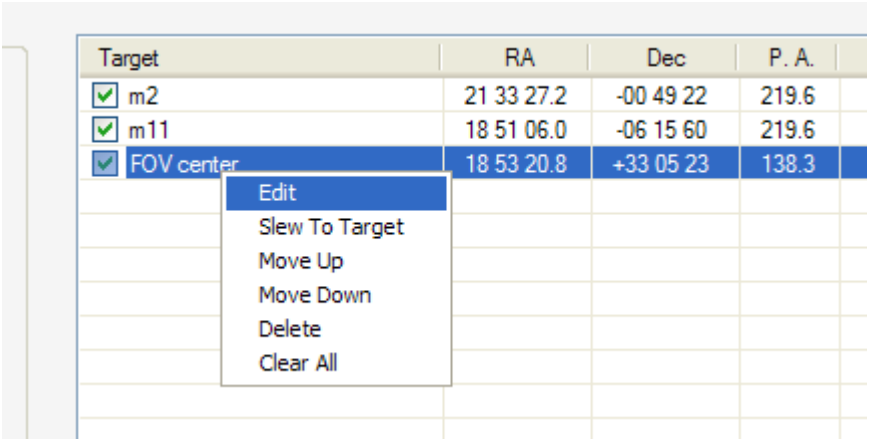
M57 is located to the left of the imager FOVI. The guider FOVI is at 12 o'clock and happens to be positioned over a suitable guide star but that is of no help. Note the two squares that are part of the FOVI. Clicking and dragging on the center one translates the FOVI; clicking and dragging the lower one in a circle rotates the FOVI. First I will translate the FOVI to a position that includes M57 and a guide star is somewhere between the two circles.



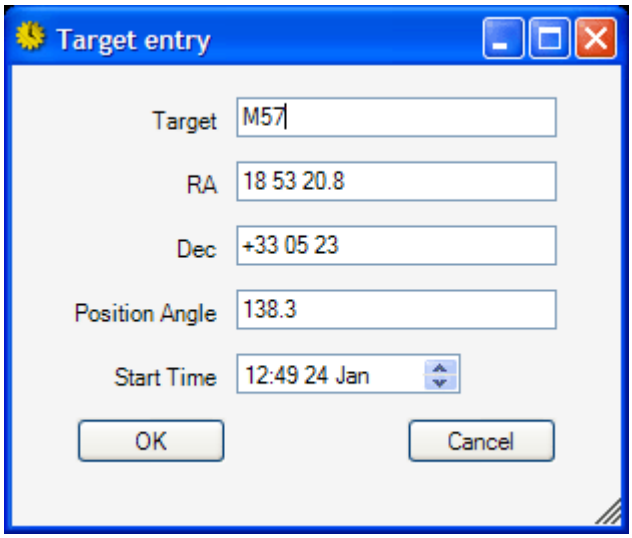
I have moved the FOVI off-center and there is a suitable guide star at the 1 o'clock position.



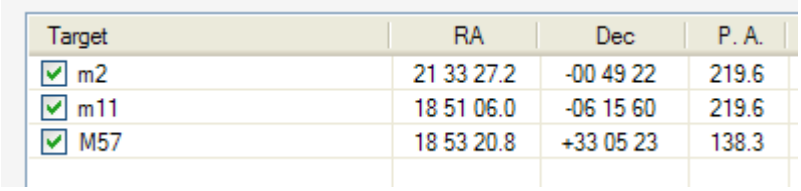
The guider FOVI now includes the guide star. TheSky6 indicates a position angle of 138.3. By hovering the cursor over the guide star, I see information about the magnitude of the guide star. This guide star is more than suitable for this image. The next step is to use this information as a target for CCDAutoPilot. With CCDAutoPIlot connected to TheSky6, all that is required is to hit the Get button on the Targets page with no entry in the field. The RA and Dec of the center of the FOVI and it's position angle will be automatically transferred to the Targets List as shown below.



Note the coordinate information is now in the Target list with the non-unique name "FOV Center". By right-clicking on FOV Center, I can then select the edit menu to change the name to something more descriptive, like M57!



I have entered M57 for the target name. After hitting OK, the target list looks like this:



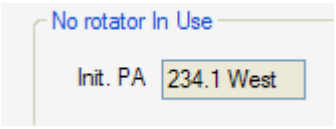
Target	RA	Dec	P. A.
m2	21 33 27.2	-00 49 22	219.6
m11	18 51 06.0	-06 15 60	219.6
M57	18 53 20.8	+33 05 23	138.3

I have now completely described the position of the target for CCDAutoPilot. When this target is selected for running, the telescope will slew to the target, rotate the rotator as needed to match the PA of 138.3, plate solve and adjust the telescope pointing so that it is within a few arc-sec. of the desired target. Since guider calibration is no longer necessary with the automatic calibration algorithm of CCDAutoPilot, guided imaging can now begin at this location.

This same technique can be repeated as many times as required for an evening's imaging session. You do not need to be connected to the actual telescope or camera hardware, just be connected to TheSky6. You can plan an entire evening's imaging away from the telescope and, when you are later connected to your telescope and camera, focuser and rotator if used, begin imaging. You can be sure imaging will proceed as planned.

For those without a rotator...

You can use much of the same technique described above but with some modification. If you do not have a rotator connected, and have initialized your system, you will find this entry in the "No Rotator In Use" box:



When you move the FOVI as described above, and assuming the value shown above for Init. PA, you will need to insure your FOVI PA is 234.1 if the target is on the same side of the meridian as that indicated in Init. PA and 234.1 - 180 or 54.1 if the target is on a side of the meridian different from that indicated in Init. PA. Of course, if you can not get a suitable guide star in the guider FOV, you will need to physically rotate your camera and then Initialize. Initializing will of course give better guider calibration than conventional calibration.

Light Frames

Light frames are the main goal of everything we are doing - this is our "data". Assuming color data is desired, we need to take data through appropriate filters if using a monochrome camera, make sure focus is maintained for each filter, be aware of the differing atmospheric extinction for each filter and properly combine the color data appropriately for the given filters and sensor quantum efficiency. CCDAutoPilot can help with all of these requirements but you must make some tactical decisions. One of the first is whether to use StairStep or Shuffle for image acquisition

Stairstep Acquisition

Here you acquire data that is least impacted by atmospheric extinction at lower altitudes and that which is more impacted at higher altitudes. Red and Green data is least impacted (that is why the setting sun is yellow) and Blue and Luminance is most impacted. In a typical LRGB imaging approach, the L data provides the resolution information and the RGB provides the color information. Using the letters R, G, B, L to represent the color or clear frames, stairstep acquisition would be something like:

RRR GGG BBB LLLLLLLLL BBB GGG RRR

The goal would be to center the L frames on the meridian crossing to optimize the critical luminance data. If the meridian crossing does not occur in the middle of your available dark time, you could do something like this:

BBB LLLLLLLLLLLLL BBB GGGGGG RRRRRR

One disadvantage of stairstep is of clouds roll in at some point in the evening, you might not have a complete data set from which to assemble the data. The advantage is you have an optimally acquired data set by minimizing the effect of the atmosphere as much as possible.

Shuffle Acquisition

Here, the data is acquired sequentially so that you always have enough data to assemble an image. It would look like this:

LRGB LRGB LRGB LRGB etc.

Here you have data after the first set and the longer you go, the more data, and presumably the better SNR you get. The disadvantage here is that your critical L data is at varying altitudes and therefore subject to varying atmospheric effects due to seeing and air mass. A secondary consideration is that when you determine your RGB combine ratios, the RGB data was taken at varying altitudes so atmospheric extinction correction becomes tedious.

Color Combine Ratio

Assuming you have an accurate color combine ratio measurement for your OTA/Filters/Camera, you will need to correct your data for atmospheric extinction impact on each data frame. CCDAutoPilot, Professional Edition (only), keeps track of each color frame's altitude for you. If you have previously obtained your color combine ratio either automatically via CCDAutoPilot or manually enter it,CCDAutoPilot will provide the extinction corrected color combine ratio for each target, whether you used Stairstep or Shuffle Acquisition.

Calibration Frames

Calibration frames consist of dark, bias and flat frames that are used to remove various sensor and OTA defects from the data. The better job we do with calibration, the better our data is and the more we can stretch it in post-processing to reveal faint details. First, some definitions of the calibration frames:

- **Dark:** This is a frame that is exposed *with the shutter closed* for the same duration and at the same camera temperature as the light frame to which it will be applied. Needless to say, this also means for the same camera.
- **Bias:** This is a frame that is exposed *with the shutter closed* at the same temperature as any light frames to which it will be applied. The exposure duration is 0 sec. Thus a Bias frame is a 0 sec. dark frame.
- **Flat:** This is a light frame that is exposed to capture the pixel-to-pixel sensitivity variation for a given sensor and the overall light fall-off of the OTA. It must be taken at a low enough signal level to insure linear operation.

Usage

Dark frames are **subtracted** from the light frames. This subtraction removes pattern noise, a fixed artifact of a given sensor and dark signal, a false signal that increases linearly with exposure time. To avoid adding noise to the data, an appropriate number of dark frames must be combined to make a master dark frame. This typically reduced the noise by the square root of the number of frames being combined. Based on the sensor, the camera operating temperature and exposure duration, it is possible to calculate the number of darks to be combined to reach a desired noise contribution as a percentage of total noise. CCDAutoPilot provides such a calculator.

Bias frames are handled like dark frames - they are **subtracted** from the light frame we are trying to correct. If exposure times are short enough, time-matched dark frames are not required for correction since little dark signal will accrue. Thus for short exposures, a zero-time-exposure dark frame, i.e. a bias frame, can be subtracted to remove pattern noise from the short-exposure light frame. The principal noise component of a bias frame is read noise. The noise contribution from read noise is reduced by the square root of the number of frames being combined.

Flat frames are **divided into** the light frames. Note that they are not subtracted. Mathematically, if S is the signal, F represents the loss/change in going through the sensor and OTA and L is the resultant acquired light frame, then L = F * S. since what we want is the unmodified signal S, then S = L/F. That is why the flat frame is divided into the light frame. Noise from this division behaves differently than subtraction. Noise from division combines as the reciprocal as the sum of the reciprocals. (For electrical engineers, this is like resistors in parallel.) An example may make this more clear.

Let's assume we have a camera with a gain (g) of 1.4 and have exposed a number of flats to a level of 20,000 ADU. Each flat will have a signal of 1.4 * 20,000 or 28,000e. The SNR of such a flat is the square root of the signal, 28,000 in this case, or 167. Now, let's assume we have a light frame that has a faint area SNR of 3, generally considered a minimum level of SNR for a very faint region. 1/167 + 1/3 = 0.339. 1/0.339 = 2.95. Thus, our original faint area SNR was very minimally degraded - in fact one would be hard-pressed to measure the degradation! If we combine 4 flats, we get a SNR of 334. The resultant impact on our faint area SNR is to reduce it to 2.97. Where flat SNR becomes important is on high SNR areas, areas of bright signal. Assume we have a galaxy core that is 8000 ADU. Its SNR, using the above discussion, is 106. Our 4 flats would reduce this SNR to 80. This is a more significant issue but may or may not impact the appearance of the resultant processed image.

One occasionally hears you need "a million electrons" of flats. Lets see what that means. In the above flat example, this would correspond to 1,000,000/28,000 or 36 flats. Properly combined, our master flat would have an SNR of 167*6 or 1000. The impact on our faint area SNR is 2.99 and our galaxy core is 95.8. Clearly more flats are better but how much is enough? That is left to you to determine. I suspect for aesthetic imaging, 4 flats is more than sufficient but for scientific purposes, i.e. milli-mag photometry, more are required.

Acquisition

A "suitable number" of dark and bias frames may be taken at any time, assuming the ambient light level is low enough. Typical CCD cameras are very sensitive and not very light-tight so if care is not taken, the dark frames might have a gradient from light leakage.

Flat frame acquisition is a subject of much debate, discussion and opinion, which is beyond the scope of this discussion. There are basically two types of flats - sky flats and artificial flats.

Sky flats are taken at twilight with the telescope pointing to a specific area in the sky that has a minimum light gradient. The gradient is a function of the FOV of the imaging system, the larger the FOV, the larger the gradient. Also, during twilight, the sky brightness is constantly changing so exposure times must be adjusted to maintain a desired signal level. Lastly, since there is a limited amount of twilight available, both the number of flats and the filter sequence must be optimized to get the needed flats. Further, if you use a rotator to acquire data on both sides of the meridian, you need to determine whether your OTA's light fall-off or vignetting is sufficiently symmetrical after rotation or not. If not, you'll need to take flats at both rotations, i.e. PA's. The number

of flats is generally limited by exposure and download times as well. So there is a lot that needs to be considered. While experimentation on the number of flats that can be acquired during twilight is required, all of the other considerations are provided automatically by CCDAutoPilot.

Artificial flats are taken with the telescope pointing to a uniformly illuminated light source. The design and performance of such an artificial source is challenging. Such flats can be taken at the end of the evening while the environment is still dark. Here there is less of a limitation on the number of flats to be acquired since the light source can be on as long as necessary.

References

For more details, background and analyses, the interested reader may want to review my papers on various image acquisition topics.

Data Organization

A large number of files can be expected over the course of an evening's imaging session. In addition to your light frames, you will have flat frames and most likely dark and bias frames. CCDAutoPilot has a set of file and folder naming conventions that can serve as a good default. You always can of course choose your own names and structures by suitable entry in the description fields for light frames, dark and bias frames and flat fields.

Default File Names

Default file names were chosen to allow easy data sorting and identification from Windows explorer. Dates are added to dark and bias frame file names to facilitate dark library aging. Filter names and position angles are added to file names so that flats can be appropriately matched to the light frames. If using Maxim version 5, a readout mode index is added to the file name. If no entry is made in the description fields for Light, Dark & Bias and Flat frames, the default file names will be:

Light: <Filter>R<readout index>_<PA>_<Target>_<serial number>.fit
Dark: <temp>DarkR<readout index>_<Time><Binning>_<yyMMdd>_serial number.fit
Bias: <temp>BiasR<readout index>_<Binning>_<yyMMdd>_serial number>.fit
Flat: <Filter>FlatR<readout index> _<PA>_<Target>_<serial number>.fit

<Filter> is the name of the filter used for the exposure
<readout index> is the index shown for the selected readout mode. This entry will be present only with Maxim version 5
<PA> is the position angle and side-of-meridian used for the exposure
<Target> is the target name from the target page
<serial number> is a simple sequential number.
<temp> is the sensor operating temperature.
<Time> is the exposure time in sec.
<Binning> is the binning used, !x1, 2x2, etc.
<yyMMdd> is the year, month, day of the exposure, e.g. Jun 20, 2008 would be 080620

Some examples with Maxim version 5:

RedR1_236W_M63_00123.fit
This is a light frame taken of M63 at a PA of 236° west of the meridian with serial number 00123. Readout index 1, corresponding to an Apogee camera's monochrome (preflash) mode, is used.

-15BiasR0_1X1_080620_00124.fit
This is a bias frame taken June 20, 2008 with a camera temperature of -15°C with serial number 00124. Readout index 0, corresponding to an Apogee camera's monochrome mode, is used.

-15DarkR1_1200s1x1_080620_00125.fit
This is a dark frame taken June 20, 2008 with a camera temperature of -15°C with serial number 00125. Readout index 1, corresponding to an Apogee camera's monochrome (preflash) mode, is used.

Red_FlatR0_236_PA West_M63_00126.fit
This is a flat frame taken at an equivalent PA of 236° west of the meridian when M63 was the last target with a serial number of 00126. Readout index 0, corresponding to an Apogee camera's monochrome mode, is used.

And with CCDSoft or Maxim version 4:

Red236W_M63_00123.fit
This is a light frame taken of M63 at a PA of 236° west of the meridian with serial number 00123.

-15Bias1X1_080620_00124.fit
This is a bias frame taken June 20, 2008 with a camera temperature of -15°C with serial number 00124.

-15Dark1200s1x1_080620_00125.fit
This is a dark frame taken June 20, 2008 with a camera temperature of -15°C with serial number 00125

Red_Flat236_PA West_M63_00126.fit
This is a flat frame taken at an equivalent PA of 236° west of the meridian when M63 was the last target with a serial number of 00126.

If Atuo-Generate Folders is checked in CCDAutoPilot's Options page, then appropriate folders will be generated off the specified Images Folder. for example, if C:\Astronomy is the specified images folder then light frames for June 20, 2008 will go into: C:\Astronomy\080620\ and dark, bias and flat frames will go into C:\Astronomy\080620_CalibrationFrames\. Additionally, any log files will go into C:\Astronomy\CCDAutoPilot_Logs\ and any unsolved sync images will go into C:\Astronomy\CCDAutoPilot_SyncImages\.

If AutoGenerate Folders is not checked, then all files and logs will go into C:\Astronomy\.

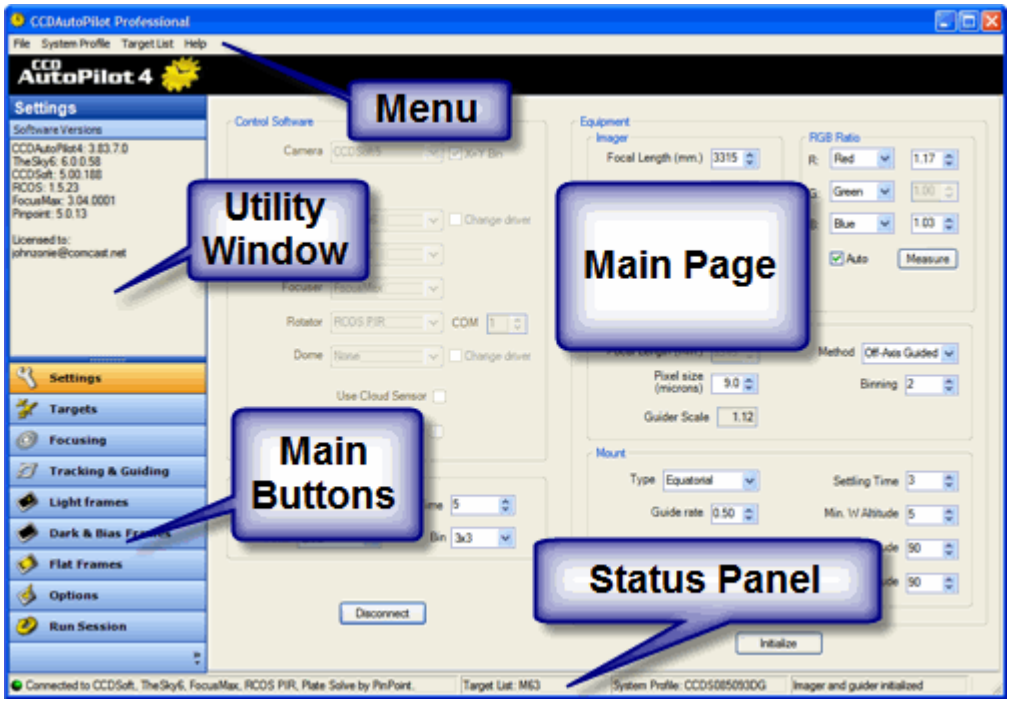
Customized names

You can generate your own names by filling out the appropriate description field for each exposure series. You can even generate your own folders by having the first characters indicate a folder name followed by "\". Assume the description field is "John\Clear1x1" and the target name is M63. The resultant file name will be Clear1x1_M63_00123.fit, located in a sub-folder, John, of the specified Images folder. Assuming the Images Folder is specified as C:\Astronomy, then the completely qualified file name is:
C:\Astronomy\John\Clear1x1_M63_00123.fit

You can see what the resultant name will look like by using the Review Session button on the Run Session page with Details checked.

Overview

CCDAutoPilot's user friendly interface is continued and enhanced in version 4. This overview will give the general organization of the interface. The rest of the command summary will give details for each command by page or menu. Here is a view of the opening window.



There are a number of aids to operation. With most settings, hovering the mouse over a given control (checkbox, entry field, button, etc.) will give some tips on its use and application. From any page, hitting F1 on the keyboard will bring up the command summary help file topic for that page. Where a given field entry might be long (status panel at the bottom of the window, paths, command files, etc., hovering the mouse will show the full field. Items that are grayed out are not usable. Hovering the mouse over many of the controls will display a "tool tip" giving some hints on that control's use. It takes around a half-second with the mouse till for the tool tip to appear.

The main buttons at the lower left bring up the corresponding main page and utility window. There is a status panel at the bottom of the main page that has four panes. The first shows the connection status, the second the target list in use, the third the system profile in use and the fourth shows status of any activity initiated from the user interface.

CCDAutoPilot uses three key files, the system profile, the target list and the Control File.

System Profile

The system profile represents the settings you would use from night to night for consistent operation of your imaging system. This includes not only all the settings on all the pages but includes the selected control programs on the settings page. You can have multiple system profiles if you have multiple camera/OTA systems. The system profiles end in .ap4 and are registered to Windows. Double-clicking on a system profile will start CCDAutoPilot with that system profile loaded. Any control programs that are not loaded will be started.

Target List

The target list represents your chosen target(s) and would most likely change from night to night. The target list stores the coordinates, start and end times for the targets (only one in CCDAutoPilot Basic), along with the related light frames from the Lights Page, dark and bias frames from the Dark & Bias Frames page and flat frames from the Flat Frames page. The target list may be generated during the day using CCDAutoPilot's planning feature for execution at a later time. A target list must have at least one target to take any light frames.

Control File *(Professional Edition Feature)*

The control file provides external control and configuration of CCDAutoPilot. By use of the Control File Editor, various notification configurations can be defined. An external program can write to the control file to control session execution, notifications and other CCDAutoPilot activities. See the Control File Editor topic for details.

Menu

The menu structure is at the top of the main window and is shown below.

File

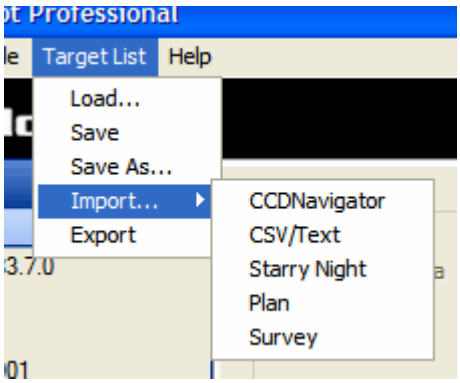
- **Preferences:** Brings up the Preferences page. See here for detailed information.
- **Tools:** Brings up the Tools page. See here for detailed information.
- **Exit:** Closes CCDAutoPilot

System Profile

The menu commands for system profiles are:

- **New:** This selection unloads the existing system profile and replaces it with a new default one. All settings will need to be reentered again.
- **Load:** This selection opens a file window allowing you to navigate to a particular location to load another system profile. The loaded system profile will replace the one currently in use. If CCDAutoPIlot is connected, it will be disconnected so that the newly loaded system profile may be used.
- **Save:** This selection saves any changes you may have made to the currently defined system profile, overwriting the selected profile.
- **Save As:** This selection opens a file window allowing you to navigate to a particular location and save the current state of CCDAutoPilot to another profile name. The extension ".ap4" will be automatically added to the file name when OK is hit.

Target List

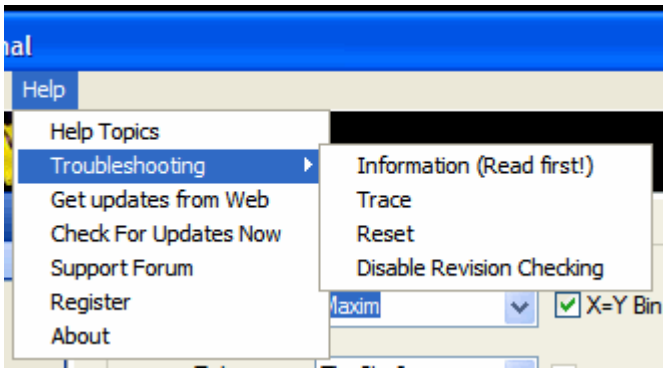


- **Load:** This selection opens a file window allowing you to navigate to a particular location to load another target list. The loaded target list will replace the one currently in use.
- **Save:** This selection saves any changes you have made to the Targets page, the Light Frames page, the Darks & Bias page and the Flat Frames page to the currently defined target list.
- **Save As:** This selection opens a file window allowing you to navigate to a particular location and save the current target list to another name. The extension ."xml" will be automatically added to the file name when OK is hit.
- **Import:** This selection offers a number of imports to assist the user that may have other target lists, plans and schedules in different formats or from other programs. Target lists can be imported from CCDNavigator, from a text file and from such programs as Starry Night, ACP Planner and ACP. Thus a user can bring his desired targets from these sources into CCDAutoPilot and still take advantage of the flexibility and features offered in CCDAutoPilot. See the Targets topic in the Command Summary section for more details.
- **Export:** Exports the current target list coordinates only, RA, Dec. and PA to a text file.

Note: For text file import and export, the delimiter between elements of the target list changes, depending on the region's decimal character. If the decimal character is '.', then the delimiter is a ','. If the decimal character is ',', then the delimiter is a tab character

Help

Extensive help tools and information are provided to provide support and troubleshooting.



- **Help Topics:** Accesses the CCDAutoPilot Help System.
- **Troubleshooting**: Accesses Troubleshooting information, Trace and Reset tools. See the Troubleshooting Overview topic for details.
- **Get Updates from Web:** When checked, CCDAutoPilot will check each time CCDAutoPilot is started to see if there are any updates available. If there are, they will be automatically downloaded and installed. This feature may be disabled by clearing the check mark next to the menu item. If it is checked, it will be updated on the next day CCDAutoPilot is loaded. See the Updates topic
- **Check For Updates Now:** Forces an immediate update check. See the Updates topic
- **Upgrade to Professional Edition:** Provides a link to purchase the Professional Edition upgrade
- **About:** Brings up the version number and user licensing information window.

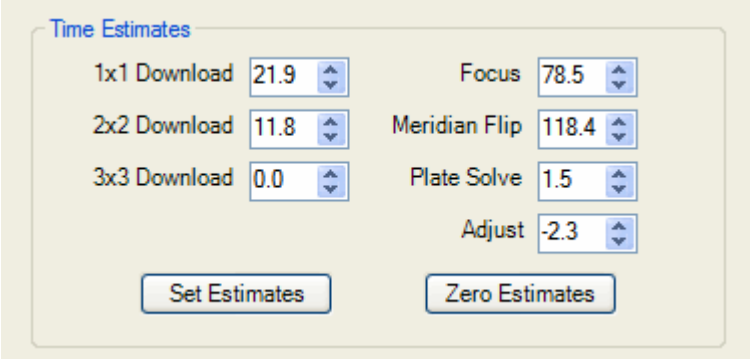
Preferences

The preference page allows setting infrequently changed settings.

Contents

Time Estimates
PinPoint Settings
Sky Flat Settings
Email Settings (CCDAutoPilot Professional Feature)
FITS Keywords
Optec Rotator
Dome
Cloud Sensor
Control File (CCDAutoPilot Professional Feature)
Flip-Flat

Time Estimates

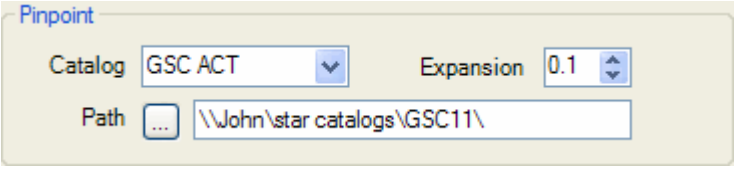


A key aspect of planning is the estimation of various event timings that occur during the course of an imaging session. These events are shown above. One can either enter estimates or let CCDAutoPilot develop them using its internal learning algorithm. The more sessions are run, the more accurate the estimates become. At the end of each run, the actual event history is compared with the estimates and the values are adjusted. Any differences are shown in the adjust box. As additional sessions are run, the magnitude of this adjust box decreases. When a run estimation is made, these event times are used to make the session estimated times more accurate.

The user can use the Zero Estimates button to reset all estimates to 0 and start the learning process again from scratch. The set estimates can be used to enter an estimate where none exists or to enter a revised value. In the above screen capture, the 3x3 download time is 0 because none have been taken. One could enter a reasonable 7 sec., based on the 1x1 and 2x2 download time if 3x3 binning were planned. Hit Set Estimates and that 7 sec. estimate would be refined in future sessions.

In general, these settings are best made automatically.

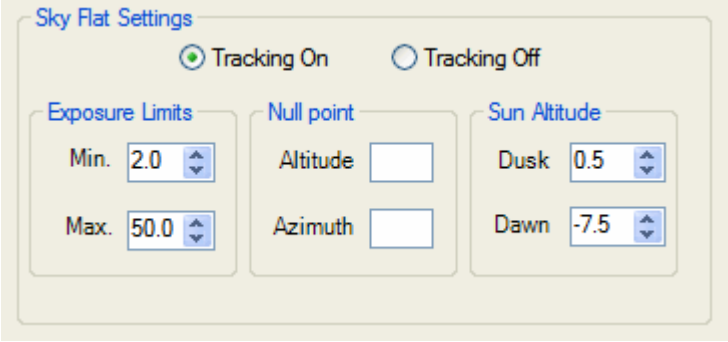
PinPoint Settings



In order for PinPoint to successfully plate solve, the catalog type, Expansion and Path to the catalog must be properly entered. Depending on your catalog used, select the Catalog and use the path button to navigate to the corresponding location of that catalog. Expansion should be left at 0.0, unless your telescope pointing is considerably off and/or your FV is small. In that case, increasing the Expansion to higher values will increase the search radius at the expense of increased plate solve time.

Note that you can **not** use the stellar catalogs from TheSky for PinPoint. TheSky's stellar catalogs are compiled in a proprietary manner for performance reasons. You need to obtain standard stellar catalogs either via download of on CD's.

Sky Flat Settings



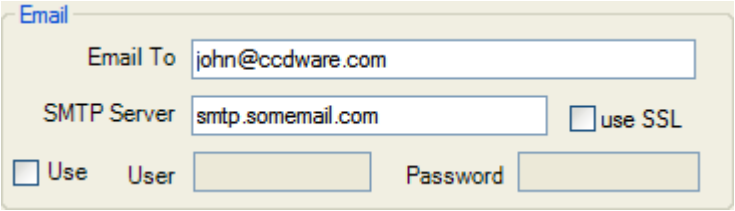
Sky flats are obtained automatically at dusk and dawn.

- **Tracking On/Tracking Off:** When taking flats at twilight, especially at dawn, it is possible to get some bright stars in the flats. These stars should be easily removable in the flat stacking (combining) process. Some users prefer to have star trails for their combining. In this case, tracking off will reduce the intensity of the stars at the expense of trails. Tracking on keeps the stars relatively small but of higher intensity. When tracking is on, a 6 arc-min. enhanced is automatically applied to each sky flat, insuring any stars to not line up from one flat to another. Statistical stacking techniques such as various sigma reject algorithms better remove small, intense stars on dithered images. If using these techniques, Tracking On is recommended.
- **Exposure Limits:** The minimum exposure time should be chosen such that the moving shutter doesn't impact the flat. 2 seconds or greater is a good starting point. Since sky flats are being taken at variable exposures, it is desirable to keep the maximum exposure short so that dark current doesn't increase to the point were actual darks are required and a simple bias subtraction will remove any pattern noise from the sensor. Depending on the sensor 30 - 60 seconds is a recommended maximum.
- **Null Point:** As long as these fields are blank, CCDAutoPilot will automatically determine them. If you have a specific need to set one or the other, the one set will be used and the other will be determined by the program. If both are set, both will be used.
- **Sun Altitude:** These settings define the solar altitude at which measurements of sky brightness begin to meet your specified target ADU level. You can either leave them where they are or you can fine-tune them, based on the solar altitude recorded in the log for successfully acquired sky flats. In order to prevent dawn flats to continue to try in situations where a dome is closed independently of CCDAP, dawn flats will abort if the sun has risen 10 degrees plus the dusk sun altitude setting. This will allow the rest of the session to complete normally even if the dawn flats are unsuccessful with a closed dome.

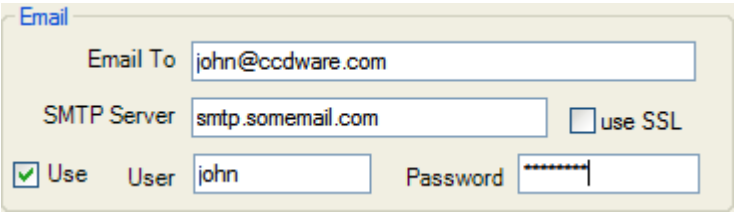
Email Settings (*CCDAutoPilot Professional Feature*)

Email notification is possible of significant events during the course of a session. In concert with the Control File and the utility window on the Options page, you can receive an email notification of a number of events. Enter an email address to which you want the notifications sent. TIP: If you enter the email address for your cell phone's SMS text message, you can receive a text message. You can enter more than one email address as long as they are separated by a comma ',' but no spaces or any other punctuation. You can test these settings using the Email test button on the Tools page.

In order to receive these notification, you must have a valid email account established on the observatory's computer and CCDAutoPilot must be properly configured.



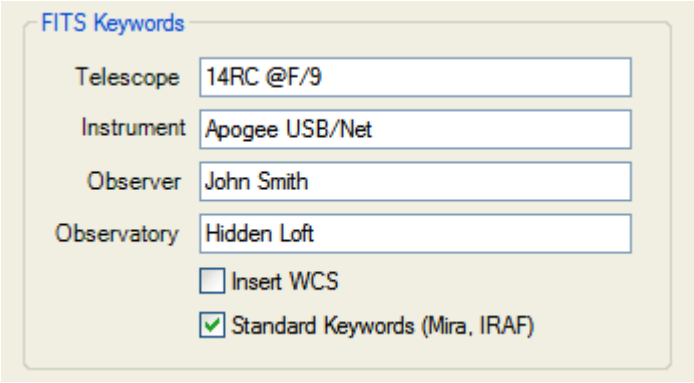
As a minimum, you will have to enter the SMTP server, which is the same that is entered in your email client's account setup. If you need to enter a port other than the default standard which is port 25, enter the smtp server name followed by a colon ':', followed by the port name. For example: smtp.mail.net for a standard port and smtp.mail.net:505 for a non-standard port 505. If your server requires you to use Secure Sockets Layer, check the SSL box. CCDAutoPilot will use the default credentials (UserName and Password) you have entered in your email setup for that account. Use the Email test button on the Tools Page. If you get an Authentication Error, proceed to enter your UserName and Password as described next.



Check the Use box and enter your User Name and Password. Now use the Email button on the Tools Page to verify proper

operation.

FITS Keywords



FITS keyword information can be inserted into every .fit data file you take. The entries for Telescope, Instrument, Observer and Observatory correspond to the FITS keywords, TELESCOP, INSTRUME, OBSERVER and OBSERVAT respectively. For light frames, values wil be entered for read noise (RDNOISE) and gain (GAIN) based on the values entered on the Tools page for Read Noise and Gain respectively. For best results, you should either measure your camera's gain and read noise. Less optimally, you can enter the manufacturer's data for these parameters.

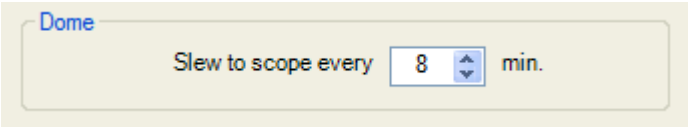
If Insert WCS is checked, WCS data will be written to the FITS header as well. This option is available only when PinPoint is selected for plate solving. Note that this will require additional time during a session as a plate solve will have to be made for each data frame and then added to the FITS data. For other than scientific purposes, this is best left unchecked. This option is disabled (grayed out) if Maxim Lossless Compression is checked since plate solving for inserting World Coordinate System data into the FITS header is not possible with compressed FITS data.

If Standard Keywords is checked, the FITS Keyword IMAGETYP will use professional for light frame, dark frame, bias frame and flat frame will be used - LIGHT, DARK, BIAS and Flat, respectively. If cleared, the SBIG standard will be used, Light Frame, Dark Frame, Bias Frame and Flat Field respectively. It is recommended that the Standard keywords be used.

Optec Rotator

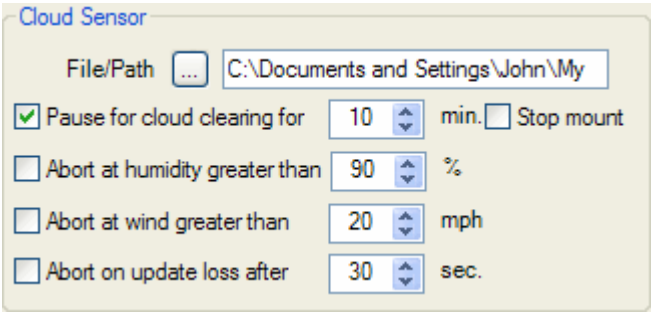
The Optec Pyxis rotator can be put into a sleep mode between rotations by checking the Sleep Pyxis Between Rotations box. This reduces the power to the rotator. The downside is there may not be enough holding power to keep an off-center camera from rotating. If this is a problem, this box should not be checked.

Dome



This determines how frequently CCDAutoPilot should adjust the dome slit position to the telescope when using AutomaDome. (There is no need for any auxiliary VB script to maintain this alignment as CCCDAutoPilot does this internally.) Unless the dome slit is particularly narrow and/or the OTA aperture is particularly large, it is recommended that this be kept to 8 minutes or longer. If more frequent adjustments are desired, the dome/telescope system should be checked over an extended period of time (hours) to verify proper operation.

Cloud Sensor



CCDAutoPilot uses the single line data facility of the Boltwood family of cloud sensors. With this facility, multiple observatories can share a common cloud sensor as long as it is networked to each observatory. Set up the cloud sensor to write the single line file. Use the file/path button to navigate to the location where this file is written. The remainder of the settings depend on whether a version I or version II cloud sensor is being used. The run abort condition is set if the cloud sensor reports very cloudy or rain.

- **Pause for cloud clearing (I & II):** When checked, if clouds come in and the cloud sensor is not "very cloudy", the run will pause for the time specified waiting for the clouds to clear. If it clears before the specified time, the run will resume, if not the run abort condition will be set.
- **Stop Mount:** When checked, mount tracking will be turned off while waiting for the clouds to clear.
- **Abort on Update Loss after xx sec:** When checked, the run abort condition will be set if the cloud/weather system stops updating for the specified time. See the Cloud Sensor Notes.

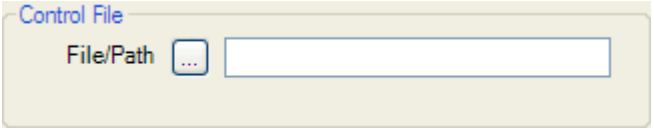
The following are Professional Edition features only.

- **Abort at humidity greater than(II only):** When checked, the run abort condition will be set if the humidity exceeds the specified level.
- **Abort at wind greater than (II only):** When checked the run abort condition will be set if the wind speed exceeds the specified level
- **Abort at Cloud Sensor Failure:** When checked, the run abort condition will be set if the cloud sensor head stops communicating with the base.

Run Abort Condition
Should any weather condition be set, CCDAutoPilot will attempt to perform the Shutdown steps on the Options page - turn off tracking, park the telescope, Set the Pyxis rotator position to 0 if used, close the dome and run the final application, whether these are checked or not. The camerqa cooler will not be warmed up in case dark frames are scheduled. A failure of any of these attempts will not impact subsequent steps.

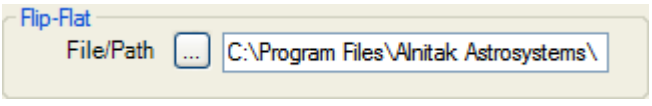
Caution and Disclaimer
Both the Cloud Sensor documentation and common sense advise against relying on this device to protect valuable equipment. It is mainly intended as a monitor of sky conditions. See the Cloud Sensor documentation for details. CCDAutoPilot responds to changing sky conditions as a convenience to the user and in no way should be considered a fail safe approach. The most reliable usage, again without guarantees, is to have a direct connection between the Cloud Sensor and the dome control hardware emergency close switch with no intervening software. The dome controller should be on an uninterruptible power supply (UPS) to be able to close the dome in the event of a power failure.
None of this is any substitute for an attendant.

Control File (*CCDAutoPilot Professional Feature)*



Use the button to navigate to the name and location of the control file. See the Control File Editor topic for details on the file structure.

Flip-Flat



Use the button to navigate to the Flip-Flat control file, aacmd.exe. This was formerly ffcommand.exe. Use the appropriate .exe file that came with your Flip-Flat. The default location for this file is
C:\Program Files\Alnitak Astrosystems\Flip-Flat Controller.
If you have installed it somewhere else, please navigate to that location. See Flip-Flat Notes for more information.

Tools

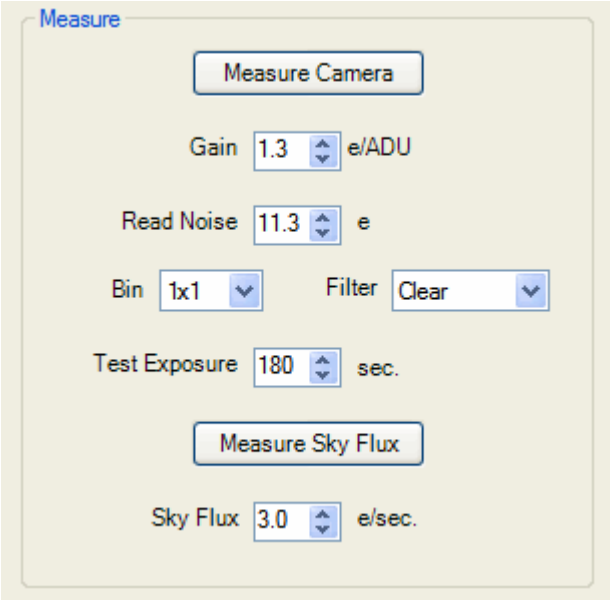
CCDAutoPilot provides tools for setting up and optimizing your imaging system.

Contents

[Sub-Exposure Calculator](#)
[Test Buttons](#)
[Guide Calculator](#)

Sub-Exposure Calculator

As described in the [Imaging Strategies Overview](#), characterization of the imaging camera and site sky glow can aid in determining sub-exposure duration. The Sub-exposure calculator consists of two parts, Measurement and Analysis.

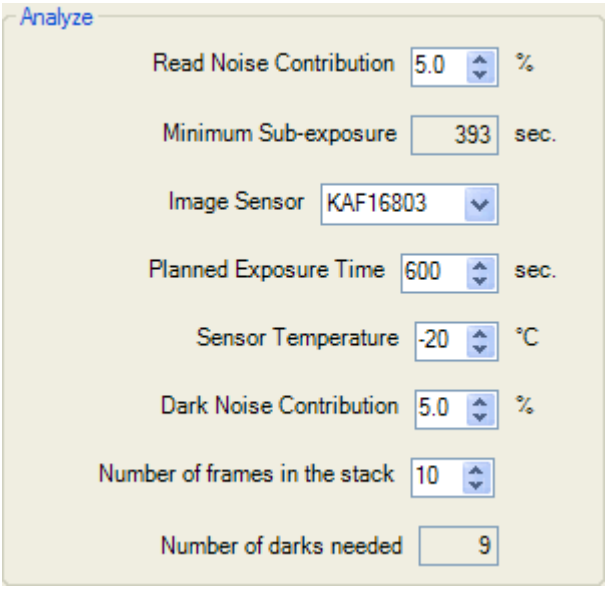


First, the camera read noise and gain must be measured. Many vendors supply values for these terms but it is good to measure your specific camera. The read noise measurement requires no special setup but the gain measurement does. For the gain measurement, you will be asked to somewhat uniformly illuminate your imaging camera to approximately 20,000 ADU by adjusting the exposure to reach that level. If you are not prepared to do that, you can accept the camera manufacturer's value and proceed.

Before measuring the camera, select a binning and a filter. I suggest your first measurement be at 1x1 and you use a clear filter. Hit the Measure Camera button. You will be prompted through the steps for the measurement. When complete, there will be an entry for Read Noise and, if measured, Gain. In theory, read noise should be unchanged when binning, if the binning is done in hardware and there are no other noise sources introduced by the binning process. With some cameras, this is not the case.

The next step is to measure your sky flux. Try an exposure of 180 to 300 sec., depending on your ambient light. This measurement will take some time as a light exposure and an auto-dark exposure will be taken. Once the exposures are complete, the Sky Flux will be displayed at e/sec.

Gain, read noise and sky flux are the key ingredients necessary to proceed to the Analyze box.



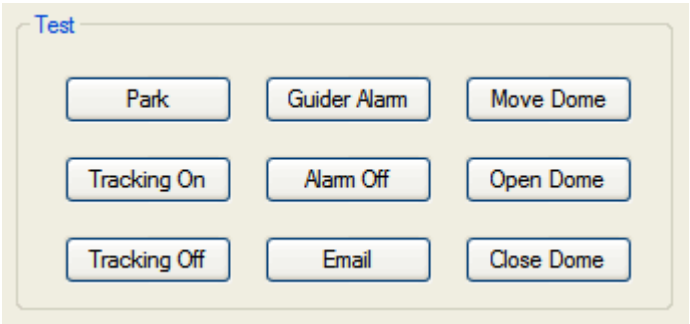
Select the contribution to total noise you wish to assign to the camera read noise. This is a percentage of the noise that will be contributed by the sky flux. The underlying concept is to expose long enough so that the noise from the sky flux overwhelms the read noise such that the read noise contributes the indicated percentage to the total noise. A good starting point is 5%. Entering a Read Noise Contribution value automatically calculates the minimum sub-exposure duration in sec. For more details and analysis, see my paper on *Sub-Exposure Times and Signal-to-Noise Considerations*.

Next, choose your image sensor. If necessary, consult your camera documentation or vendor for your sensor type. If your sensor is not available, you can add it if you have the necessary data. See here for the file structure. Enter your planned sub-exposure time. Select your Sensor temperature, Dark Noise contribution and the number of sub-exposures in your stack to get the number of mean combined darks you need. (Because any master dark is subtracted from each sub-exposure, it is correlated. This means any noise that is in the master dark eventually will appear if the stack is deep enough, just as faint details appear when the stack size is larger.) Experiment with changing your Sensor Temperature and Dark Noise Contribution. As you further cool your camera, you will see the number of darks needed slowly decreases. Now warm up the camera. The number of darks will increase slowly at first then faster. You want to be in the area where it increases slowly if possible. For more details and analysis see my paper on *Sub-Exposure Times and Dark Frames*.

It should be mentioned that the number of darks is based on a mean combine. However, in order to eliminate cosmic ray hits to the dark stack, you would normally use a min-max. clip combine. In this case, you need 2 more darks than for a mean combine. If you use a median combine, you will need 1.6 times the mean number of dark frames. Median combine is the least efficient combine method.

Caveat: This is a bit of a simplification of a very complex topic. Narrow band imaging, extremely dark skies, etc. will mandate much colder camera operation since the sub-exposures will become longer. Nevertheless, this is a good starting point for determining a starting point for your sub-exposures, camera operating temperature and number of darks.

Test Buttons

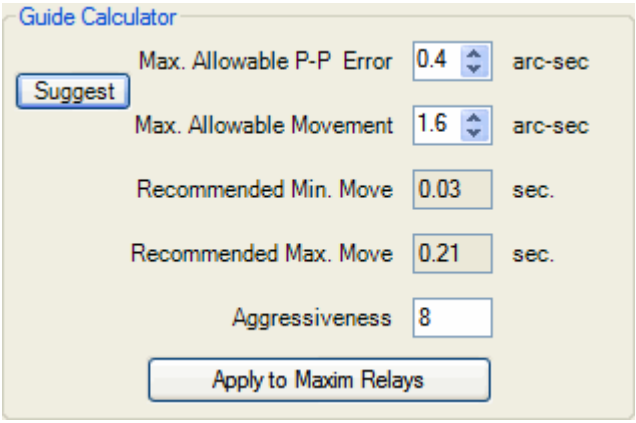


These buttons cause the indicated actions to be performed. They may be used to test communications to the ultimate hardware through the various software layers before committing to an automated run. It is recommended this facility be used whenever hardware changes or a suspicion of things not going right arises.

IMPORTANT: CCDAutoPilot can only send the Tracking Off and Park command to your telescope control program. It is your responsibility to verify that your mount behaves properly when it receives these commands. Please take advantage of the test buttons to verify proper communications with your mount and dome. Hit these buttons one at a time to test whether your chosen telescope control program turns off tracking or parks the mount. If you don't get the expected results, consult the manufacturer of your telescope control program for support. CCDAutoPilot sends standard commands for tracking off and park in accordance with ASCOM and TheSky6's defined interfaces.

- **Park:** This button should send the mount to its park position. With most telescope control programs and/or mounts, this park position must be pre-defined by the user.
- **Tracking On:** This button should turn the mount tracking on.
- **Tracking Off:** This button should turn the mount tracking off.
- **Guider Alarm:** This gives an example of the alarm that sounds when guiding fails and the AGRS cannot restore it. This button can be used to set the sound level desired.
- **Alarm Off:** This turns off the alarm.
- **Email (*Professional Version feature)*:** Hitting this button sends a test email to the address indicated on the Preferences page.
- **Move Dome:** This is a simple test of slewing the dome. Hitting this button should move the dome 15° clockwise.
- **Open Dome:** This button should open the dome shutter.
- **Close Dome:** This button should close the dome shutter.

Guide Calculator



This calculator allows you to determine your optimum minimum and maximum move parameters for your system. Proper setting of these parameters is important for optimal guiding. When connected to your camera control program, the guide calculator will automatically determine whether DirectGuide (CCDSoft only) or camera relays is in use and calculate minimum and maximum recommended moves automatically. These parameters can be loaded into your camera control program. For more information, see the online Guide Calculator.

- **Max. Allowable P-P Error:** Here we try to determine when we want your mount to actually make a correction. If your guider error is only .05" arc-seconds, there is no need to make an correction. If your min move setting is set to low, then you guider relays will move the mount every guider cycle. This can result in mount oscillations or chasing atmospheric turbulence. My best suggestion in setting this value is about 75% the image scale in which you are imaging. For example, if you are imaging at 1.2" asp, then set this value to 0.9" asp. This way a guider correction is only sent when the centroid of the guide star is 0.45" asp off in either the X or Y axis from the selected guide star position.
- **Max. Allowable Movement:** This value is not required to achieve great autoguiding, but it does protect us from some extreme situations that could ruin a sub-exposure. For instance, if a cosmic ray hit is sensed on the autoguider CCD, this could cause your autoguiding software to think that the centroid of the star has moved many, many pixels from center. Therefore it is going to attempt to correct the mount for this error. If you have no max move setting, this will result in a very large correction and a ruined exposure. If you have a limit to the size of the correction, i.e. max move, then this effect can be mitigated by not allowing a large correction. Setting this value too low may result in under correction, so its best to set this value about 2X - 4X larger than the above 'Peak to Peak Maximum Allowable Error' setting.
- **Suggest:** Hitting this button will cause recommended settings to be entered for the above two values and represents a good starting point. If you are unsure of what to enter, hit the Suggest button.
- **Recommended Min. Move:** Based on the above entries, this is the recommended minimum move amount for your guider.
- **Recommended Max. Move:** Based on the above entries, this is the recommended maximum move amount for your guider
- **Aggressiveness:** With the recommended minimum and maximum move, this is the recommended aggressiveness setting for your guider
- **Apply To <guider>**:Hitting this button will automatically enter the recommended values into your camera control program. The button name will indicate your camera control program (CCDSoft or Maxim) and the corresponding guide method (Relays or DirectGuide for CCDSoft, Relays or MicroGuide for Maxim).

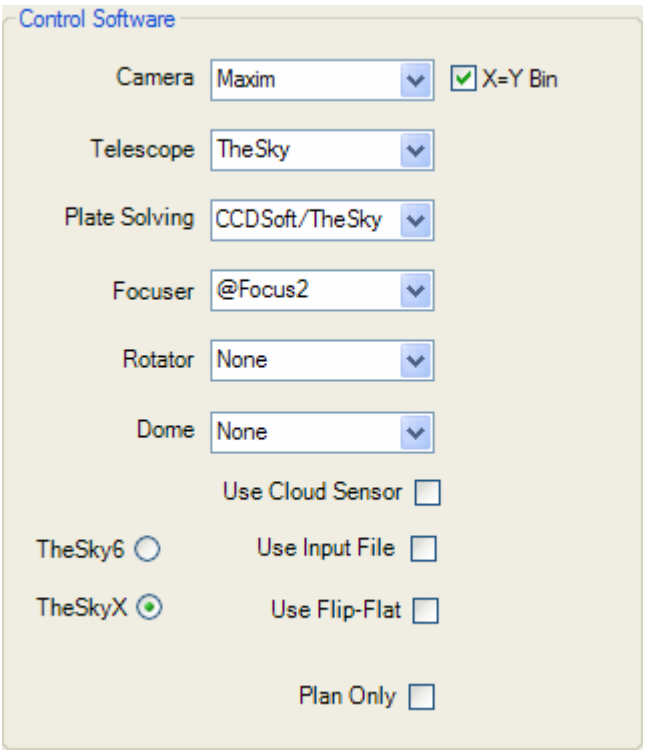
Settings

This is where you define the various programs that CCDAutoPilot will use to control your equipment. In order to plan a session, the only connection required is to the telescope control program so that target information can be obtained. The telescope need not be powered on or connected. In fact, a session can be planned on one computer having the appropriate telescope control program and executed on another.

Contents

Control Software
Utility Window
RGB Ratio Measurement
Equipment Settings

Control Software



- **Camera:** Select from Maxim, CCDSoft or None as desired. If Maxim is selected, you can elect to have x and y binning be the same via the x=y bin checkbox. If it is not checked, a window will appear, giving the user a chance to enter the desired vertical binning. Also if Maxim is selected, go to the Camera Control window, hit the Settings button to bring up the Guider Settings window. Select the Advanced tab. Under Guider Motor Control, make sure to select Do Not Change On Pier Flip. The first time you connect to your camera, the filter names and binning options will be read and stored in the system profile. You can subsequently save this profile as a planning profile for that camera.

- **Telescope:** Select from TheSky, ASCOM, ASCOM/TheSky or None as desired. TheSky selection uses TheSky for planetarium data and telescope control. ASCOM has no planetarium data but uses ASCOM for telescope control. ASCOM/TheSky uses TheSky for planetarium data and ASCOM for telescope control. To change the ASCOM telescope driver selection, check the Change driver checkbox when ASCOM is selected and you will be presented with the ASCOM chooser.

- **Plate Solving:** Select from CCDSoft/TheSky, PinPoint or None as desired. Regardless of what plate solving selection is made, either Maxim or CCDSoft can be used as the camera control program for image acquisition and guiding. Due to licensing restrictions, the full version of PinPoint is required. When CCDSoft/TheSky6 is used for plate solving, both programs must of course be present. For most of the features of CCDAutoPilot, one of the plate solving selections must be chosen.
- **Focuser:** Select from FocusMax, @Focus2 or None. Either FocusMax or @Focus2 can be used for automatic focusing at various times in the course of a run.
- **Rotator:** Select from Optec Pyxis, RCOS PIR, ASCOM or none. When the Optec Pyxis is selected, a COM port for controlling the rotator must be specified. Any other program used to control the rotator must be closed. Manual control of the rotator is still possible on the Targets page. When the RCOS PIR is selected, the TCC software is controlled via CCDAutoPilot but the TCC application can remain open and "live". To change the ASCOM rotator driver selection, check the Change driver checkbox when ASCOM is selected and you will be presented with the ASCOM chooser.
- **Dome:** Select from ASCOM, AutomaDome, Digital Dome Works Control Program (DDWCP) or none. To change the ASCOM dome driver selection, check the Change driver checkbox when ASCOM is selected and you will be presented with the ASCOM

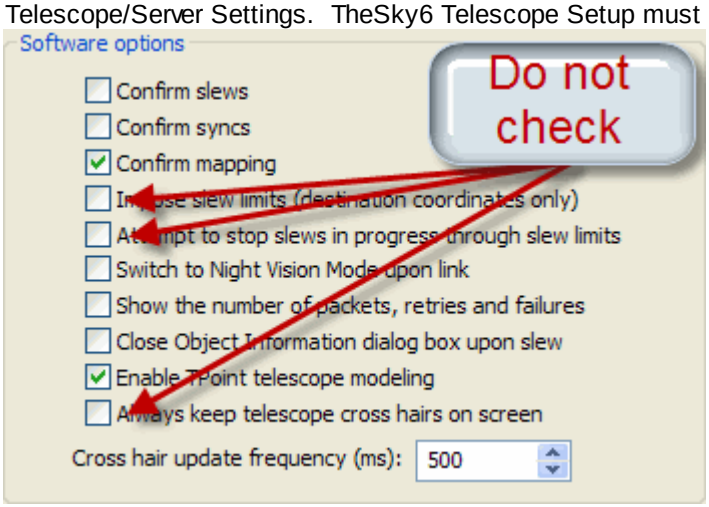
chooser.

- **Use Cloud Sensor:** CCDAutoPilot uses the Boltwood Cloud Sensor (or equivalent) one line data facility. Set the file/path for this data on the Preferences page then check this box. CCDAutoPilot will automatically determine whether it is Cloud Sensor I or Cloud Sensor II.
- **Use Input File:** (*CCDAutoPilot Professional Feature)* Activates the Control File facility when checked. See the Control File Editor topic.
- **Use Flip-Flat:** When checked, the Flip-Flat will be used as the light source for dusk and dawn flats. Be sure to select the appropriate COM port for Flip-Flat control. See Flip-Flat Notes for more information.
- **Connect:** Once your selections are complete, hitting this button establishes the software connections to the chosen applications so that they can be controlled by CCDAutoPilot. Once the connections are established, this button changes to Disconnect. Hitting this button will then disconnect the chosen application. You can Disconnect, change the selected applications and then Connect again without closing CCDAutoPilot

- **Plan Only:** When checked and the Connect button is hit, only the specified telescope program is connected to CCDAutoPilot. The telescope mount itself is not connected to either the telescope program or CCDAutoPilot. This mode allows target planning either independently with TheSky or manually with ASCOM, or importing CCDNavigator plans. You are able to edit and adjust your image acquisition plan without being connected to your observatory. You are notified of this condition in CCDAutoPilot's title bar and status panel. To exit the planning mode, Disconnect and uncheck the Plan Only checkbox

- **TheSky6/TheSkyX:** CCDAutoPilot supports both TheSky6 and TheSkyX. Select the version of your choice when the telescope selection includes TheSky and before hitting the connect button. There are some settings that must be made manually for each version:

- **TheSky6:** TheSky6 must have "Allow remote connections" and all boxes in the Remote client capabilities" checked under Telescope/Server Settings. TheSky6 Telescope Setup must not check the boxes indicated below:



- **TheSkyX**: Make sure you are using version 10.1.9 or later. If you are using a Paramount, you will need to make the following change for accurate meridian flipping:
  1. Connect to the Paramount
  2. In TheSkyX, Select Paramount as mount. On the telescope TAB (not menu), Hit Tools button, select Bisque TCS
  3. In the TCS Parameters tab, click on the + sign next to Ini parameters to expand.
  4. Click on Flip HA and then hit the Edit button. Enter a value of 0

Note: Due to a bug in TheSkyX, the above steps do not work in version 10.1.8. You will need to manually edit the file ImagingSystem.ini. It is located in either
C:\Documents and Settings\John\My Documents\Software Bisque\TheSkyX Professional Edition or
C:\Documents and Settings\John\My Documents\Software Bisque\TheSkyX Theater Edition,

depending on your installation. Open this file in Notepad and find the line under [MKSDRIVER0]
FlipHourAngleMinutes=xxx and change it to read:
FlipHourAngleMinutes = 0

Plate Solving

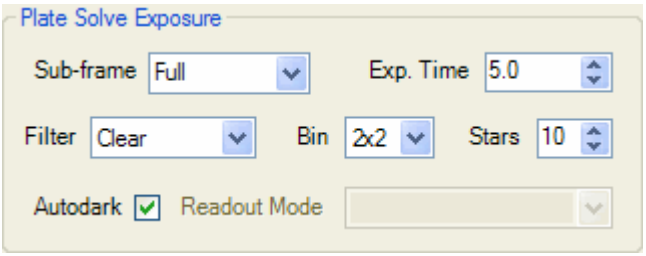
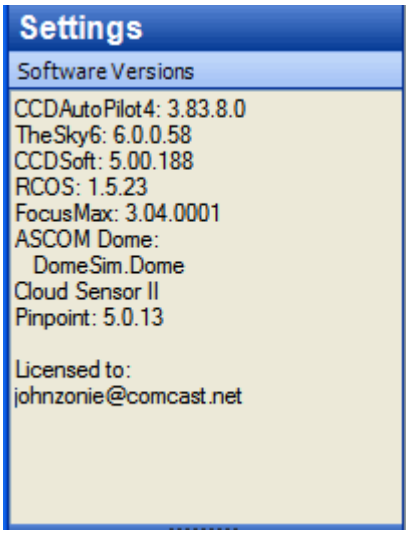


Plate solving is an essential requirement for automated imaging and requires proper settings to achieve success. See Plate Solving Notes for more detail.

- **Sub-frame:** Choose an appropriate sub-frame for plate solving from full size to 1/16 size. Sub-framing less than full are useful with wide field systems to speed up plate solving. Sub-framing is mandatory when using CCDSoft/TheSky6 to insure the Autoastrometry limit of 1 square degree FOV is not exceeded. See here for more details.
- **Filter:** Select the filter to be used for plate solving. This is normally your most transmissive filter, usually clear or luminance.
- **Exp(osure) Time:** This should be determined experimentally for your system. The goal is to get enough stars for a successful plate solve without excessive exposure time. A good starting point for a 3000 mm focal length system is 5 sec. Depending on your FOV, you may need to go longer or shorter.
- **Bin:** Binning your plate solve exposure will usually give you better performance with increased star detection at long focal lengths. Even with short focal lengths, binning may work out well, perhaps with a suitable sub-frame selection. Again, this setting is best determined experimentally.
- **Stars:** This setting allows you to set the minimum number of stars to be used to accept a plate solve as valid. For best reliability, this should be set to 10. In certain cases, acceptable performance may be achieved with a lower number, bur careful testing is needed to insure accurate results.
- **AutoDark:** This applies to CCDSoft only and should normally be checked. With shutterless cameras, you may get better results by unchecking AutoDark, depending on how the camera's driver handles a request to autodark.
- **Readout Mode:** Sets the camera readout mode for plate solve images. See Readout Modes. This selection is available only with Maxim v5.

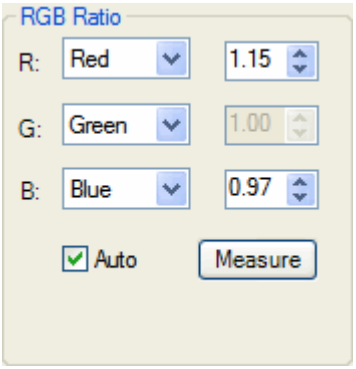
Utility Window



When connected, the versions of software is shown, along with the ASCOM drivers chosen, if any. Also, the license information is shown.

RGB Ratio Measurement

CCDAutoPilot can automatically measure your RGB Ratio, sometimes called a G2V ratio for the spectral signature of a sun-like star. This is a widely accepted method of determining your color combine ratios when assembling your final color image from RGB filtered data.



To begin, first select the R; G; and B; filters. The G: filter will be used as the reference. Typically in English, R: will be Red, G: will be Green and B: will be Blue. If using a BVR filter set, then R: would be R, G: would be V and B: would be B. Then proceed as follow, depending upon your telescope control program.

TheSky6: Point your telescope to a point in the sky near the zenith. If Auto is checked, CCDAutoPilot will locate a number of G2V stars and slew to the first G2V star. If you are initialized, it will center the star in your FOV. If you don't check Auto, you will have to manually slew to a known G2V star. CCDAutoPilot will then automatically adjust the exposure to meet its measurement criterion, take a number of flux measurements through each filter, correct the measurement for atmospheric extinction and show the resultant combine ratio. You will be asked to inspect the first image for each star to insure there is not a close double in the image. If there is, simply move on to another star; if not, allow the measurement to proceed. You can measure additional stars if you wish.

ASCOM: Automatic selection of G2V stars is not possible. Therefore manually slew the telescope to a known G2V star then hit the Measure button.
CCDAutoPilot will automatically adjust the exposure to meet its measurement criterion, take a number of flux measurements through each filter, correct the measurement for atmospheric extinction and show the resultant combine ratio. You will be asked to inspect the first image for each star to insure there is not a close double in the image. If there is one, please select and slew to another star.

In general, it is advisable to measure a few G2V stars. The expected measurement accuracy is +/- 0.1. It is also worthwhile measuring on different nights. High, thin clouds can reduce blue transmission, leading to erroneous results.

Color Combine Ratio Calculation (*Professional Edition Feature*)

As a target is imaged during a session, CCDAutoPilot will keep track of the altitude of each sub-exposure. At the conclusion of each target's data acquisition, a report is generated giving the extinction-corrected RGB combine ratios, based on the initial RGB Ratio measurement made above. It doesn't matter whether the data was acquired in Stairstep or Shuffle mode. Here is a portion of a log showing the Combine Ratio Measurementt:

```
Color combine ratios
...Red          Green          Blue
...1.15         1.00           0.97
```

And here a a log excerpt after acquiring data for a low altitude target:

```
Summary for M8
Red data extinction correction factor: 1.11
Green data extinction correction factor: 1.19
Blue data extinction correction factor: 1.23

Corrected Color Combine Ratios
                Red     Green   Blue
Exposure hours  1.3     1.3     1.3
Average Alt.    29      29      33
Combine Ratio   1.07    1.00    1.00
```

Data from all three color filters are of course required to calculate combine ratios. In cases where one is making up one or another color only and not all three, extinction correction factors are also provided to aid in combining data properly when taken over multiple nights.

Equipment Settings

See the Initialization topic for details.

Initialization

Initialization is the process of telling CCDAutoPilot about your equipment parameters and arrangement. Successful initialization is essential for automated imaging. Before initializing. settings are needed for the imaging system, the guider and the mount.

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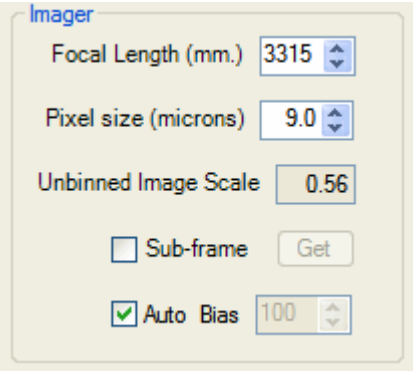
Imager Settings
Guider Settings
Mount Settings
Initialization
Unguided Initialization
Guided Initialization
Hints
When to Re-Initialize
Easy Initializing

Imager Settings

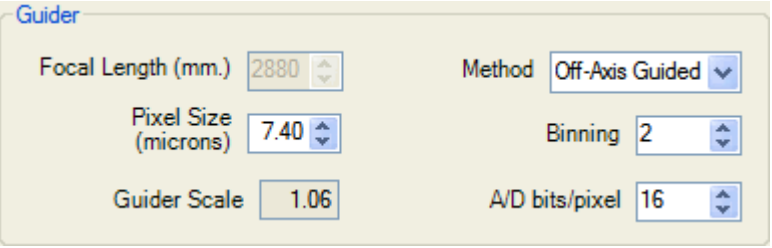


CCDAutoPilot needs to know the approximate unbinned image scale for your imaging system. Enter the OTA Focal Length in mm and the Imaging Camera pixel size in microns and press enter. The Unbinned image scale will automatically calculate. You can also click on the up/down arrows at the side of the entry box to adjust the values.

If you wish to use a portion of your imaging sensor for all your imaging, CCDAutoPilot will maintain your desired sensor cropping for light frames and all calibration frames, including flats. When the Sub-frame box is checked, the Get button will become active and you will be prompted through the steps to define your sub-frame. That definition will be maintained in your system profile.

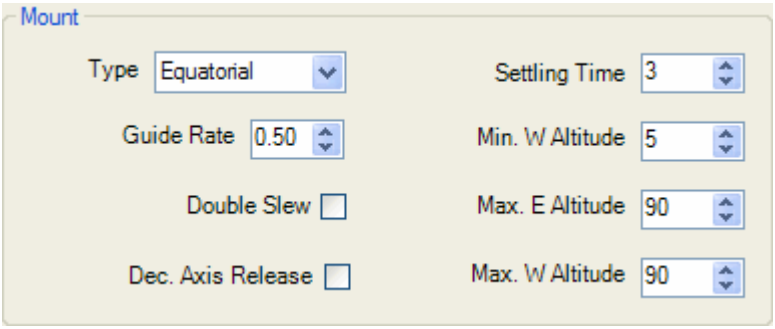
For most users, the Auto button should be checked. With this checked, flat frame auto-exposure will take into account your camera's bias level when targeting your specified ADU level. This does not mean it will do an automatic bias or dark subtract. That should be done post-acquisition with a high quality master bias.

Guider Settings



First, select your Method of guiding. If you are using Self-Guided or Off-Axis Guiding, enter only your guider's pixel size in microns and your guider's binning. If you are using a guide scope, enter your guide scope's Focal Length in mm as well as the guider's pixel size in microns and your guider's binning. Be sure to set the A/D bits/pixel appropriately for your guider. If you are using a CMOS guider, the appropriate setting should most likely be 8. For CCD guiders, the setting should be 16. Consult your guide camera documentation. If there is any doubt, take an over-exposed image of a star manually with your camera control program. Measure the peak ADU. If it is 255 or 355, then set the A/D bits/pixel to 8; if it is 65535 or so, set the A/d bits/pixel to 16.

Mount Settings



Enter your mount type, either Equatorial or Fork.

Enter your mount's guide rate, represented as a fraction of sidereal tracking rate. Here it is shown at 0.50 and would typically be referred to at .5x. This is generally a characteristic of each mount and can be set with most mounts. For best results, guide rate should be a fraction of the sidereal rate. Choose whether to use a double slew to the target. With some mounts, a second slew releases belt tension for improved guiding. Checking Dec. Axis Release will perform a programmed series of declination axis motions to release any binding and may improve guiding. **Caution:** Be sure to verify observatory clearances visually before engaging this option. The scope could slew +/- 25 degrees in dec. away from the target.

Enter a setting time for your mount. This is how long you want to allow the mount to settle after a slew. Values can range from 3 sec. for high quality, modestly loaded mounts to 30 sec. for lower quality or more heavily loaded mounts. You will need to experiment on what is best for your mount.

You can set altitude limits for your mount, depending on your OTA and camera geometry and observatory walls. Setting a Min. W Altitude limit will insure your mount stops tracking before that limit. This is a nice fallback in case you miscalculate your run time. If Min. Alt is set to 0, there will be no minimum altitude limit applied. If this limit is exceeded during a target run, the light frame acquisition will cease for this target. Either the next target will be selected and acquired or the next programmed task will be executed. Max. E and Max W. Altitude limits can prevent your OTA from coming too close to your pier or tripod.

With the above setting, we are now ready to initialize CCDAutoPilot. You will need to be connected to your camera and telescope via the appropriate control programs and have selected a Plate Solve method. If you are using PinPoint for plate solving, make sure the settings are correct on the Preferences page. For unguided imaging, CCDAutoPilot will confirm your image scale and determine the difference between your imaging camera and the Position Angle in TheSky. If you are using a rotator, it will calibrate any rotator offset so that it can precisely move to a desired PA automatically. For guided imaging, additional data will be taken on your guider's orientation and sensitivity by doing a guider calibration. The necessary information from this process will be saved in the system profile.

Unguided Initialization

Simply point the telescope to a point in the sky above 60° altitude and hit the initialize button. CCDAutoPilot will take an image and plate solve it. You will given an opportunity to save the data to a system profile. Please do.

Guided Initialization

Point your telescope to a point in the sky above 60° altitude. Adjust the telescope position so that a reasonably bright guide star is located in the guider's FOV. With your camera control program, choose a guide star exposure to get a good signal. Again using your camera control program, calibrate your guider, making sure the guide star stays on the guide chip throughout the calibration. Once a successful calibration is completed, you are ready to Initialize. Hit the Initialize button. CCDAutoPilot will take an image and plate solve it. It will then perform a guide calibration. Upon successful completion, you will be given an opportunity to save the data to a system profile. Please do.

Hints

Choose meaningful names for your profile. Some examples are MX080526RY, which would mean to me Maxim, May 26, 2008, camera relays used. Another might FSQCS0526DG, which would mean FSQ-106 telescope, CCDSoft, May 26, 2008, DirectGuide. Anything that helps you identify the profile afterward. Remember you can double click the profile to launch CCDAutoPilot so meaningful names are helpful.

As long as you don't disturb the relationship between your imager, guider and the sky, you don't need to initialize again. No matter where in the sky you image, any RA, Dec or PA, either side of the meridian, CCDAutoPilot will provide optimized calibration vectors to your camera control program. (These are not simple transformed guide vectors from a possibly marginal calibration;

these are derived from proprietary algorithms to optimize guiding performance.)

When To Re-initialize

- Imaging telescope FL change, either different telescope or focal reducer
- Guide telescope FL change
- Different imager or guider
- If using a powered rotator, change to the relationship between the imaging camera and/or guiding camera to the rotator
- Change in guide method, e.g. from self-guided to Off-axis guided
- Change in guide control, e.g. from camera relays to DirectGuide or MicroGuide
- Change in guider binning
- Change in camera control program, e.g. from Maxim to CCDSoft
- Lose your home setting with the RCOS PIR

Easy Method for Initializing

This method requires TheSky6 and saves you from hunting the telescope position to get a guide star centered in the guider FOV. Read the sections on Unguided and Guided Initialization.
1. Perform an unguided initialization. Save the profile.
2. Using the techniques outlined here, position TheSky's FOVI so that a suitable guide star is in the guider's FOV.
3. Slew to the FOV_Center target with precision slew checked. Once the process completes, you should have the guide star on the guide chip.
4. Run a guider calibration with your camera control program to insure the guide star stays on the chip for all movements
5. Set your guide method as desired and initialize again.

Targets

CCDAutoPilot can handle an almost unlimited number of targets (*Professional Edition only*). There are a number of facilities to enter and edit targets and the target list itself.

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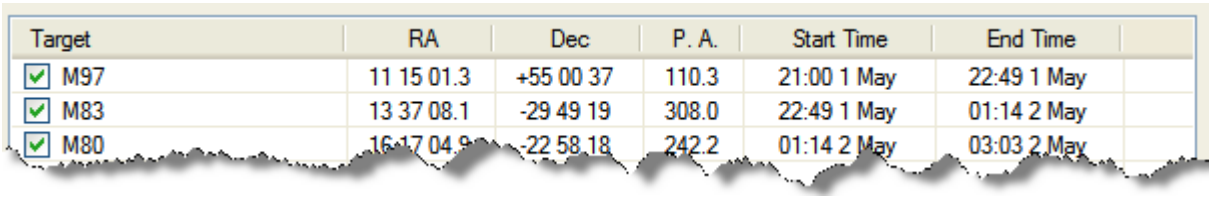
Target List
Context Menu
Target Functions
New Entry
Utility Window
Options
Rotator

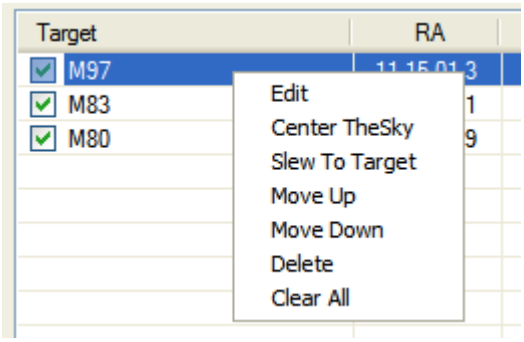
Target List



The target name, along with its coordinates, RA, Dec, PA are shown, along with the starting time and ending time of that target's imaging. The end time is computed from the entries on the Light frames page. If the leading check box is checked, that target will be part of the session; if not checked, it will be skipped.

Right-clicking on a target line will bring up the context menu. You can click on the title for Target, RA and Dec to sort on that entry in ascending order. Click again to sort in descending order.

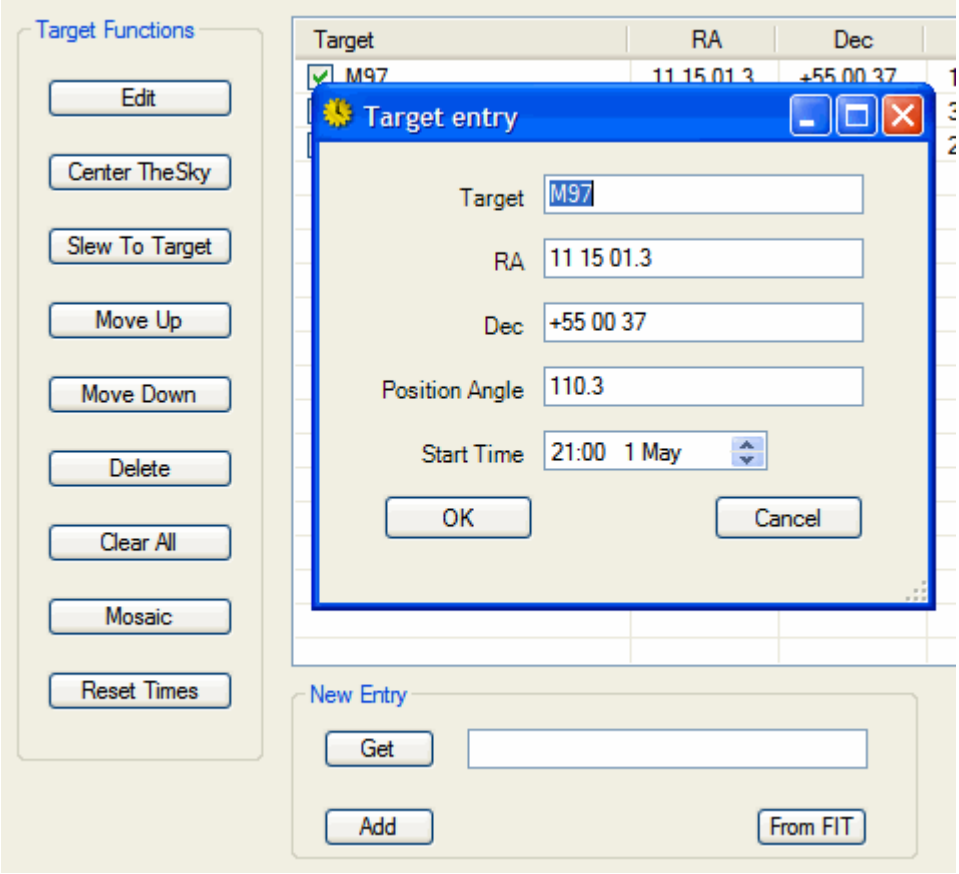
Context Menu



an item in the context menu may be selected by clicking on it.

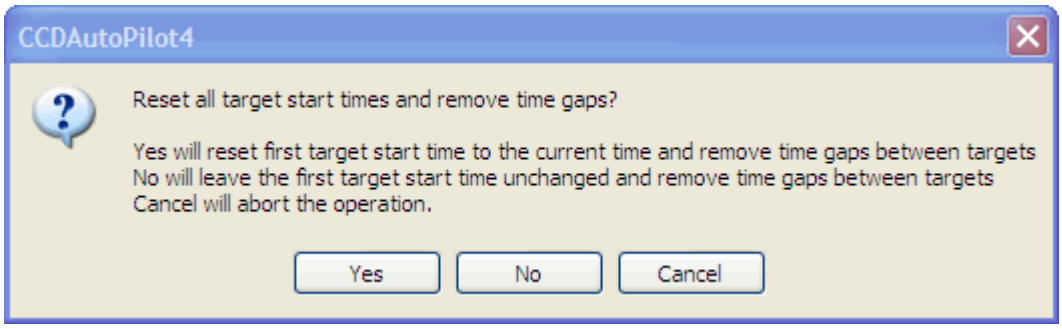
- **Edit** brings up the Target Entry window with the information from the selected target filled out. (see below)
- **Center TheSky** will center the FOVI on the target coordinates when using TheSky6
- **Slew To Target** will slew the telescope to the target coordinates. If Precision Slew is checked, the target will take a plate solve after slewing and then correct the telescope position to be within a few arc-sec. of the desired coordinates.
- **Move Up** will move the target line up in the list.
- **Move Down** will move the target down in the list.
- **Delete** will delete the highlighted target line from the list.
- **Clear All** will delete the entire target list after confirmation.

Target Functions



On the left are buttons that replicate the functions of the context menu. Additional functions not on the context menu are:

- **Mosaic:** Used to create a target list from the mosaic function in TheSky (*Professional Edition only*). With the desired mosaic set up in TheSky, pressing the Mosaic button will bring them into the Target List. Each mosaic element may then be edited by using the Edit Function or Edit Button. If you are doing guided imaging, then you can move the FOV indicator as needed to locate a guide star and replace each Mosaic entry in the target list with an adjusted FOV Center, via the Get button.



- **Reset Times:** Used to eliminate time gaps and optionally reset the first target start time to the current time. All subsequent targets will start as soon as the previous target completes. Use this feature if you want maximum target acquisition efficiency. If you wish imaging for a given target to start at a specific time, for example around the meridian, then adjust the target start time via the Edit function and do not hit the Reset Times button after doing this.

New Entry

You can add a target using the following buttons:

- **Add:** Used to manually add a target. This opens the Target Entry window at right for manually entering target name and coordinate information. Since the target name will ultimately be part of the data file names, it must not include the Windows "forbidden characters", '*/:<>?|'. Such characters will be stripped from the target name if present. There are certain formatting conventions that must be followed for the coordinates. RA must be in hh<space>mm<space>ss.s, where hh is the RA hours, mm is the RA minutes and ss.s is the RA seconds. Dec. must be entered in <sign>dd<space>mm<space>ss, where <sign> is the sign of the declination with an explicit '+' or '-' required. dd is the Dec. degrees, mm is the Dec minutes and ss is the Dec. seconds. All numeric entries must be separated by a space. The Position Angle is entered as a value between 0 and 359. Start time must be entered by using the up/down buttons with the cursor place over the appropriate value being edited - hours, minutes, say and month. When satisfied with your entry, click OK to add this target entry information into the Target List.

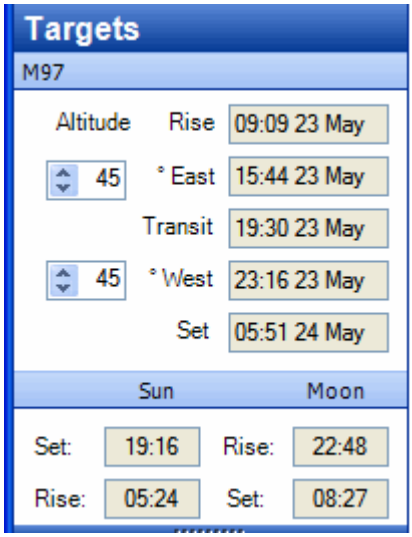
- **Get:** (TheSky6 feature only) Enter a target to search for by entering its name in the space provided and hit the Get button. If it exists in TheSky6's database, the coordinates will be transferred into the Target list. If Get is hit with no entry, the RA and Dec of the FOVI's center in TheSky6 will be entered. The PA of the FOVI will also be entered. It is the FOVI center that determines

the transferred coordinates, not any selected star or object. If you want to get a selected star in TheSky's window, move the FOVI over that object. This is a powerful target framing feature that is described in more detail here. When used in conjunction with a rotator, you can select a suitable guide star using the FOVI and CCDAutoPilot will move the scope and the rotator to those precise coordinates.

- **From FIT:** When hit, a file navigation window is opened, allowing you to navigate to a FIT file from a prior image acquisition. If the keywords (FOCALLEN, XPIXSZ and XBINNING) are in the FITS header and have valid values, those values will be used for plate solving. If any of them are missing, plate solving will attempted using the unbinned image scale from the Imager section of the Settings page. If the plate solve is successful, the coordinates in RA, Dec and PA will be entered into the Target List.

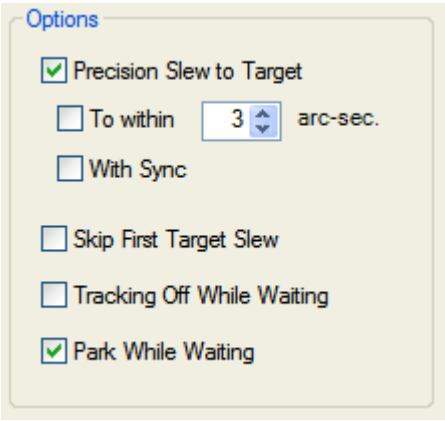
The above steps completely define the target to be acquired. There is no need to go to the target in advance and take test images for guide star positioning or guider calibration. If you have properly initialized your equipment as defined on the Settings page, have an accurate FOV Indicator in TheSky and select Precision Slew to Target in the Options box, the target will be precisely centered and the guide star will be in the guider FOV.

Utility Window



The top portion of the Utility Window shows the Ephemerides for the selected target. You can see the east and west altitude as you desire either to avoid obstructions east or west of the meridian of if you don't want to image below a specific altitude, 45° in this example. The lower portion of the window shows the ephemerides for the sun and the moon (TheSky6 only) for the current date as an aid to planning.

Options



Various options are available for slewing to a target and what to do while waiting.

- **Precision Slew to Target:** When checked, the slew to every target consists of a translation to the specified RA/Dec coordinates, rotator movement to the desired position angle and a plate solve and correcting slew to insure a very accurate positioning of the telescope. Unless you have excellent pointing, and/or a wide field guider, this option should be used for guided operation.
- **To within arc-sec:** If you have a requirement for more precision, you can specify the slew accuracy tolerance. CCDAutoPilot will slew to the target, plate solve and correct the position, then see what the pointing error is. If it exceeds your specified tolerance, it will repeat this process up to 3 times to do as much as possible to meet your tolerance requirement.

With Sync: When checked, the telescope will be sync'd to the plate solved coordinates. This can be used if your mount has

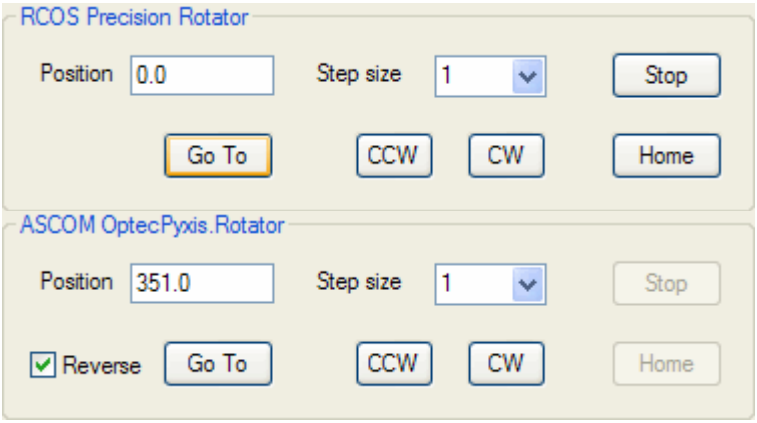
significant pointing errors to insure SkyStar centers the focus star on your imager for accurate focusing. If this is not a concern, then this option can be left unchecked. This option should be cleared for permanent setups with good pointing accuracy as may be obtained with a suitable Tpoint model. If checked, any Tpoint models should be disabled as repeated syncing into a Tpoint model is not recommended and will result in pointing inaccuracies. Use either With Sync or Tpoint but not both.

- **Skip First Target Slew:** When checked, a slew to the first target is skipped. This may be useful where you have already framed the target to your satisfaction and are ready to proceed with imaging it. If Tracking Off While Waiting or Park While Waiting is checked, Skip First Target Slew will be unchecked.
- **Tracking Off While Waiting:** When checked, tracking will be turned off while waiting for the target exposure start time to occur. If dusk flats are selected, tracking will be turned off as soon as dusk flats are completed. At target exposure start time, tracking will be turned on. When checked, Skip First Target Slew will be unchecked.
- **Park While Waiting:** When checked, the telescope will be parked while waiting for the target exposure start time to occur. If dusk flats are selected, the telescope will be parked as soon as dusk flats are completed. At target exposure start time, the telescope will be unparked to allow slew to the target. When checked, Skip First Target Slew will be unchecked.

Rotator

While control of the rotator is essentially automatic and transparent to the user once the system has been initialized, the rotator controls are provided as a convenience to the user. It is recommended that all camera rotation be handled by selecting the desired Position Angle. CCDAutoPilot will handle the rest.

Here are two examples of the rotator control. Different functions are visible or enabled, depending on the rotator selected.



Rotator In Use: When a rotator is connected, the controls will be active and the title of the box will indicate the rotator being used. Here, a RCOS Precision Instrument Rotator is shown.

- **Position** shows the current position of the rotator in the rotator's units. It is also used to enter a desired position for the Go To button
- **Step Size** determines the amount the rotator will move either counter-clockwise when the CCW button is hit or clockwise when the CW button is hit. Although step sizes are indicated by the drop down box, a manual entry will also be taken and used
- **Stop** stops the rotator movement.
- **Go To** slews the rotator to a specific position. This position is defined when the user enters the desired position into the Position box.
- **CCW** moves the rotator counter-clockwise by an amount indicated in the Step Size box.
- **CW** moves the rotator clockwise by an amount indicated in the Step Size box.
- **Home** moves the rotator to its home position.
- **Reverse:** When an ASCOM rotator is used and the ASCOM driver supports changing the rotator direction, the reverse checkbox is displayed. When checked, this reverses the rotator direction. The required direction is that which causes the image plane, when viewed from behind the telescope to rotate in a CW direction when the CW button is pushed. This should give a decreasing rotator position. See rotator notes.

No Rotator In Use
In this case, all controls associated with a rotator are disabled and the title box will so indicate.

Focusing

Since the quality of any automated imaging run depends on achieving and maintaining an accurate focus over the course of the evening, CCDAutoPilot provides many choices for automated focusing. In addition to some active methods, you can also use passive methods such as filter offsets and temperature compensation. You can even use a combination of methods. You should choose the strategy that works best for your equipment and seeing. Both FocusMax and CCDSoft's @focus2 focusing methods are supported.

When an equatorial-mounted telescope is pointed east of the meridian, any focusing activity scheduled to occur within 10 minutes of the meridian crossing will be deferred until the after telescope has crossed the meridian and the mount has flipped.This deferral does not take place with fork-mounted telescope. This focus deferral only occurs when Enable Meridian Flip is checked

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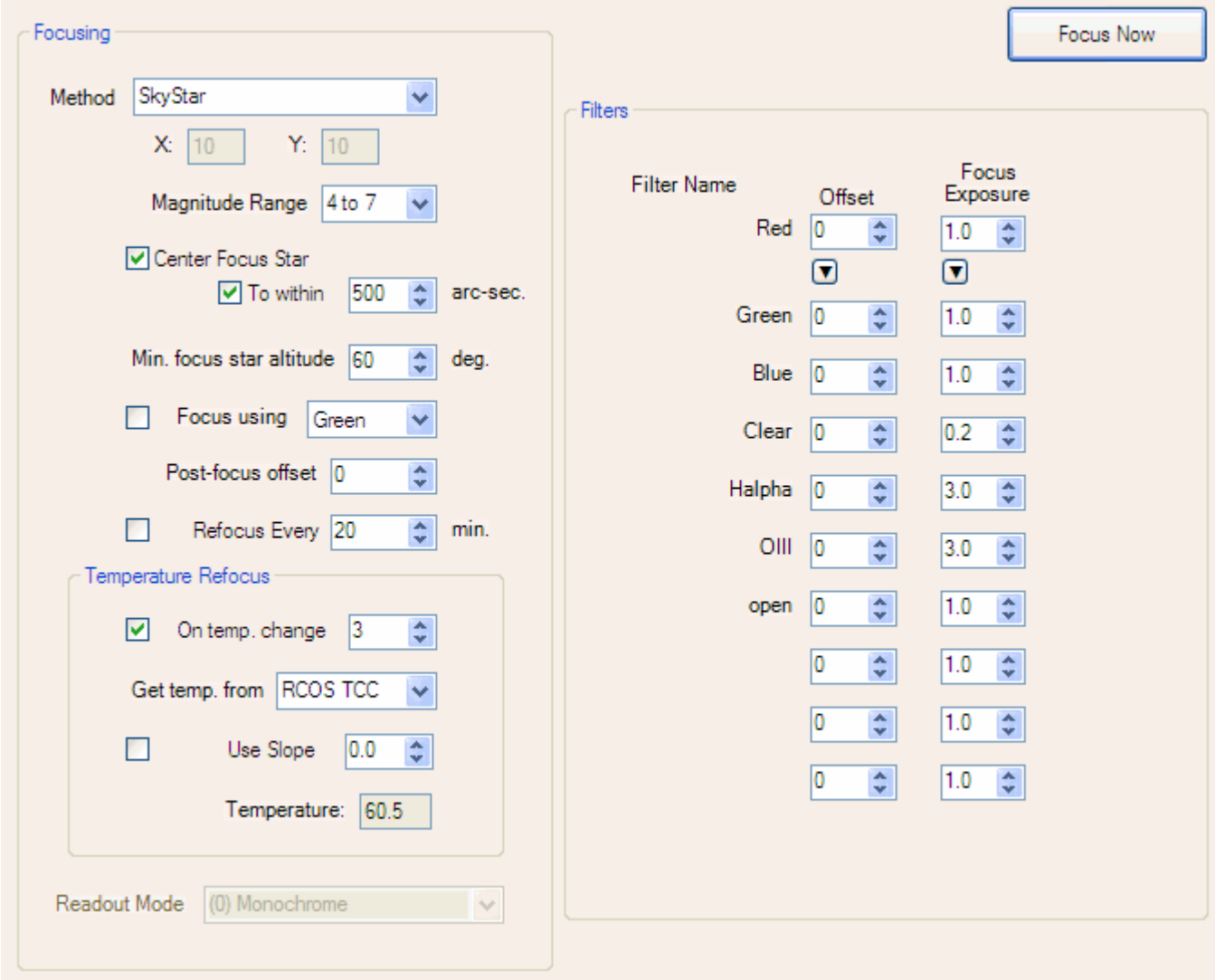
Utility Window

Focusing with FocusMax



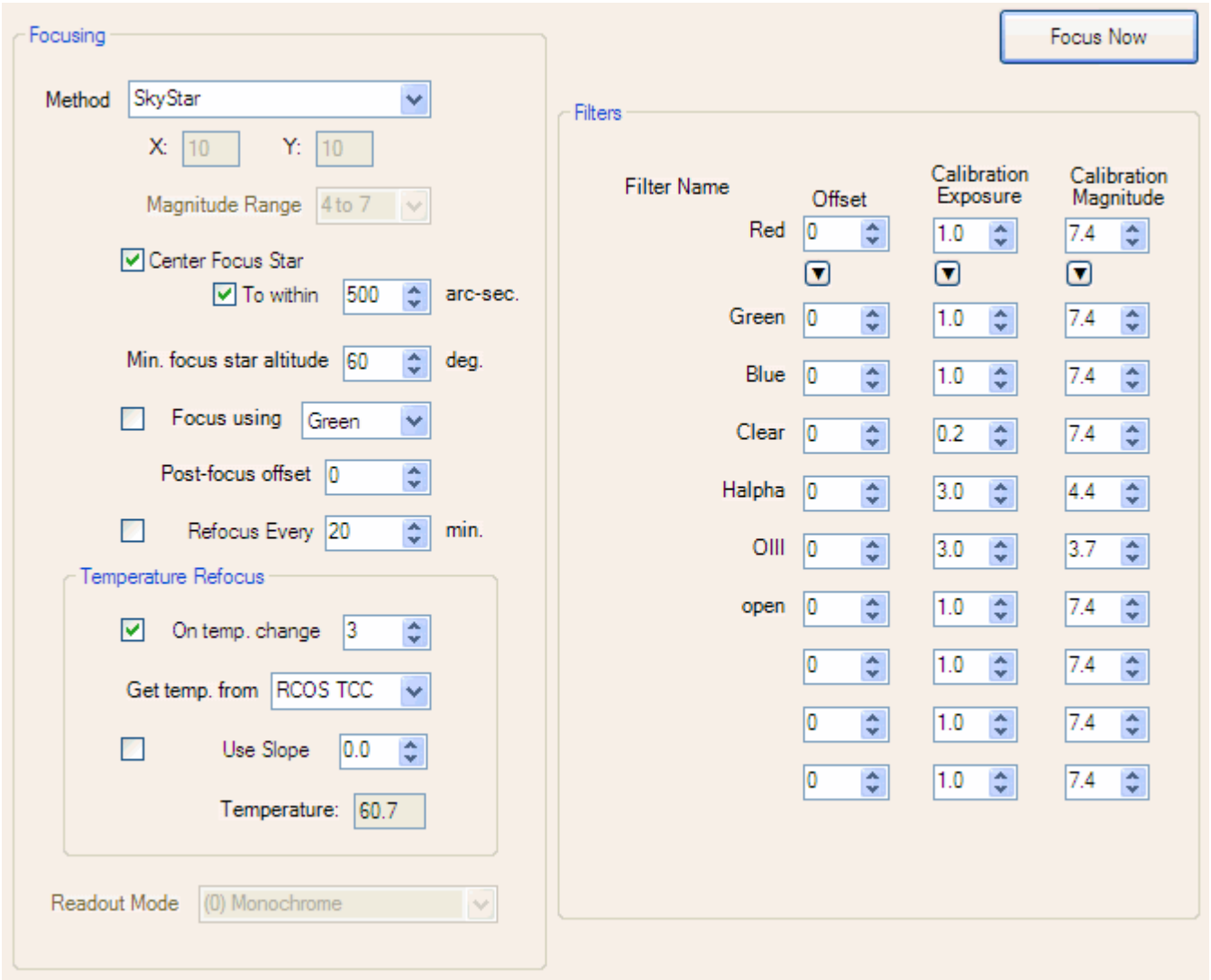
Before proceeding, insure that FocusMax is set up properly for your system. Consult FocusMax documentation for specifics. Once all the software is connected to CCDAutoPilot, you can use the Focus Now button to verify operation.

FocusMax can be used with either CCDSoft or Maxim. When FocusMax is connected, there are a number of active methods of focusing available. Active methods do not rely on predicting the focus position but actually *focus* the system at appropriate times. As such, this would be expected to give you the most optimal focus at any point in time. The trade-off here is the time to do the focusing. Depending on the method chosen, active focusing can add from 30 to 240 seconds, depending on the method used, camera download time etc.

- **Focus Now:** This button will focus the system using the options specified on this page.

- **Focus Exposure:** As mentioned above, these fields provide a convenient entry point for the FocusMax starting exposure. With most systems, the shortest exposure is suitable for focusing through the clear filter and the exposure time should be increased for less transparent filters. For example, you might set a 1 sec. exposure for color filters and a 2 - 4 second exposure for narrow band filters such as Halpha or OIII.
- **Brightest star in FOV:** FocusMax will choose the brightest object in the field of view. This is fine if there are no bright extended objects such as galaxies in the field but if there are, FocusMax will attempt to focus on that and will most likely be unsuccessful.
- **Focus at X, Y:** One way to avoid the above problem is to select a specific x,y coordinate for a target star. Take an unbinned image and note the coordinates of the brightest star. Enter those coordinates in the X and Y boxes. FocusMax will use that coordinate with a 100 x 100 pixel box around it to focus.
- **Sky Star:** With this technique and TheSky6, CCDAutoPilot will plate solve the current location, slew the scope to an nearby star, focus there using FocusMax and slew back to the original location. If guiding was in process, it will be stopped for focusing and restarted automatically once the telescope has returned to the target coordinates. This technique guarantees a suitable star for focusing and uses the very powerful data query technology of TheSky6 to select stars of an appropriate magnitude to be used for focusing. SkyStar has some additional options: **Center Focus Star:** When checked, a precision slew to the focus star will be made, insuring the focus star is in the center of the FOV. When checked, **To within xxx arc-sec.** allows you to specifiy how close the focus star will be to the center of the imager's FOV. **Magnitude Range:** 4 magnitude ranges are provided for the focus star - 4 to 7, 5 to 8, 6 to 9 and 7 to 10. Select the range that is appropriate for your system. **Minimum focus star altitude:** Regardless of where the telescope is pointing, focusing will always use a star above this minimum altitude. As a minimum, you **must** have the Guide Star Catalog (GSC) selected as one of the Stellar Core databases in TheSky.
- **Focus Program Picks Star:** This is similar to Sky Star but it is all done within FocusMax using AcquireStar and requires the full version of PinPoint. Unlike SkyStar, whatever filter you use to focus on will be the same filter used for plate solving. ~~This may be problematic when using low transmission filters such as Halpha and other narrow band filters.~~ CCDAutoPilot will use precision slew to correct any returning slew errors from the focus program.
- **None:** No focusing is used. This setting might be used if it is desired to use only filter offsets.

Focusing With @Focus2



Before proceeding, insure @Focus2 is properly set up for your system. @focus2 is a feature of CCDSoft and can therefore be

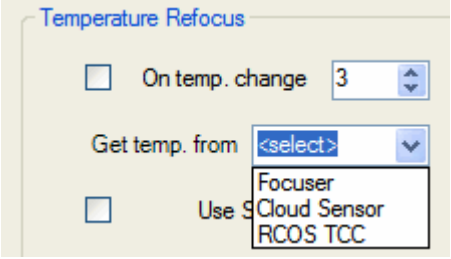
used only with CCDSoft. @Focus2 requires a calibration of what length exposure is required for what magnitude star to achieve approximately 20,000 ADU counts. This calibration is required for each filter and may be entered in the appropriate fields as shown in the above screen shot. Consult the CCDSoft documentation for proper setup. Depending on the spectral type (star color) of a chosen focus star, you may get different results, even with the same magnitude star. The effect is minimal with broadband filters such as clear filters and gets progressively more pronounced as the filter bandwidth tightens. For example, a red filter will show this effect more than a clear filter but much less than a Halpha filter. For RGB filters, I recommend calibrating on a G2V filter to "center" the spectral range. For best results with @Focus2, you should focus using the clear filter, determine and use filter offsets for your system. Once calibrated and with all the software connected, you can use the Focus Now button to verify operation.

- **Focus Now:** This button will focus the system using the options specified on this page.
- **Calibration Exposure:** This is the exposure time in seconds required to achieve a peak count of 20,000 ADU for the corresponding stellar magnitude below.
- **Calibration Magnitude:** This is the stellar magnitude required to achieve a peak count of 20,000 ADU for the corresponding exposure.
- **Brightest Star in FOV:** @Focus2 will choose the brightest object in the field of view. This is fine if there are no bright extended objects such as galaxies in the field but if there are, @Focus2 will attempt to focus on that and will most likely be unsuccessful.
- **Sky Star:** With this technique and TheSky6, CCDAutoPilot will plate solve the current location, slew the scope to an nearby star, focus there using @Focus2 and slew back to the original location. If guiding was in process, it will be stopped for focusing and restarted automatically once the telescope has returned to the target coordinates. This technique guarantees a suitable star for focusing and uses the very powerful data query technology of TheSky6 to select stars of an appropriate magnitude to be used for focusing. SkyStar has some additional options: **Center Focus Star:** When checked, a precision slew to the focus star will be made, insuring the focus star is in the center of the FOV. When checked, **To within xxx arc-sec.** allows you to specifiy how close the focus star will be to the center of the imager's FOV. **Magnitude Range:** 4 magnitude ranges are provided for the focus star - 4 to 7, 5 to 8, 6 to 9 and 7 to 10. Select the range that is appropriate for your system - 4 to 7 is a recommended starting point. **Minimum focus star altitude:** Regardless of where the telescope is pointing, focusing will always use a star above this minimum altitude. As a minimum, you **must** have the Hipparcos/Tycho Catalog selected as one of the Stellar Core databases in TheSky.
- **Focus Program Picks Star:** Working in concert with TheSky6, CCDAutoPilot will first plate solve the current location. @Focus2 will then slew to a suitable focus star and focus the system. If guiding was in process, it will be stopped for focusing and restarted automatically once the telescope has returned to the target coordinates. **Magnitude Range:** 4 magnitude ranges are provided for the focus star - 4 to 7, 5 to 8, 6 to 9 and 7 to 10. Select the range that is appropriate for your system. **Minimum focus star altitude:** Regardless of where the telescope is pointing, focusing will always use a star above this minimum altitude. As a minimum, you **must** have the Hipparcos/Tycho Catalog selected as one of the Stellar Core databases in TheSky.
- **None:** No focusing is used. This setting might be used if it is desired to use only filter offsets.

Common Capabilities

- **Focus using <filter>:** If your filters are sufficiently parfocal, i.e. they all focus at the same point, you may choose to use one specific filter for focusing. That way you can avoid having to deal with different focus exposures for different filters. If your filters are not parfocal, you should determine and use filter offsets.
- **Post Focus Offset:** This setting can be used to minimize the effects of OTA field curvature. The intent is to "split the difference" between perfect focus at the center and focusing at the edge of the field of view. For OTA's without a field flattener and/or a large imaging chip, there can be a significant difference in the focus position between center and edge. First, determine the focus at the center of your OTA and then determine it at some point away from the center. A good starting point is 60% of the way to the corner. You can use the Focus Now button to determine these values. Average a number of focus runs at each location. Calculate the offset and enter it in the Post Focus Offset. For best results, the Center Focus Star option and SkyStar focusing should be used. After achieving focus, the post focus offset will be added or subtracted to the focus results, according to the sign of the entry.
- **Refocus every xx minutes:** Depending on the numeric entry, the focus method will be executed at the start of each series and every xx minutes thereafter. The next exposure that comes along that is xx or more minutes after the last focus will be executed. In other words, the time for an interval focus is determined before an exposure starts. If xx minutes has elapsed since the last focus, a focus run will be performed; if it hasn't elapsed, the checking process will repeat before the next exposure starts. You should set up a brief series of exposures to insure FocusMax can focus satisfactorily with all of the planned filters in place, adjusting the focus exposure to be appropriate to a given filter as described below. Make any adjustments to the FocusMax settings required.

Temperature Refocus



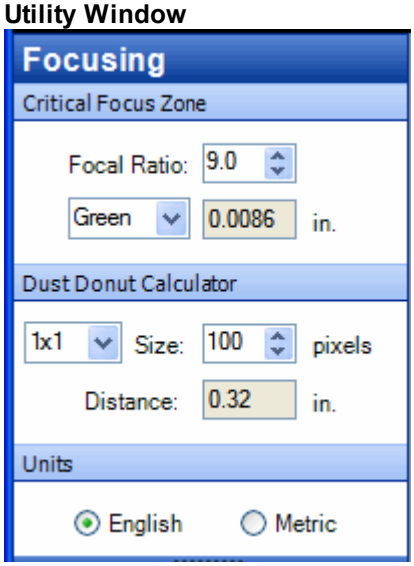
By characterizing your imaging system's performance, it is possible to refocus only when necessary. Knowing how much temperature impacts your focus, you may elect to refocus every time the temperature change is such that your focus moves out of the Critical Focus zone. Thus, having a source of temperature measurement and knowing how much of a change will adversely impact your focus, you can check On temp. Change, enter a suitable change amount, select the source of temperature measurement, and refocus as needed. Depending on what control programs are connected to CCDAutoPilot, the available choices will be selectable as temperature sources. Make sure you choose one if you are using this option.

Readout Mode
This entry sets the camera readout mode used for focusing. See Readout Modes. This selection is available only with Maxim version 5.

Passive Methods
These are methods that rely on the predictability of your system's optimal focus position. To the degree your system is not predictable, your focus will be less optimal

- **Temperature Compensation:** If this box is checked and your focuser supports temperature compensation, it will be enabled. Temperature compensation will be disabled automatically during the main exposure. At the conclusion of the main exposure, temperature compensation will be re-enabled and a 5 second delay will be initiated to allow time for temperature compensation. To use temperature compensation, the user must provide a **Compensation Slope** that appropriately characterizes the system. This value should be counts/temperature needed to maintain focus. When **Temp. Compensation** is checked, the Focuser Temperature will be shown. If "n/a" is shown, the focuser does not report temperature and temperature compensation can not be used. There are many ways to determine the compensation slope. The basic process is to measure the focus point at different temperatures and calculate the slope. Am imaging session with 10 minute exposures and a focus before every exposure during a period of temperature change is a good way to get the raw data. A least squares fit then gives a good slope. The compensation slope should be in units of focuser count per unit temperature. Be sure the temperature reported, °C, °F or counts used for the measurement is the same as that reported as Focuser Temperature. The focus starting point will be determined at the beginning of a run and the starting temperature noted. At each subsequent focus, the starting point and temperature will be redefined. Between exposures, the focus point will be adjusted, based on the current temperature and the user-supplied Compensation Slope. **Note:** If focuser temperature compensation is enabled in either your focuser or focus control program, it will be disabled when CCDAutoPilot is connected.
- **Offset:** enter how many counts you wish your focuser to move for a given filter. Normally one filter would be the reference and the others would move an amount, either + or -, relative to that reference. The reference filter should be the filter you select for plate solving - usually a clear or luminance filter. If your filters are parfocal, i.e. they all focus at the same focuser position, you would enter 0 for all the filter offsets. The  button at the top sets all filter offsets to the same value as that of the first filter entry. If some filters, typically some Halpha filters, are sufficiently non-parfocal, you can speed up the active focusing method considerably by entering the offset. That way, automatic focusing will start closer to the ultimate focus position

Utility Window



There are two calculators provided with your choice of English or Metric units. The Critical Focus Zone calculator gives the depth of the CFZ as a function of the wavelength of light and the Focal Ratio 9F/#) of your system. This calculator can be useful to determine how often you need to refocus with temperature changes or even how repeatable your focusing is. The other calculator is useful for determining where a dust particle is by measuring its resultant dust donut diameter in pixels. Simply measure the

diameter of the dust donut in pixels and define the binning used. Based on the unbinned plate scale entered on the Settings page, the distance from the imaging plane to the dust particle is calculated.

Tracking & Guiding

CCDAutoPilot provides a number of options for guided and unguided imaging. You can also image through the meridian using CCDAutoPilot's pioneering meridian flip technology.

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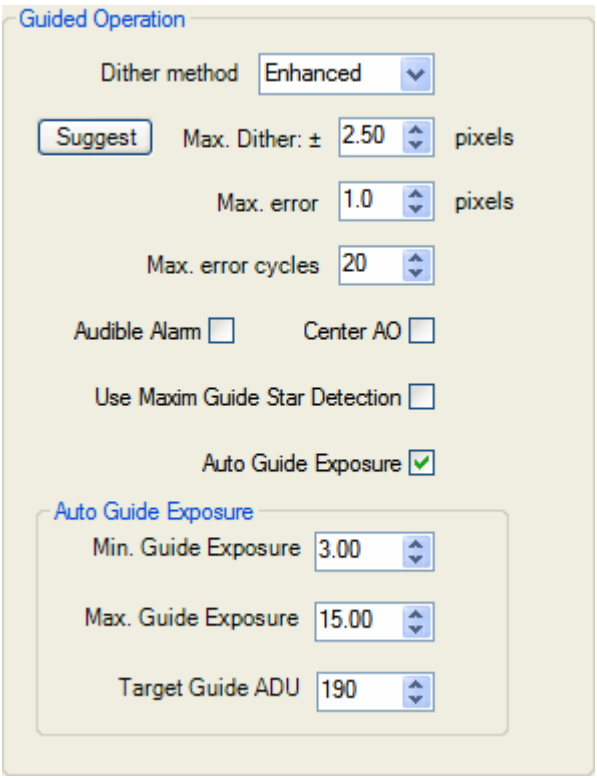
Guided Operation



After successful initialization, CCDAutoPilot automates the guided operation parameters for optimal guiding. Regardless of where you are pointed in the sky and at what rotation your camera is, the optimal guide vectors will be developed and applied to your camera control program. Initial guide star detection is accomplished in CCDAutoPilot. Its location is determined through three exposures to avoid selecting a cosmic ray hit or other artifact via an outlier rejection routine. For automatic guide star exposure, three measurements are averaged to more accurately set the guide exposure time. And if the guide star is lost due to passing clouds, the Automatic Guide Star Recovery routine (see below) is invoked to try to recover the guide star if at all possible.

Dithering

Dithering is a process whereby the guide star location on the guider chip is moved between image exposures in either a random or optimized manner. When the guider control repositions the guide star to the new location, the image will be slightly displaced on the imager chip. When the resultant images are aligned and properly combined, hot and cold pixels, cosmic ray hits and other sensor-specific artifacts are removed, much better than any hot/cold pixel routine can ever hope to achieve. The resultant image is smoother and artifact-free. See this link for more details on this technique.

Dithering can be done either totally randomly, as determined by a random number generator, or in a controlled manner to maximize separation between each sub-exposures artifacts while minimizing the overall guide star movement. Both options are provided. The amount of the dither is user-definable. Here is a discussion on how to set the amount of dithering.

- **Dither method:** Select Enhanced (preferred) or Random.

Maximum Dither: This is the peak dither value and can go +/- from the starting direction. As an example, suppose Enhanced Dithering is selected with a Max Dither of 3 pixels. The first sub-exposure will leave the guide star position undisturbed. The second will move the X position of the guide star + 3 pixels. The third will move the X position of the guide star - 3 pixels *from the first exposure.* Thus the total movement between the second and third exposure is 6 pixels but the movement relative to the first sub-exposure is ± 3 pixels. If dither is set to 0, guiding will not be stopped between exposures except for any specified focusing actions.

- **Suggest:** this button will enter a Max. Dither value, based on the parameters of your system entered on the settings page. This can be a starting point from which you can experiment if you desire.

Automatic Guide Star Recovery (AGRS)
Many times when a guide star fades, the guider drives the telescope off the target in its quest to find the guide star. CCDAutoPilot has a technique to prevent this from happening in an attempt to minimize data loss. If the guide star position is not recovered to the user-specified tolerance in a user-specified number of attempts, AGRS institutes a number of procedures in an attempt to recover the guide star. If all those attempts fail, the image is allowed to continue unguided to prevent the guide star search from driving the telescope from its intended target. AGRS is repeated at the start of the next sub-exposure so that, if the passing cloud has passed for example, the guide star is recovered and guiding continues on target. An optional Audible Alarm can be sounded to alert a nearby operator of the failed guide star recovery attempt. This has proved instrumental for some users in alerting them to an impending bad weather condition, although this should not be relied upon for equipment protection.
Max. Error: If the maximum error is specified at 0, AGRS is disabled; if it is any other value, AGRS is enabled. This entry specifies the value the guide error has to get down to during guider restart before the exposure is permitted to continue.
Max. Error Cycles: This specifies how many tries the guider has to get the guide star error below the Maximum Error. If the guider does not get the guide error below the specified Maxim Error in the specified Maximum Error Cycles. AGRS is activated.

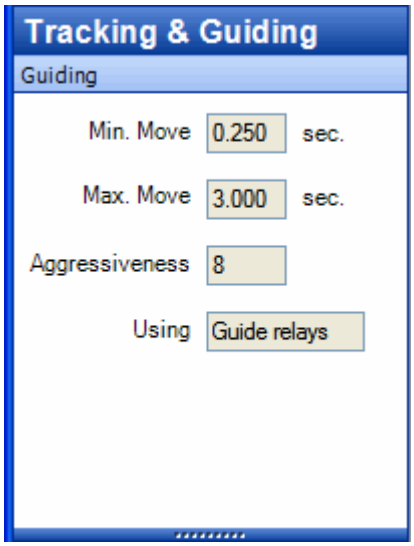
AO Center: When an Adaptive Optic corrector is used for guiding, the mirror/glass position could be at some point other than 50% when slewing to a target. Checking this box centers the mirror/glass at the neutral position.

Use Maxim Guide Star Detection: With some guiders, guide star detection may be problematic. Even though every effort is made by CCDAutoPilot to select an appropriate guide star, in some cases it may be appropriate to use Maxim's guide star selection routine. Checking this box allows this option. Note that if this option is checked, Auto Guide Exposure is not possible nor is the ability to ignore saturated guide stars. (It is generally agreed that best guiding performance is obtained with unsaturated stars. CCDAutoPilot uses technology to avoid saturated stars for guiding.)

Automatic Guide Exposure
When Auto Guide Exposure is checked, CCDAutoPilot will set the guide exposure automatically to achieve the Target Guide Exposure you have entered within the Min. Guide Exposure time and Max. Guide Exposure time you specify. This automatic setting is done at the star of each series and after a meridian flip. If it can't get to your target level within the range you specify, it will go to the Min. Guide Exposure time if the Guide ADU is too high or to the Max. Guide Exposure time if the Guide ADU is too low.

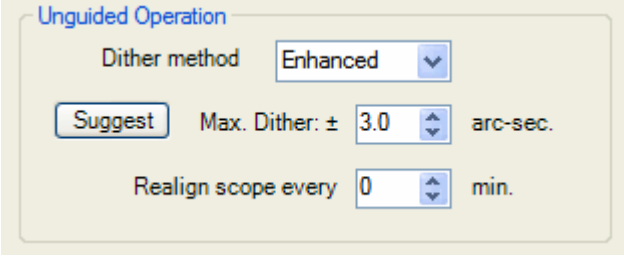
When using Auto Guide Exposure, the Guide Exposure settings on the Light Frames page are ignored and grayed out as a reminder except in one case. If the Guide Exposure on the Lights page is 0, this is interpreted as a desire for unguided imaging for the series with a zero value Guide Exposure. If you intend to use Automatic Guide Exposure for guided imaging, be sure to enter non-zero value(s) for the series you wish to be guided *before you select Automatic Guide Exposure,* to avoid the series being unguided. Once you have a non-zero value entered, 1 sec. will suffice, select AutoMatic Guide Exposure and the guide exposure will be in the range you specify, between Min. and Max. Guide Exposure.

Utility Window



As a reminder, your guider settings are displayed in the Utility Window.

Unguided Operation



Dithering

Dithering is a process whereby the guide star location on the guider chip is moved between image exposures in either a random or optimized manner. When the guider control repositions the guide star to the new location, the image will be slightly displaced on the imager chip. When the resultant images are aligned and properly combined, hot and cold pixels, cosmic ray hits and other sensor-specific artifacts are removed, much better than any hot/cold pixel routine can ever hope to achieve. The resultant image is smoother and artifact-free. See this link for more details on this technique.

Dithering can be done either totally randomly, as determined by a random number generator, or in a controlled manner to maximize separation between each sub-exposures artifacts while minimizing the overall guide star movement. Both options are provided. The amount of the dither is user-definable. Here is a discussion on how to set the amount of dithering.

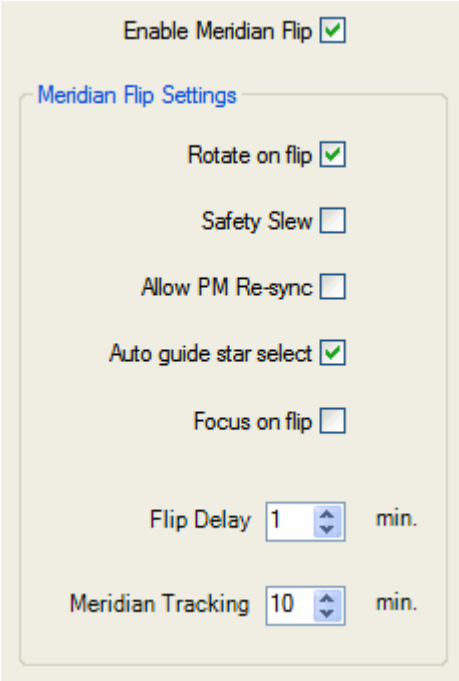
- **Dither method:** Select Enhanced (preferred) or Random.
- **Maximum Dither:** This is the peak dither value and can go +/- from the starting direction. As an example, suppose Enhanced Dithering is selected with a Max Dither of 3 arc-sec. The first sub-exposure will leave the guide star position undisturbed. The second will move the X position of the guide star + 3 arc-sec. The third will move the X position of the guide star - 3 arc-sec. *from the first exposure.* Thus the total movement between the second and third exposure is 6 pixels but the movement relative to the first sub-exposure is ± 3 arc-sec.
- **Suggest:** this button will enter a Max. Dither value, based on the parameters of your system entered on the settings page. This can be a starting point from which you can experiment if you desire.

Periodic Realignment

When a long series of unguided exposures are taken, the mount will gradually track off the target. By using this feature, the telescope is periodically realigned to the target coordinates. (If any periodic focusing using SkyStar is implemented, target realignment will occur during that process. If that is used, additional periodic realignment will occur only as long as the time between SkyStar focus runs has exceeded the realignment period.

Realign scope every x minutes: If 0 is entered, this function is disabled. If a non-zero value is entered, the telescope will be realigned to the target coordinates via a precision slew after the current exposure completes and after the specified interval has elapsed.

Crossing the Meridian



Automatic meridian flipping essentially uses software to turn an equatorial mount into a fork mount functional equivalent. This is achieved by allowing the telescope to track a target up to the meridian, stop the exposure, move the telescope to the other side of the meridian and then continue tracking. If a rotator is employed, the camera is rotated by 180°, the guide star is reacquired and guide calibration is appropriately adjusted. All this is accomplished automatically. Automatic meridian flipping depends on successful plate solving and initialization.

- **Enable Meridian Flip:** Checking this enables the telescope to track through the meridian when going from east of the meridian. If checked and the target is west of the meridian, it will of course have no effect. For most users, this option can be left checked. Uncheck it if you are using a fork mount or an equatorial mount that is capable of tracking through the meridian without damage.
- **Rotate on Flip:** If checked and a rotator is connected to CCDAutoPilot, the meridian crossing event will also trigger a rotator movement by 180°. Thus the images on the west of the meridian will be the same orientation as on the east side of the meridian.
- **Safety Slew:** Some mounts, notably the Gemini, will not flip even though the target has crossed the meridian. Checking Safety Slew will slew the mount one hour past the meridian, which will force the flip, and then back to the target. This should eliminate the need for the AM stop offset setting and it should be set to 0.
- **Allow PM Re-sync:** If this option is checked, an image is taken and plate solved after a meridian flip. The mount is then sync'd to the center of the solved image. The correcting slew is then from this reference. Recommended for portable setups or for setups with poor pointing accuracy. If this option is cleared, there is no sync and the correcting slew is made from the plate solved position. This option should be cleared for permanent setups with good pointing accuracy as may be obtained with a suitable Tpoint model. If checked, any Tpoint models should be disabled as repeated syncing into a Tpoint model is not recommended and will result in pointing inaccuracies. Use either Allow Re-sync or Tpoint but not both.
- **Auto guide star select:** If checked, an automatic detect of the brightest star in the field will be used to guide. If unchecked, the run will pause until you select a guide star and tell it to continue.
- **Focus of flip:** When checked, the focus method chosen on the Focus page will be executed immediately after the meridian flip and before the next exposure.
- **Flip Delay:** This is the number of minutes to delay the meridian flip. Some mounts may require a longer delay than the default 1 minute to determine the target has passed the meridian. You should experimentally determine you particular mount's characteristic.
- **Meridian Tracking: If the value entered is positive**, this indicates the number of minutes your mount can track past the meridian and defers the flip for the your specified number of minutes. Depending on the above two settings, you may be able to get another exposure in before meridian crossing and eliminate the wait time for the meridian flip. Observatory users using DDW or ASCOM for observatory control should insure their shutters permit crossing the meridian by the PM Tracking time since dome tracking is disabled 2 minutes before a meridian flip. AutomaDome has no such limitation since it integrates tightly with TheSky. **If the value entered is negative**, the mount backs up 1 hour in RA in the east and the session waits for the specified number of minutes. This is helpful if you cannot allow your OTA to point to the zenith (Alt. = 90°) due to interference with a camera. It can also be used if your mount has some ambiguity in slewing to a location whose RA has passed the meridian. By setting Meridian Tracking to -10 or so, the target RA will be 10 minutes past the meridian before meridian flip is enabled. Some experimentation may be required for the smallest negative value that will work.

Tips on efficient meridian usage

With the various time settings, you can increase your meridian usage efficiency. AM stop offset is generally not needed and can be left at 0. Flip delay is the amount of time your mount has to track past the meridian before it (the mount) knows it is time to flip and will do so. For most mounts, this can be set to 1. PM Tracking requires a bit more discussion. Let's assume you have determined your mount can safely track past the meridian for 15 minutes. Set the PM Tracking to 12 minutes for a safety margin. Now, assume you are taking 10 minute sub-exposures at the time the mount approaches the meridian. Assume your meridian crossing is at 22:05. Here is a schedule of events you might see:

21:50	Take 10 minute exposure
22:00	Take 10 minute exposure
22:05	(Time to flip - deferred)
22:15	Flip meridian
22:18	Take 10 minute exposure

Now, if PM Tracking were set to 0, this would be the result

21:50	Take 10 minute exposure
22:00	Wait for meridian flip
22:05	Flip meridian
22:09	Take 10 minute exposure

Here are some excerpts from an actual log with PM Tracking set at 10 minutes:

>>> Here is the target information
20:02:28 Target: M1
20:02:28 Rise: 13:51 6 Feb
20:02:28 45° E elevation: 17:32 6 Feb
20:02:28 Transit: 20:50 6 Feb
20:02:28 45° W elevation: 00:09 7 Feb
20:02:28 Set: 03:50 7 Feb

20:05:49 Solved RA: 05 34 30.2, Dec: +21 59 17

20:05:49 Target RA: 05 34 30.2, Dec: +21 59 17 , PA: 358.4
20:05:49 Meridian flip after 20:51 Tue 6 Feb
>>> The mount would have flipped at 20:51 without the buffer time

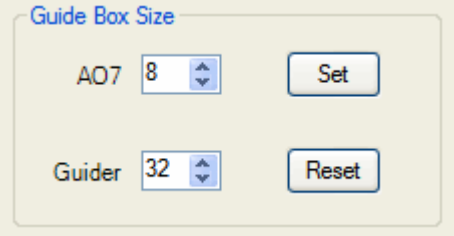
>>> The exposure completed after the meridian flip time but before the 10 minute buffer elapsed.
20:43:31 Exposing...
20:54:15 D:\Astronomy\070206_M1\Clear356E_M1_00006.fit

>>> And then the mount flipped immediately.
20:54:18 Waiting for meridian flip time...
20:54:18 Meridian flip starting...

If your mount is capable of longer tracking past the meridian, the flip can be deferred longer, for example in the case of an Astro-Physics mount which can track for a number of hours past the meridian, depending on telescope, camera, declination, etc.

Warning: It is up to the user to determine the proper setting for PM Tracking. In addition to consulting your mount's documentation, you should also experiment at various declinations, while watching the mount. If you rotate your camera, you should also verify the PM tracking at various camera rotations.

Guide Box Size



Guide Box Size (CCDSoft only)
This setting allows adjusting the size of the guide star box. This is the image that is visible when the guider is operational. The settings must be set before guiding is enabled. You can set either the AO7 guide star box or the conventional guider guide star box. Changing during guiding will not have any effect. Due to Maxim's automation interface limitations, this feature is available only with CCDSoft.

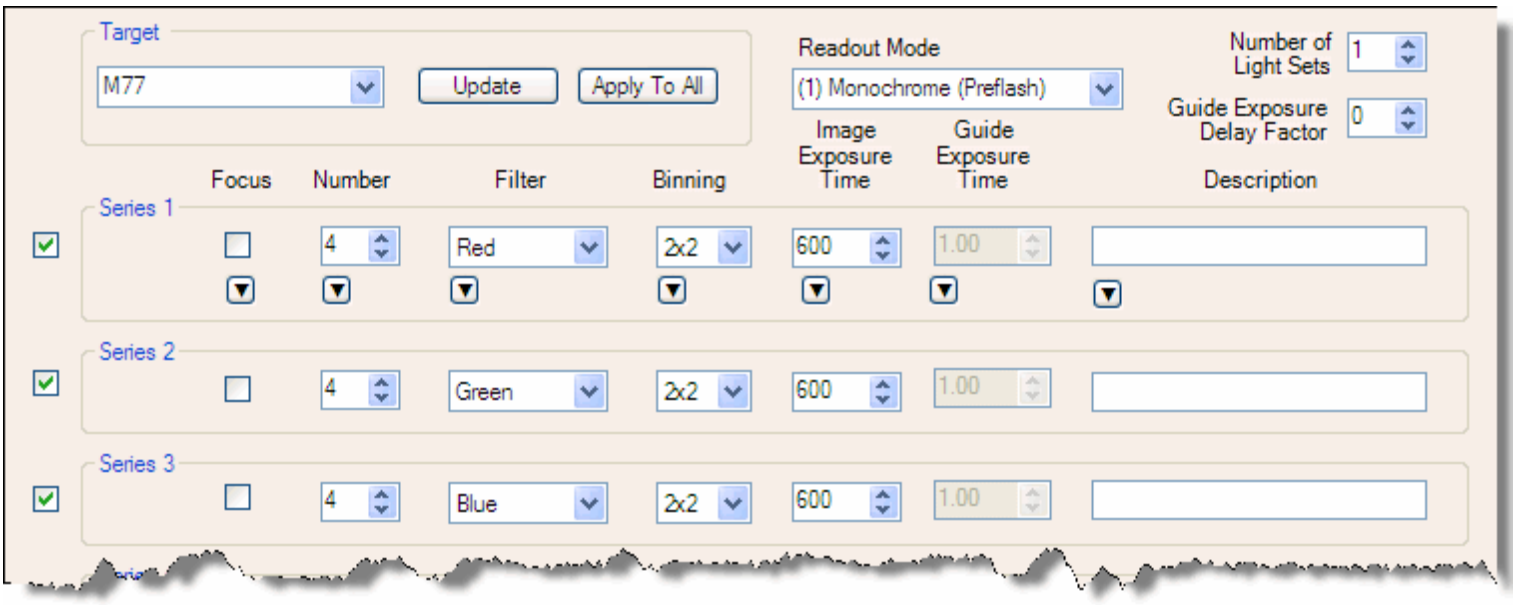
- **Set:** Enters the values shown for the guide box size.
- **Reset:** Resets the guide box size to the default values of 8 for the AO7 and 32 for conventional guiders.

Light Frames

This page sets up the actual light frames that will be acquired during the imaging session. For a multi-target session (*Professional edition only*), you can specify a unique set of exposure conditions, including guide exposure, *for each target independently.* For the standard edition, there is one target and one set of exposures. The Utility Window can help you optimize your light frame acquisition.

Contents

Light Frame Acquisition (Reference)
Target Selection
Exposures
Utility Window



Target Selection

This box selects the target whose light exposures you wish to edit. The drop down will be populated with all the target names that are present in the Target List. Select the one whose light frames you wish to edit. After editing the light frames (see below), you have two choices:

- **Update:** Hitting this button will apply the light frame selections to that specific target.
- **Apply to All:** Hitting this button will apply the light frame selections to all of the targets on the list.

You should save the Target List as you make changes to each target's light frames.

Exposures

Here is where you set the specifics of your exposure plan. There are 8 series of exposures possible for each target but you are not limited to 8. By using multiple identical target entries, it is possible to select a virtually unlimited number of exposure prescriptions.

For each series, the checkbox at the left of each series enables or disables that series. When disabled, the series information is grayed out. The remainder of the series information is:

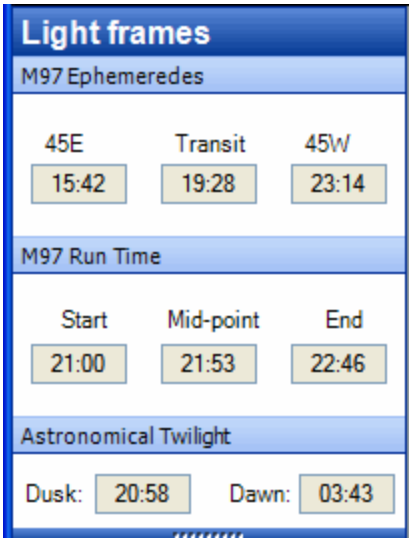
- **Focus:** When checked, the chosen active focusing method will be applied at the start of each series.
- **Number:** This is the number of exposures that will be taken in this series before moving on to the next series.
- **Filter:** This is the filter that will be used for this series. Filter naming and selection will be according to the names and capabilities of your camera control program.
- **Binning:** This is the degree of binning that will be used for this series. Binning will be according to that reported by your camera control program and your specific camera.
- **Image Exposure Time:** This is the length of time your imaging camera will be exposed in seconds.
- **Guide Exposure Time:** This is the length of time for your guide exposure. Allowable range is 0 to 50 sec. in 0.1 sec steps. If 0 is entered, that series will not be guided. If Auto Guide Exposure is enabled, the guide exposure setting will be disabled (grayed out) as a reminder.
- **Description:** Here you can enter a specific description for the exposure. If no description is entered, the file name for the exposure will be automatically generated as follows: <Filter><E/W>_<Target>_<sequence number>.fit. <Filter> is the name of the filter for the series. <E/W> indicates which side of the meridian, East or West, the image was taken. <Target> is the target name, as defined in the target pulldown. The sequence number is a 5-digit number that identifies one exposure from another. If

you enter a description, the file name will be <Description>_<Target>_<sequence number>.fit, where <Description> is the description entered. Since the description will ultimately be part of the data file names, it must not include the Windows "forbidden characters", '*/:<>?|'. Such characters will be stripped from the target name if present. There are certain formatting conventions that must be followed for the coordinates.

Below each item in Series 1 is the  button, which replicates the series 1 settings into all of the other series for easy editing.

- **Guide Exposure Delay Factor:** If this value is non-zero, a delay equal to the guide exposure for the specified filter times the number entered is applied before the actual exposure initiates. With AGRS enabled, this can usually be left at 0.
- **Number of Light Sets:** This is the number of times each series will be repeated for each target. For example, assume series 1 has 3 red-filtered (R) exposures, series 2 has 2 green-filtered (G) exposures and series 3 has 5 blue-filtered (B) exposures. If this number were set at 3, the selected target would be exposed in this sequence: RRRGGBBBBBRRGGBBBBBRRGGBBBBB. With this capability, you can be sure to get at least some data with each filter, when conditions may not bode will for a totally clear evening.
- **Readout Mode:** Selects the readout mode used for light frames. See Readout Modes. This selection is available only with Maxim version 5.

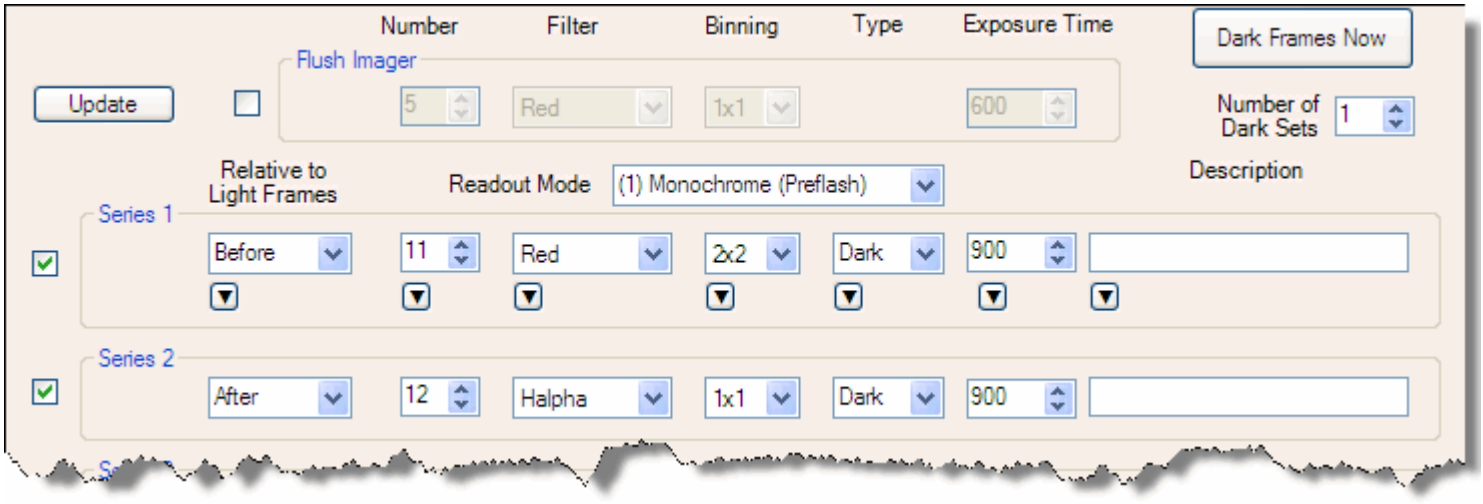
Utility Window



The utility window has helpful reference data to allow you to optimize your session. When a target is selected, its Ephemerides is shown in the top portion of the window. The transit time, along with meridian limit time for whatever east and west meridian limits you used for the Targets page Utility Window are repeated as well. Next, the run time is shown for that specific target. Lastly Astronomical twilight times are shown. By changing the number of frames on the light page, you can optimize your run to center on the meridian. When you hit the Update button, the revised run time is shown. You can do this for each target.

Dark & Bias Frames

CCDAutoPilot give many possibilities for automatically acquiring calibration frames to make maximum use of your available evening. Without good calibration data, your resultant images will be less than they could be. Dark and Bias Frames, together with Flat Frames, provide the calibration data needed for best results. The Utility Window can help you obtain darks in whatever time is available before or after your light frames.



For each series, the checkbox at the left of each series enables or disables that series. When disabled, the series information is grayed out. When the Flush Imager series is checked, the series will be run once before any subsequent dark or bias frames are acquired. The Flush series is used to remove any residual image that may remain after light frame exposures of bright objects. You should experiment with your specific camera to see what kind of flush series is appropriate.

The remainder of the settings for each series is:

- **Relative to Light Frames:** You have the ability to take the series before, after or both before and after the light frames. Depending on your automation plan, you can maximize the calibration frames acquired in an evening this way.
- **Number:** This is the number of exposures that will be taken in this series before moving on to the next series.
- **Filter:** This is the filter that will be used for this series. Filter naming and selection will be according to the names and capabilities of your camera control program. If you have a shutterless camera, you can select an opaque filter slot for your darks.
- **Binning:** This is the degree of binning that will be used for this series. Binning will be according to that reported by your camera control program and your specific camera.
- **Type:** Select either bias or dark. A bias frame is essentially a 0-length exposure time dark.
- **Exposure Time:** This is the length of time your camera will be exposed in seconds.
- **Description:** Here you can enter a specific description for the exposure. If no description is entered, a default file name for the exposure will be automatically generated. For a bias frame, the file name will be <Camera temperature>Bias<Binning>_<yymmdd>_<sequence number>.fit, where <Camera Temperature is the operating temperature of the camera, Binning is the selected binning, <<yymmdd> is the date the exposure is taken and <sequence number> is the 5-digit sequence number used to identify one exposure from another. For a dark frame, the default file name <Camera Temperature>Dark<Exposure Time><Binning>_<sequence number>.fit. The only difference from the bias frame default is the addition of the exposure time to the file name. If you enter a description, the file name will be <Description>_<yymmdd>_<sequence number>.fit, where <Description> is the description entered. Since the description will ultimately be part of the data file names, it must not include the Windows "forbidden characters", '*/:<>?|'. Such characters will be stripped from the target name if present.

Below each item in Series 1 is the ▼ button, which replicates the series 1 settings into all of the other series for easy editing

- **Number of Dark Sets:** This is the number of times each series will be repeated.

- **Dark Frames Now:** This button will take the dark and bias frames specified on this series immediately. All that is required is a camera connection.
- **Readout Mode:** Sets the readout mode used for dark and bias frames. See Readout Modes. This selection is available only with Maxim version 5.

Utility Window

The Utility Window shows your planned light frames and, this case, the dark frames that are acquired before and after the light frames. The sky flat acquisition time is also provided. In this example, I wait until 21:00 to start so that my first target can get above 45° east altitude. During the time between civil dusk at 19:48 ant the first target start time, I grab some dark frames to refresh my dark library. Similarly, I see some time between the last target's light frame and the start of dawn flats so I can grab some more dark frames. Thus, you can maximize your camera usage during the entire evening if you wish.

Flat Frames

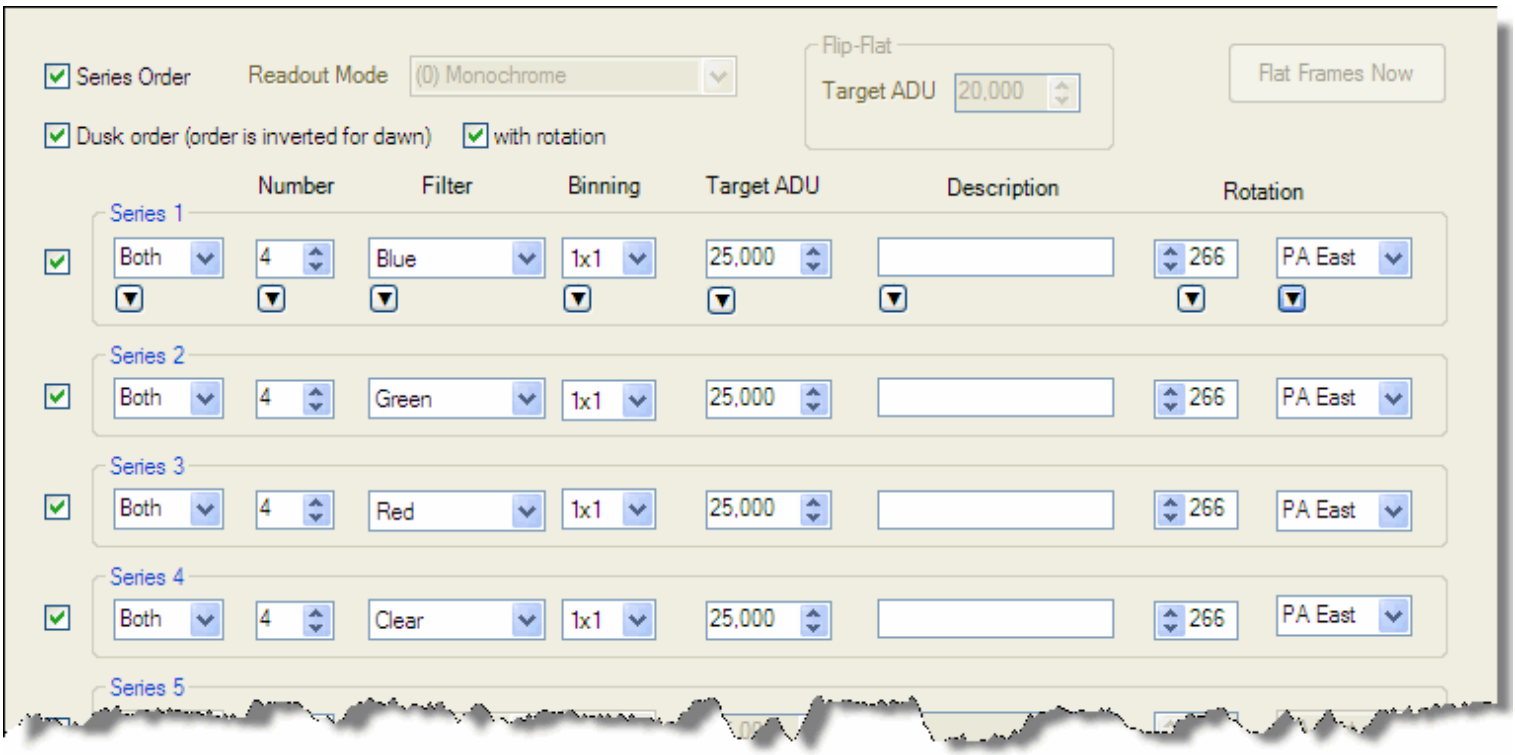
Get any group of professional astronomers together and sooner or later the subject will turn to flat fielding. Flat frames are essential if the faintest parts of a target are to be detected. The basic concept is to point the system to a uniformly illuminated light source and take an exposure. The resultant exposure will capture all of the imperfections in the system - vignetting, dust on the optical surfaces, off-axis optics and other disturbances. Various illuminated screens are normally used for a target. Or, the twilight sky itself can be used! There is a specific point in the twilight sky called the null point that has the most uniform lighting. When dawn or dusk flats are selected, the telescope is automatically slewed to this point at the appropriate time.
While some may avoid flat frames due to the assumed difficulty in acquiring good ones, CCDAutoPilot makes the acquisition of high quality flats very easy. By pointing the telescope to the proper point in the twilight sky, a very uniform light source for flat fields is obtained. The difficulty of dealing with the changing brightness of the twilight sky is resolved by the efficient auto exposure routine that dynamically adjusts the exposure to the changing conditions to meet the desired exposure target, expressed in ADU (Analog-Digital Units) or "counts" as it is commonly called. Even with an artificial light source, such as a dome screen or light box, flats can be taken automatically.

Flat levels are measured with a sub-frame in the center of the imager during both the automatic exposure setting and when measuring the actual downloaded flat to minimize calculation time. This is a new feature, starting with version 4.15.1.

When planning flats with a rotator, the Utility Window shows the Position Angles for your target(s) as a helpful reminder.

Flip-Flat support is integrated into CCDAutoPilot. See Flip-Flat Notes.

Exposures



There are 8 series of exposures possible for your flat series and these can be obtained at dusk, at dawn or both. For each series, the checkbox at the left of each series enables or disables that series. When disabled, the series information is grayed out. The remainder of the series information is:

- **Dawn/Dusk/Both:** The specified series will be taken at the selected point in the day.
- **Number:** This is the number of exposures that will be taken in this series before moving on to the next series.
- **Filter:** This is the filter that will be used for this series. Filter naming and selection will be according to the names and capabilities of your camera control program.
- **Binning:** This is the degree of binning that will be used for this series. Binning will be according to that reported by your camera control program and your specific camera.
- **Target ADU:** This is the desired count level for your flats. The level should be chosen to be in the linear range of your camera. The linear region is 30-45% of the full count level. For a 16-bit camera, typical levels are 20,000 to 30,000 ADU
- **Description:** Here you can enter a specific description for the exposure. If no description is entered, the file name for the exposure will be automatically generated as follows: <Filter>_Flat<Rotation>_<Target>_<sequence number>.fit. <Filter> is the name of the filter for the series. <Rotation> is the position angle for the flat. <Target> is the target name, as defined in the target pulldown. The sequence number is a 5-digit number that identifies one exposure from another. If you enter a description, the file name will be <Description>_<Target>_<sequence number>.fit, where <Description> is the description entered. Since the

description will ultimately be part of the data file names, it must not include the Windows "forbidden characters", '*/:<>?|'. Such characters will be stripped from the target name if present.

- **Rotation:** This is the position angle at which the flat will be taken and consists of two parts, the angle and side of meridian. If you don't have a rotator, these settings will be ignored. You can enter the angle and then select from PA East (for flats corresponding to exposures east of the meridian or, PA West for flats corresponding to exposures west of the meridian. If you want flats specified at a particular rotator angle, Select Rotator. If you want no rotation, select None.I

Below each item in Series 1 is the  button, which replicates the series 1 settings into all of the other series for easy editing.

The need for separate flats for each filter and rotation depends on each situation. Experimentation is needed to determine what kind of sensitivity your system (and you!) have to flat optimization. CCDAutoPilot gives you all the tools and capabilities you need to get the flat frames of your choice automatically and with minimal work on your part.

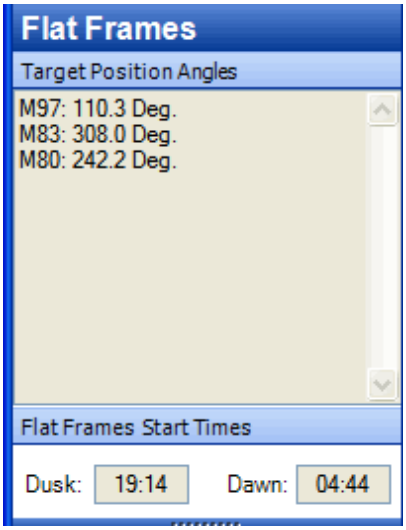
Options

- **Series Order:** When checked, flats will be acquired in the order they are entered on this page. In this example, dusk flats for the blue filter will be acquired first. The next series will not be initiated until the blue flats are acquired. If series order is unchecked, each dusk flat planned will be tried to see it the ADU target can be met, regardless of the series order. If you know your relative filter transparencies, you can take advantage of series order to increase your sky flat acquisition efficiency. In the example shown, the blue flats are taken first at dusk, since that is the least transparent filter. Then green, red and finally clear as the sky darkens. At dawn, the flats are taken in reverse order starting with the clear flats and ending with the blue flats as the sky brightens.
- **Dusk Order:** When checked, whatever order is entered for the flats will be inverted at Dawn. Note that when this is checked, "Both" is automatically set for all series. To use this option effectively, set your dusk flat order from least transparent filter to most transparent filter. For example, Ha, B, G, R, L. When your dawn flats are taken, the order will be reversed to L, R, G, B, Ha in this example. This maximizes twilight use for the highest number of flats.
- **with Rotation:** When checked, the dawn flats will be rotated from the dusk flats. For example, if you select PA East for the dusk flats, then the dawn flats will be PA West and vice versa. If you select Rotator for the dusk flats, the rotator will be moved by 180 degrees for dawn. This, together with the Dusk Order option, will allow an appropriate set of flats to be acquired when using the stairstep method of data acquisition.
- **Flat Frames Now** Hitting this button immediately begins acquisition of the flat frames specified in the active series. This is most useful when an artificial flat illumination source, such as a screen or light box is available. Exposure will be automatically determined and flat acquisition will proceed unattended.
- **Readout Modes:** Selects the readout mode to be used for flat frames. See Readout Modes. This selection is available only with Maxim version 5.

Flip-Flat

When the Flip-Flat option is enabled on the Settings page, a single setting is used for the Target ADU. See Flip-Flat Notes for more details.

Utility Window



The utility window shows a listing of your target position angles as an aid in planning your flats. Also shown is the estimated sky flat start time.

Options

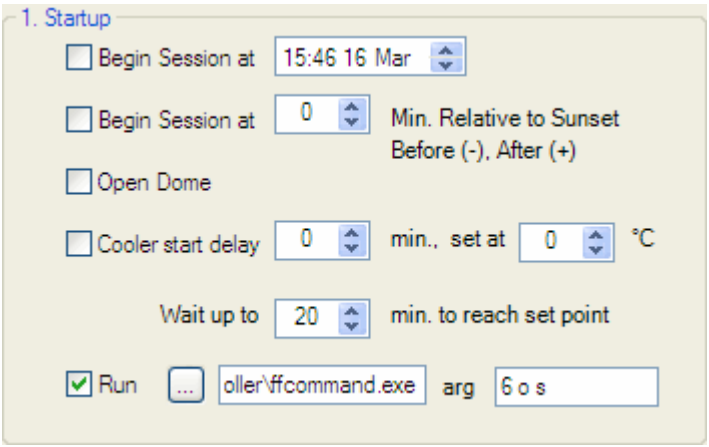
This page gives you the ability to completely customize the session to your needs and your systems capabilities. The session is roughly divided into three sections, each with their own set of customization options and each include the ability to launch a user-provided program at various places throughout the section.

Contents

1. Startup Section
2. Data Acquisition Section
3. Shutdown Section
Data Storage
Customization
Utility Window

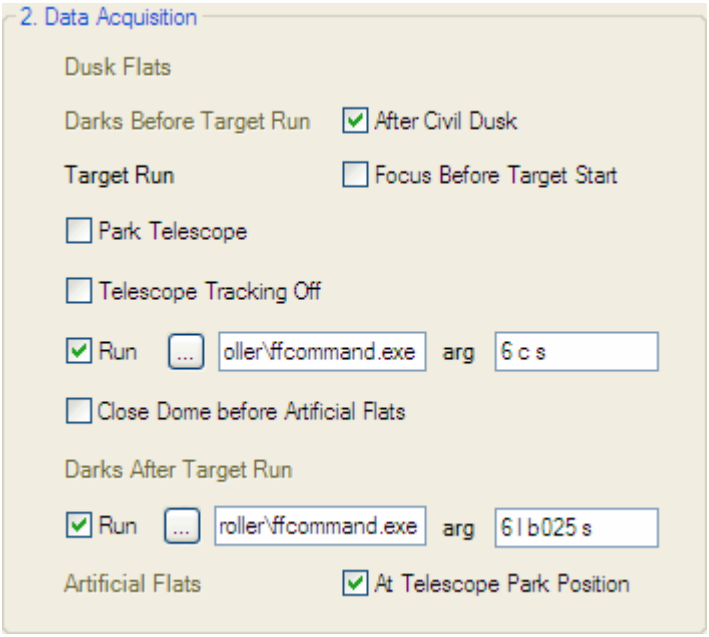
1. Startup

This section programs the desired startup activities prior to data acquisition.



- **Begin Session at a specified starting time:** When checked, the session will start at the specified time
- **Begin Session at a number of minutes relative to Sunset:** When checked, the session will start the specified number of minutes before (-) or after (+) sunset. Only one of the two Begin Session options can be checked.
- **Open Dome:** When checked and connected to appropriate dome automation software, the dome shutter will be opened at the session start time. If the dome fails to open, the run will abort.
- **Cooler start Delay:** When checked, this will allow the cooler to come on after the specified number of minutes delay and at the specified set point. The delay is defined as the time from the previously completed startup task. If this is the first checked task, it will be measured from session start.
- **Wait up to:** CCDAutoPilot will wait up to the specified number of minutes for the cooler to reach the set point specified above. As soon as the set point is reached, the session will continue; if the set point is not reached in the after the specified number of minutes, the session will continue.
- **Run:** When checked, the application in the space provided will be run. Navigate to this application by using the  file open button. The run will not proceed until this application completes and closes. Arguments for applications may be entered in the arg(ument) field next to the application. If any arguments are present, the application will be executed with the defined arguments.

2. Data Acquisition



Any planned data activities are shown here in the order they will be executed. If a data activity is disabled (grayed out), the activity is not planned. In the example, no darks are planned after the target run. This serves as a reminder to what you have specified for your data gathering.

- **After Civil Dusk:** Since most CCD cameras are not sufficiently light tight to permit quality darks when it is light out, checking this option will force any dark acquisition to wait for civil dusk so that it should be sufficiently dark.
- **Focus Before Target Start:** Checking this option will cause a focus run, using the settings specified on the Focus page, before any target acquisition begins. This is helpful when you are using a telescope whose focus point changes with temperature and your last focus was anear the end of a previous evening when it was cooler than it is at the start of a session now. Focusing will start from the current telescope position using the filter specified for plate solve exposures and the focus settings on the Focus page.
- **Park Telescope:** When checked, the telescope will be parked at its user-defined park position
- **Telescope Tracking Off:** If desired, or if the mount doesn't support parking, the telescope tracking will be turned off, leaving the telescope in its current position.
- **Run:** When checked, the application in the space provided will be run. Navigate to this application by using the ... file open button. The run will not proceed until this application completes and closes. Arguments for applications may be entered in the arg(ument) field next to the application. If any arguments are present, the application will be executed with the defined arguments.
- **Close Dome before Dawn Flats:** When checked, the dome shutter will be closed. This option could be used either when no dawn flats are planned and only dark and bias frames are needed.
- **Run:** When checked, the application in the space provided will be run. Navigate to this application by using the ... file open button. The run will not proceed until this application completes and closes. Arguments for applications may be entered in the arg(ument) field next to the application. If any arguments are present, the application will be executed with the defined arguments.
- **At Telescope Park Position:** When checked, flats from an artificial light source can be acquired at the telescope park position as soon as the dark frames are completed. These artificial flats will require a light source to be turned on appropriately. By using the previous Run command and a software-commandable light source, it can be turned on before flat acquisition.

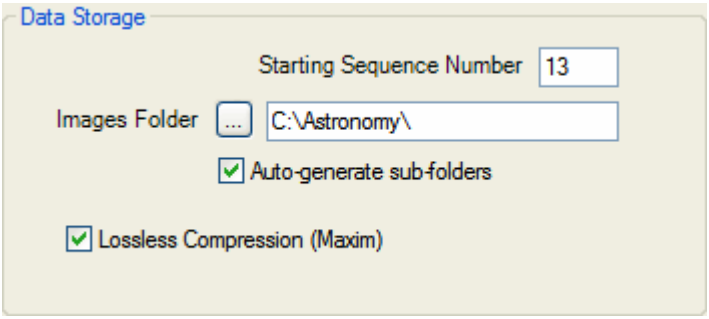
3. Shutdown

This section programs the desired shutdown activities.

- **Abort Light and Dark Frames at Dawn:** When checked, any light frames or dark frames still planned will be aborted before the planned start of sky flats, whether any are planned or not. This box is automatically checked if any dawn flats are selected. It should be unchecked if you want to take artificial flats at the telescope park position.
- **Re-park Telescope after Dawn Flats:** When checked, the telescope will return to its park position after dawn flats are completed. If a Pyxis rotator is being used, it will be moved to the 0 position.
- **Telescope Tracking Off after Dawn Flats:** If desired, or if the mount doesn't support parking, the telescope tracking will be turned off, leaving the telescope in its current position.
- **Close Dome after Dawn Flats:** When checked, the dome shutter will be closed at the conclusion of dawn flats.
- **Cooler Warmup:** When checked, the camera cooler set point will be set to +25°C. This is done in place of merely turning the cooler off in case the camera's driver controls the cooler ramp-up. This becomes more important in large chip cameras. In such cases, wait for the cooler duty cycle to get to 0% before turning off the camera.
- **Run:** When checked, the application in the space provided will be run. Navigate to this application by using the ... button. The run will not complete until this application completes and closed. Arguments for applications may be entered in the arg (ument) field next to the application. If any arguments are present, the application will be executed with the defined arguments.

Data Storage

You an specify where your data is to stored either on a local PC or over a network. See the Data Organization topic for more details.



- **Starting Sequence Number:** This entry will be the sequence number of the first exposure taken in the series. The number is maintained in the registry so that all exposures in a consecutive period are assured of having a unique identity. While it is possible to edit this entry, it is recommended it be left intact so that the chance of over-writing previous data is minimized.
- **Images Folder:** This is the root or base folder in which all exposure files are located. Using the ... button, navigate to the desired base folder for your images.
- **Auto-generate sub-folders:** When checked, this powerful option will arrange your exposures in an easy-to-use and logical manner, without your having to worry about folder names. The Images Folder specified above will be the base. Light frames will be located in a folder with the name <yymmdd><Target>. Calibration frames, consisting of dark frames, bias frames and flat frames, will be located in a folder with the name <yymmdd>_Calibrationframes. And all CCDAutoPilot logs will be located in a folder with the name CCDAutoPilot_Logs.
- **Lossless Compression (Maxim):** When checked, all FITS data files, light frames, dark and bias frames and flat frames are compressed using Maxim's proprietary lossless compression algorithm. This makes file sizes considerably smaller than uncompressed files but they can only be opened in Maxim and not any other program. This option is only available when Maxim is used as the Camera Control Program. If this option is checked, Insert WCS can not be used and the selection will be disabled.

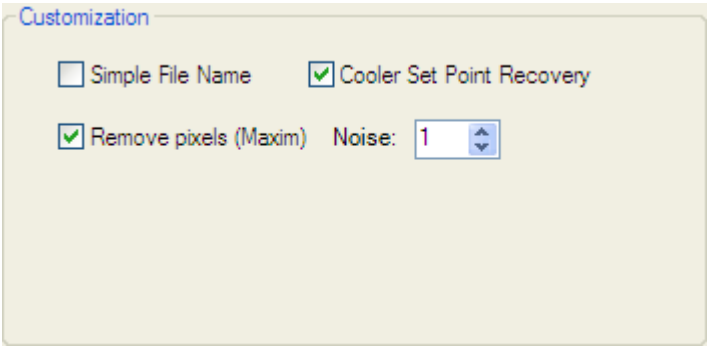
Here is an example. Assume you have defined your Images Folder as C:\Astronomy and on January 22, 2006, you imaged M42

and M78. At the end of your automated run, you will find the following folders created with the appropriate data in them:

Light frames: C:\Astronomy\060122_M42 and C:\Astronomy\060122_M78
Calibration frames: C:\Astronomy\060122_CalibrationFrames
And your log for the night's activities will be in C:\Astronomy\CCDAutoPilot_Logs

Customization

Additional customization options are available here.



- **Simple File Name:** If checked, the light frame file name will be <target>.fit. Note that this is intended for a single light frame per target. Taking more than one image per target will result in only the latest one being saved and the prior ones being overwriten.
- **Cooler Set Point Recovery:** If checked, the cooler set point specified in the Startup section, *whether cooler start is checked or not,* will attempt to be maintained, whether or not camera firmware attempts to set it back to a warmer temperature or not. Typically, an Apogee Alta prevents the cooler running at 100% power if the desired set point is not reached and sets the set point back. This becomes a problem as the evening goes on and the ambient temperature is reduced so that cooler power is not at the maximum. This feature of CCDAutoPilot will keep trying to set the cooler to the set point in the Startup section.
- **Remove Pixels (Maxim):** When checked, CCDAutoPilot will automatically execute Maxim's Remove Bad Pixels process for all frames, Light, Dark, Bias and Flats, taken during the session. See the Maxim help file for details. The Bad Pixel Map in Maxim must be pre-defined and unique for each binning. For example, a bad pixel map for 1x1 binning **must** have the name "Map1", for 2x2 binning, the name **must** be "Map2", for 3x3 binning, the name **must** be "Map3". Any other name will not be accepted by CCDAutoPilot.
- **Noise:** This represents the small amount of Gaussian noise that is added to the interpolated images to improve appearance. See the Maxim help file for more details.

Remove Pixels Usage Note

When this feature is configured and checked, it will be applied to all frames, light, dark, bias and flat. If you already have library dark and bias frames taken without this option and want to use them with light frames acquired with this option checked, then you should run your masters through Maxim, apply the appropriate bad pixel map and save the master to a new name. If you don't do this, your calibrated image might not look correct. For example, assume you have a bright column that you remove with the bad pixel map. This column will not show up in your light frame but if it is in your dark frame, you will have a black column in your reduced image. If you run your master dark through the Remove Bad Pixels routine manually in Maxim, save that dark and apply it to your light frame taken with the Remove Pixels option checked, your calibrated image should look proper.

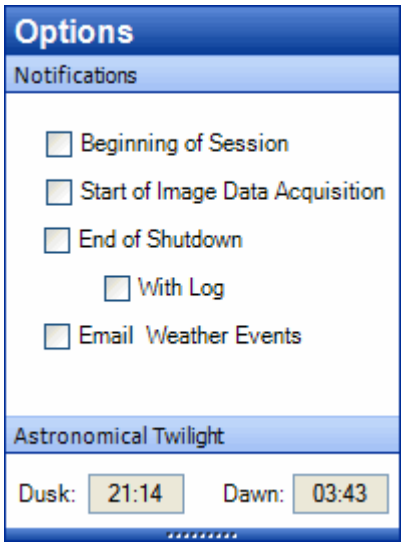
If you select this option, you should make bad pixel maps for all binnings that you use, including those you use for plate solve exposures. That way, hot pixels will be removed and the plate solving routine won't mistake a hot pixel for a star.

While there are many ways to develop a bad pixel map, one way is to use a master bias. It should be made up of 20 - 40 individual bias frames, the more the better. Move the information windows around to measure the level (ADU's) of the bad pixels you want to remove. Hit the AutoGenerate button and use the threshold adjustments in Maxim to define the pixels that should be replaced. Next, process the bias frame to see what pixels will be removed.

It is strongly recommended that you experiment with this feature before committing it to an evening's session.

Note: Enabling this feature **modifies** your original data by the Remove Bad Pixels process **before** it is saved. There is no way to "undo" this modification. Science users should carefully consider whether this option is appropriate for your data requirements. You can evaluate this by not checking the option and manually running it through Maxim's "Remove Bad Pixels" process.

Utility Window



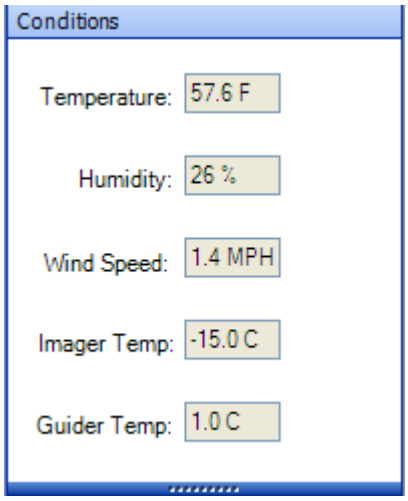
Email notifications (*Professional Edition Only*) can be selected for the indicated events. The notifications will be sent as selected according to the Email settings on the Preferences page. Weather Event notifications will be for any of the events specified for the Cloud Sensor on the Preferences page.

Also shown for reference is Astronomical twilight.

Run Session

When everything is ready for your run, you can review both the setup and the session itself from the Run Session page. On first switching to this page, and assuming a camera, real or simulated, is connected, you will immediately be presented with a preview of the planned session if your target list is less than 10. If you have more than 10 targets, you will have to generate the session review explicitly by hitting the Review Session button.

Utility Window

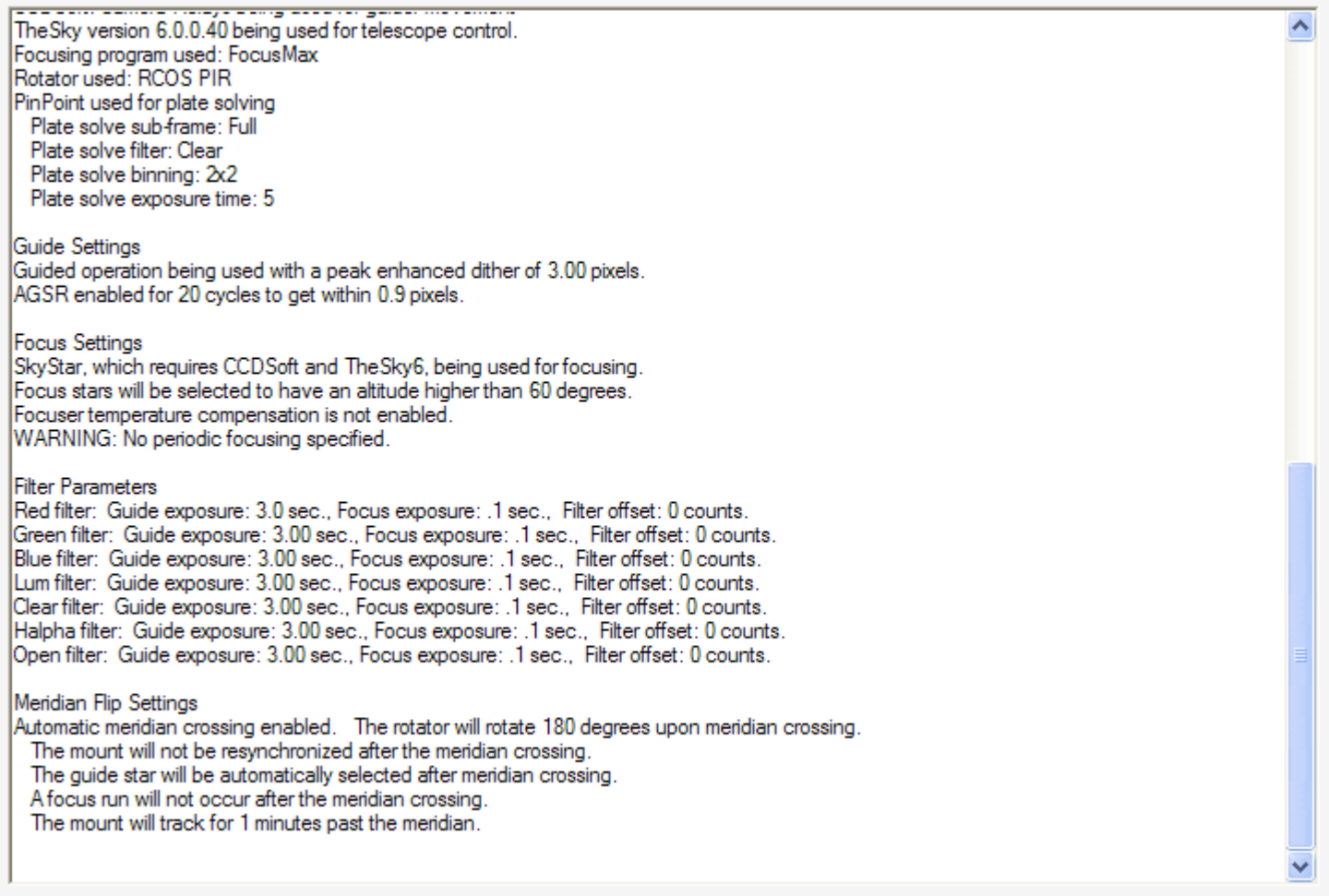


Environmental and camera information is provided, if available. Temperature comes from the source specified on the Focusing page. Humidity and Wind Speed requrie a Boltwood II or equivalent. Imager Temp. comes from the camera control program. At present, guider temperature is available only from CCDSoft.

Session Review

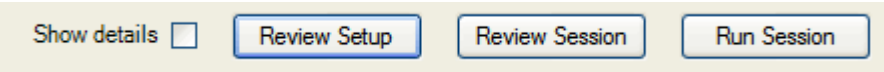
This is a portion of a typical preview log. It shows information in summary form about the session to be run, ending with an estimate of the elapsed time. By using the additional controls, more information may be obtained before committing the run.

Setup Review



This is a portion of a typical setup review window. It will show information about the equipment, software, tracking, guiding and focusing that will be used for the run.

Controls



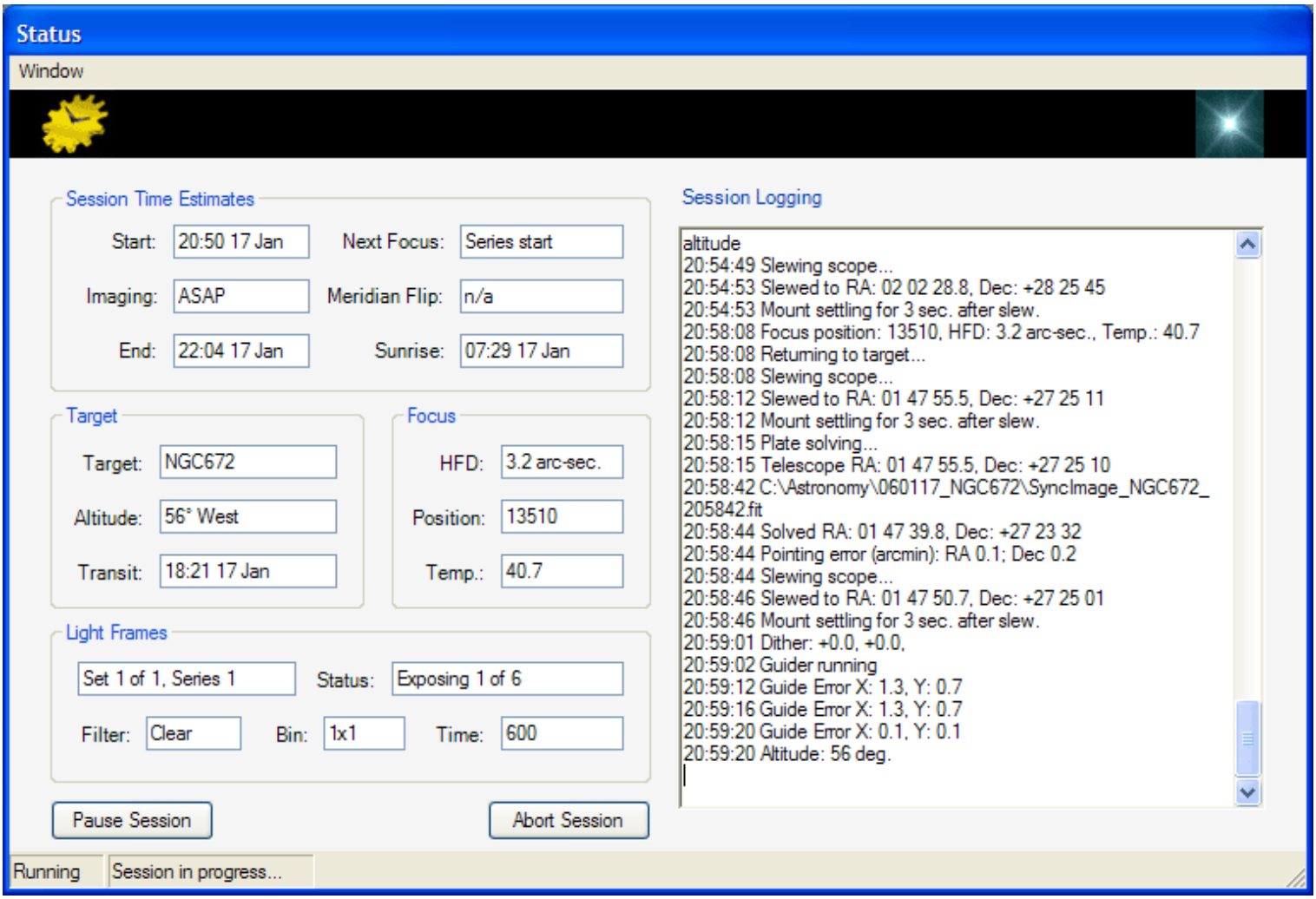
- **Show Details:** Checking this option will show more detail in the preview, including actual file names where possible. Leaving this box unchecked provides summary information.
- **Review Setup:** Hitting this button generates the Setup Review information. It may be called at any time by hitting the Review Setup button.
- **Review Session:** A session review is generated whenever the user switches to the Run Session page. It may also be called at any time by hitting the Review Session button.
- **Run Session:** This button initiates the actual session. When it is hit, the main window is minimized, the status window is opened and the run begins, with monitoring provided by the smaller and scalable status window.

A note about starting a run...

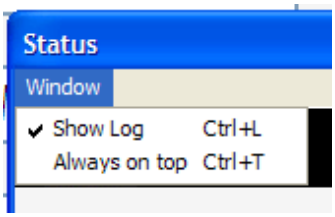
Since CCDAutoPilot has no way of knowing where your system is with respect to filter offsets and focusing, it assumes that the system is in focus with user-specified plate solve filter in place and that filter is the reference or zero-offset point for any other filter offsets used. If in doubt, use Focus Before Target Start on the Options page to insure proper focus at the star of the light frame acquisition.

Status

Once the Run Session is hit on the Run Session page, the main window is minimized and the Status window is loaded. If the main window is restored via the Windows Task Bar, you can make changes to any data acquisition series that are not already underway. This is useful if you have already started a run and want to change something.

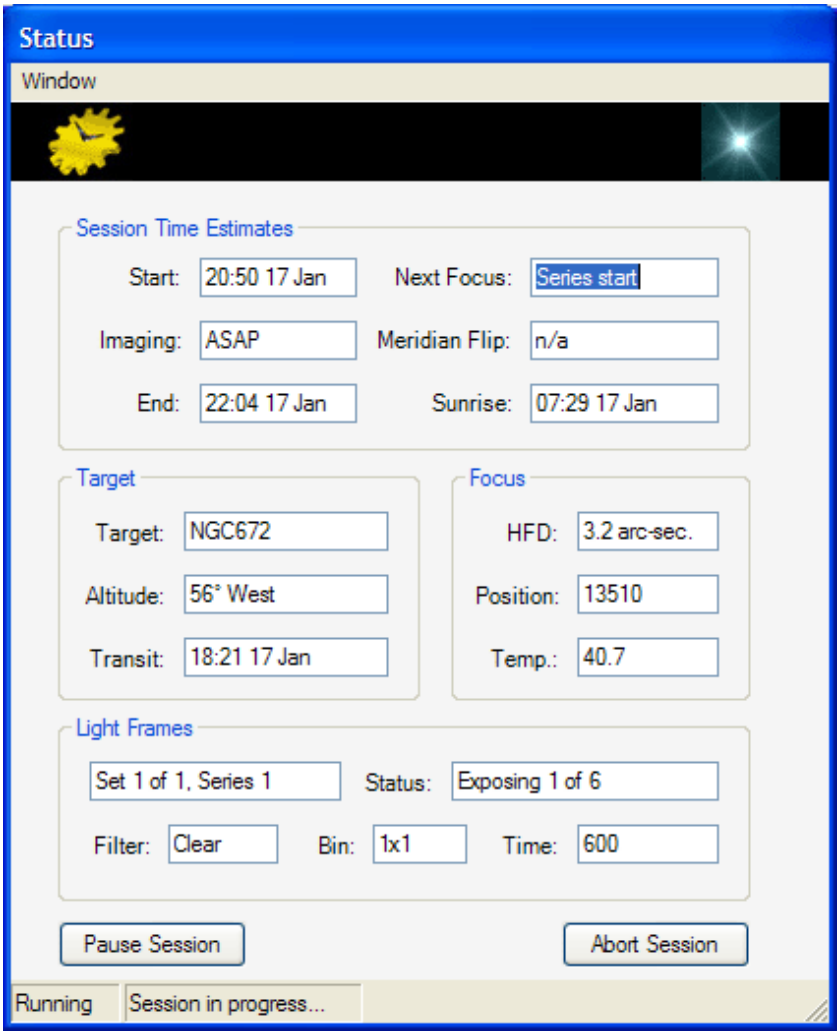


The window is resizeable as the user desires. There are also some options selectable from the Windows menu:



- **Show Log (Ctrl-L):** When this item is checked, the detailed log at the right is shown. When it is not checked, only the summary information is displayed. This selection may be toggled by holding down the Control key and then hitting 'L'
- **Always on Top (Ctrl-T):** When this item is checked,d the status window is made the topmost window on the desktop. This prevents other windows from hiding crucial session information. When it is not checked, the status window's behavior is normal, i.e. it can be hidden by other windows. This selection may be toggled by holding down the Control key and then hitting 'T'

Summary Information



Session Time Estimates

- **Start:** indicates the run start time
- **Imaging:** indicates the time the light frames will begin. If the user has specified a delayed start for the first target on the Targets page, this will indicate that time. Otherwise, it will indicate ASAP.
- **End:** indicates the expected ending time of the run, not including any dawn flats
- **Next Focus:** indicates when the next automatic focusing activity will take place. Series start indicates at the next series, otherwise the time of the next scheduled focus is indicated.
- **Meridian Flip:** If the target is east of the meridian, this indicates the expected time of the meridian flip. If the target is west of the meridian, this field will so indicate. If a fork mount is being used, n/a will be indicated since there is no meridian flip with a fork mount.
- **Sunrise:** indicates the time of local sunrise

Target

- **Target:** indicates the target, as defined on the Targets page.
- **Altitude:** indicates the altitude of the target and whether it is east or west (of the meridian).
- **Transit:** indicates the time the target will transit (cross) the meridian.

Focus

If no focus program is used, all these entries will indicate "n/a". Otherwise:

- **HFD:** indicates the Half-Flux Density of the focused star, as reported by FocusMax. This is not necessarily the same as FWHM (Full Width Half Maximum) as normally used for stellar profile measurements. HFD is a good relative indicator of focus however.
- **Position:** indicates the focuser position, as reported by FocusMax, for your focused position.
- **Temp:** Reports the ambient temperature in whatever units (°F, °C, counts, etc.) the focuser in use reports temperature. If the focuser doesn't report temperature, then "n/a" is indicated.

Bottom Box

The title of this box will change, depending on the activity in progress. For Light Series as shown above, it will show the progress in terms of the number of Sets, what series is underway, what progress is made in the series and what Filter, Binning and Exposure time is being used for the exposure in process.

- **Pause:** The Pause button allows the run to be paused at an appropriate point, usually the completion of the exposure in process. Once paused, the title of this button changes to Resume and hitting it again will resume the run. This is convenient if you have to go out to the telescope, put a light on and adjust something. When you are done, you can resume the run from where you paused.
- **Abort Session:** This is used to totally abort the running session. When hit, the session abort routines will be initiated and the Abort Session button will be grayed out. Once the abort routines complete, the main window will be restored. Be sure to wait for the main window to reappear to insure CCDAutoPilot has completely aborted the session in progress and is in the proper state to restart a run. If there is any doubt, close and restart CCDAutoPilot. The status window can either be left open or closed as desired. Closing the status window causes its position and size to be remembered so that it will be restored to the same size and position when Run Session is hit again.

Status Bar

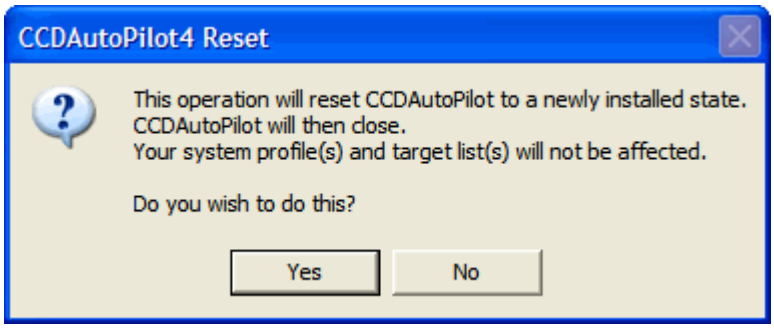
A status bar is provided at the bottom of the status window to indicate various activities.

Additional Applications

CCDAutoPilot comes with two additional applications, Reset and a Control File Editor. Both are accessible from the Start/Programs/CCDWare/CCDAutoPilot4 menu.

CCDAP4 Reset

Reset is used to restore the system to a default installation point, as if CCDAutoPilot4 had never been initially run.

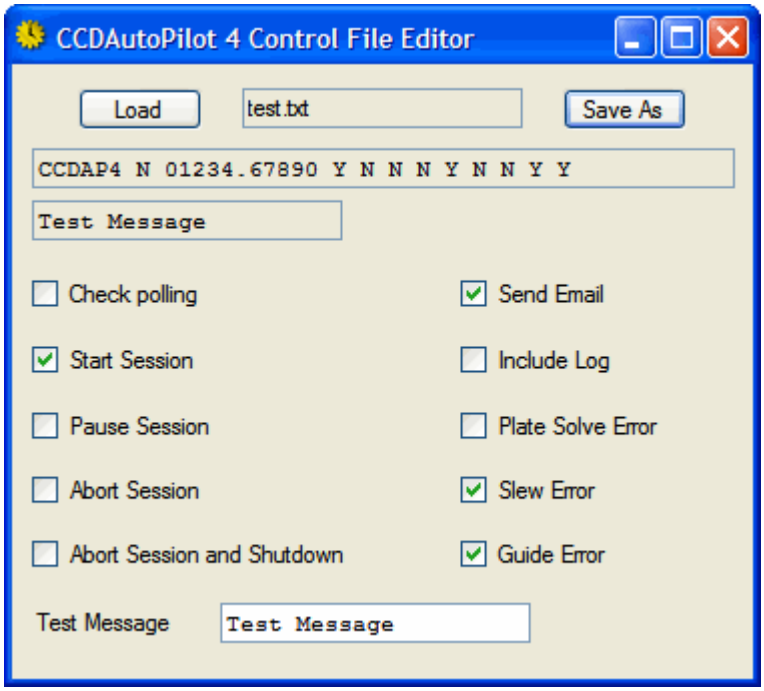


You will be asked to confirm Reset before proceeding.

Control File Editor

Professional Edition Feature

The Control File facility allows a number of additional options that are useful for more sophisticated remote observatories, whether remote is in your back yard or across the globe. This file can be created or modified by any text editor. The Control File Editor provides a convenient way to create the control file as well.



- **Load:** Loads an existing file for editing
- **Save:** Saves the open file or creates a new one
- **Test Message:** Enter up to a 20 character string that will accompany any email messages or log entries as desired
- **Characters 1 through 6 (CCDAP4):** These characters must be "CCDAP4". This string of characters is used to validate this as a control file.
- **Check Polling (Character 8:** If Y, the following field must be updated more frequently than the CCDAutoPilot polling time of 6 sec. This option is useful for sophisticated observatory control systems to insure communication between a client application and CCDAutoPilot. If the following field is not updated within the polling interval, the current run is aborted. If this character is anything other than Y, the next field is ignored.
- **Character 10 through 20:** This string can be generated by a Now(days) function in the client program. As long as this string changes between CCDAutoPilot polls,the run will progress if Character 8 is Y.
- **Start Session (Character 22):** If Y, the run will start when the Run Session is pressed on the Run Session page of

CCDAutoPilot. If set to anything other than Y, the session will not start until the character changes to Y.

- **Pause Session (Character 24):** If Y, the run will pause in the same manner as when the Pause Session button is pressed on the Status window. When set to anything else, the run will resume as when the Resume Session button is pressed on the status window.
- **Abort Session (Character 26):** If Y, the run will be aborted as if the Abort Session button is pressed on the Status window.
- **Abort Session and Shutdown (Character 28):** If Y, the run bill be aborted as if a cloud sensor had triggered the Run Abort Conditions. Additionally, the imager cooler will be warmed up.
- **Send Email (Character 30):** If Y, an email will be sent using the Email address and SMTP server settings on the Preferences page. Any other character and no email will be sent.
- **Include Log (Character 32):** If Y, the current log will be attached to the email sent as above. Any other character and no log attachment will be included.
- **Plate Solve Error (Character 34):** If Y, any plate solve error will result in a message "Plate solve error" being sent to the email address, assuming character 30 is Y. Any other character will result in no message.
- **Slew Error (Character 36):** If Y, any slew error will result in a message "Slew error" being sent to the email address, assuming character 30 is Y. Any other character will result in no message.
- **Guide Error (Character 38):** If Y, any automatic guide star error failure will result in a message "Guide star not recovered. Imaging unguided." being sent to the email address, assuming character 30 is Y. Any other character will result in no message.
- **Reserved Identifier (Character 48)**
- **Message (Characters 50 through 70):** Up to 21 characters can be appended to any messages sent from the above events.

Format

The control file consists of a single line file that may or may not be updated continuously as the need arises. When Use Input File is checked on the Preferences page and a suitable file is entered by the File/Path button, this file will control CCDAutoPilot.

Here is the general structure of that file:

```
0         1         2         3         4         5         6         7
12345678901234567890123456789012345678901234567890123456789012345678901234567890
CCDAP4 N 01234.67890 y N N N N N N N N            Test Message.....X
       |              | | | | | | | | |            |
Y=Check+              | | | | | | | | |            |
                      | | | | | | | | |            |
Y=Enable start++++++++ | | | | | | | |            |
                       | | | | | | | |            |
Y=Pause, else resume++++ | | | | | | |            |
                        | | | | | | |            |
Y=Abort run++++++++++++++ | | | | | |            |
                         | | | | | |            |
Y=Abort Run and Shutdown++++ | | | |            |
                            | | | |            |
Y=Send Mail++++++++++++++++++ | | |            |
                             | | |            |
Y=Send Log++++++++++++++++++++ | |            |
                              | |            |
Y=Report plate solve error++++++++ |          |
                                   |          |
Y=Report slew error+++++++++++++++++ |        |
                                    |        |
Y=Report guide star recovery error++++       |
                                             |
Reason/text message (21 characters)++++++++++++++++
```

The top line indicates character position, starting with 1 and going through 70. The character positions have meaning as defined below:

Usage

By the judicious choice of these options, you can arrange for any number of notifications and control. Some examples:

Assume you have a sophisticated weather and observatory control system such that if primary power is lost, you have enough UPS power to secure the system. You might use the Abort function to abort the run. Then, assuming your observatory is properly constructed, you can close the slit and gracefully power down the system. You can be notified of this by email or text message,

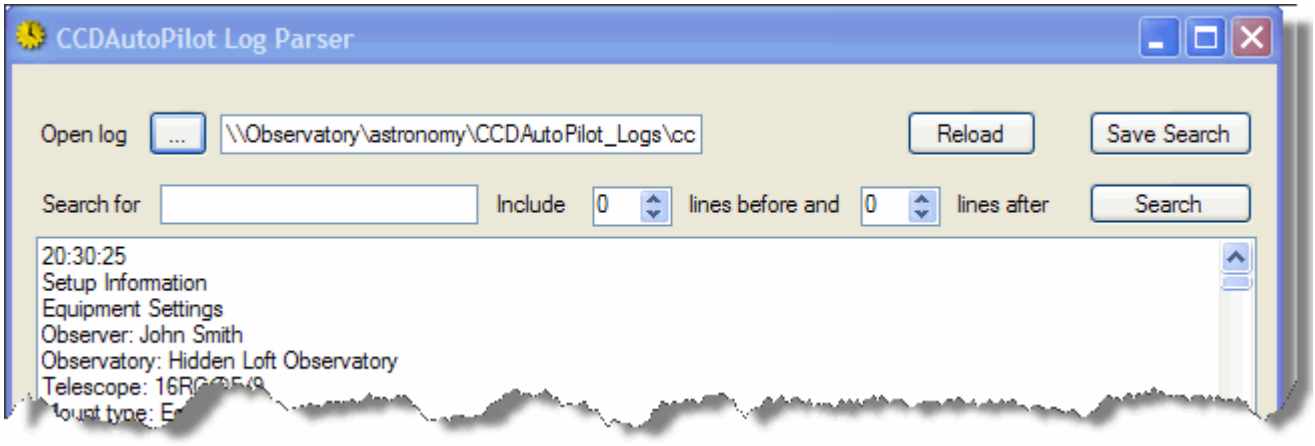
along with any additional text, identifying the reason for the change

You can your email address of your phone's text message subscription to receive notification of any plate solve or guide star failure.

Note that, independent of this control file, you can elect to be notified via email of run completion and receive the log as an attachment by checking the appropriate boxes on the Preferences page.

Log Parser

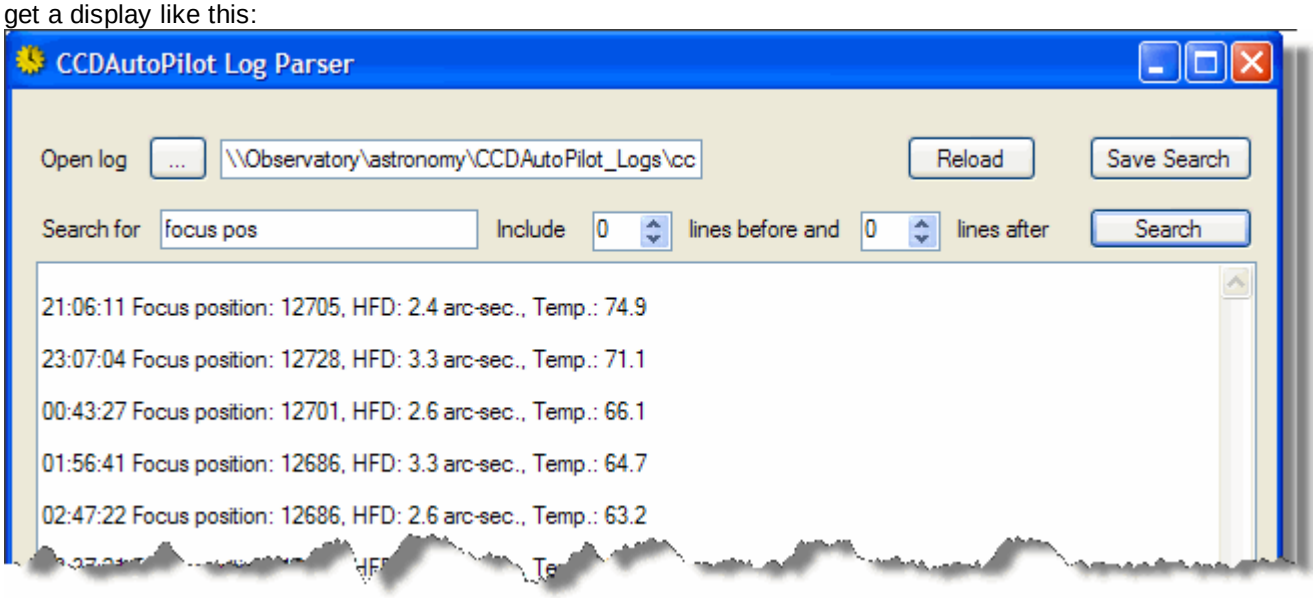
CCDAutoPilot logs have a lot of information in them and it can be a bit tedious to find what you are looking for. Log Parser allows you to search a log for a specific set of characters (search term) and display all lines containing those characters. You can specify showing a number of lines before or after the line containing your search term.



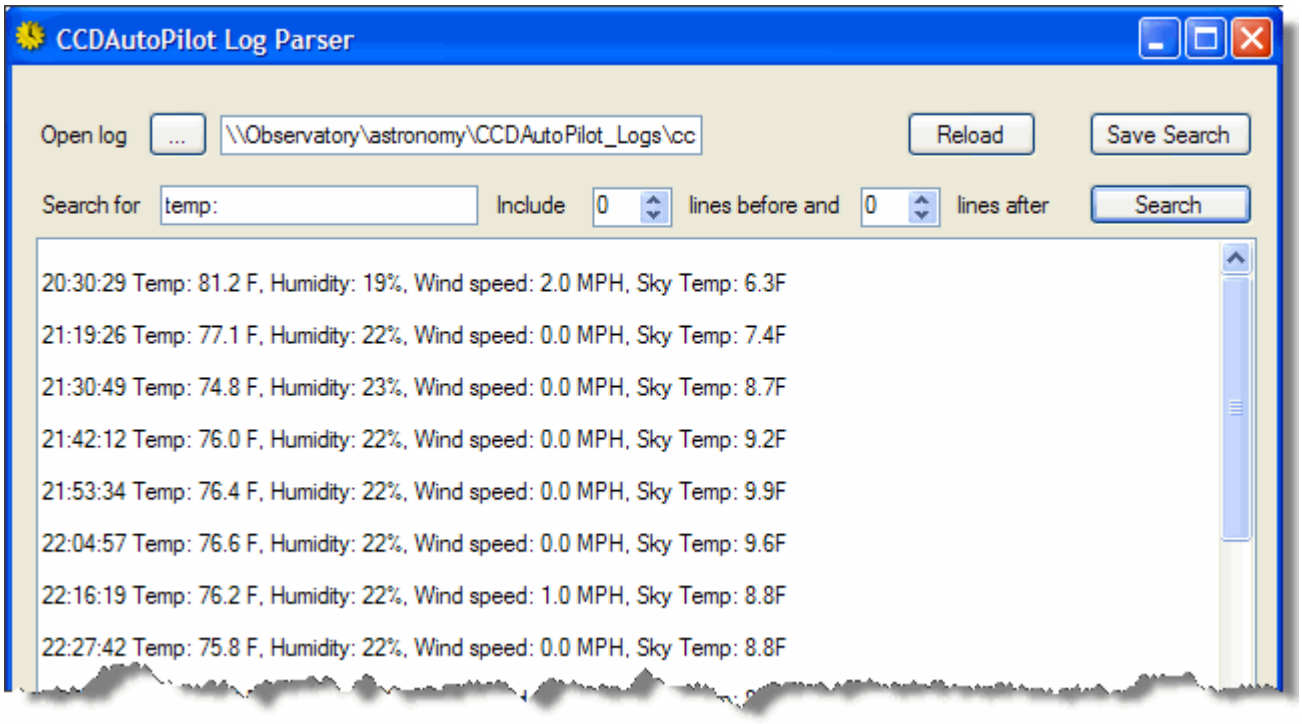
- **Open log:** This opens a window from which you can navigate to and select the log you wish to examine. Once the log is selected it is displayed in the text window.
- **Search for:** Enter the search term you wish to use for the search. You can enter the number of lines before and after the search term,
- **Search:** This searches the log for all instances of the search term and displays any lines before or after the search term you have specified.
- **Save Search:** Allows you to save the search to a new file. The default file name will be the same as the original log file with "_sort" appended to the log file name. Of course you can name it anything you wish.
- **Reload:** Reloads the original log file, replacing the search display.

Examples

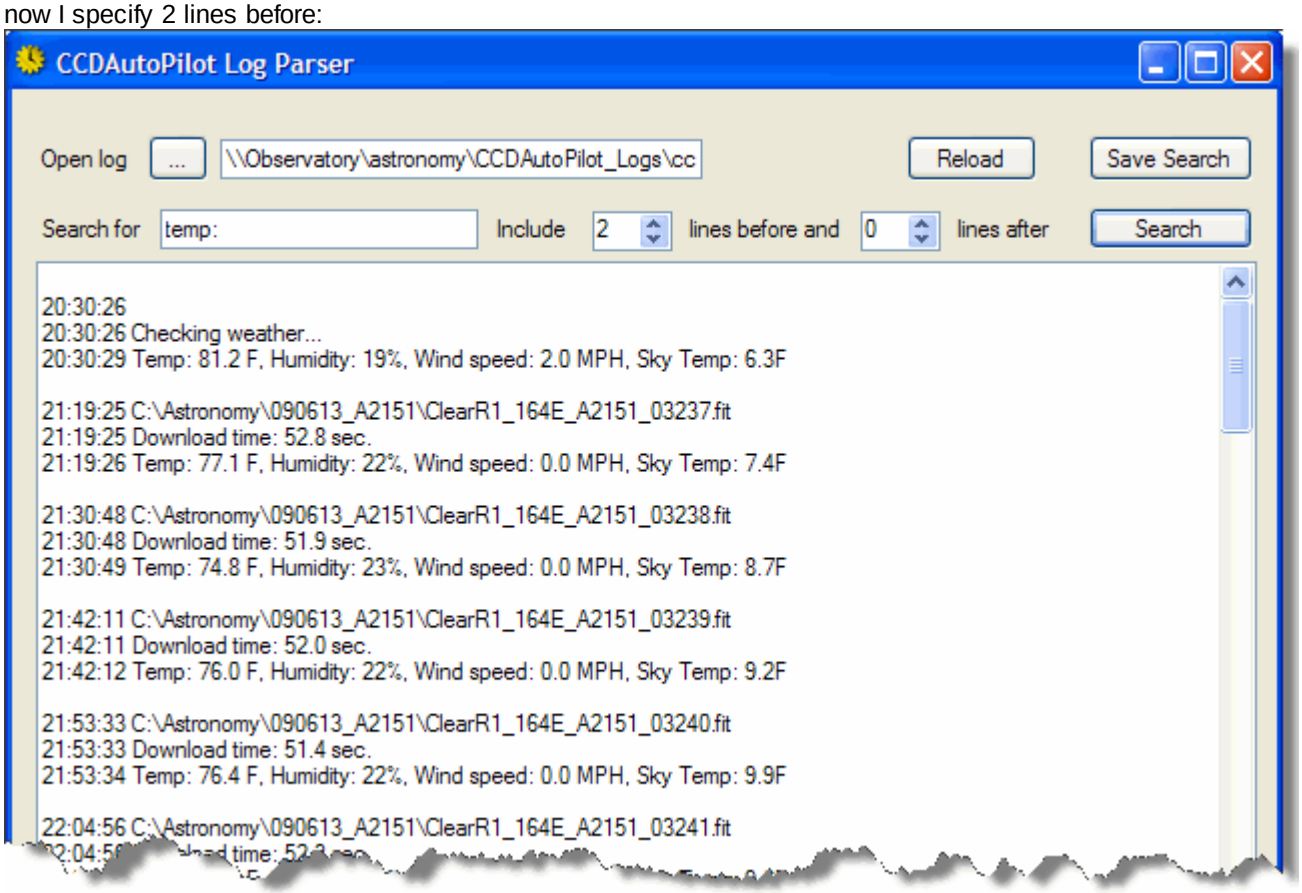
If I want to see how focus changes with temperature over the course of an evening, I can enter "focus pos" as a search term and get a display like this:



Suppose I want to see how the weather changes over the course of a session (a cloud monitor is used in this example). Here I enter "temp:" as the search term:



Now I want to see what the weather is at the conclusion of each light frame exposure. I still enter "temp:" as the search term but now I specify 2 lines before:



As you can see, there are many repeating events and relationships that can be extracted from the log by Log Parser.

Overview

Observatory automation is a complex undertaking. While every attempt has been made to make this undertaking as simple as possible, the complexity should not be underestimated. Over half of all problems reported arise from failure to read the Help system. If you are having problems in a specific area, first carefully read the associated Help topic. The First Use topics are specifically recommended before starting. Remember that while CCDAutoPilot is open, you can always bring up the Help topic for a specific page by hitting the F1 key.

CCDAutoPilot is an executive program. As such, it issues commands via defined software interfaces to the programs it controls such as camera control programs, telescope control programs, focusing programs, rotators and dome control programs. In order to function, the controller programs (called servers) must be properly loaded and accessing their appropriate hardware properly. The steps outlined below should get you up and running.

There are many complex interactions and, while every effort has been made to make this software as bug-free as possible, they unfortunately can and do occur. Additionally, new features will be added from time to time. CCDAutoPilot has the capability of automatically updating the program from the web.

Contents

Troubleshooting Techniques
Mount Issues
Camera Issues
Focuser Issues
Rotator Issues
Cloud Sensor Issues
Dome Issues

Techniques

Important: If some or all of your control programs are not started, CCDAutoPilot will attempt to start them in what should be the proper order. Depending on your PC's performance, they may or may not start properly. If things don't seem to be operating properly, start them manually before starting CCDAutoPilot. For example, assume you are using RoboFocus to control your focuser, FocusMax for focusing and CCDSoft to control your camera. Load and start RoboFocus, confirming it connects to and can control your focuser hardware. Next Load CCDSoft, confirming it connects to your camera. Take a short image to be sure. Next, load FocusMax since it must control both RoboFocus and CCDSoft. Finally, load CCDAutoPilot.

Step-by-step

1. Make sure the .NET 2.0 framework is installed. You can verify its installation by going to Control Panel, Add/Remove Programs and making sure there is an entry for "Microsoft .NET Framework 2.0". If that entry is not present, please install it before proceeding. See the Application Requirements topic for a link to the Microsoft download location.

2. Insure installation of all programs required for your operation is proper and functional by testing them standalone. See the Application Requirements topic for links to all programs. Make sure you are using the latest version of CCDAutoPilot. The most recent version information and change history can be found here.

3. Verify you have the minimum version level for the above programs. CCDAutoPilot will warn of out-of-revision programs and prevent operation. See the Application Requirements topic for minimum version requirements. Of course, higher version numbers can be used. Program version numbers can generally be checked by the Help | About menu on the individual program. For programs that do not support this feature, you must locate the program's .exe file, right click on it, select properties and select the version tab.

4. Before connecting CCDAutoPilot to any of your programs, be sure the programs are able to properly control their related hardware. Can you take an image with your camera control program? Can you slew the telescope with your telescope control program? Can you control your focuser and focus with your focuser program? Does your rotator program control your rotator? Does your dome control program move your dome?

5. Connect to CCDAutoPilot and use the test buttons on the Tools page to verify CCDAutoPilot is able to control the appropriate hardware *through* your programs.

6. On the Targets page, create a target using the Get function with TheSky6 or the Add button otherwise. Uncheck Precision Slew to Target and hit the Slew to Target button. Does the mount slew properly?

7. Set up a single, short exposure on the Light Frames page. Run a short session to confirm the telescope slews to the target and takes a short exposure.

8. Add other functions and complexities gradually, verifying proper operation with each addition.

When things don't go as expected

While every effort has been made to trap invalid user entries, some slip by. These are addressed as they are identified but with over 600 controls, there is a lot of opportunity for bad entries or combinations. Here are some techniques to help resolve such a problem.

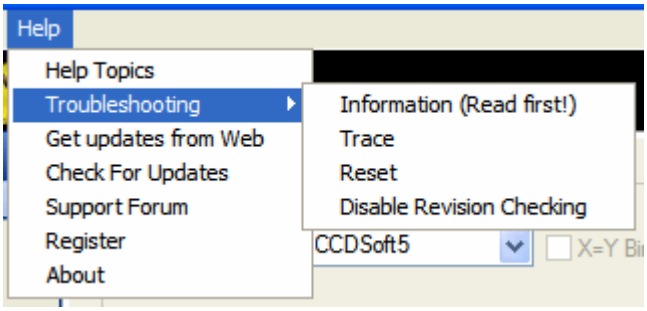
- **Global Error Handler:** CCDAutoPilot traps and handles many potential errors during the course of a session. Occasiional setup and input errors can lead to errors as well (unhandled exceptions). Should the latter error occur, CCDAutoPilot will capture the error information and setup information in a file and notify you of the file name and location. This file is located in (My) Documents\CCDWare\CCDAutoPilot4\ and will have a file name of the format ErrorY<yyyymmdd>_<hhmmss>.log. Next, CCDAutoPilot will attempt to run a script named RunOnError.vbs located in Program Files\CCDWare\CCDAutoPilot4\ if it exists. This script can be set up to park the telescope, run an external application, etc. Google "wsh help" for more information on scripting. Next, CCDAutoPilot will launch your browser and link to the CCDWare support forum. Finally CCDAutoPilot will close. If the error is repeatable and the next steps don't resolve the issue, feel free to post the error file to the CCDWare support forum for assistance.

- **Reset:** If CCDAutoPilot fails to load, selecting CCDAP4 Reset from the Start menu resets all key data as if CCDAutoPilot were never installed (except for the trial period status of course). Your system profile(s) and target list(s) are not affected. You can also access this function from CCDAutoPilot's Help/Reset menu item.

- **Create a new System Profile:** From the System Profile menu, select New to create a new system profile. Of course you will

need to re-enter all your settings but often this resolves the issue of a bad setting.

- **Task Review:** Open Task manager and select the Processes tab. If you click on the Image Name table header, the processes will be sorted in alphabetical order for easy viewing. Verify that one and only one process is running for each server program you have operating. If you see more than one process, then proper automation is not possible. You should either reboot your PC (easiest) or close all programs and use the End Process button to stop any server programs that remain running. This can happen when a run is aborted and the abort process is not allowed to complete. After hitting the Abort button on the status window, remember to wait until the main window restores (re-opens). This minimizes the chance of multiple processes in task manager.



- **Information (Read First):** links to the Troubleshooting Overview.

- **Trace:** While the status window and the attendant log provide event logging during an active run, there are possible occasions when things don't go as expected before starting an actual session. The trace facility can be used whenever things don't seem to be "working right" before running a session. The Trace facility provides diagnostic information for this condition. When this topic is selected, CCDAutoPilot's trace facility is turned on and CCDAutoPilot closes. When CCDAutoPilot is next started, the trace facility is engaged and a trace file will be written in the CCDAutoPilot4 data directory. The data directory is located at My Documents\CCDWare\CCDAutoPilot4 (XP and Prior) and Documents\CCDWare\CCDAutoPilot4 (Vista).A new file is written each time CCDAutoPilot is started. The file has a file name of Tr ace<yyyymmdd>_<HHmmss>. l og and will record any error messages. When Trace is enabled, all plate solving images ("Sync_Image") are saved, whether successful or not. Trace being on is indicated by a check next to the Help menu selection. To turn Trace off, select this topic again. CCDAutoPilot will close and Trace will be disabled when CCDAutoPilot is next started. Contact support for interpretation of any messages in the trace file.

- **Disable Revision Checking:** This should normally not be checked to enable revision checking of the various applications that will be connected to CCDAutoPilot. However, it may be checked for trouble shooting purposes. When checked, application revision checking is not enabled and CCDAutoPilot operation may be compromised. Checking this in concert with enabling the Trace facility above can be used to trouble shoot unexpected results.

- **Remove and Reinstall CCDAutoPilot:** While this should not be necessary. it has been shown to help resolve some unique issues. This should be used in conjunction with the CCDAutoPilot Reset Tool. First remove CCDAutoPilot then run the CCDAutopilot Reset Tool. If possible, it is a good idea to reboot your PC before reinstalling.

Support

If none of the above resolves the issue you are having, please use the CCDAutoPilot support forum, which is also accessible from the Help menu.. If you have problems during a run, be sure to post the related .log file as an attachment. If you are having problems that prevent a run from starting, post the error log file described above.The more detail you include in your problem report along with the suggested attachments, the more quickly the issue can be resolved.

Plate Solving Notes

Plate solving is a technique that measures precisely where the telescope is pointing by taking a CCD image and then using various pattern matching techniques, matches the stars in the image to a given star catalog. Knowing approximately where the telescope is pointing and the system image scale, plate solving algorithms can calculate the center of the image to sub-arc-second accuracy. Successful plate solving is **essential** for automated imaging.

In order to be successful, three things are required: telescope coordinates, known image scale and sufficient catalog stars in the image.

- **Telescope coordinates:** CCDAutoPilot gets this information from the mount via the chosen telescope control program. Generally the coordinates must be within one or two FOV's and is easy to do. Problems with plate solving are generally not related to telescope coordinates. The telescope coordinates, RA (OBJCTRA) and Dec. (OBJCTDEC), are written into the image's FITS header for any images acquired by CCDAutoPilot. (see note below.)
- **Image scale:** CCDAutoPilot gets this information generally from the FITS header. Image scale is calculated from the pixel size (XPIXSZ), binning (XBINNING) and imager focal length (FOCALLEN). These keyword values are written into the image's FITS header for any images acquired by CCDAutoPilot. A successful initialization will cause these values to be properly written, based on the Imager Settings information. See note below.
- **Star Catalog:** When using TheSky6, catalog selection is automatic. In the recommended default setup, GSC, Tycho and UCAC are used. TheSky6 starts with the GSC and proceeds to more dense catalogs as needed. When using PinPoint, the chosen star catalog must be defined by the user and only one at a time is available. Fortunately for most uses, the GSC is sufficient. Very narrow FOV's may need to use USNO A2.0. This has more faint stars but may fail on wider FOV's.

Note: If you are using image data that was not acquired by CCDAutoPilot, as for example using the "From FIT" button on the targets page, these parameters must be correct in the fits header. If CCDAutoPilot is not initialized, then the FITS header information may not be correct. Camera control programs typically provide for entering most of the data based on the camera driver. However, the user must enter the correct focal length for the imaging system in the appropriate setup section. Failure to do this will cause plate solves to fail.

Assuming all of the above, then the next issue is the plate solve exposure parameters. The goal is here is to get a sufficient number of stars in the image. For most users, a binning of 2x2 or 3x3 is more than sufficient and will both speed plate solving time and increase sensitivity. Of course, use the most transmissive filter, usually the clear or luminance filter. Sub-framing is appropriate for wide FOV's both to speed plate solving, and in the case of CCDSoft/TheSky plate solving, to insure success. CCDSoft/TheSky has a maximum FOV limit of 1 square degree. Set a suitable sub-frame to get below this limit. While PinPoint doesn't have such a limit, sub-framing may make it a bit speedier. Lastly, the exposure must allow sufficient stars for reliable plate solving.

Using CCDSoft and TheSkyX Professional

TheSkyX, when used in combination with CCDSoft, gives greatly improved plate solve performance over TheSky6. The 1 square degree limitation no longer applies. A number of 10° x 10° FOV's have been successfully solved very rapidly with TheSkyX. You may need to adjust the residual tolerance in CCDSoft to get successful wide angle plate solves. Unfortunately the only way to access this initially is via the results window after a successful plate solve in CCDSoft. I suggest you use a quarter frame exposure with CCDSoft, solve the plate and increase the residual from its normal 0.5 arc-sec. to something like 5 arc-sec. if you are doing wide field imaging.

Determining plate solve exposure parameters

A good starting point is 5 sec., binned 3x3, through a clear filter. Take some images manually first and use your desired plate solve program. For CCDSoft, use Tools/Insert WCS AutoAstrometry. You will need to manually enter your image scale. For PinPoint with Maxim, use Analyze/PinPoint Astrometry. For PinPoint with CCDSoft, use Visual PinPoint to solve saved CCDSoft exposures.

Experiment with different exposures and note the number of stars used in the solution. You will need at least 10 and more is always better. Adjust the exposure to achieve a good number of stars. Move to a star-poor region of the sky and repeat the test a couple of times to insure good results. Adjust exposure times as needed. If your FOV is small and you are using PinPoint, you may need to use the USNO A2.0 catalog.

During a CCDAutoPilot session, the number of stars used in the solution is shown in the log for every plate solve. Examine your log to make sure you have a sufficient number of stars for reliable plate solving and adjust your plate solve parameters appropriately.

Mount Notes

Make sure your mount is capable of responding to commands issued by CCDAutoPilot through the Telescope Control Program's automation interface. This can be verified by using the Test buttons. If those buttons don't have the desired result, there is no way CCDAutoPilot can cause those actions to happen. Check the mount driver software. Many times there is a later revision that may address some missing functionality.

Specific hardware notes

- **Gemini:** To allow proper meridian flip operation, check the Safety Slew box on the Tracking and Guiding page. See Meridian Flip for details. Alternatively, on your Gemini controller, set the Goto Limit to exactly the meridian - 90 degrees.
- **Paramount GT1100:** For the original Paramount, check Safety Slew on the Tracking and Guiding page. See Meridian Flip for details.

Camera Notes

CCDAutoPilot gets its filter and binning information from the Camera Control Program when it first connects with your actual camera connected. It will save that information in the system profile so that you can use that profile for session planning. However, the camera control program automation interfaces do not allow changing the filter names or binning back. At this point in their development, the only alternative if you have different cameras with different filter sets or names is to manually enter them in the camera control program. Hopefully that will change in the future. When it does, CCDAutoPilot will be updated to handle it.

Camera Sensors

The Sub-exposure calculator needs to know sensor characteristics for your camera. A starting list is provided in a file called sensor.ini, located in the CCDAutoPilot4 program folder, typically C: \ Pr ogr am Fi l es\ CCDWar e\ CCDAut oPi l ot 4. There is space for 32 entries. While it will be updated from time to time, you can enter your own data if you wish. The file should be edited in notepad or similar text editor, not Word. Make a backup copy before editing, just in case something goes wrong. The four entries are separated by a comma with no spaces and must be numeric data. The last entry should be a blank line. The four entries are:

- Sensor name
- Dark signal in e/pixel/sec
- The temperature in Centigrade at which the dark signal is measured
- The dark signal doubling temperature in Centigrade times 10. In other words, if the dark signal doubling temperature is 6, this entry should be 60.

Some sensors have been superceded by new versions by the sensor manufacturer. The new version typically has the same or better performance characteristics as the one it replaces. Some examples are:
KAF11002 replaces KAF11000
KAI4021 replaces KAI4020

Specific Hardware Notes

SBIG STL with Remote Guide Head and Off-axis guider

When using an SBIG STL-series camera with the SBIG remote guide head and an off-axis guider such as the Astrodon MOAG-A, be sure to orient the remote guide head so that its connector is closest to the STL body, as shown at left. Select "Off-axis Guided" for the guide method.

FLI ProLine and Apogee Alta cameras
Some large format sensors benefit from having a selectable readout mode to reduce residual bulk imaging (RBI). See the Readout Mode topic for more information.

Maxim v5.05/5.06.
There is a bug introduced in Maxim v5.05 that resets the guider binning to 1 upon program restart. If you simply change the binning to 2, the guider will be sub-framed to 1/4 of the active sensor, resulting in possible loss of guide star. When starting or restarting these versions of Maxim, be sure to reset the guider binning to 2 **and** hit the reset button to get your full guide chip again. Diffraction Limited is aware of this issue and it will be resolved in Maxim 5.07.

Readout Modes

Some cameras support multiple readout modes. Maxim version 5 has been adding support for these multiple readout modes and CCDAutoPilot allows selecting appropriate readout modes for focusing, plate solving, light, dark and flat frames independently on the appropriate CCDAutoPilot pages. (This feature is not supported currently by CCDSoft.) Choosing the appropriate readout mode can be most helpful in optimizing session efficiency.

For example, some large format cameras suffer from residual bulk imaging, RBI, in which ghosts of previously exposed bright stars or objects appear in successive frames. Some manufacturers, notably Apogee and FLI, have developed techniques to reduce or eliminate RBI. However, these techniques can add significant time, 5 to 20 sec. or so, to the expose/download process and there are some cases where RBI elimination is not needed. For example, focusing consists of a number of generally short exposures. With a 5 - 20 sec. RBI elimination process, which is not necessary for focusing, focusing will be significantly longer. CCDAutoPilot gives you the capability to choose when to use such RBI elimination techniques and when not to.

For your light frames, where you want the highest quality, RBI elimination should be activated. For the corresponding dark frames, it should be activated as well. However, for focusing and plate solve exposures, you want things to move fast and RBI elimination can be deactivated. Similarly if you are taking sky flats, the twilight interval is relatively brief. Here RBI is much less of an issue and RBI elimination can be deactivated here to maximize the number of twilight exposures. Of course, when bias-subtracting your sky flats, you should use a master bias frame created from a number of bias frames with RBI elimination disabled.

If your camera supports it then, here are some recommendations:

Apogee cameras: Use Monochrome (Preflash) for best quality light and dark frames; use Monochrome for plate solving, focusing and sky flats.
FLI cameras: Use Normal for best quality light frames and dark frames. Use Fast for plate solving, focusing and sky flats.

Reminder: If you follow these recommendations, be sure to use a master bias for flat calibration using the same readout mode as the flat frames themselves.

Focuser Notes

If a focuser works properly through the focus program, it should work fine through CCDAutoPilot. If you are using temperature to determine when to focus, make sure you select the proper temperature source on the Focusing page.

Specific Hardware Notes

- **Optec Focuser:** Be sure to turn off the Optec's temperature compensation. The focuser can not be remotely commanded if it is turned on. If temperature compensation is desirable, use CCDAutoPilot's internal temperature compensation routine.

Rotator Notes

When using an automated rotator, it is critical that the rotator rotate in the proper position. Some rotators have no way to change them and are coded as such. Others are settable and settings must be made so that operation is in the correct direction. References to direction are viewed from the camera end and should be as follows:

Specific Hardware Notes

- **RCOS PIR:** This is fixed by design. CCW rotation should result increasing position counts or degrees.
- **Optec Pyxis:** There are setup options. The option should be chosen in which CCW rotation results in increasing position counts or degrees. For the 2" Pyxis, this is normally the Reverse direction and for the 3" Pyxis, this is normally the default direction. See the Pyxis control software help file under PYXISparms.txt for specifics.
- **Astrodon TAKometer:** By design intent, CCW rotation should result in increasing position counts or degrees. If the rotator position is negative, it should get less negative; if it is positive, it should get larger. For example, CCW rotation should result in the position moving from -150 to-140 or 30 to 40. If this is not the case, try loading factory defaults to see if this solves the issue. Direction may also be changed by the RoboFocus Control Box, which drives the TAKometer. Unlike other rotators, the TAKometer must be accurately calibrated to give good results. Follow the instructions in the TAKometer documentation. Once you have completed calibration, rotate the TAKometer to +180 and note the rotator's position, perhaps against a fixed reference. Then rotate to -180. The rotator should come to the same point If it does not, re-calibrate as needed. Ideally, you should get within ±1 degree.

Cloud Sensor Notes

CCDAutoPilot accesses the Cloud Sensor via the Single Line Data Facility, as described in the Boltwood Cloud Sensor documentation. In order to access the cloud sensor data, you must set up a file name and location for this data from the Clarity software. Then, CCDAutoPilot must be told where this file is located from the Preferences page. This file can be located on a PC different from the one CCDAutoPIlot is running on, allowing multiple observing sites at a single location to use the same Cloud Sensor.

When Abort on Update Loss is checked on the Preferences page, the run will abort if the cloud sensor stops providing updated data for the time period indicated. For most dedicated cloud monitoring programs, this update time should be set to 30 sec. In some cases, as for example the WeatherWatcher described below, this time should be longer.

Specific Hardware Notes

Boltwood Cloud Sensor: Make sure your temperature settings for cloudy and very cloudy are set properly to indicate the appropriate conditions.

CloudWatcher: The CloudWatcher supports complete networked operation such that each client can set their own thresholds for what constitutes cloudy and very cloudy. This equipment provides Cloud Sensor I functionality, i.e. monitoring of sky temperature to determine cloudy conditions and a rain sensor.

WeatherWatcher: When integrated with CloudWatcher and an appropriate commercial weather station, a Cloud Sensor II compatible file can be used for CCDAutoPilot input. This configuration adds humidity and wind speed from the weather station to cloud and rain monitoring from CloudWatcher. Because weather stations update their data less frequently than CloudWatcher, you may need to adjust the timout in Abort on Update Loss. You should set the time to be 3 times the weather station update time. For example, if the weather station fastest update is once per minute, set the timeout to 180 sec.

Dome Notes

CCDAutoPilot makes every attempt to work with available domes. Some automation interfaces are more robust than others. Use the test buttons to verify CCDAutoPilot can operate the dome rotation and open and close the shutters. If those buttons don't have the desired result, there is no way CCDAutoPilot can cause those actions to happen. If you are using AutomaDome, don't set the update time too short. Longer times, 8 - 10 minutes or so, seem to give more reliable operation.

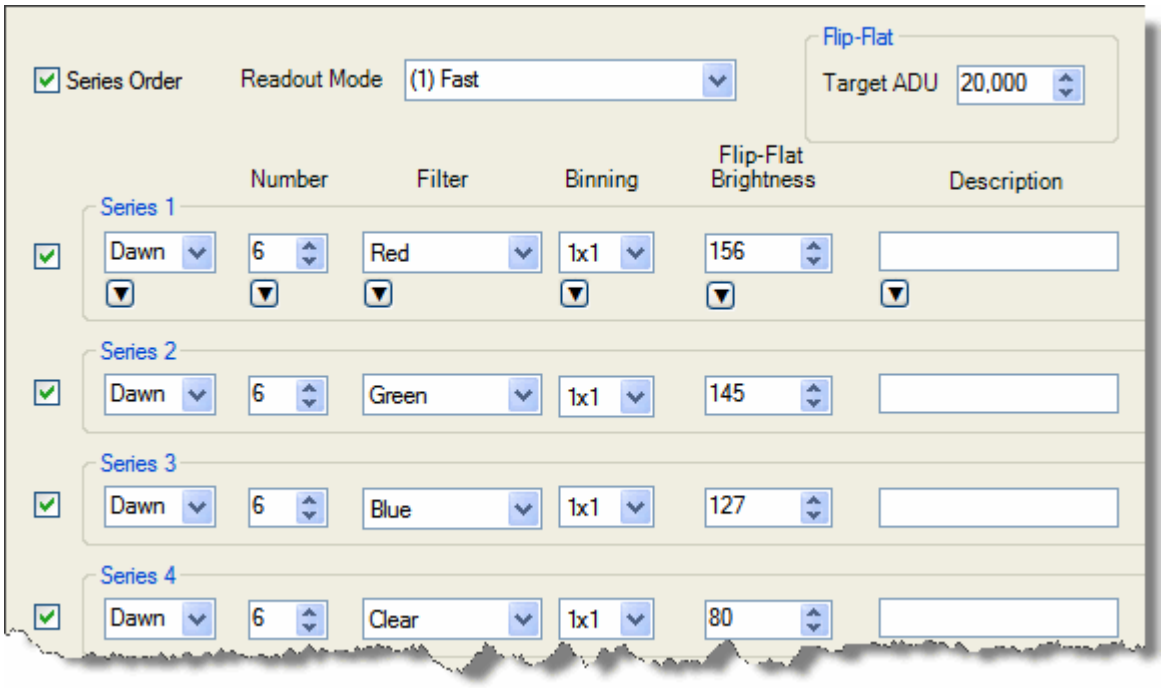
Flip-Flat Notes

The Flip-Flat is a telescope accessory that allows taking artificial light source flats at the conclusion of an imaging session. Session support is integrated into CCDAutoPilot.

When Use Flip-Flat is checked on the Settings page and the Flip-Flat control program, aacmd.exe, is properly located, the Flip-Flat will provide the illumination source for flats under CCDAutoPilot control. Be sure the Flip-Flat Controller windows application is **not** running. If dusk flats are selected, the Flip-Flap will be first be closed and then be turned to the specified brightness setting at the start of dusk flats. It is recommended that After Civil Dusk be checked on the options page to prevent light leakage from the setting sun from impacting the flat quality. The Flip-Flat will then be turned off once the dusk flats are completed. It will then open at the start of the Target run portion of a session session and close after the Target run completes. If Artificial Flats at park position is checked on the Options page, the Flip-Flat will be closed and turned on when the dark frames are completed after the Target run. It will be turned off when the flats are completed.

If you are using a Flat-Man XL, everything will work exactly as it does for the Flip-Flat, although the open and close commands issued by CCD Autopilot will be ignored. If you have both a Flip-Flat and a Flat-Man XL installed on your system, you must make sure that you select the com port appropriate for the device you would like CCD Autopilot to control during that session before you connect.

User entry fields are adjusted on the Flat Frames page.



The desired ADU target for all filtes is entered in the Flip-Flat box at the top for Target ADU. Then, individual Flip-Flat Brightness settings can be set for each series. The settings range from 0 to 255, with 255 being the brightest setting. This is useful to get the Flip-Flat brightness in a suitable range for different transparency filters. Set the number higher for less transparent filters and lower for more transparent ones. This should be consistent with the minimum and maximum Flat exposure times on the Preference page. In general, only an approximate brightness setting is needed for the Flip-Flat as CCDAutoPilot's internal automatic brightness control logic will fine-tune the exposure to the desired Target ADU level as it does with sky flats.

Troubleshooting

Imaging Strategies