Unofficial

SEESTAR S50 USER GUIDE

For indoor and outdoor use only - No fat no cholesterol

Tom Harnish

June 2024

V0.7

Edit by

Murray and Gloria Foster

If you find typos or grammatical errors, the fault is entirely mine.
If you find mistakes in fact or disagree with an opinion, please send an email to admin@ Seestar.online

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FOREWORD

This guide was created to make it easier for you to enjoy your Seestar. Posts and comments in social media forums make it clear that an introduction to the little telescope would help a lot of people who are just getting started in astronomy and astrophotography.

I'm delighted that new people are enjoying the wonders of the night sky. Imagine! The light from a galaxy that can be captured by your Seestar has traveled for millions of years and the nebulae you can capture are so huge our whole solar system is smaller than a single pixel in the image. Seestar lets you see and share all that.

Some people want to push the capabilities of the Seestar way beyond what it was designed for, and that's fine. But I'm reminded of a preteen Hawaiian youngster—a tour guide to jungle waterfalls—who, when I described the Seestar, said, "Awesome! Galileo would be trippin' man!"

In that vein, Steven Stills' song, "Love the One You're With" applies to backyard astronomy. There's always better technology, always ways to improve something, but what we have available now is far better than anything Galileo could have dreamed of. Enjoy your Seestar!

Limited in extent, imperfect in execution, and in parts only suggestive in character, this little book may perhaps serve as a foundation on which students of astronomy may raise the superstructure of their own experience, and in that case the author's intention will be fulfilled. He will be especially gratified if his endeavor tends to increase the number of those who consider the heavens.

T. W. Webb, Celestial Objects (1893)

HISTORY

The Seestar telescope was released by ZWO (Zhen Wang Optical) in 2023 after 5 years of R&D and testing. ZWO was founded in 2011 and their first product was the ASI130MM, a monochrome CMOS camera designed for astrophotography. With the Seestar they aimed to create a user-friendly, all-in-one telescope that would make astro imaging accessible to beginners. The Seestar combines a telescope, camera, and mount into a single unit, along with built-in software for locating, capturing and processing images of targets.

The Seestar quickly gained popularity due to its relative ease of use, portability and affordable price especially when compared to traditional astrophotography setups. The Seestar has been praised for making the hobby more accessible to a wider audience, particularly those who may have legitimately been intimidated by the complexity and cost of traditional astrophotography equipment.

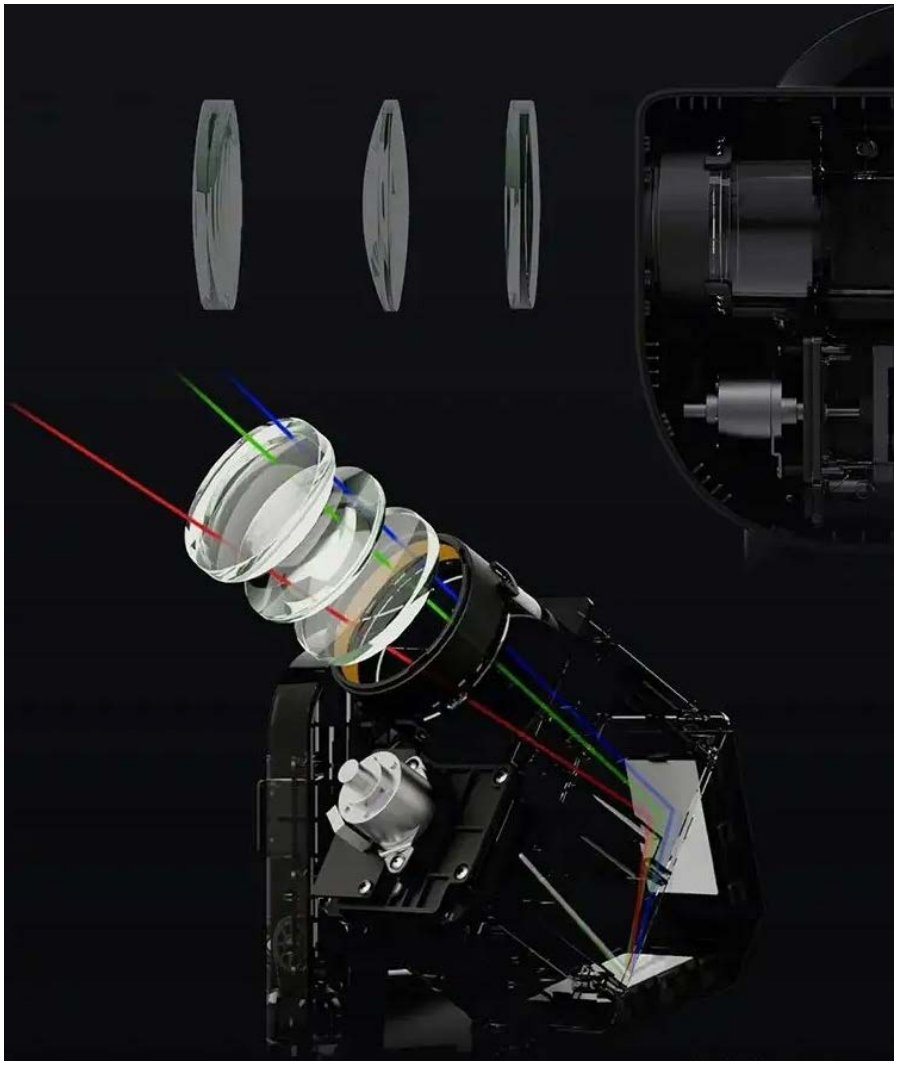
The Seestar is a relatively new product, but it has already made a significant impact on the world of amateur astronomy. It represents a trend towards more integrated and user-friendly telescopes that can help more people enjoy the wonders of the night sky.

Paradoxically, by attracting novices to astronomy, the Seestar has revealed a gap between what even the simplified Seestar can do and what people new to astronomy and astrophotography understand. This guide aims to bridge that gap. If it doesn't the fault is entirely mine. It's not you.

CHAPTER 1
TELESCOPE SYSTEM

Your Seestar is a unique instrument. On the outside, only the outermost lens, an on/off button, four battery-level lights, and a USB-C port are visible. And that's all you really need to know about the hardware, so you can skip to Chapter X. But if you're interested in the details keep reading.

Inside there's a 50mm aperture, 250-mm focal length, *f*/5 triplet apochromatic[1] telescope with three lenses to correct for color fringing, a Sony IMX462 CMOS camera, a quad core 64-bit computer, 64GB of eMMC memory, a rechargeable 6000mAh battery, a Wi-Fi hotspot and Bluetooth radio, plus gears and motors to make the telescope move up and down in altitude and turn left and right in azimuth. (That's why it's called an alt/az telescope.)



There's also a motor that will automatically focus the scope for you, although you can do that manually if you prefer. And there's even a little heater you can turn on

[1] An apochromatic telescope, often shortened to "apochromat" or "apo," is a type of scope designed to correct for chromatic aberration, a type of distortion where a lens fails to focus all colors of light to the same point. This results in color fringing or blurring in images. Seestar avoids that with the special lenses.

to keep dew from fogging up the lens.

If all that isn't enough, there are three filters inside: an opaque (dark) one for calibration, a UV / IR Cut filter for the Moon, galaxies and stars, and a dual-band filter to enhance nebulae and reduce light pollution. The computer controls the dark one when you start taking pictures of deep sky objects (aka Skywatching in Seestar lingo). It takes about a minute, and during that time, a bunch of images are created, but only electronic noise is collected, and the result is subtracted from your pictures to make them smoother. These images are called "darks". Happily, you don't have to worry about any of that because the Seestar takes care of it for you.

When you pick a target, the Seestar will decide if the narrowband filter will help, generally when you select nebulae, but you can ignore the recommendation if you prefer and just stick with the UV/IR filter which prevents star bloat[2].

Finally, the Seestar also comes with an orange and silver external solar filter that you insert in the front of the tube, which you *must* do when shooting the Sun. Don't get fingerprints on the lens or filter!

All this is controlled by an app on your mobile phone or tablet (more about that in Chapter X). The app allows you to choose several different kinds of astro targets and there's even a terrestrial mode for looking in neighbor's windows, I mean watching birds (same thing if you're in the UK, I'm told).

The included tripod is special because it's made of carbon fiber to make it light. It has 3/8" bolt that goes up into the turntable in the bottom of the scope, which means any tripod with a 3/8" bolt can be used. But it also means that you can't just sit the Seestar down on a table without the tripod

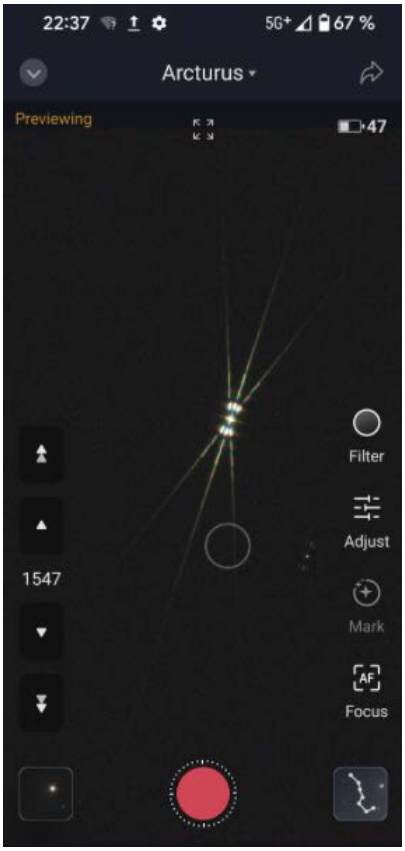
[2] UV and IR light have different wavelengths than visible light, which means they focus at slightly different distances within a telescope. When UV/IR light isn't focused correctly, it creates a halo around stars, making them appear larger and less defined.

and expect it work. The turntable won't touch the surface and will rotate inside the base. Just keep in mind that, however you do it, you want the scope to be absolutely steady. If you use the little tripod, put it on the ground or a solid table. If you use a tall tripod, make sure it's hefty and won't jiggle in a puff of wind.

You really don't need anything else, but there are several popular add-ons. The most useful is a leveling base that makes getting the Seestar level much easier than fiddling with the tripod legs. $19-$39 for essentially the same exact device, so shop around.

A lens hood/dew shield has been demonstrated to improve the contrast in images. Some have a base with prongs that lets light in if you aren't careful, so look for one with a solid bayonet-type base. A lens hood is easy to 3D-print, but if you buy one, you'll find them from $15 to $40.

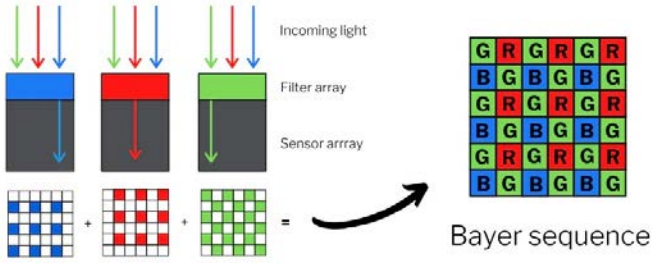
Some people find a Bahtinov Mask handy to check the focus. When it's in front of the lens you'll see a tiny X over a bright star, you adjust focus until a vertical line equally splits the X. Every time I use mine the auto focus is spot on, so YMMV (Your Mileage May Vary). $12 -$20



CHAPTER 2
CAMERA

Nothing in this chapter is required knowledge to use the Seestar. But if you want to geek out on the details of the Seestar's camera read on.

The Seestar's camera uses a sixth generation 2.1 megapixel Sony IMX462MC CMOS sensor with 2.9µm square pixels in a 6.46mm diagonal array. This produces a 1920 x 1080 image. It's a color camera using a GRBG Bayer matrix.



Only one colored filter is applied to each pixel of the sensor. This narrows the sensitivity of that pixel to incoming light that's the color of that filter. Then, using highly proprietary algorithms, manufacturers process the incoming pixel values to extract RGB color and intensity information to create a color image.[3]

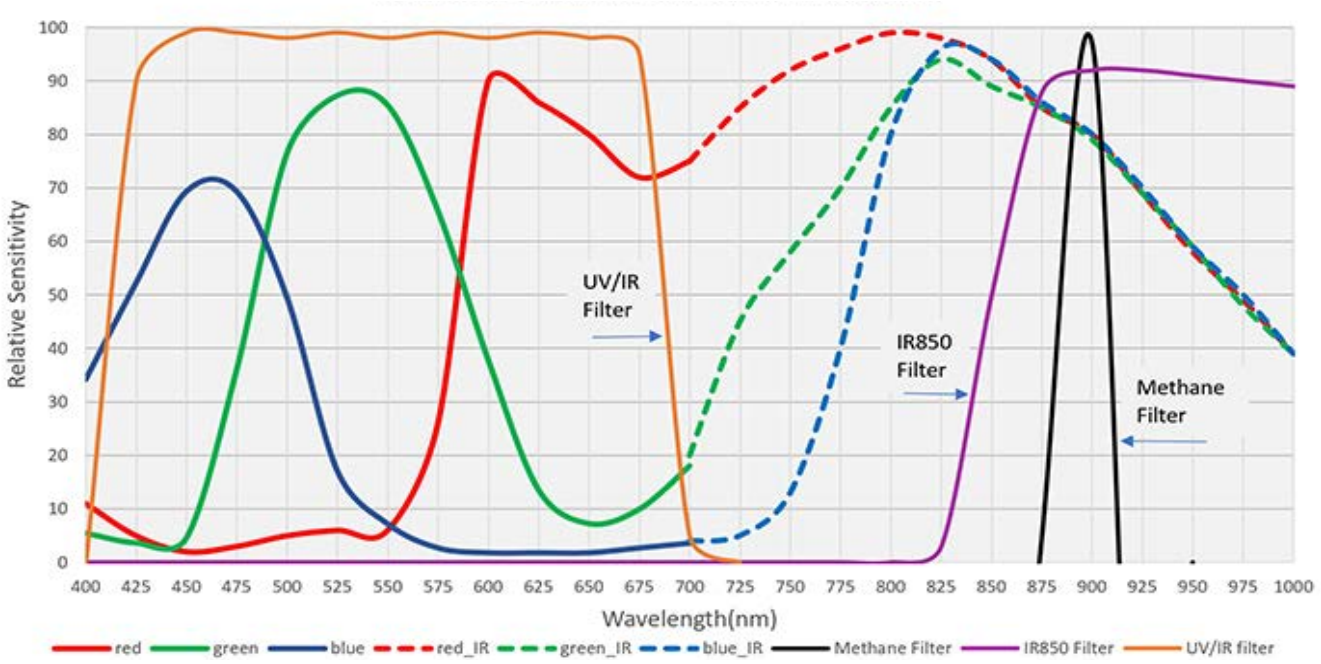
In the IMX462MC sensor, the photodiode portion of the pixel well is physically deeper than in previous Sony sensors, allowing photons of longer wavelength to penetrate deeper into the substrate. This dramatically increases the sensor's sensitivity to red and near infrared light. The RGB filters over the pixels become transparent at near infrared wavelengths, so the sensor displays almost equal peak sensitivity to near infrared light as it does to light in the visible spectrum.

The IMX462 sensor is back-illuminated and has what Sony calls Super High Conversion Gain for very low read noise at high gain. This is ideal for stacking hundreds or thousands of short images. One benefit of the back-illuminated CMOS structure is high sensitivity. In a typical front-illuminated sensor, photons from the target entering the photosensitive layer of the sensor must first pass through the metal wiring that is embedded just above

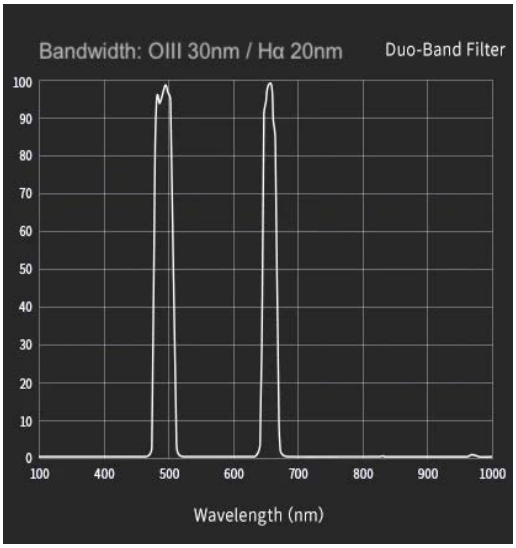
[3] Color resolution in an image is lower than the pixel resolution of a specific sensor. This is why monochrome sensors are preferred for more advanced work. To create a color image, three B&W images are created using red, green, and blue filters. Then the three filtered images are algorithmically combined to produce an RGB color image. Also, as is the case of most of the images that we are seeing from various space telescopes, the sensor data may be from light wave lengths that are outside the visible spectrum and are therefore represented as colors that we can see.

the photosensitive layer. The wiring structure reflects some of the photons and reduces the efficiency of the sensor.

In a back-illuminated sensor, the sensor is “face down” so the light is allowed to enter the photosensitive surface from the reverse side. In this case, the sensor’s embedded wiring structure is below the photosensitive layer. As a result, more incoming photons strike the photosensitive layer and more electrons are generated and captured in the pixel well. This ratio of photon to electron production is called quantum efficiency. The higher the quantum efficiency the more efficient the sensor is at converting photons to electrons and hence the more sensitive the sensor is to capturing an image of something dim.



The sensitivity curve above shows a UV / IR cut filter which only allows light from about 400 to 700 nm to reach the sensor, cutting out the near infrared, where the camera is very sensitive, which causes star bloat.



The light pollution filter blocks all light except in two narrow bands covering OIII and Ha, both of which are predominant in nebula. Note that a lot of light is blocked, so images collected with this filter require a lot more data collection (exposure) time to produce good results.

CHAPTER 3

OPERATION

The Seestar is not easy to use. If it were, this guide wouldn't be necessary. If you have never thought in astronomical terms or are not comfortable with mobile apps in general you'll definitely find some Seestar concepts and operations befuddling. (That's an often-used astronomical term.) It doesn't help that the User Interface is bizarre, the English is poorly translated from Chinese, and some functionality is just weird.

For example, I've been using computers since the '60s (IBM 360) but couldn't get my new Seestar to turn on. Mainly that was because I didn't RTFM. (That's a computer term that means Read The F'ing Manual.) You should. There's some stuff there that isn't here.

Turning on the Seestar

Since you didn't read the manual (and neither did I) getting this thing to go to work is befuddling. You push the button with the ubiquitous power icon on it and nothing happens. You push again and again, and nothing. Then you get mad, and just like an elevator button, you press and hold it in, goddamnit. And it works! Won't help with elevators, but you have to hold the Seestar on/off button down until you hear two beeps.

If your scope is brand new and this is the first time you've turned it on, short press the power button for one second and then long press for two seconds. You must have Internet access (first time only).

Cool, but still nothing is happening, the Seestar just sits there. That's because you have to wait for t**he** computer to boot up and connect to your mobile device**.**

You control the telescope with an app on your phone or tablet. You must download it from the Apple App Store or Google Play. Use this QR code to get the one you need.

Download on the App Store

GET IT ON Google Play

Now, here's an often misunderstood arrangement. The computer in the telescope does all the work, your mobile device is only a monitor. You can close the app, you can delete it from your phone, you can turn off your phone, you can mail it to another city, and the Seestar will go right on doing the last thing you told it to do.

Which leads us to another commonly misunderstood detail: your phone talks to the Seestar via Seestar's built in Wi-Fi hotspot. You don't need to be in range of cell towers or home Wi-Fi. In the middle of Sierra Madre mountains or the Gobi desert with no outside-world connections, your Seestar will work just fine.

Of course, all this assumes your Seestar (and mobile device) are properly charged. At home you can use a USB-C cable attached to a 12V power converter or a computer. But if you're away from home and the Seestar or mobile device battery goes dead, you're out of the astronomy business. So, carry a power bank with you if you're away. I bought a 50,000mAh battery pack (over 8x the capacity of the built in battery) for just $20 after an Amazon Lightning Deal and manufacturer's discount coupon. Depending on what deals you find, you can a buy a power bank that will recharge both your scope and mobile device for $20-$50.

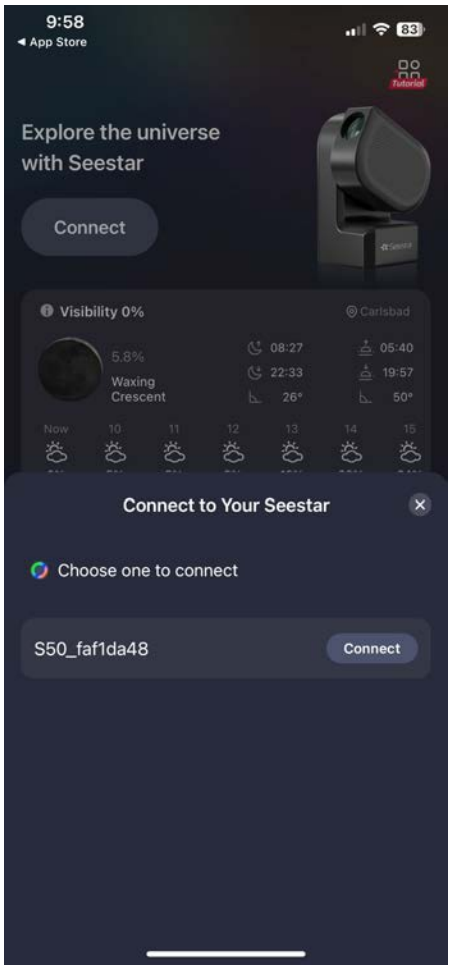
By the way, a cool feature of the Seestar is it'll draw power from a connected power bank before it starts to use the built-in battery. If the Seestar is depleted when you plug the power bank in, the power bank will not only keep the Seestar running but also start to recharge it, too. Good for ZWO for this design.

Supposedly the built in battery is good for six hours, my experience is it's more like four**,** less if you have the dew heater on or if it's very cold where you are. So, as in other things astronomical, as I've said, YMMV.

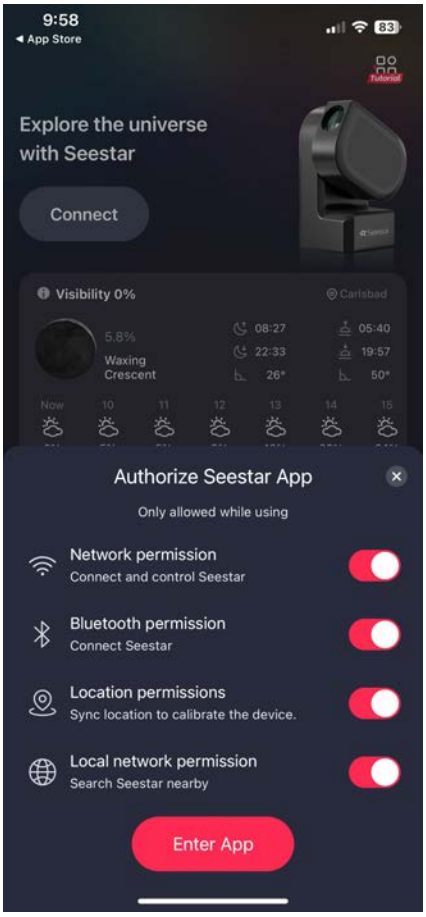
Where the six-hour estimate comes from, I suspect, was a thoughtless conversion of 6000mAh to 6Ah or six amp hours, which is accurate only if the device uses one amp per hour. And it doesn't.

Connecting a Mobile Device to Seestar

When you turn the Seestar on, you'll hear a voice prompt that says, "Power on, ready to connect." If you then launch the app (in my case on an iPhone) you'll see a pretty "splash screen" with mountains and our view of our galaxy, the Milky Way.[4]



Usually, the Seestar will automatically connect to the app and take you to the Home Screen. Press the Connect button if it doesn't.



If this is your first start-up, after you see the splash screen you'll be asked to allow the app to use your Bluetooth, Wi-Fi network, and location**.**

During this first-time set-up process you'll see a pop-up screen that has links to some short video tutorials. Definitely watch every one, preferably now or at least later. If you don't do it from this screen now, you'll find a link to the tutorials in the top right corner of the Home Screen. It's labeled "Tutorials." (Duh.)

Next, the first-time set-up process will show you what you have enabled and present you with a button mis-labeled Enter App. You already in the app so it should say something like "Join Seestar**".** But whatever. Tap the button and you'll

[4] For those who might not know, what you're looking at when you look at the Milky Way, is a cross-section of our galaxy looking toward the center. You can't see it behind you because we're out toward the edge, so there's not a lot to see in that direction. The edge-on view of M82 on page 17 presents a lovely Seestar view looking toward the center of another galaxy from far, far, away (about 12-million light years). A light year is the distance that light travels in a year and many of the objects that we can see with Seestar are much farther away than this.

see a screen that lets you choose your Seestar, possibly from a list if there are other Seestars nearby.

Tap Connect and you'll see a very useful feedback graphic that proves something is going on...or not. If you're too far from the Seestar, or forgot to turn it on, a similar graphic will report *No Seestar Found* and offer some suggestions. The process works well, and you'll get connected unless you're like one guy who bitched about it not connecting until someone asked if the Seestar was properly charged. Never heard another peep from him. Things like that remind me of my grandfather's wise saying, "It's a poor craftsman who blames his tools."

Anyway, when all goes well the graphic slides off the bottom of the screen and you're looking at the Home screen. Ta-dah!

Turning off the Seestar

At the bottom of the settings screen (tap the picture of the Seestar at the top right of the Home Screen or the Me button at the bottom), hiding out of sight in a not-so-handy spot off the bottom of the screen, is a big red Slide to shut down slider bar.

M82 by Andrej Flis

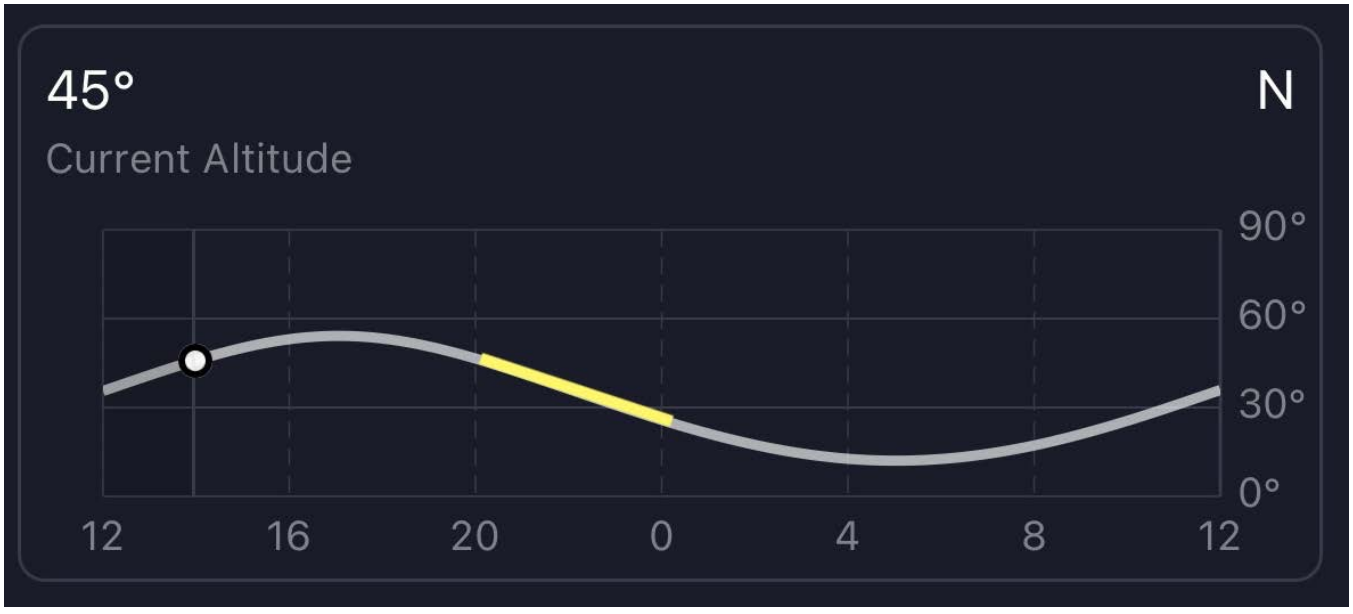
CHAPTER 4
FIELD ROTATION

Field rotation smears stars in long-exposure photos, because of the Earth's rotation. Alt-az mounts like the Seestar's don't compensate for this rotation so stars at the edges of your image may appear as streaks instead of points.

Note that field rotation is most pronounced when an object is near your meridian[5], as the object's altitude changes rapidly, leading to longer streaks. And it's gets worse the closer you are to the equator.

To minimize field rotation, you can use a couple of strategies. Short exposure times helps, but the best solution is to limit your data collection[6] to times when your target isn't close to the meridian.

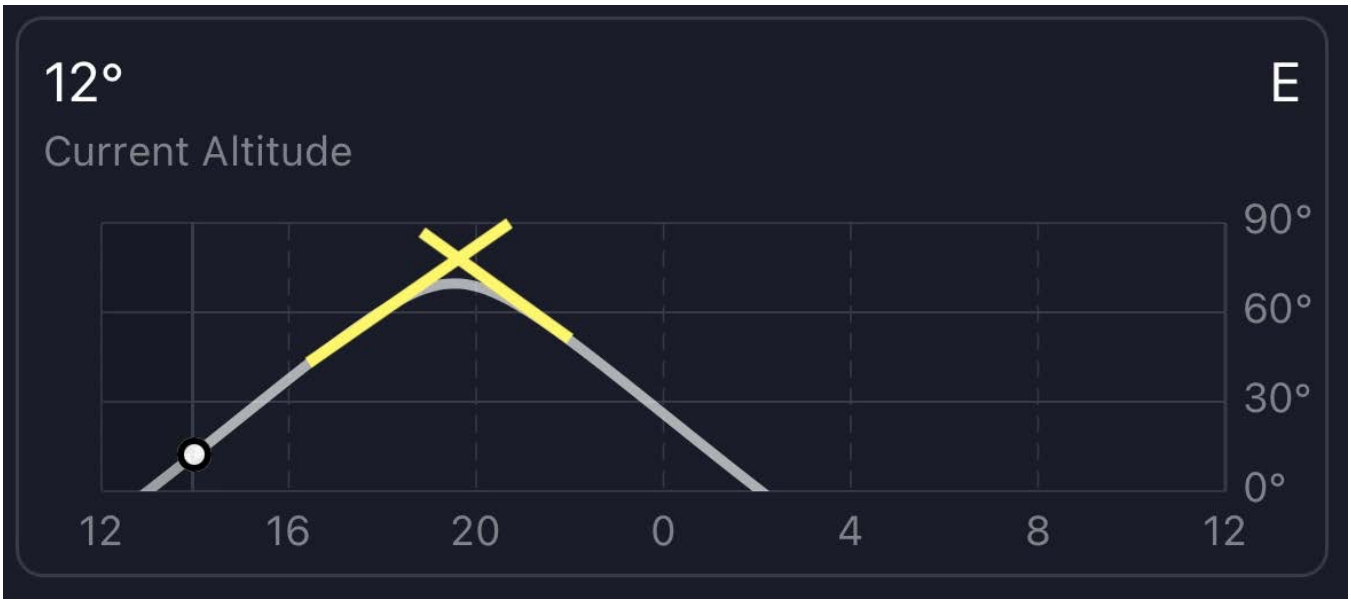
Visibility plots can help you predict how an object's path changes through-out the night, offering a slick way to estimate field rotation. By drawing imaginary tangent lines on the visibility curve, you see how much field rotation will occur. The tangent line for a target at 2000 (8PM) and 2400 (midnight) basically overlap, so there will be very little problem.



[5] An imaginary line you are on that extends from the North Pole to the South Pole

[6] Astrophotography uses a telescope as a funnel to direct light into a camera sensor that detects photons, converts their intensity into a value and stores the values as data for later processing

This tangent line technique also makes it clear why capturing images during a meridian crossing will create the greatest field rotation.



If you start at 1600 (4PM) and end at 2200 (10PM) you'll enjoy field rotation of almost 90º.

So plan your sessions for when the target isn't near the meridian and is closer to the horizon where field rotation is less severe. But keep in mind that the atmosphere is very distorted near the horizon, so don't go too low.

As a rule of thumb try to capture targets that are close to east (90º) and west (270º), not north (0º) or south (180º), above 30º from the horizon and below 70º. Obviously, that's not a firm rule. In other words, YMMV.

By the way, many post-processing software packages can help correct field rotation, but it's not always a perfect solution. Just sayin'.

If you get tired of the field rotation issue you can buy an equatorial mount, telescope, camera, guide scope with camera, ASIair, filter holder, and filters. The cost will be 4x - 6x what you paid for the Seestar.

If that's out of the question, you can buy a good Dobsonian for about the price of the Seestar. But all it will do is sit there just taking up *a lot of space* unless you learn how to find things in the night sky. And even then it won't let you see really dim objects like the Seestar's sensitive camera will.

Like cameras, the best telescope to own is the one you use a lot. Seestar gets my vote.

CHAPTER 5

SOFTWARE

Earlier I wrote that the Seestar does all the work and your phone or tablet is just a monitor, which is true, but that's not the whole story. The app you downloaded is what helps you manage the Seestar and provides the tools to find, capture and process images.

The app's Home screen will show your Seestar, provide a local weather forecast, offer five observation modes you can choose from (one hides off the screen on an iPhone), offer some observing recommendations, and display a bottom menu that includes a Home button and, among other things, an awesome SkyAtlas.

Five main modes

Stargazing Mode: This mode really should be called DSO (Deep Sky Objects), because it is designed for exploring and capturing galaxies, nebulae, star clusters, comets, asteroids, and double stars. Seestar's GoTo feature automatically locates and tracks celestial objects based on your selection from the extensive database in the app's SkyAtlas. Plate solving[7] technology ensures quick identification and centering of the target object in your field of view, while image stacking combines multiple exposures to reveal faint details and reduce noise. Light pollution and UV/IR Cut filters are automatically applied to enhance the results.

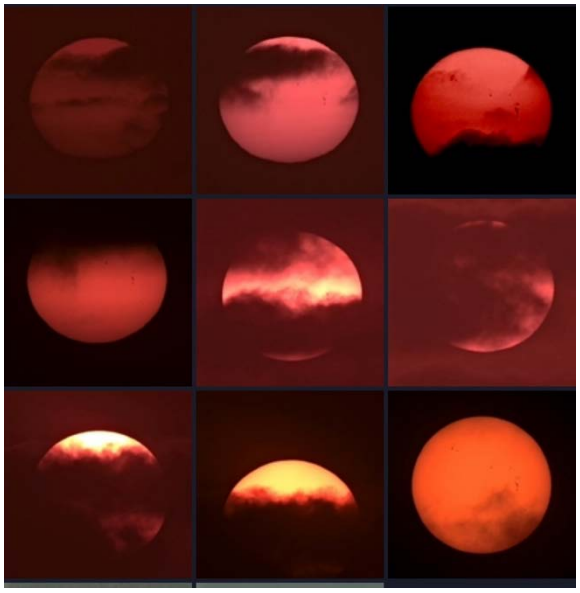
On page 17 is an example of what's possible if you're patient (30 hours of data collected by Scott Cumella on many nights). But, happily, one thing that makes the Seestar so

[7] Plate solving is the process of analyzing a captured image to determine the precise coordinates and orientation of the telescope, ensuring accurate tracking and identification of celestial objects.

much fun is that in minutes you will begin to see objects that are simply invisible to an observer without a large telescope. In less than an hour you can produce an image good enough to post on social media or send to your friends.

Lunar Mode: Seestar's GoTo feature will find the Moon (even during the daytime**)**, automatically keep the Moon centered in the frame, as it travels across the sky, while the telescope and camera capture lunar features like craters, mountains, and valleys with 2x and 4x views. Video recording capabilities (MP4 or AVI) allow you to use software to collect a bunch of frames in close succession and then select the sharpest frames in the movie so you can process them later. ZWO's ASIstudio software is easy to use and produces decent results, although dedicated astrophotographers will spend hours post-processing an image with special software. AstroEdit (right) is my choice for iPhone post processing if you don't want to spend a lot of time because it has special features, yet is quick and easy to use—and its only $2 (iOS only so far).

Solar Mode: Will let you safely observe and photograph the Sun's dynamic surface with Seestar's Solar Mode. The telescope's tracking system will find and follow the Sun's movement throughout the day, making it easy to capture Sunspots and other solar features in detail....it can be fun even on cloudy days.



A built-in reminder insures you **install the solar filter** before observing the Sun to prevent accidental damage. You won't ruin your eyes with this scope if you leave the filter off, but you will fry the camera sensor if you don't put it on or take the filter off while the scope is still pointed at the Sun. It's easy to just yank off the filter knowing you're going to turn the scope off, but it will still be pointed at the Sun unless you move the Seestar first.

Planetary Mode: You can reduce the camera's gain so the bright planets aren't entirely blown out (over exposed). I combined two images, one exposed for the surface of Jupiter and one exposed to show the four inner Galilean Moons.[8]

Scenery Mode*: Seestar isn't just for celestial wonders; it also doubles as a capable terrestrial telephoto camera. In Scenery Mode, the Seestar will track an object but you also have full manual control over the camera's direction and settings. Video and Time-lapse functionality offer some interesting ways to capture the world around you, too.*

I live close to the Pacific Ocean near big Navy and Marine Corps bases and have had some fun taking pictures and videos of ships and boats. I even managed to get video of a unique unmanned robot ship launching a kite for a better view over the horizon.[9]

[8] Jupiter has about 2.5x more mass than all the other planets combined and rotates so fast there's a bulge at its equator! It very nearly was a second Sun.

[9] marine-traffic.com will tell you who's-who anywhere in the world's oceans...assuming they aren't traveling incognito. flight-aware.com will tell you what airliner enhanced your image of the Moon or Sun.

CHAPTER 6
FIRST RUN

On the first setup, you mobile phone or tablet tickles the Seestar's Bluetooth (because no configuration is required) and then Seestar's firmware asks you a few questions to configure the Wi-Fi hotspot and you're in business—even in the middle of nowhere with no local Wi-Fi network or cellular service. This process works very well, and instructions are clear. But what if you're near civilization or at home and want to use a local Wi-Fi network?

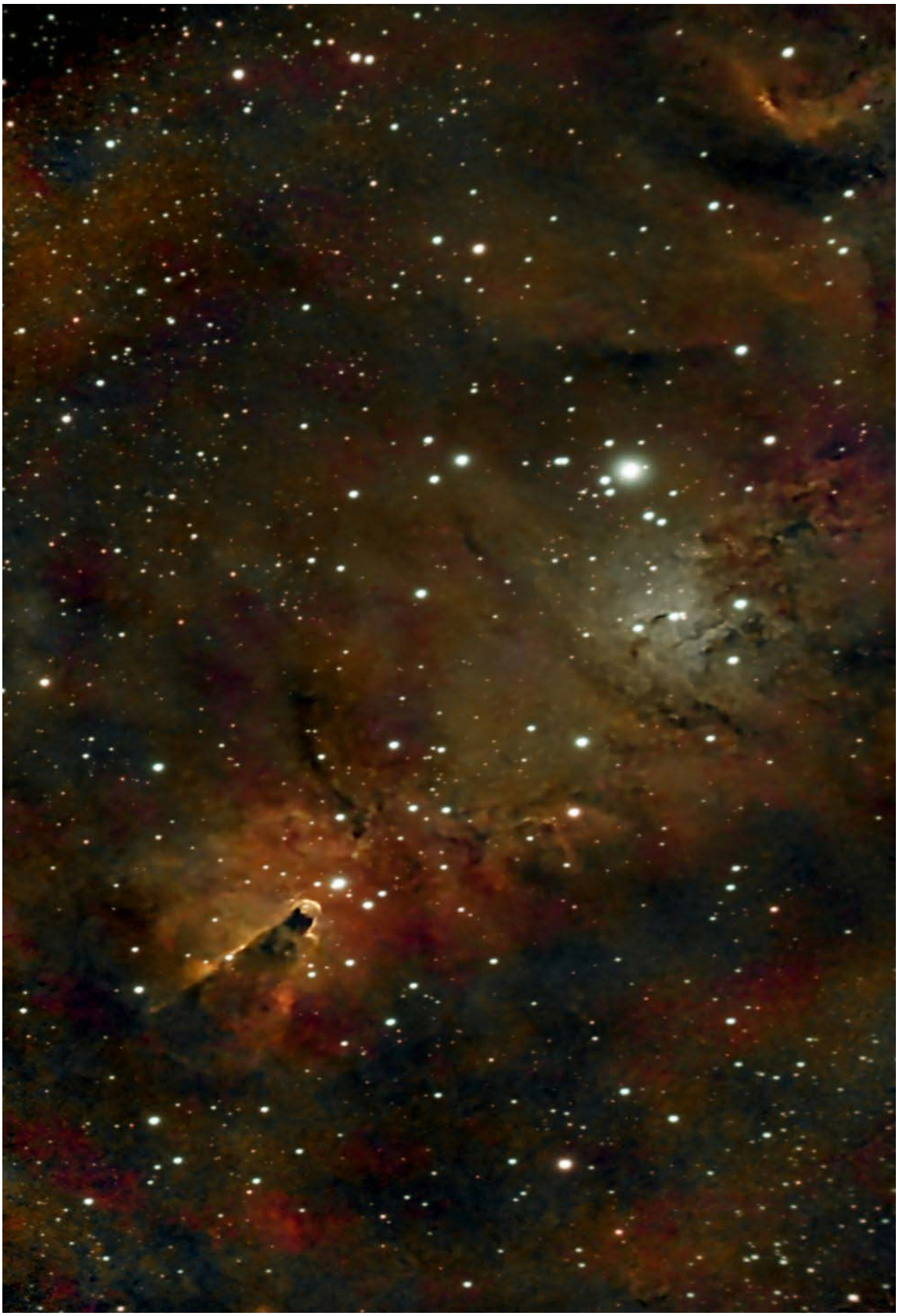
Station Mode is the answer. Press the Me button, bottom right menu item on the Home Screen, then tap the Wi-Fi button. Pick the Wi-Fi network you want to use, enter your ID and password, and now the Seestar is just another node (station) on that network. You can surf the web on your mobile device while you stay connected to your Seestar. The Seestar will look like an external hard drive, and that's where you'll find the images and video files that Seestar saved for you. With Station Mode you can even live stream what you're capturing to a smart TV in the living room, and to Facebook, or YouTube using free Open Broadcast Software (OBS) which is available for Windows, Mac and Linux.

Okay, you can tell the Seestar what to do from your phone/tablet and also surf the web. Cool. Now what?

In a limited sense, you can just plop the Seestar down, turn it on, and start capturing images—limited in the sense that it will only really work using Stargazing (DSO) mode.

The Seestar knows where it is (your mobile device told it), it knows what time it is (ditto), it has a built in compass so it knows where it's pointed[10], and it will figure out where the horizon is with Horizontal Calibration, no finicky leveling required. If you tell it you want to image, say, Cone Nebula), the Seestar will slew to where it thinks it should be, take a picture, perform some magic using plate solving so it knows where it actually is looking, do some quick spherical trigonometry calculations to compute where it needs to go, and then repoints the scope. It will keep doing that until the Cone Nebula is centered in the camera's view.

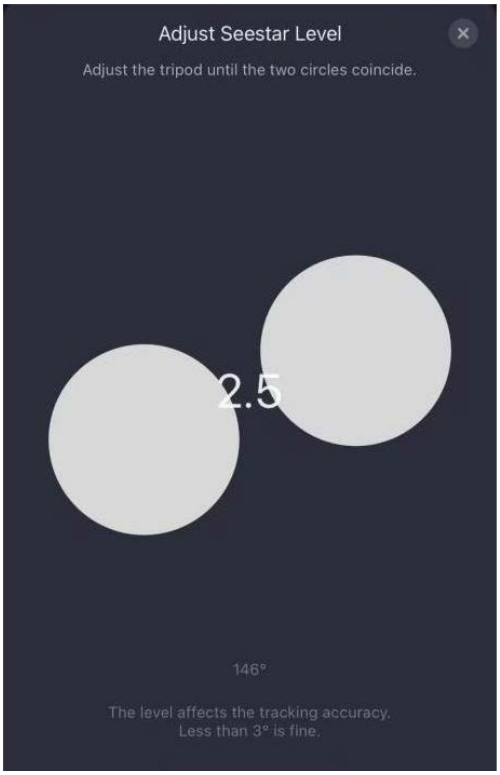
[10] Initially, and after bouncing around while traveling, you should recalibrate the compass. Tap the picture of the Seestar on the Home Screen or tap the Me button on the right end of the bottom menu, then tap the Advanced Feature label, then tap Compass Calibration. Watch the graphic, turn around three times, click your heels twice, and yell "Galileo" when it's finished. Only takes a few seconds.

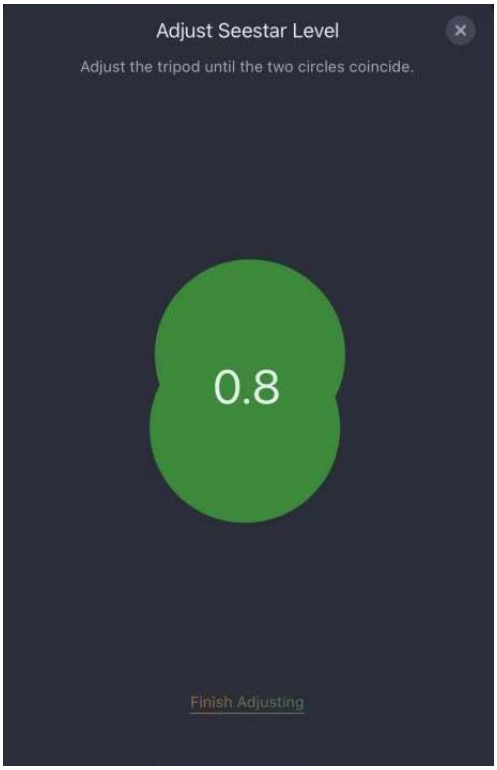


Cone Nebula (NGC 2264) by Scott Cumella

In another case of YMMV, some Seestar owners will insist you have to carefully level the telescope and recalibrate the compass every session. If you want to find the Sun or Moon it does have to be level.[11] But to capture images of DSOs (deep sky objects), plate solving will do the job. When you're hunting DSOs, it automatically does a horizontal calibration using a three-star plate solve to compensate if your leveling is a little off, and then it goes to your target.

Regardless of my opinion and experience, or anyone else's, if the Seestar isn't happy because the internal sensor says it isn't level, it will pop up a screen with two white circles that you are supposed to overlap by adjusting the Seestar so it's level. Why they didn't use a graphic representation of a plain old bubble level is beyond me.





You can fiddle with the tripod legs (or that leveler add-on thingy on page 10) to get the two circles to overlap. When you're close, the circles will turn green. Try to get the number down to 0.5 or less.

[11] You can help the scope find the Sun by slewing it in azimuth until the Sun shines through the crack between the telescope arm and the main body. That crack is also a handy aiming sight when you're trying to shoot the Moon or something in Scenery Mode. *Don't look through the crack at the Sun!*

CHAPTER 7

SETTINGS

Across the bottom of the Home Screen is a menu with some useful and not so useful buttons. The most useful one is on the far right. It takes you to settings.

Bottom Menu

Seestar (Star Icon): This button will take you to the Home Screen, your central hub within the app, the digital command center of your space ship. It provides immediate access to all essential functions and information. From here, you can initiate an observation session, review your image gallery, adjust settings, access tutorials, and more. Captain's Log, star date 2024...

SkyAtlas (Constellation Icon): Embark on a virtual tour of the night sky with the SkyAtlas. This dynamic map showcases stars, constellations, planets, nebulae, even comets, asteroids and satellites. You can scroll around or search for a specific target. The blue rectangle is where the scope is pointed, the red one is your target.

Community (Cyclops Saturn Icon): The Seestar Community, according to ZWO, is your connection to a vibrant network of fellow astronomy enthusiasts and Seestar users. Share your astrophotography images, exchange tips and tricks, ask questions, and engage in discussions. Learn from experienced users, find inspiration, and celebrate your celestial discoveries together. It's a place to foster friendships and a shared passion for the cosmos. They wish. Most people use Facebook, cloudynights.com, Discord, or Reddit.

Nearby (Map Pin Icon): Discover the backyard astronomers around you who use a Seestar and see the images they've shared. You'll also find a dark sky map showing 15 levels from "Excellent dark Sky" to "Inner city sky." Why they don't use the much more common Bortle 1-9 scale for the same thing is beyond me.

Me (Unidentifiable Icon): The quickest way to Sounds, Focus, Anti-dew and Watermark settings. It's also the **quickest way to reach the "Slide to shut down" button** which is hiding down below, off the screen. You have to scroll down the page to get to it.

Settings Page

The settings page is conveniently labeled Log In. To what I don't know, and it doesn't say. I tried several different combinations of ZWO, ASIair and Seestar names and passwords and got nowhere.

Next down the screen is a picture of a Seestar with indicators for battery charge and available memory space for new images and movies. Each RAW (FITS[12]) image takes up 4.2 MB. MP4 movies are relatively small because they're compressed, but RAW (.AVI) movies can get huge, depending on how long they are. I have a typical movie of the Sun that is 838.1MB, for example.

Now, for the settings...the ones you see when you tap the iconic, recognized everywhere, settings wheel in the top right corner of the settings/Log In page.

Language gives you the choice of six mostly Oriental languages or "Follow System", which is what you want.

Clear cache apparently clears some quick access data. When I tapped it to see what it might be, without so much as a by your leave, it erased something. Scared me to death because I thought I'd just erased all the pictures and movies saved on the Seestar. (Yes, I have backups.) But the memory space available didn't change, so that wasn't what was deleted. Thank goodness.

Help & Feedback takes you to the official ZWO tech support forum, also available from a browser at https://bbs.zwoastro.com/t/seestar. Curious place. Mixture of unanswered question, lots of bitching, and some very smart useful replies. Go figure.

About reveals your current app version and provides access to a Statement about the open source software they use. Well, some of it anyway. You'll also find a long list of versions and related enhancements.

Version Update takes you to either the App Store or Google Play where you can download an app update. If your mobile device has "Automatic Updates" on, it will have already done that. If there's a firmware update too, it will make you do that (unfortunately). There have been a few glitches in updates which creates quite a ruckus among social media denizens—especially those who can't be bothered or don't know how to read.

[12] A FITS image (Flexible Image Transport System) is a standardized digital file format primarily used in astronomy to store, transmit and process scientific data. Unlike common image formats like JPEG or PNG, FITS files are not compressed and are designed to preserve the integrity of scientific data, including astronomical images, spectra and other types of measurements.

Now for the settings...the ones you see when you tap the Me button in the bottom menu on the Home Screen.

Wi-Fi shows you the name and password for the Seestar's Wi-Fi hotspot. And this is where you set up Station Mode to connect your Seestar to your home network for remote control and image transfer.

Firmware is the internal software that controls Seestar's operation. Updates are available to fix bugs and add new features. An occasional glitch drives everyone nuts when the update has a problem. Can you spell QA? To their credit, issues are usually corrected quickly.

Device Info provides information about your Seestar's serial number and the current firmware version number.

Sound is where you control the volume of the Seestar's voice. After the first couple of sessions, I put mine on mute, mostly because I was worried the neighbors would be concerned if they heard voices in the middle of the night.

Focus allows you to turn on the focus panel so you can manually adjust the focus of the Seestar's camera. Note the Current POS number after you've focused on a bright star. If you're fooling around with the focus and get lost (I have) you can just go back to that number and know your spot-on or very close. If you're way off, autofocus may not save your bacon. The Sun. the Moon and DSOs all focus at minutely different places/numbers. And yes, the focus point for any of them changes with temperature. Refocus when you change targets to keep stars sharp. Poor focus is the most common problem with beginners images, so focus on focus when you're starting out with the Seestar.

Anti-Dew is where you turn on the Dew heater which helps prevent dew from forming on the Seestar's camera lens. It also uses up the battery big time.

Image Watermark is where you turn on or off a watermark that is superimposed on the bottom of your images. (But not on the RAW or FITS pictures.) I kind of like it, actually. I just wish it provided a bit more information such as how many subframes were stacked, what was the total exposure length and what was the total clock time required to capture all of the subs, etc.

Advanced features, oddly, provides access to additional Seestar features such as exposure time. I would have thought it was a basic feature. But maybe they're right, given the rejection rate with anything but 10 second frames.

Slide to shut down, conveniently hiding off the bottom of the screen, is slide bar where you turn off the Seestar.

Advanced features

Enhance EXP which should be called Exposure Length, gives you a choice of 10, 20, or 30 seconds. When stacking, there's a quality algorithm that decides whether to add a new image to the stack or throw it out. Quite a few get thrown out at 20 seconds, a whole bunch at 30 seconds. So, I now always use 10 seconds and still lose a few. I recently collected 30 minutes of data, 10 seconds at a time, and it took 53 minutes on the clock! The algorithm is persnickety, so clouds or a slight jiggle is enough to have a frame thrown out.

Skip Horizontal calibration allows you to bypass the horizontal calibration process when the Seestar is getting ready to start stacking photos (which they call Image Enhancement). Essentially, the Seestar checks three stars and determines with plate solving what level really is regardless of how you've adjusted the scope. You can only use it with "Skywatching Mode" (DSO) and it's worth the short delay before starting hours of photon collecting.

Save each frame saves every individual frame used during stacking, so you can use them in post-processing and stack them yourself. Rejected frames are not saved.

Adjust Level opens up the white/green circles so you can get the scope as level as possible by adjusting the mount.

Compass calibration, calibrates the Seestar's compass. That's so it knows where to look when you tell it to GoTo a target. If your scope has trouble finding the Sun or Moon, try calibrating the compass. For Skywatching (DSO) it's not important because the Seestar is calculating where to point based on plate solving, anyway.

Level sensor calibration lets you calibrate the internal level sensor. To use it you put the Seestar on a level surface (not just flat, *level*) and follow the instructions to rotate the scope until the green circle is complete. Like compass calibration, you should have to do this only once unless you're lugging the scope around. The catch is, if you drove up a mountain and bumped over a dirt road to get to a really dark place, what are you going to use as a level surface?

SkyAtlas Sync (Internet access required) synchronizes Seestar with the online SkyAtlas database to update object locations and to refine comet and asteroid locations.

Reset button long push restores Seestar to factory settings. Short push resets the Wi-Fi.

RTSP (Real Time Streaming Protocol) and free OBS (Open Broadcast Software) will enable you to broadcast live video from Seestar for world-wide real-time viewing and sharing via Facebook Live or YouTube. When you have everything else under control, then tackle this. It isn't straightforward.

Auto shutdown automatically turns off Seestar after a set period of inactivity to conserve power.

The Great Globular Cluster in Hercules (M13)

CHAPTER 8

ACQUISITION MODES

At this point I assume you have your mobile device talking to Seestar, and you're looking at the Home Screen.

If you're about to embark on your first session with the Seestar, do it during daylight when you can see what you're doing. Start by selecting the **Scenery Mode** on the Home Screen, hiding out of sight over there on the far right end of the Stargazing, Solar, Lunar, Planetary, Scenery row if you're on an iPhone (under the weather forecast).

In the center of the Scenery screen is a little white circle that turns into what amounts to a "joystick" that you control by sliding your finger on the screen. It has a Slow and Fast mode both of which are, frankly, frustrating because they aren't very precise. And when you return the "joystick" to the center, the scope keeps going and overruns what you wanted to look at. It is especially bad in the Fast mode. But with a little practice you'll get the hang of it.

Slide the joystick up on the screen: and the Seestar arm with the scope in it (known as the OTA or Optical Tube Assembly) will start to elevate in altitude up toward horizontal. Move the joystick left and right and you'll see the See-

star slew in azimuth. Now practice by trying to center distant targets and fiddle with the focus so you learn how it works[13].

If you happen to be in a location where distant objects move slowly such as ducks on a lake or boats on the ocean the Seestar will track then if you tap the square with a dot in it and then draw a line across the object you want to track. The Seestar will put a box around it, move it to the center of the screen, and then keep it there. It's not the most reliable and is easily confused by objects in the foreground. But when it works it's fun to make a movie.

Now let's go get some pictures of our closest star using **Solar Mode**. First make sure the compass has been calibrated (see the footnote on page 23) and the scope is level.

Use the crack between the OTA and the base as an aiming sight and point the scope using the joystick just a little to the left of the Sun[14]. To avoid looking at the Sun, just watch the shadow on the ground. When the crack appears as a light line in the shadow, point the scope a little left.

Now, tap the solar icon on the Home Screen, and insert the solar filter as directed. You may have to use the "joystick" to raise the OTA some so you can get at the front of the scope to insert the filter. Once the solar filter is installed, click the OK button and the scope will go find the Sun. Usually.

You only get one chance to do the solar filter thing wrong. If you point the scope directly at the Sun without the filter it will turn your Seestar into an expensive paperweight. That especially applies to taking the filter off too. In your mind you're going to shut down or go to some other target, but the scope is still pointed directly at the sun. Be sure to slew the scope away from the Sun first.

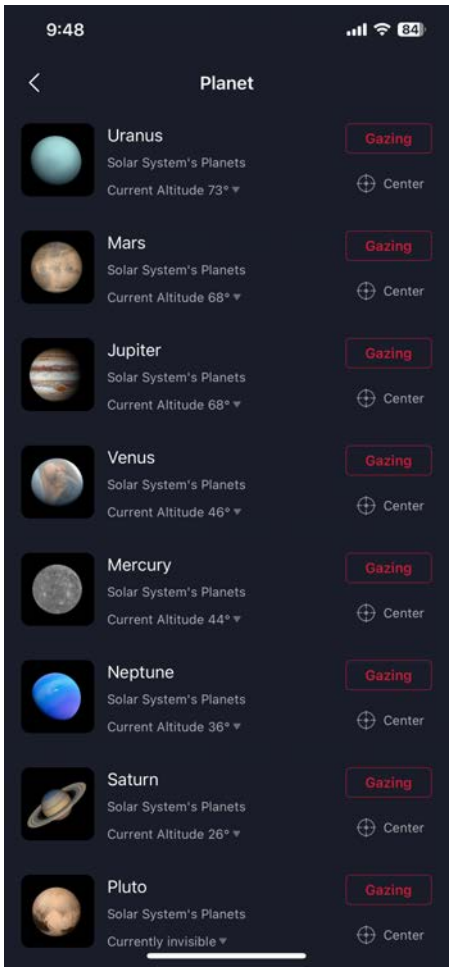
[13] If the focus buttons aren't on the left side of the screen, touch the image of the Seestar at the top of the home screen or the Me button at the bottom. Then scroll down to and press the Advanced Features button hiding out of sight on the bottom of the screen. Then turn on the Focus Panel. Note the default focus number so you can go back if you get lost. And, of course, you can always us AF (Auto Focus).

[14] The scope will set the altitude based on your location and the time and then hunt in azimuth for a bright spot. Be patient, you may see the target flash through the screen but it will come back and put it in the center. Usually. If it's 30º or 40º past your target, tell it to stop, slew it back to the left, and try again.

So now that you've found old Sol, you can use the same process in **Lunar Mode**, even during the day if you can see the Moon in the sky.

Both the Sun and Moon Modes have 2x and 4x enlargement (*not* zoom) buttons, so you can have some fun looking at Sunspots and craters. The buttons will select a small portion of the image and display it full screen like this 2X view. DSLR folks refer to it as digital zoom so you're forgiven if you think there is some actual zoom involved. But nothing in the optical path changes in the Seestar (or DSLRs). You're looking at the same data, just displayed larger.

Imaging in **Planetary Mode** is a little different because the planets appear tiny thanks to the short focal length (250mm) of the Seestar, and because they're very bright spots in the black night sky. Left to its own devices, the Seestar will expose for the dark background and completely blow out (over expose) the planet, obliterating the dark bands and light zones on Jupiter, the rings of Saturn, and frost on the pole of Mars.



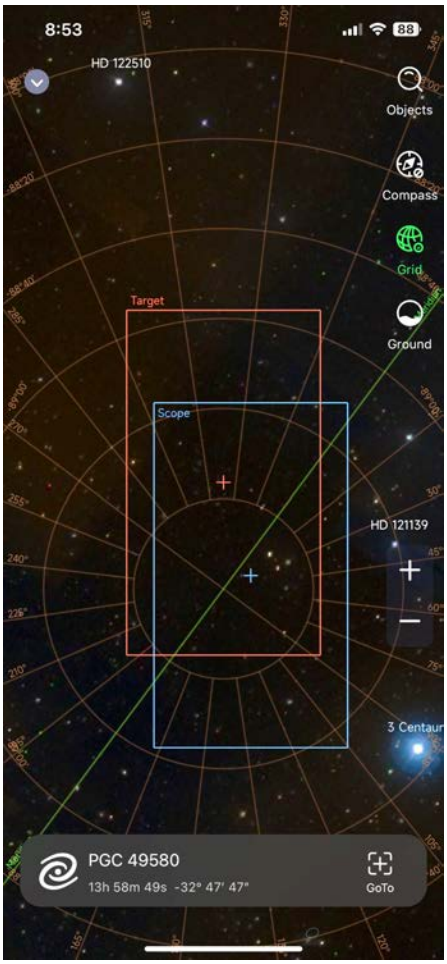
And here we come to a truly aweful User Interface design, so buckle up. After selecting Planetary in the mode list on the Home Screen, you'll see a blank screen with No Object at the top. Tap the SkyAtlas icon on the Bottom right corner and then tap the Objects button on the top right corner of the next screen. Even though we're in Planetary Mode the SkyAtlas will let you select the Sun or Moon or DSOs. You want to tap the Planet button (an image of Jupiter mostly off the screen on an iPhone but OK on a tablet) and you'll see yet another screen that (finally) lists the seven other planets and the minor planet Pluto.

If you tap the image of any planet you'll get a nice description and some details. Scroll down and you'll see a handy

chart that shows what time the planet is visible from your location, it's current altitude and azimuth so you'll have an idea if it's going to be behind that tree or not before you waste time asking Seestar to find it. The white dot graphically tells you what the current time is and the line shows what the planet's altitude will be when it's above the horizon. Drag the dot and it will show altitude, but Alt and Az don't change which would be more useful.

On the screen that lists the planets, if you tap the Center button you'll be shown the planet's location in the SkyAtlas, but the Seestar won't slew to it unless you press the GoTo button at the bottom of the screen. Tap the oddly named Gazing button (maybe Observe or Imaging would be better?), you'll be shown the planet's location on the sky map, the scope will slew to its location, and it will go through its plate solving routine to put the planet in the center of the screen.[15].

Zoom out using the minus button while it's slewing and you'll see a blue rectangle (where your scope is pointed) moving toward the red rectangle (your target).



Note that you can drag the sky around when the scope is not slewing so that other planets (anything, actually) are under the red rectangle. When it is a recognizable object (one of 12,000), the Seestar will name it and present the GoTo button for your viewing pleasure.

A very cool feature of the SkyAtlas screen is the Compass button. Tap it, and you'll see the constellations, DSOs, bright stars, and planets or whatever is located where you're pointing your mobile device, day or night. It's far too sensitive to tiny motions, but you can learn a lot of astronomy if you play with it on a cloudy night or in the bathroom.

The most awe-inspiring feature of the Seestar is its **Stargazing Mode** (which should be called DSO). This is where the Seestar really proves that you got a hell of a good deal for $499. This is the mode for capturing deep-sky images. Here's what it does:

Automatic Dark Frame Calibration: The Seestar automatically takes and applies dark frames to the image, correcting for sensor noise and improving the final result.

[15] They have the labels reversed. Center should take you there and center the object, gazing (sic) should let you observe its location without moving.

Live Preview: The app provides a real-time view of the night sky through the Seestar's camera. This allows you to see (dimly) what the telescope is pointed at and make adjustments as needed.

Target Selection: You can select your desired target either from the app's recommendations or by manually choosing an object from the SkyAtlas.

Automatic GoTo and Tracking: Once you've selected a target, the Seestar automatically slews to the object and begins tracking it, compensating for the Earth's rotation.

Image Capture and Stacking: The Seestar captures multiple short exposures of the target and stacks them together in real-time. This stacking process reduces noise and enhances faint details in the image.

Narrowband filter: If you're shooting nebulae, Seestar will apply the dual band filter to emphasize Hydrogen alpha (Ha) and Oxygen three (O_3) emissions. If you're in a light-polluted area, you can enable the filter to minimize its impact on an image. It is not recommended for galaxies.

Image Saving and Sharing: Once you're satisfied with the image, you can save it to the Seestar's internal storage or share it with the Seestar Community.

My first Seestar image (M51)

In essence, Seestar's DSO Mode (I mean Stargazing Mode) takes care of the technical aspects of capturing astro images[16], allowing you to focus on enjoying and the lovely sharing of images of deep-sky objects you produce.

[16] To be pedantic, what the Seestar does is not astrophotography. No silver halide is involved. But this isn't a battle I'll fight because common usage always wins. That's why we call the event sunset not earthrise even though we've known for 800 years the Sun isn't rotating around the Earth.

CHAPTER 9

SAVING AND EXPORTING

Seestar image and video file saving and downloading involve a few different options depending on the type of file and your desired method of retrieval.

Saving:

JPG and MP4 are standard formats for photos and videos, respectively. Seestar automatically saves JPEG images to the "My Album" folder in your Seestar, while AVI (RAW) videos are saved in the "Video" folder. These files are ready for viewing and sharing immediately.

RAW (FITS): These are unprocessed image files that are not compressed so they allow for greater flexibility in post-processing. Seestar saves them in My Album in Seestar Files, accessible from the Home screen.

Downloading:

You can move your images from the Seestar to a computer directly from the mobile app.

You can select JPEGs in My Album and tap the share icon. This will give you options to download, export, or share the image directly from your mobile device.

Connecting to a Computer:

You can connect Seestar to your computer using the provided USB-C to USB-A cable included in the Seestar package, or an aftermarket USB-C to USB-C if that’s what your computer uses. Your computer should recognize it as a removable storage device. You can then access the "eMMC" folder where images and videos are stored. A USB-C thumb drive will work too.

If you enabled Station Mode on Seestar and have connected your computer to the same Wi-Fi network you can use the Mac Finder or the Windows File Explorer to access the files stored on the Seestar.

CHAPTER 10
HINTS

Rapid iteration means software changes frequently. Ignore old complaints or bad ratings about early software releases. It's easy to panic about some horrible problem only to find out it was an issue a year ago but isn't now.

Beware advice from a poster child for the Dunning-Krueger effect[17]. They're often, but by no means always, one of the most prolific posters on social media. (That might include me, so as I've said, YMMV.)

I know it's old-fashioned, but the more your read about astronomy and astrophotography the more you'll enjoy and appreciate the Seestar.

There are oodles of YouTube videos about the Seestar, astronomy and astrophotography. Some are exceptionally good. Some are exceptionally bad. You can usually tell that they will be good if the presenter doesn't spend 10 minutes yapping about him- or herself before getting to the topic.

Planetary is not one of Seestar's strengths. But if you focus carefully, adjust the gain carefully, and process carefully using drizzle[18] you can produce some decent, even good, planetary images.

The orange solar filter is called a white light filter because it passes the full spectrum of visible light, not because the light it produces is white (because it isn't).

[17] The Dunning–Kruger effect is a cognitive bias in which people with limited competence in a particular subject overestimate their abilities.

[18] Drizzle is an image processing technique used to combine multiple images, improving resolution and detail. Drizzle can be thought of as "drizzling" the information from each individual image onto a higher-resolution canvas, resulting in a sharper and more detailed final image. But it comes with a price: noise.

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Baby Seestar nursery