

INSTRUCTION MANUAL

Orion® StarShoot™ Solar System Color Imaging Camera III

#52018



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Welcome to a new world of adventure. Your new StarShoot Solar System Color Imaging Camera III (SSSSI-III) is capable of capturing detailed, full-color images of astronomical objects in our solar system. The planets, Moon, and Sun (with optional solar filter) can all be imaged to create spectacular views on your computer which can be saved for emailing or printing later. The SSSSI-III can even be used during the day to take images of terrestrial subjects. You'll find that this inexpensive, yet easy to use, camera will enhance all of your journeys with your telescope.

Please read this instruction manual before attempting to use the camera or install the needed software. For the most detailed information on specific camera and software functions, consult the MaxIm DL Essentials Help menu.

Parts List

- StarShoot Solar System Color Imaging Camera III
- USB Cable
- Parfocal ring
- CD-ROM

System Requirements (refer to Figure 1)

Telescope

The SSSSI-III can be used with virtually any telescope that is compatible with 1.25" format eyepieces. The camera simply is inserted into a focuser in the same way as a standard eyepiece (Figure 2). If you use a star diagonal, you should remove it. In order to reach focus, the telescope must have approximately 0.2" (6mm) of inward focus travel relative to where a standard eyepiece focuses. If your telescope does not have enough inward focus travel, you will need to use an optional 1.25" barlow lens to extend the telescope's focal plane to the camera's imaging plane.

For most types of astro-imaging with the SSSSI-III, using a telescope with a focal length of at least 1000mm is recommended. Otherwise, the image scale may be too small. To increase the effective focal length of your system, use a barlow lens or other type of tele-extender lens.



Figure 1. To use the SSSSI-III, a telescope, mount, and computer are required.



Figure 2. The SSSSI-III fits into 1.25" focusers, just like a standard 1.25" eyepiece.



Figure 3. The **Launcher** provides an easy menu for software installation.

Mount

An equatorial mount is not absolutely required for imaging with the SSSSI-III, as the maximum exposure time is a fraction of a second, too short for astronomical objects to drift significantly during the exposure. Use a sturdy mount that is appropriately sized for the telescope tube being used.

For obtaining the best planetary images, however, we do recommend an equatorial mount. Planetary imaging requires combining many individual images, and having an equatorial mount will prevent the planet from drifting out of the field of view of the camera during the time it takes to acquire the large number of images necessary. A motor drive (single-axis) is recommended too.

Computer

A computer is also needed. For astro-imaging in the field at night, a laptop computer is highly recommended. MaxIm DL Essentials requires Windows XP or Vista.

The following hardware is required:

- Processor – Pentium III™ or equivalent, or higher
- Recommended minimum memory size is 256 MB.
- Disk Space – 100 MB minimum, 500 MB or more recommended for saving images.
- Video Display – 800 X 600, 16-bit color or higher. 1024x768 or higher is recommended.
- Mouse
- Internet Explorer 4 or higher required to display on-line help
- High Speed USB 2.0 port



Figure 4. When initially connecting the SSSSI-III to a computer, a **Found New Hardware** notification will appear and automatically install the camera to your computer.

Software and Driver Installation

Before the camera can be used, software and a camera driver must be installed onto your computer. Turn on your computer and allow the Windows operating system to load as normal. Insert the included CD-ROM into your computer's CD-ROM drive, and the Launcher will appear (Figure 3). This allows you to install the MaxIm DL Essentials software, and the Orion StarShoot Solar System Imager camera driver.

Software Installation

1. Insert the CD-ROM into the drive. The **Launcher** will appear. If you are using Windows Vista, the **AutoPlay** window will appear first. Select **Run Launcher.exe**.
2. Click **Install**.
3. The **InstallShield Wizard** will start. Click **Next**.
4. Read the MaxIm DL License Agreement. If you agree with the terms, then select **I accept the terms in this license agreement** and click **Next**.
5. You are now ready to install. Click **Install**. The installation will proceed.
6. Microsoft DirectX 9 or higher is required. Click **Yes** to install the update.
7. The installation is now complete. Click the **Finish** button.

Camera Driver Installation

Now that the software is installed, the camera driver must also be installed. Do not connect the SSSSI-III to your computer yet.

1. Return to the **Launcher** and click **Install SS Camera**.
2. The **InstallShield Wizard** appears. Click **Next**.
3. The installation will commence.

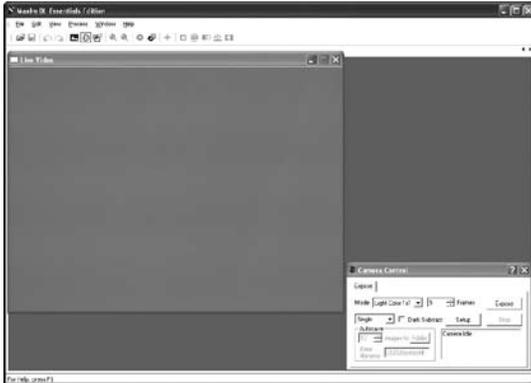


Figure 5. The **Live Video Window** and **Camera Control Window** both automatically appear when the SSSSI-II is connected to the computer and the MaxIm DL Essentials program is opened.

4. When the wizard is complete, click **Finish**. This has installed the driver software; next we must install the camera itself.
5. Plug in the camera into your computer's USB port.
6. A **Found New Hardware** notification will appear in your Windows task bar (Figure 4).
7. Wait a few moments and the camera will automatically install on your computer. When **Device Installed Successfully** notification appears you will be ready to use the camera.
8. Open MaxIm DL Essentials from the icon on your desktop. The **Live Video** and **Camera Control Window** should appear.

Once the driver is installed, the computer will recognize the SSSSI-III whenever it is plugged in.

Getting Started During Daylight

We recommend using the SSSSI-III for the first time during the day. This way, you can become familiar with the camera and its functions without having to stumble around in the dark. Setup your telescope and mount so the optical tube is pointing at an object at least a couple of hundred feet away. Insert an eyepiece and focus as you normally would.

To obtain first images with the SSSSI-III, follow these step-by-step instructions:

1. Plug the camera into your computer's USB port. Notice the blue LED shining on the camera; this LED light indicates the camera is connected and receiving power from the computer.
2. Open the MaxIm DL Essentials icon now installed on your computer's desktop.
3. Essentials should automatically connect directly to your camera with a **Live Video Window** and **Camera Control Window**. Your **Live Video**

Window will only show light and dark before the camera is coupled to your telescope.

4. When the camera is connected to the computer for the first time, the **Live Video Window** (and subsequent images captured with the camera) will display at 640x480 resolution. To change to full resolution mode, click the Setup button in the **Camera Control Window** and select **Video Capture Pin**. In the Properties window that pops-up, select **1280x1024** under the **Output Size** heading, then click **OK**. The **Live Video Window** will now display at full resolution, and will occupy most of the computer monitor's screen. Any images captured with the camera will now also be at full resolution. To move the **Live Video Window** out of the way, click on the top bar of the window and drag it to the desired location on the computer screen. Upon subsequent start-ups, the camera will automatically operate at full resolution.
5. To connect the camera to the telescope, simply replace the telescope's 1.25" eyepiece with the camera. Make sure the securing thumbscrew on the focuser drawtube is tightened after the camera is inserted.
6. You will now need to refocus the camera for the centered object. Focusing will be the hardest thing to learn in the initial stages. If you are starting out in daylight, as is recommended, you may need to turn the brightness control of the camera down before attempting to focus. This is done by clicking on the **Setup** button in the **Camera Control Window**. Select **Video Capture Filter**, and to the right of **Exposure** make sure the **Auto** box is checked. Then adjust **Contrast and Brightness**. If the daytime image brightness is still too bright to produce an acceptable image on your computer screen, you may need to stop-down the aperture of your telescope.
7. Turn the telescope's focus knob so the focuser drawtube moves slowly inward. The drawtube needs to go approximately 6mm inward from where the eyepiece focuses (for most eyepieces). Look at the **Live Video Window** on the computer screen and adjust the focus knob accordingly to determine best image focus.

Note: The camera's field of view is fairly small. It is approximately equivalent to the field of view through the telescope when looking through a typical (i.e. not wide-field) 10mm focal length eyepiece.

8. Image orientation can be changed by rotating the camera within the focuser drawtube. Simply loosen the thumbscrew on the drawtube and rotate the camera until the desired image orientation is achieved. Retighten the thumbscrew on the focuser drawtube when done. You may need to slightly refocus (using the telescope's focus knob) if the focuser drawtube has moved a bit inward or outward when the camera was rotated.
9. Select **Light Color 1x1** mode in the **Camera Control Window**.
10. Set **Frames** to 1 in the **Camera Control Window**. You can increase this number to automatically add successive frames into the resultant image for higher image quality. If the object is moving due to poor atmospheric

seeing conditions, wind, or a shaky mount, however, increasing the Frames to more than 1 will generally decrease image quality. You can take many individual frames and add them together (“stacking” or “combining”) later, this will be discussed in detail in the “Astronomical Imaging” section.

11. Select the **Single** beneath the **Mode** box in the **Camera Control Window**.
12. Keep the **Calibrate** box unchecked in the **Camera Control Window**.
13. Click the **Expose** button in the **Camera Control Window**. An image will appear in a window.
14. You can save the image for processing later, if you wish. This is done by selecting **Save** from the **File** menu.

You have now taken your first picture with the SSSSI-III! This simple method of imaging is exactly how the camera is used to capture terrestrial subjects during daylight hours. Close-up images of birds and other wildlife or faraway vistas can all be obtained in this way with the SSSSI-III. Solar images can also be taken during the day with an optional full-aperture solar filter over the front of the telescope.

Take some time to use the camera and MaxIm DL Essential software during the day to become familiar and comfortable with their basic operation. For best results, you can optimize your images with the camera controls.

Camera Controls

For best images, you can adjust the camera controls through MaxIm DL Essentials to fine tune the image. You can see how the camera controls affect an image in the **Live Video Window**.

In the **Camera Control Window**, click the **Setup** button, then choose **Video Capture Filter** and you can access the camera controls. Here you will find the **Brightness**, **Contrast** (best at 50% or higher), **Hue**, **Saturation** (level of color), **Sharpness** (keep this low as it can add noise), and **Exposure** controls. The **Exposure** control is a gain adjustment that allows additional flexibility in adjusting image brightness. You can either manually adjust this by unselecting the **Auto** box and manually moving the slider, or have automatic adjustment by leaving the **Auto** box selected. For usual operation, the **ColorEnable** box should remain checked. For black and white camera operation, uncheck this box. The **Cancel Flicker** button enables and disables the flicker function. The default has the flicker function disabled, and there should be no reason to use this function with normal usage of the camera. If the image in the **Live Video Window** begins to flicker on and off, the flicker function has been mistakenly enabled; click the **Cancel Flicker** button to cancel this function. To return the camera controls to their default settings, click the **Default** button.

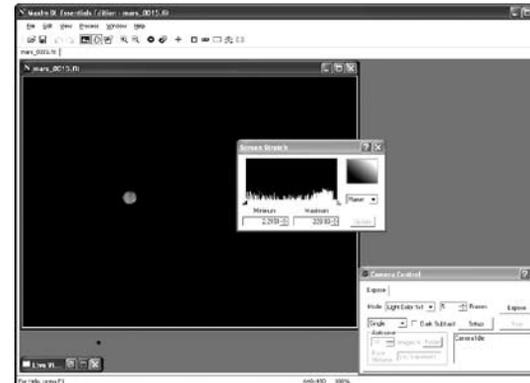


Figure 6. The settings in the **Screen Stretch Window** greatly determine how an image will appear on your computer screen.

The other camera controls are available by clicking the **Setup** button, and selecting **Video Capture Pin**. This accesses the Stream Format property sheet, which allows you to set additional parameters. The **Frame Rate**, while generally should be left at 15 frames/second for the sharpest planetary images, can be toggled down to 7.5 frames/second for brightest exposures. (You can also use the **Video Capture Filter** selection described previously to adjust image brightness.) Check the **Flip Horizontal** box to change the orientation of the image display in the **Live Video Window**. **Color Space / Compression** selects the codec used by the camera; in this case it is RGB 24. The Output Size can be used to shrink the image size if desired; the camera defaults to 640x480, but you should raise this to the highest setting (1280 x 1024) for the maximum possible resolution. The other parameters shown with the **Video Capture Pin** selection cannot be adjusted.

Try several different settings to get a feel of how the camera controls work and affect the resultant image on the computer screen. The **Brightness** and **Exposure** controls are the ones you will use the most. The telescope being used, seeing conditions, and object being imaged will dictate how these camera controls should be set. Usually Exposure will be set first, then Brightness is adjusted as needed.

Screen Stretch Window

The function of the **Screen Stretch Window** (Figure 6) is to properly map the image brightness levels captured by the camera into corresponding image brightness levels on the computer screen. A typical camera image has each pixel (light detecting site, over 1,300,000 pixels form a single SSSSI-III image) represented as a number depending on brightness. This has to be mapped into the video monitor's brightness range. It is important to set the screen stretch appropriately, or a great image may look terrible!

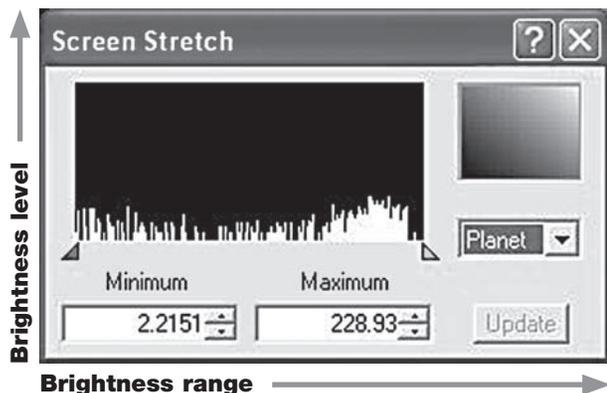


Figure 7. A histogram is a visual representation of the range and level of brightness in an image.

*Note: The **Screen Stretch Window** does not work for the **Live Video Window**, only for open images captured by the camera.*

In the **Screen Stretch Window**, you will notice a graph. This is called the “histogram” of the currently displayed image (Figure 7).

A histogram is a simple bar graph that shows the range of brightness in an image. Each bar in the graph represents a level of brightness; the bar to the far left in the histogram represents the dimmest pixels, and the bar to the far right is for the brightest pixels. The height of the bar is the total number of pixels at that brightness level in the image. Every image has a different histogram depending on how much of the image is bright or dark. Directly viewing the histogram of your image in the **Screen Stretch Window** provides an easy interface for making decisions on how the screen stretch should be set.

In MaxIm DL Essentials, the two parameters entered in the **Screen Stretch Window** are **Minimum** and **Maximum**. A pixel that is at the **Minimum** value is set to zero (black), and a pixel at the **Maximum** value is set to 255 (white). An easy way to adjust the **Maximum** and **Minimum** values is to move the slider arrows located directly under the histogram of the image in the **Screen Stretch Window**. The red slider arrow corresponds to the **Minimum** value and the green arrow corresponds to the **Maximum** value. Simply left-click and then drag each arrow to adjust it to the desired level. The best results are obtained by tweaking the arrows (numbers) until the most pleasing display appears.

There are also seven automatic settings in the **Screen Stretch Window**. Typically, Moon and Planet will give the best results. The default screen stretch setting is Moon.

Instead of using the **Screen Stretch Window**, it is faster to use the **Quick Stretch** facility. This allows you to modify the image appearance instantly with small up/down and left/right movements of the mouse. To do this, hold down the **Shift** key, then left-click and drag the mouse on the image. You’ll find this feature to be a great convenience when fine adjusting the screen stretch to get an image to look its best.

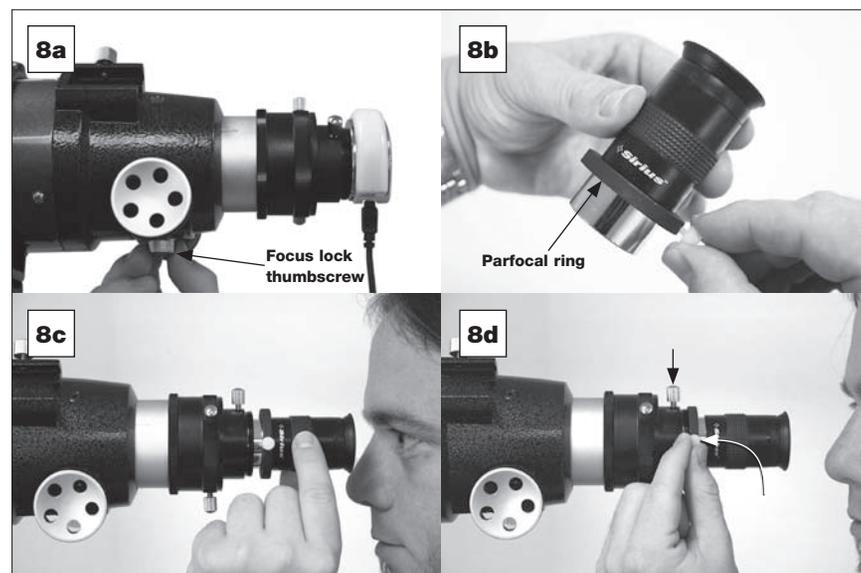


Figure 8a-d. (8a.) To properly set the position of the parfocal ring on an eyepiece, first focus the camera in the telescope. If you have a focus lock thumbscrew on your telescope’s focuser, tighten it. **(8b.)** Place the parfocal ring on the eyepiece’s barrel and slide it all the way up. Tighten the thumbscrew on the ring. **(8c.)** Remove the camera, and focus the eyepiece by sliding it in-and-out of the focuser drawtube. When eyepiece focus is achieved, tighten the thumbscrew on the focuser drawtube to secure the eyepiece in that position. **(8d.)** Now, loosen the thumbscrew on the parfocal ring, slide the ring all the way forward, and retighten the thumbscrew on the ring.

The problem with stretching is determining exactly how to stretch the image for best effect. Often there are several different possibilities for the same image. Trial-and-error will be the best way to judge what the best screen stretch setting is. Try several different settings until you find one you think looks best. When the image is subsequently saved, the screen stretch setting information will be kept when the image is next opened.

Use of the Parfocal Ring

A parfocal ring is included with your camera to help with focusing. The ring is intended to be used with a 1.25" eyepiece (not included), preferably one with a focal length of at least 10mm to provide high enough magnification for precise focusing. The ring goes on the barrel of the eyepiece. When the ring is properly positioned on the barrel, you can use the eyepiece to focus, replace the eyepiece with the camera, and the camera should be close to focused.

To properly position the parfocal ring on the eyepiece barrel, first insert the camera into the telescope's focuser drawtube. Set MaxIm DL Essentials so the camera displays on the computer's screen in **Live Video** mode. Focus the camera as precisely as possible by visual inspection of the image on your computer screen. You do not need to actually capture an image, just look at the live preview on the computer. If you have a focus lock thumbscrew on your telescope's focuser, tighten it firmly once sharp camera focus is achieved (Figure 8a). Place the parfocal ring on the eyepiece barrel, and slide it up the barrel as far as it will go and loosely tighten the thumbscrew on the ring (Figure 8b). Now, replace the camera with the eyepiece, being careful not to change the position of the focuser drawtube. Bring the eyepiece into focus by sliding it in and out of the focuser drawtube (Figure 8c). Do not use the focus knob of your telescope to focus at this time.

Note: If you cannot obtain a focus with the eyepiece by pulling it out of the focuser drawtube, you will need to try another eyepiece.

When the eyepiece is in focus, tighten the securing thumbscrew on the focuser drawtube to secure the eyepiece in that position. A significant portion of the eyepiece's barrel should be extending out from the focuser drawtube. Now, slide the parfocal ring down the eyepiece barrel, and seat it against the focuser drawtube (Figure 8d). Securely tighten the thumbscrew on the ring. The parfocal ring is now properly positioned on the eyepiece's barrel.

Now that the parfocal ring is properly positioned, focus the camera by first focusing with the eyepiece. Simply insert the eyepiece as far as it will go into the focuser drawtube, and focus with the telescope's focusing knob. Then, replace the eyepiece with the camera, and the images on the computer screen should be very close to focused. Use the live preview mode to achieve a precise focus with the camera. You'll find that using the parfocal ring on an eyepiece will serve to focus the camera much more quickly.

Astronomical Imaging

Now that you're familiar with basic camera and software operation, it's time to take the SSSSI-III out at night under the stars to capture some astronomical images. We recommend starting with the Moon, as it is easy to acquire into the camera's field of view, and typically does not require stacking of multiple exposures as planetary images do.

Imaging the Moon

Imaging the Moon is much like imaging terrestrial objects during the day. Since the exposure is very short, it is not critical that the telescope be precisely polar aligned. Best focusing will be achieved by first focusing on a bright star near the Moon.

When the moon is past half full, it is hard to get detail due to the tremendous glare off of the lunar surface. Most detail, even on a sliver of a moon, will be



Figure 9. The Moon's surface detail looks the best along the terminator.

at the terminator (that tiny thin line between the shadow and light, see Figure 9). To get more of the moon in the image, a focal reducer will need to be used. For close-ups of craters use a barlow lens (see "Using Focal Reducers and Barlow Lenses").

Imaging Planets

The best planetary images will be obtained by stacking (combining) many individual images in order to improve image contrast, brightness, and detail.

Since you will be taking multiple images over a period of time, it is important you have a decent polar alignment in order to keep the planet within the field of view of the camera. To this end, having a motor drive (at least single-axis) will also be helpful. Otherwise, you will periodically need to rotate the R.A. slow-motion knob to keep the planet within the camera's field.

To take multiple images of a planet for stacking:

1. Acquire the planet into the field of view of your eyepiece that has the parfocal ring attached to it, and center it in the eyepiece's field of view. Focus the eyepiece with the telescope's focuser. If you are using an equatorial mount with a motor drive, make sure the motor drive is on and engaged.
2. Remove the eyepiece and replace it with the SSSSI-III. If the parfocal ring was set properly on the eyepiece, the camera should be close to focused.
3. Focus the camera using the telescope's focus knob. If you are having trouble determining best focus, try focusing on a bright star near the planet. You can also use the histogram functions for most accurate focus, this will be explained later.
4. In the **Camera Control Window**, set the Mode to Light Color 1x1.
5. Set **Frames** to somewhere between 1 and 10 to start. This number indicates the number of frames MaxIm DL Essentials will actually put into each individual captured image. Be careful not to set this number too high, especially if seeing conditions are poor. Otherwise, the captured images will be blurry.

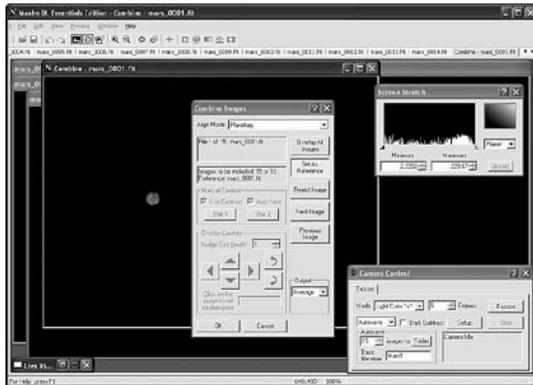


Figure 10. The **Combine Images** window allows “stacking” of individual images into one high-quality resultant image.

Note: The Frames setting is not meant to replace stacking of resultant images. It simply puts more data into each image by overlaying subsequent frames on top of each other. These images are then stacked as described later.

6. In the box beneath the **Mode** box, choose **Autosave**. Now set the number of images you would like the camera to take under **Autosave**, select the file folder in which you would like to save the images with **Folder**, and enter in a **Base filename** for the captured images. Typically the name of the object being imaged, such as “Mars1”, will be entered here. If “Mars1” is the **Base filename**, and you choose to **Autosave** five images, then the images will appear in the selected file folder as “Mars1_0001.fit”, “Mars1_0002.fit”, “Mars1_0003.fit”, “Mars1_0004.fit”, and “Mars1_0005.fit”.

7. Click **Expose**, and the camera will commence taking the images.

Now that we have multiple images of the planet, we will combine the images to form one high-quality resultant image. To do this:

8. Select **Open** from the **File** menu. Find the folder you indicated with **Folder**, open it, and select all images for stacking using the mouse left-click and the **Shift** key. All of the individual images selected will open in MaxIm DL Essentials.
9. Select **Combine** from the **Process** menu. In the pop-up window, you will see all of the images currently open in MaxIm DL Essentials. Choose the individual images you want to stack and press the **>>** button, or simply click **Add All**. Click the **OK** button when done.
10. The **Combine Images** window will appear (Figure 10). For **Align Mode**, choose **Planetary**. In the **Output** box, select **Average**.
11. Use the **Next** and **Previous Image** buttons to see how each individual image looks. If you see an image that looks poor, you can reject it from the stack by clicking the **Reject Image** button.

Note: At least one image must be used as the reference image for the stacked images to be overlaid upon. The default uses the first image for the reference

*image. If you reject the first image or otherwise want to use another image as the reference, click the **Set As Reference** button when the desired reference image is actively displayed. If the image currently chosen as the reference is rejected from the stack, and another reference image is not selected, you will not be able to **Overlay All Images**.*

12. Click the **Overlay All Images** button. All of the selected images will stack on top of each other to form one resultant image. Click **OK**. You have now composed your first planetary image. Use **Save** under the **File** menu to save your image at this time. To make it look its best, you will want to adjust the **Screen Stretch Window to Planet**. You may also want to do some image processing, see the section entitled “Image Processing” for more information.

Imaging Planets: Recording Video

In the prior section, individual images of a planet were auto-saved for subsequent stacking later. Another way to obtain images for stacking is to take several seconds of video of the planet, then break the video into individual frames for stacking. Since the SSSSI-III has a maximum frame rate of 15 frames per second at maximum resolution, you can literally obtain hundreds of images for stacking in seconds! You save time by taking one video instead of dozens of individual pictures!

To record a video of the planet:

1. Acquire the planet into the field of view of your eyepiece that has the parfocal ring attached to it, and center it in the eyepiece’s field of view. Focus the eyepiece with the telescope’s focuser. If you are using an equatorial mount with a motor drive, make sure the motor drive is on and engaged.
2. Remove the eyepiece and replace it with the SSSSI-III. If the parfocal ring was set properly on the eyepiece, the camera should be close to focused.
3. Focus the camera using the telescope’s focus knob. If you are having trouble determining best focus, try focusing on a bright star near the planet.
4. In the **Camera Control Window**, set the **Mode** to **Video**. Set **Seconds** to correspond with the video length. Remember, the camera takes 30 frames per second. So if you want 150 individual frames for stacking, set **Seconds** to 5.0.
5. Click the **Setup** button in the **Camera Control Window**. Choose **Output File** from the pop-up menu and select the file location where you want the .avi video saved to. Type in a name for the file in **File name**. Click **Save**.
6. Click **Expose**, and the SSSSI-III will commence taking the video. The image as it appears in the **Live Video** window is exactly what will be recorded. If you wish to play back the video, click on the .avi file from its recorded file location. Now that we have a video of the planet, we will break the video up into its component images for stacking. To do this:

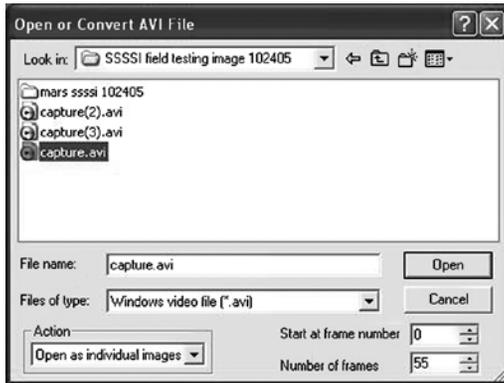


Figure 11. The **Open or Convert AVI File** window breaks video into individual images for subsequent stacking.

7. Choose **Open or Convert AVI File** from the **File** menu. The **Open or Convert AVI File** window will appear (Figure 11).
8. Select the file location of the .avi video saved prior. At the bottom left of the **Open or Convert AVI File** window, in the **Action** box, select **Open as individual images**. (Alternatively, the **Convert to BMP files** selection in the **Action** box breaks the video into individual frames and saves them for opening and processing later.) At the bottom right of the **Open or Convert AVI File** window you can select the video frame number to start with (usually will be 0) and the number of frames to break out into individual images. Use caution, however; opening many hundreds of frames at once can be confusing and burdensome. Click **Open**. Now that we have multiple images of the planet, we will combine the images into a single image. To do this:
 9. Select **Combine** from the **Process** menu.
 10. In the **Select Images** window, click **Add All**. Then click **OK**.
 11. The **Combine Images** window will appear. For **Align Mode**, choose **Planetary**. In the **Output** box, select **Average**.
 12. You can see how each individual image looks by using the **Next Image** and **Previous Image** buttons. If you see an image that looks poor, you can reject it from the stack by clicking the **Reject Image** button.

*Note: At least one image must be used as the reference image for the stacked images to be overlaid upon. The default uses the first image for the reference image. If you reject the first image or otherwise want to use another image as the reference, click the **Set As Reference** button. If the image currently chosen as the reference is rejected from the stack, you will not be able to **Overlay All Images**.*
 13. Click the **Overlay All Images** button. All of the selected images will stack on top of each other to form one resultant image. Click **OK**. Adjust the

Screen Stretch Window to Planet, and use **Save** under the **File** menu to save your image. You can now perform any wanted imaging processing.

Dark Frames

A way to coax additional image quality out of the SSSSI-III is to eliminate unwanted camera “noise” from captured images. While this will generally not be needed for most types of imaging with the SSSSI-III, it may help to improve image contrast in some cases.

To do this, “dark frames” must first be captured and averaged. Dark frames are taken with no external light entering the camera. The image produced is a map of the actual noise in the frame being produced by the camera. When a dark frame is subtracted from a regular (“light”) image, the noise in the resultant image is reduced. You will find, however, that the short exposures that can be taken with the SSSSI-III will not contain much camera noise to begin with. So, subtracting dark frames from images (prior to combining) will not have a great effect on resultant images.

Note: To most effectively use dark frames to subtract noise out of resultant SSSSI-III images, it is important to take dark frames close to the actual time of taking the “light” images. This is because temperature changes will cause the noise pattern in the SSSSI-III to change over time. So, it is best to take some dark frames immediately before or after the “light” images are taken.

To take dark frames for subtraction from “light” images:

1. In the **Camera Control Window**, set the **Mode** to **Dark Color 1x1**.
2. Set **Frames** to whatever you set it to for taking actual (“light”) images.

Note: When taking dark frames, do not change any of the settings in the Setup button from what they were (or will be) when “light” images are taken.

3. In the box beneath the **Mode** box, choose **Autosave**. Now set the number of dark frames you would like the camera to take under **Autosave** (three to ten will generally suffice, these will be averaged together), select the file folder in which you would like to save the dark frames with Folder, and enter in a **Base filename** for the captured dark frames. Typically the name of the object being imaged with the word “dark” added, such as “Mars1dark”, will be entered here. If “Mars1dark” is the **Base filename**, and you choose to **Autosave** five images, then the images will appear in the selected file folder as “Mars1dark_0001.fit”, “Mars1dark_0002.fit”, “Mars1dark_0003.fit”, “Mars1dark_0004.fit”, and “Mars1dark_0005. fit”. Using the word “dark” in the **Base filename** will help you distinguish between light and dark frames when combining later.
4. Click **Expose**, and MaxIm DL Essentials will indicate that the camera needs to be covered to take a dark frame. Cover the front of the lens you are imaging through, and then click **OK**. The camera will commence taking and saving the dark frames. Now that you have acquired several dark

frames, you will combine them into a single averaged dark frame for subtraction from subsequent “light” images.

5. In the **Process** menu, select **Setup Dark Subtract**.
6. In the window that pops-up, click **Remove All** if any filenames appear in the window.
7. Click **Add**, and select the file folder location for the dark frames taken. Select the dark frames and click Open.
8. The selected dark frames will now appear in the pop-up window. Click **OK**. We are now ready to subtract the averaged dark frame from “light” images. This should be done to individual light images BEFORE combining them together. There are two ways to do this. If you take dark frames first, before taking “light” images, then you can automatically subtract the averaged dark frame from each individual “light” image as it is captured. If you take dark frames after you have already taken the “light” images, then you can subtract the averaged dark frame from each individual image before you combine them into a single, final resultant image.

To automatically subtract the averaged dark frame from images as they are captured, first setup the averaged dark frame as outlined previously. Now, in the **Camera Control Window**, simply click the **Dark Subtract** square so it is checked. Once this box is checked, every subsequent light frame taken with the camera will have the averaged dark frame automatically subtracted. These images are ready for stacking.

If you have already taken your “light” images or obtained individual images by recording video, then you will need to manually subtract the averaged dark frame from each image prior to stacking them into one combined image. To do this, first open all “light” images to be stacked in MaxIm DL Essentials. Do this with the **Open** command in the **File** menu. Now, click on one of the opened images, and select **Dark Subtract** from the **Process** menu. The averaged dark frame is now subtracted from the “light” image. Repeat this process for all of the “light” images opened in MaxIm DL Essentials. The individual images are now ready for stacking. You can save each image after the dark frame has been subtracted (using Save from the File menu), or you can just save the final combined image once the individual images have been stacked.

Image Processing

After you have captured and combined individual images (with or without dark frame subtraction) into a single resultant image, you may want to perform some additional image processing to bring out subtle details or to make the image appear more pleasing overall. MaxIm DL Essentials contains several functions which serve to do this.

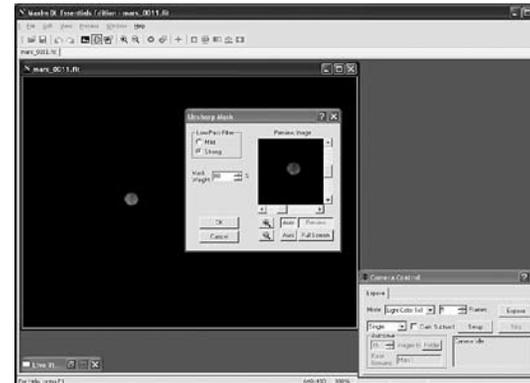


Figure 12. The **Unsharp Mask** function can help bring out subtle detail in an image.

Make Pixels Square

Make Pixels Square is not needed for the SSSSI-III. The camera’s pixels are already square. This function is used with some other cameras, such as the StarShoot DSCI II to interpolate the aspect ratio to 1:1.

Unsharp Mask

An **Unsharp Mask** is fairly simple in concept. First, a copy of the original image is smoothed (low-pass filtered) to create the mask. This mask is then scaled down in intensity by some factor (usually 50-95%), and then subtracted from the original image. The result of subtracting a blurred copy of the image from itself is to make a sharper image. This works because you are partially removing parts of the image that are smoother, while leaving untouched the parts of the image with fine detail. Usually the math is adjusted so that the average pixel values in the final image are the same as the original.

To apply Unsharp Mask to an image:

1. Select **Unsharp Mask** from the **Process** menu.
2. In the pop-up window (Figure 12), the **Low-Pass Filter** can be set to **Mild** or **Strong**.
3. The **Mask Weight** is used to control the strength of the mask. The mask weight is in percent; the higher the number, the stronger the mask.
4. Click on the **Auto Full Screen** preview button, and adjust the settings. This allows you to rapidly adjust the settings until you are satisfied with the results.
5. Click **OK** when the preview images looks its best. It is best to use a light touch with this command, to avoid over-processing the image. Over-processing can create artifacts; i.e. features in the image that are not real. It also amplifies the noise in the image.

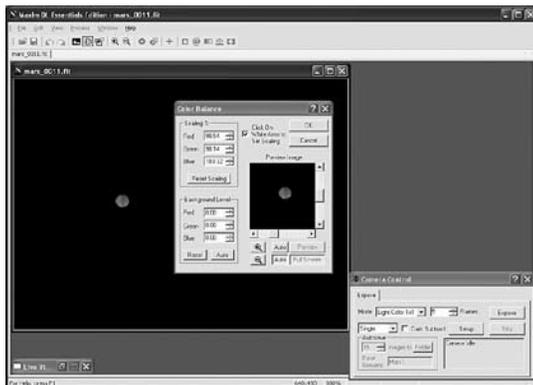


Figure 13. The **Color Balance** command allows weighting of each color plane to improve the overall color appearance of an image.

Color Balance

The sensitivity of most CCD cameras as a function of wavelength (color) is different from the response of the human eye. The filters used for creating color composites also have their own characteristics, as do the telescope optics. Although “perfect” color rendition is an elusive if not impossible goal (all individuals see colors slightly differently), it is straightforward to get “good” color balance with simple weightings. This is where the **Color Balance** command (in the Process menu, Figure 13) comes in handy to touch up the resultant colors in your images. Use the **Preview Image** to see how altering these parameters will affect your image (or click the **Full Screen** button to see the changes applied to your full image).

Color images from CCD cameras typically require a **Background Level** adjustment. This is accomplished by bringing the **Background Level** (or bias) in each color plane down to zero. Each of the **Background Level** values is subtracted from every image pixel in its color plane. Any pixel values that become negative are forced to zero. The **Auto** button automatically determines the settings necessary to equalize the image background in all three color planes. The **Reset** button resets the background level subtraction to zero on all planes.

Scaling adjustment (percent) allows you to compensate for transmittance differences between the filters used to acquire the three color planes. Values of 100% result in no change. The scaling percentages can be typed in or adjusted using the “spin” controls (small up and down click arrows to the right of the scaling numbers). The **Preview Image** is particularly helpful in monitoring the results when using the spin controls. The **Reset Scaling** button resets to 100% on all three planes.

The **Click On White Area to Set Scaling** check box enables the operation of the mouse to set the scaling. Set the **Background Level** first (you can use **Auto**), then click on a white object (e.g. a neutral-colored star) in the image (not the **Preview Image**) with the mouse. The **Scaling** settings will automatically be adjusted to make the selected point appear white. If an area of the image

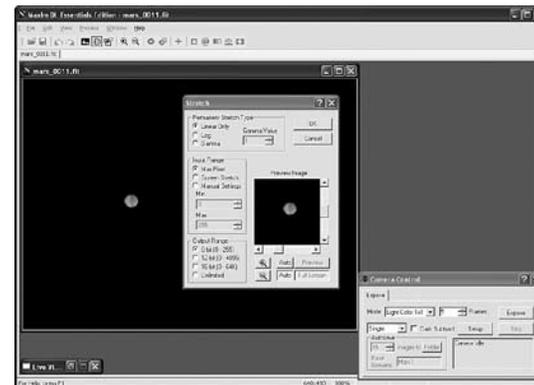


Figure 14. The **Stretch** command modifies the data contained within the image in order to improve contrast and brightness.

is known to be white (or gray), this is an easier way to determine the scaling factors, and can be used to instantly color balance the image.

Stretch

The **Stretch** command (located in the **Process** menu, Figure 14) modifies the brightness and contrast, and optionally the range (maximum and minimum pixel values) of an image. Unlike the screen stretch settings in the **Screen Stretch Window**, which only affects the how an image appears on the display, the **Stretch** command actually changes the image data pixel values in the memory buffer. In reference to the histogram, the **Screen Stretch Window** changes how the histogram is displayed on the computer screen, the **Stretch** command alters the histogram itself.

There are three elements which must be set: the **Permanent Stretch Type**, the **Input Range**, and the **Output Range**. You can use the **Preview Image** to see how changing these parameters will affect the resultant image (or click the **Full Screen** button to see the changes applied to your actual image). You can also open the **Screen Stretch Window** to see how changing these parameters change the histogram.

For the **Permanent Stretch Type**, the **Linear Only** mode is useful for adjusting the range of pixels to match a particular file format. The **Log** mode is useful for compressing the dynamic range of the image, but can be rather harsh. The **Gamma** mode allows you to selectively emphasize bright or dim parts of the image by entering a suitable **Gamma Value**. A **Gamma** of 1 has no effect - less than 1 will emphasize faint details, while a value greater than 1 will emphasize bright details.

The **Input Range** can be set to **Screen Stretch**, which in **Linear Mode** produces an output matching the current screen appearance. This is useful in producing final images for output to 8-bit image formats which have limited range. Note that the minimum and maximum values are always taken from the screen stretch settings for the original image. These can be adjusted dynami-

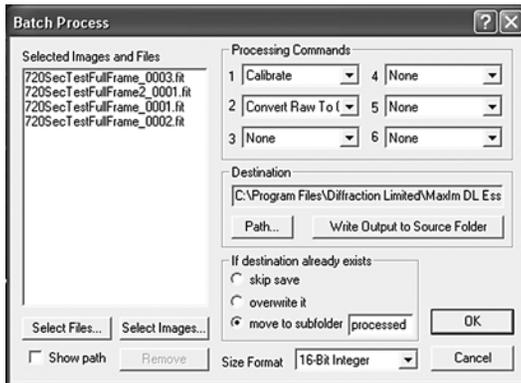


Figure 15.

cally using, for example, **Quick Stretch**. The **Max Pixel** selection sets the input range from 0 to the brightest pixel in the image. This prevents any image pixels from being saturated in the final result, but may produce images with low contrast. You can also manually set values with **Manual Settings** in a similar fashion to the **Screen Stretch Window**.

The **Output Range** is used when preparing a file to be saved in a format that has limited range. The **Output Range** maps minimum input to zero, and maximum input to 255 (8 bit), 4095 12 bit, or 65535 (16 bit) depending on the settings. Any values that exceed the limits are clipped. The **Unlimited** setting disables all limiting and is recommended when performing **Gamma** and **Log** stretches; it is appropriate when the image will be saved in floating point format.

Batch Process

Planetary imaging can require processing hundreds of images. Fortunately, **Batch Process** can be used to process multiple images simultaneously using the various commands available in MaxIm DL Essentials Edition. Select **Batch Process** from the **Process** menu (Figure 15).

Procedure for basic batch processing:

1. Select the image file you want to process from your computer using the **Select Files** button. Use CTRL-click to select individual files, and SHIFT-click to select a range of files. You can see the path for the selected files by turning on the **Show Path** check box. Or you can select images already open in MaxIm DL Essentials Edition by clicking the **Select Images** button. The window that pops-up will indicate all the images currently open.
2. Select the processing task you want done in the **Processing Commands** box. Choose up to 6 processing commands which will be executed in sequence.

3. Use the same recommended processing order for batch processing as you would normally do manually. You should 1. **Calibrate**, 2. **Adjust Color Balance**, etc.

You can remove selected images and files from the **Batch Process** list by selecting them with the mouse and clicking the **Remove** button.

4. Select the location for the saved files using the **Path** button, or click **Write Output to Source Folder** to cause the files to be saved back into the folder from which they were loaded. (This option cannot be used when an image has never been saved, for example, one freshly acquired from the camera.) In the event that saving a file will cause it to overwrite an existing file, you can select **skip save**, **overwrite it**, or **move to subfolder**. You can specify the subfolder name in the adjacent field. Use **Size Format** to select between **16-Bit Integer** and **32-Bit IEEE Float** formats for the processed images. To keep all processed image data intact (especially for stacked images), we recommend using the **32-Bit IEEE Float** format. If you need to open the resultant files in another program, however, you may need to use the **16-Bit Integer** format.
5. Click **OK** to start the **Batch Process** operation. Successfully converted and saved files are removed from the list box. If an error occurred the file will remain in the list. Point the mouse cursor at an image left in the list. The appropriate error message will appear in the **Status Bar** at the bottom of the MaxIm DL Essentials Edition main window.

Recommended Processing Sequence

What is the best order to apply the processing functions in? Here is a recommended sequence:

1. Dark Subtract
2. Combine
3. Unsharp Mask
4. Color Balance
5. Stretch

Once you have the combined frames, there is a lot more room for experimentation and tinkering. Be sure to save a copy of the combined image; otherwise you might have to go back to the beginning and stack individual images again!

Note on File Format

When saving images (using **Save** or **Save As** in the **File** menu), you have a choice of file formats. The default produces .fit files, but .tif, .jpg, .png, and .bmp file formats can also be selected. Having a choice of output file formats is useful, especially if images will be exported to other software programs for additional image processing (like Adobe Photoshop, for instance).

If you save to a file format other than .fit, you will need to check the **Auto Stretch** box, or otherwise **Stretch** the image to change the **Output Range** (in the **Stretch** command window) to match the **Size Format** (in the **Save As** window). Otherwise, the **Output Range** will likely exceed the **Size Format**, and the saved image will be ruined (will turn all white).

For example, say the **Output Range** is set to create image brightness values in 16-bit format, while the **Size Format** of a specific file format (.jpg, for example) may only support 8-bits. Since the 16-bit format sees 65535 brightness levels, and the 8-bit format can only support 255 levels, all of the levels above 255 in the 16-bit image (i.e. the vast majority of the 16-bit brightness levels) will be saved at the maximum 8-bit value of 255. So the saved .jpg will have very little brightness information from levels 1 to 254 and almost all the brightness information at level 255. Thus a white image results.

Other Features

Flip – Flips image orientation. “Folds” image about vertical center.

Mirror – Creates mirror image of current image orientation.

Zoom – Increases or decreases level of image magnification on computer screen. When you zoom in too much, you will start to see the squares of individual pixels. When zoomed in, you can use Quick Pan; simply hold down the **Ctrl** key, then left-click and drag the mouse on the image.

Night Vision – Toggles Night Vision mode. The red background helps preserve your night vision.

Window menu – These functions alter the way multiple open image frames are arranged and displayed within MaxIm DL Essential. These functions are very useful for organizing the visual display when processing large numbers of images for stacking.

Tips

Focusing

One of the hardest things to do in planetary imaging is achieving good focus. You can simply watch the **Live Video** window to focus, but you can focus “by the numbers” on a bright star to get the best focus possible. To do this:

1. In the **Camera Control Window**, select **Light Color 1x1** mode.
2. **Set Frames** to 1.
3. Turn off **Dark Subtract**.
4. Pick **focus** beneath the **Mode** selector and then click **Expose**. The camera will take repeated exposures, until you click **Stop**.
5. If you point the telescope at a bright star, you can focus more accurately “by the numbers”

MaxPixel is the value of the brightest pixel in the image. When you are in focus, it will be at its highest value. You will need to look at the value for several images in succession, because the number will bounce around with the seeing.

Note: If the MaxPixel reaches 255 (in 1 frame capture mode), the image is saturated and all three focus numbers will be inaccurate. Either pick a fainter star, or adjust the camera’s Exposure settings using the Setup button.

FWHM, or Full-Width Half Maximum, is the width of the star half-way down the sides. This provides a highly accurate measurement when you are close to focus. When you are at focus, it will be at its lowest value. This number will vary due to seeing, so it is best to look at several images before decided.

HFD, or Half Flux Diameter, is similar to **FWHM**, but works much better than **FWHM** when the star is badly out of focus. It can produce a usable number even when the star looks like a donut. Refocus often throughout your imaging session. This ensures at least some of your images will have an excellent focus. It is also not uncommon for telescope movements to alter the focus slightly, so be sure to refocus for any new astro-imaging targets.

Choosing a Site for Astro-imaging

Once you have a focused image, you may find your image shifting and washed out. This can be caused by many environmental factors. Poor seeing (movement of molecules in the air, such as heat rising) and poor transparency (moisture, smoke, or other sky contaminants) will all serve to reduce image quality. That is why most major astronomical telescopes are on high mountains in thin air, to get above much of the seeing and transparency problems. Also, wind will move your telescope and affect images. Your eyes viewing through an eyepiece can change slightly to compensate for disturbances like these, but the camera can not. Keep these factors in mind when choosing an observing site for astronomical imaging.

For the best astro-images, we recommend finding a location with dry air, some altitude, and away from city or streetlights. Even a nearby hilltop in the countryside can provide better viewing conditions than many convenient backyard locations.

Loss of Camera Connection

If the computer connection to the camera is interrupted, you will need to re-establish connection. This can happen due to several reasons; if a cable becomes unplugged, the computer “freezes”, or the software/hardware otherwise temporarily loses the data coming from the camera.

To re-establish camera connection, first close the MaxIm DL Essentials program on your computer. Then, unplug and re-plug the camera into the computer’s USB port. Now, open MaxIm DL Essentials, and the **Live Video Window** should appear indicating re-established connection between camera and computer.

Using Focal Reducers and Barlow Lenses

Focal reducers serve to decrease the focal length of your telescope. This increases the field of view seen by the camera (decreases camera magnification). This can be useful for obtaining images of wider objects, such as the full Moon or a landscape vista.

Barlow lenses, or other tele-extenders, increase the focal length of your telescope, which makes the camera field of view narrower (increases camera magnification). This is useful for high-power planetary images. Keep in mind that when the focal length is doubled, the image will become four times dimmer, so a longer exposure may be necessary.

For best planetary imaging, you should shoot with an effective focal ratio (telescope focal length ÷ telescope aperture) of F/20 or greater. This will give you a good combination of image brightness and image scale for planets. For most telescopes, a barlow lens will be required to obtain this focal ratio. For example, Schmidt-Cassegrain telescopes usually have a focal ratio of F/10. A 2x barlow lens doubles the effective focal length of the telescope, which makes the focal ratio f/20. Similarly, a 3x barlow lens will yield of focal ratio of F/30. You can also try using multiple barlows to obtain even greater effective focal ratios. There is a limit to how large a focal ratio your telescope and seeing conditions can handle, however. Experimentation will be needed to see what your telescope is capable of in the seeing conditions on a given night. If the image appears somewhat dim and fuzzy on the computer screen, you may want to consider removing the barlow lens.

USB Extension Cable

In many instances, it is likely that a longer cable for the SSSSI-III will be needed in order to comfortably setup telescope, camera, and computer. We recommend purchasing a 10' USB extension cable if you need more cord length (available through Orion, check the catalog or www.OrionTelescopes.com).

Specifications

Sensor:	MT9M001 Color CMOS progressive scan
Sensor size:	1/2"
Number of pixels:	1.3 million, 1280x1024 pixel layout
Video frame rate:	Up to 15 frames/second at full resolution
A/D conversion:	8 bit
IR filter:	Yes
Connection:	High Speed USB 2.0
Gain (brightness) control:	+10 dB
Barrel:	1.25"

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes of modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

Reorient or relocate the receiving antenna.

Increase the separation between the equipment and receiver.

Connect the equipment into an output on a circuit different from that to which the receiver is connected.

Consult the dealer or an experienced radio/TV technician for help.

A shielded cable must be used when connecting a peripheral to the serial ports.

One-Year Limited Warranty

This Orion StarShoot Solar System Color Imaging Camera III is warranted against defects in materials or workmanship for a period of one year from the date of purchase. This warranty is for the benefit of the original retail purchaser only. During this warranty period Orion Telescopes & Binoculars will repair or replace, at Orion's option, any warranted instrument that proves to be defective, provided it is returned postage paid to: Orion Warranty Repair, 89 Hangar Way, Watsonville, CA 95076. If the product is not registered, proof of purchase (such as a copy of the original invoice) is required.

This warranty does not apply if, in Orion's judgment, the instrument has been abused, mishandled, or modified, nor does it apply to normal wear and tear. This warranty gives you specific legal rights, and you may also have other rights, which vary from state to state. For further warranty service information, contact: Customer Service Department, Orion Telescopes & Binoculars, 89 Hangar Way, Watsonville, CA 95076; (800) 676-1343.



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Customer Support Help Line (800) 676-1343

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