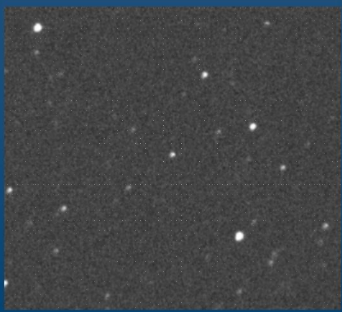
Citizen Science:

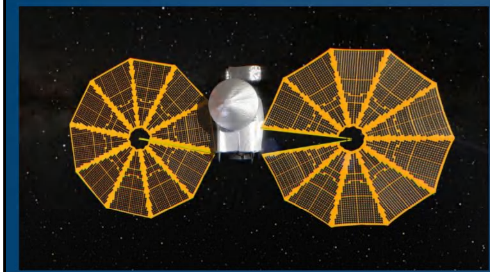
LUCY Occultations

Tom Heisey
International Occultation Timing Association (IOTA)

August 2024



LUCY Science Goals - Trojan Asteroids



- Surface geology
  - Shape, albedo, craters, layering
- Surface composition
  - regolith, minerals, organics
- Interior mass & density
  - craters, fractures, ejecta
- Satellites and rings

https://science.nasa.gov/mission/Lucy/science/

Planet formation and evolution models suggest that the Trojan asteroids are likely to be remnants of the same primordial material that formed the outer planets (Jupiter, Saturn, Uranus, and Neptune), and thus serve as time capsules from the birth of our solar system over four billion years ago. These primitive bodies hold vital clues to deciphering the history of our solar system and the environments in which all of the planets, including Earth, formed and developed.

Surprisingly, Trojan asteroids have very different surface compositions from one another. This diversity likely means that they formed in different locations in the solar system and were transported to their current orbits as the planets formed and evolved. To understand what this diversity is telling us about the history of our planetary system, Lucy has the following science objectives at each of its destinations:

Surface Geology – Lucy will map the shape, albedo (reflectivity), and crater spatial and size-frequency distributions; determine the nature of crustal structure and layering; and determine the relative ages of surface units.

Surface Color and Composition – Lucy will map the color, composition, and regolith (surface "soil") properties of the surface, and determine the distribution of minerals, ices, and organic species.

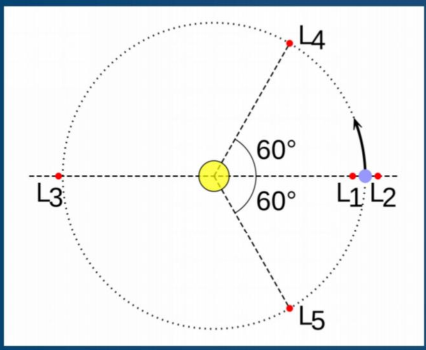
Interiors and Bulk Properties – Lucy will determine the masses and densities, and study sub-surface composition via excavation by craters, fractures, ejecta blankets, and exposed bedding.

Satellites and Rings – Lucy will look for rings and satellites of the Trojan asteroids.

Play video at https://svs.gsfc.nasa.gov/14426 or
https://www.youtube.com/watch?v=tzcosX_HIo4

On Nov 1st 2023, NASA's Lucy spacecraft will fly by the small Main Belt asteroid Dinkinesh (previously known as 1999 VD57). This asteroid flyby was added to Lucy's list of targets in January of 2023. The primary purpose of the Dinkinesh encounter is to test the spacecraft's Terminal Tracking System, which will keep Lucy's instruments pointing at the asteroid as it flies by at 10,000 miles per hour. The Lucy mission's record-breaking tour will now explore at least 10 small solar system bodies. Lucy will have the close approach with Dinkinesh as the spacecraft skims the inner edge of the main asteroid belt. After the encounter, Lucy will head back towards Earth and its second gravity assist in December 2024. That assist will send the spacecraft to explore the Jupiter Trojan asteroids.

Trojans



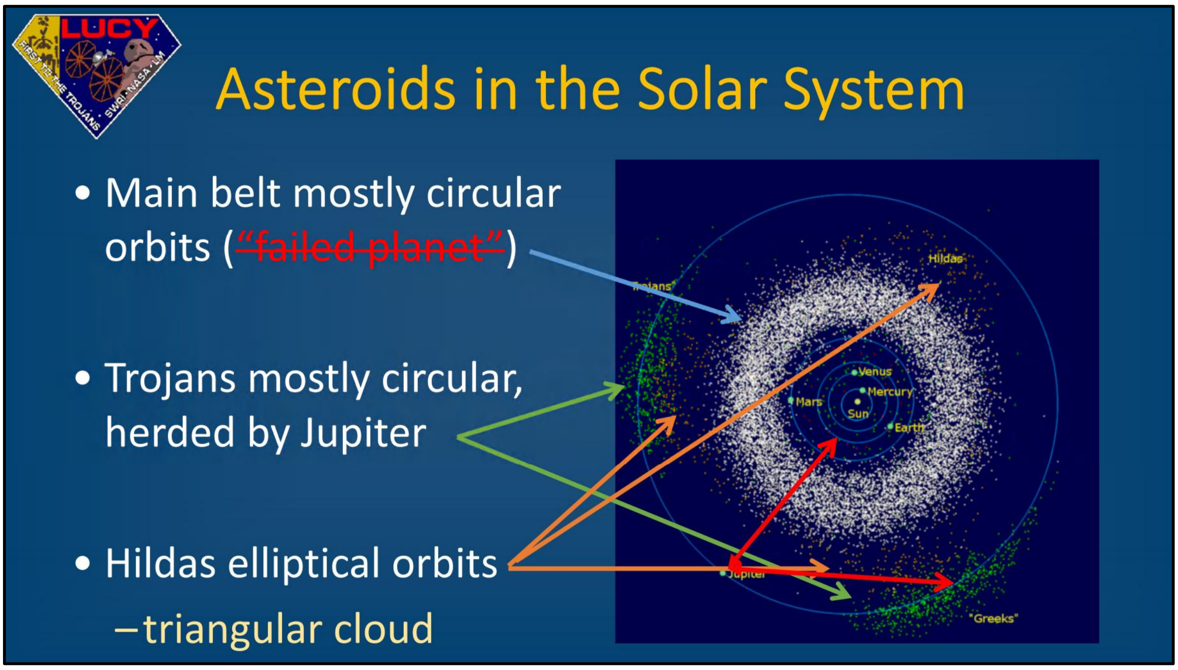
- By definition, a planet dominates its orbit
  - "herds" asteroids
- Lagrange points balance gravity between sun & body
- Mostly asteroids

https://en.wikipedia.org/wiki/Trojan_(celestial_body)

In astronomy, a Trojan is a small celestial body (mostly asteroids) that shares the orbit of a larger body, remaining in a stable orbit approximately 60° ahead of or behind the main body near one of its Lagrangian points L4 and L5. Trojans can share the orbits of planets or of large moons.

Trojans are one type of co-orbital object. In this arrangement, a star and a planet orbit about their common barycenter, which is close to the center of the star because it is usually much more massive than the orbiting planet. In turn, a much smaller mass than both the star and the planet, located at one of the Lagrangian points of the star–planet system, is subject to a combined gravitational force that acts through this barycenter. Hence the smallest object orbits around the barycenter with the same orbital period as the planet, and the arrangement can remain stable over time.[1]

In the Solar System, most known Trojans share the orbit of Jupiter. They are divided into the Greek camp at L4 (ahead of Jupiter) and the Trojan camp at L5 (trailing Jupiter). More than a million Jupiter Trojans larger than one kilometer are thought to exist,[2] of which more than 7,000 are currently catalogued. In other planetary orbits only nine Mars Trojans, 28 Neptune Trojans, two Uranus Trojans, and two Earth Trojans, have been found to date. A temporary Venus Trojan is also known. Numerical orbital dynamics stability simulations indicate that Saturn probably does not have any primordial Trojans.[3]



I was wrong at the meeting - Saying the asteroid belt is a failed planet due to the gravitational dominance of nearby Jupiter. The asteroid belt is sitting in the expected interval of a planet, but if you dig deeper there are three factors that dispute this.

1) The known mass of the belt is less than our moon, far less than a planet.

2) The current "Grand Tack" theory shows that Jupiter and Saturn formed closer to the Sun and migrated outward, wiping out the asteroid belt at one time.

3) Jupiter shepherds the belt (we see resonances with Jupiter's orbit) and that gravity prevented formation of a body.

(Good summary: https://www.space.com/16105-asteroid-belt.html)

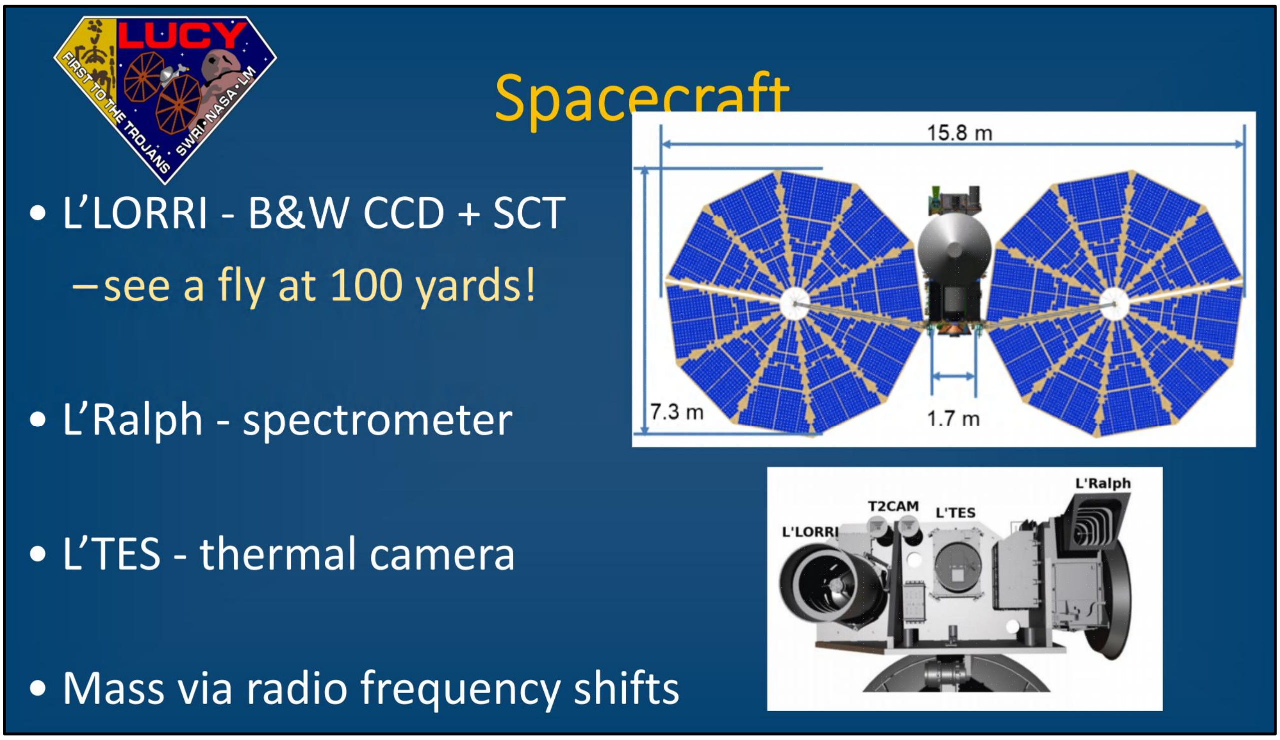
If you're confused on how asteroids can have a triangular orbit, see Scot Manley's fantastic video: https://www.youtube.com/watch?v=yt1qPCiOq-8

https://en.wikipedia.org/wiki/Trojan_(celestial_body)

The term "Trojan" originally referred to the "Trojan asteroids" (Jovian Trojans) that orbit close to the Lagrangian points of Jupiter... Astronomers estimate that the Jovian Trojans are about as numerous as the asteroids of the asteroid belt.[6]

https://en.wikipedia.org/wiki/Hilda_asteroid

Named for 153 Hilda, the first discovered. 3:2 orbital resonance with Jupiter (2 Jupiter, 3 Hilda) and reaches Jupiter's orbit at L5, L4, L3, 120 degrees apart with the inner orbit between 3.7 & 4.2 AU (avg 3.97 AU)



https://science.nasa.gov/mission/Lucy/spacecraft/

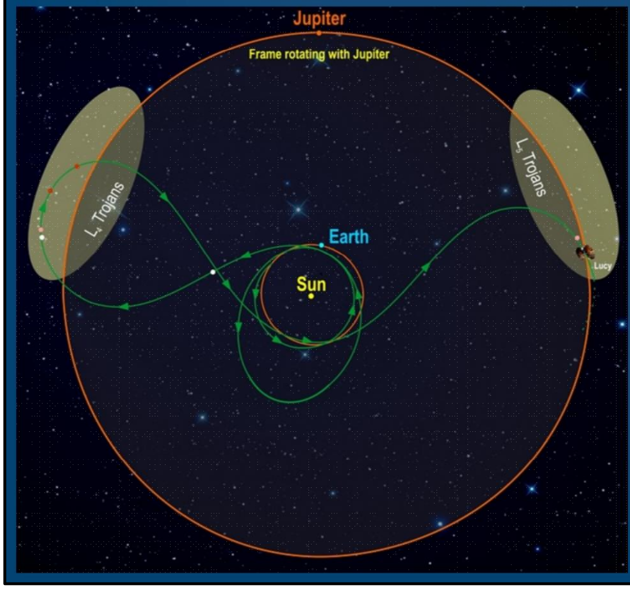
Mass determination via the Radio Science Experiment

In addition to these instruments, Lucy has a 6.5-ft-wide (2-meter) high gain antenna which will serve as the primary communications relay between the spacecraft and Earth.

Designed and built by Lockheed Martin, this same style antenna has been used to return science data from Mars

and transfer back photos of asteroid Bennu. With Lucy, the antenna will not only send back the first ever close-up images of the Trojan asteroids, but the team will also be able to use small velocity-induced shifts in the received radio frequency (the Doppler effect) to determine the masses of these never-before-visited space objects.

Targets

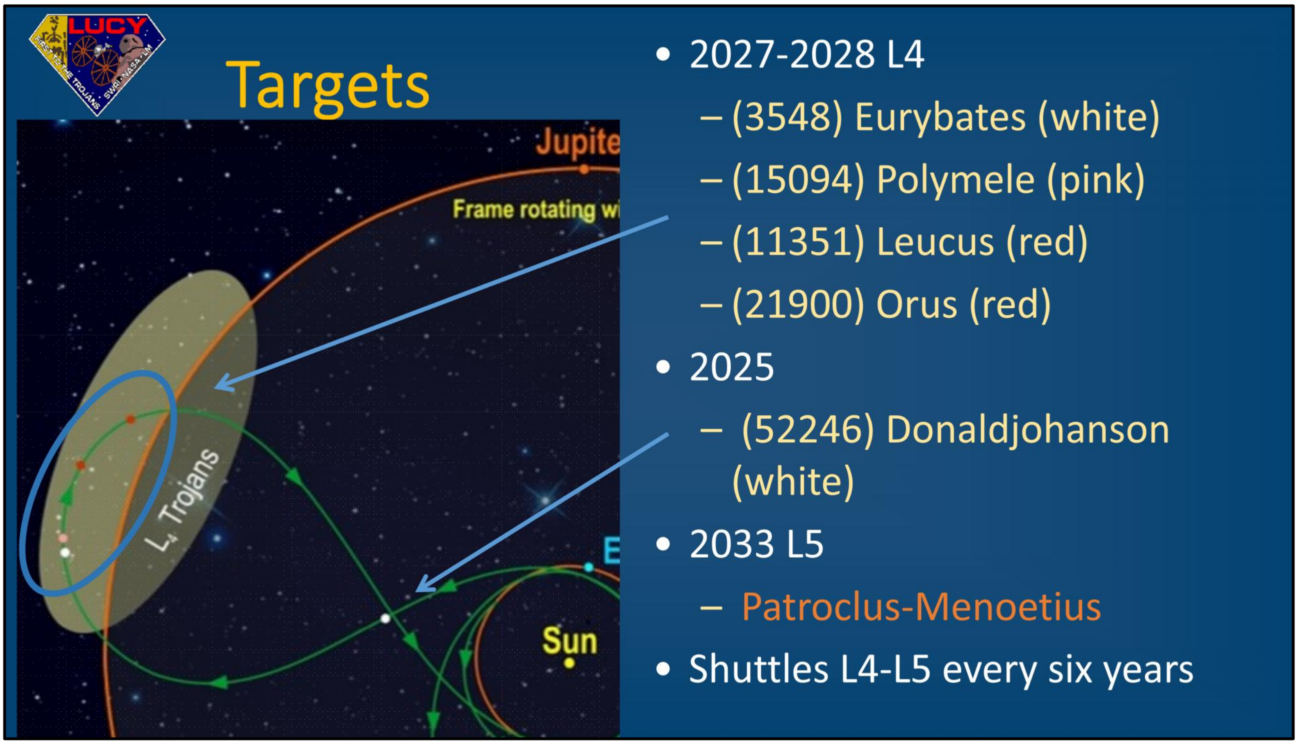


- 2027-2028 L4
  - (3548) Eurybates (white)
  - (15094) Polymele (pink)
  - (11351) Leucus (red)
  - (21900) Orus (red)
- 2025
  - (52246) Donaldjohanson (white)
- 2033 L5
  - Patroclus-Menoetius
- Shuttles L4-L5 every six years

https://www.nasa.gov/missions/Lucy/nasas-Lucy-mission-confirms-discovery-of-Eurybates-satellite/

This diagram illustrates Lucy's orbital path. The spacecraft's path (green) is shown in a frame of reference where Jupiter remains stationary, giving the trajectory its pretzel-like shape. After launch in October 2021, Lucy has two close Earth flybys before encountering its Trojan targets. In the L4 cloud Lucy will fly by (3548) Eurybates (white), (15094) Polymele (pink), (11351) Leucus (red), and (21900) Orus (red) from 2027-2028. After diving past Earth again Lucy will visit the L5 cloud and encounter the (617) Patroclus-Menoetius binary (pink) in 2033. As a bonus, in 2025 on the way to the L4, Lucy flies by a small Main Belt asteroid, (52246) Donaldjohanson (white), named for the discoverer of the Lucy fossil. After flying by the Patroclus-Menoetius binary in 2033, Lucy will continue cycling between the two Trojan clouds every six years.

Southwest Research Institute



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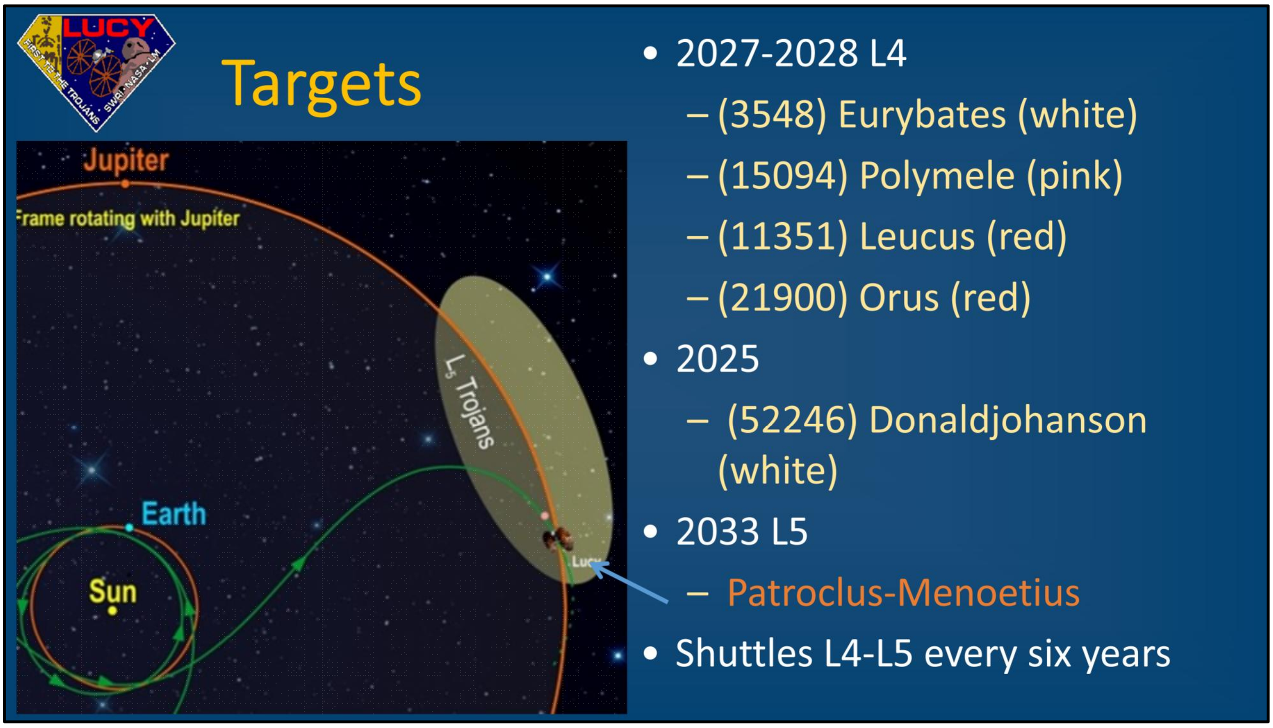

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Southwest Research Institute

SwRI Campaign

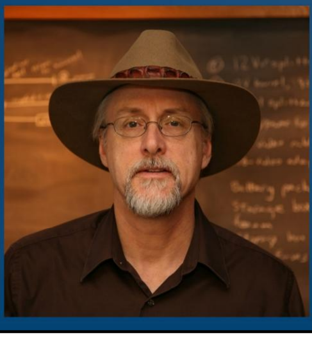
- (617) Patroclus - ~113 km across
- Menoetius - ~104 km across
- Orbit uncertainty fairly large, being refined
- Occultation can pin down orbit, size, shape
- Will assist Lucy planning during transit to L5

- https://Lucy.sari.edu/occ/predictions/20240811Patroclus/

https://Lucy.sari.edu/occ/predictions/20240811Patroclus

The Dynamic SwRI Duo

- Marc W. Buie
  - https://www.boulder.sari.edu/~buie/
  - Solar System Studies & Exploration
  - Pluto & KBO research



- Brian Keeney
  - https://www.boulder.sari.edu/~keeney/
  - LUCY, New Horizons, and Rosetta missions
  - Occultations campaigns

What Is An Occultation?

- Occultation occurs when a solar system body passes in front of a more distant object:
  - Asteroid-star →
  - Moon-star (total/graze)
  - Planet-star
  - Moon-planet
  - Comet-star
  - TNO/KBO-star

image: https://www.nasa.gov/feature/nasa-s-new-horizons-team-strikes-gold-in-Argentina

An occultation is when one body occults (eclipses) another body. Think dim eclipse. Occultations come in several flavors:

- Asteroid passes in front of a star - most common, just look at the numbers - Stars to 12 magnitude = 5,304,685, and 1,387,282

http://www.stargazing.net/David/constel/howmanystars.html

https://ssd.JPL.nasa.gov/

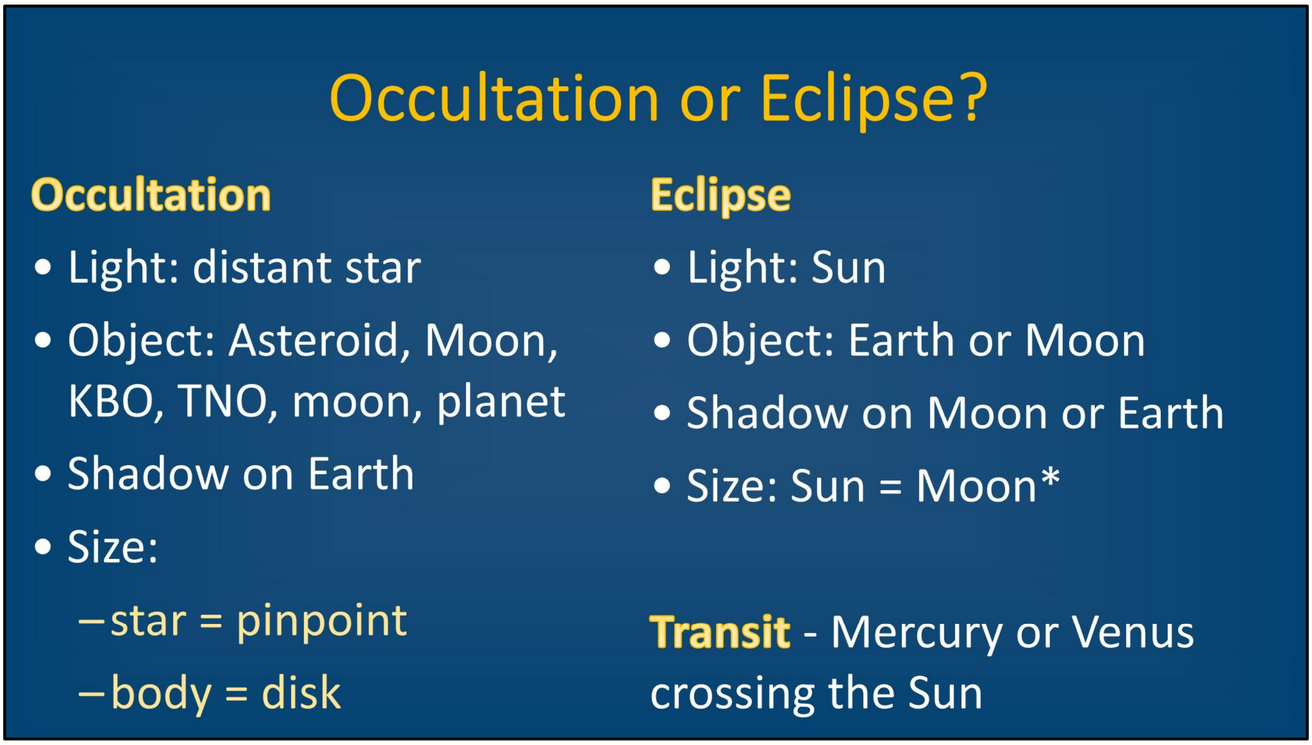
- Comet passes in front of a star - 3,962 comets, not uncommon, given the speed that comets move against the millions of background stars

https://ssd.JPL.nasa.gov/

- Our moon passes in front of a star - very common, given the moon's speed. Prior to the Lunar Recon Orbiter, lunar occultations were the only way to determine the profile of the moon's polar region, so IOTA had many campaigns to map segments of the poles. It is still a fascinating even to watch as a star blinks on and off as it passes behind the moon's polar mountains.

- Planet occults a star - relatively rare given the speed of the planets. Prior to probes to the planets, scientists used planetary occultations to get stats on the planet's atmosphere

- TNO/KBO occults a star. These slow-moving objects rarely occult a star, but these events are of high interests so scientists can determine the object's size and orbit.



NOTE: An occultation is technically an eclipse, but in general usage, an eclipse is an event with Sun, Moon, and Earth. An occultation usually used for very dim eclipses.

NOTE: From the Earth, the Moon appears to be the same size as the Sun. (Moon's disk is 400% smaller but 400% closer than the Sun)

What Does An Occultation Show?

- As one celestial body passes in front of the other, data is revealed:
  - star & x-ray source position
  - Stellar diameters (close stars)
  - orbital parameters
  - size & shape
  - atmosphere
  - doubles/companions/moons →
  - Lunar mountain shape

- (90) Antiope from an occultation on Jul 19, 2011

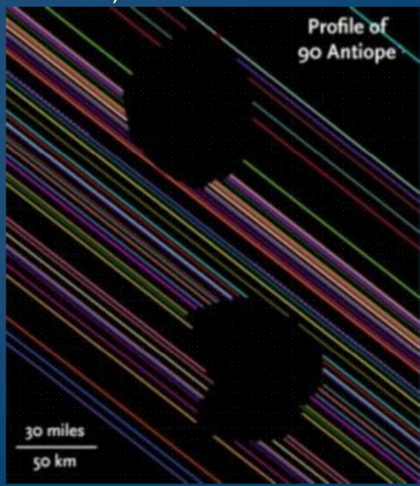


image: http://occultations.org/wp/wp-content/uploads/2017/04/Antiope_profile_2-263x300.jpg

Depending on what is know about the star and the asteroid, you can use the other body to define the other. These days, the all sky surveys have nailed down the star locations pretty well, so the starlight is a laser beam that precisely locates the event. This means we can see moons/companions, a precise location of the body, a precise shape of the body, and any atmosphere of a moon/planet. We can also precisely measure close double stars that show up in spectroscopy, but can't be split by telescopes. If the occultation has the right geometry and the stars are not on top of each other, you'll see the light curve step down twice as the asteroid covers one of the stars.

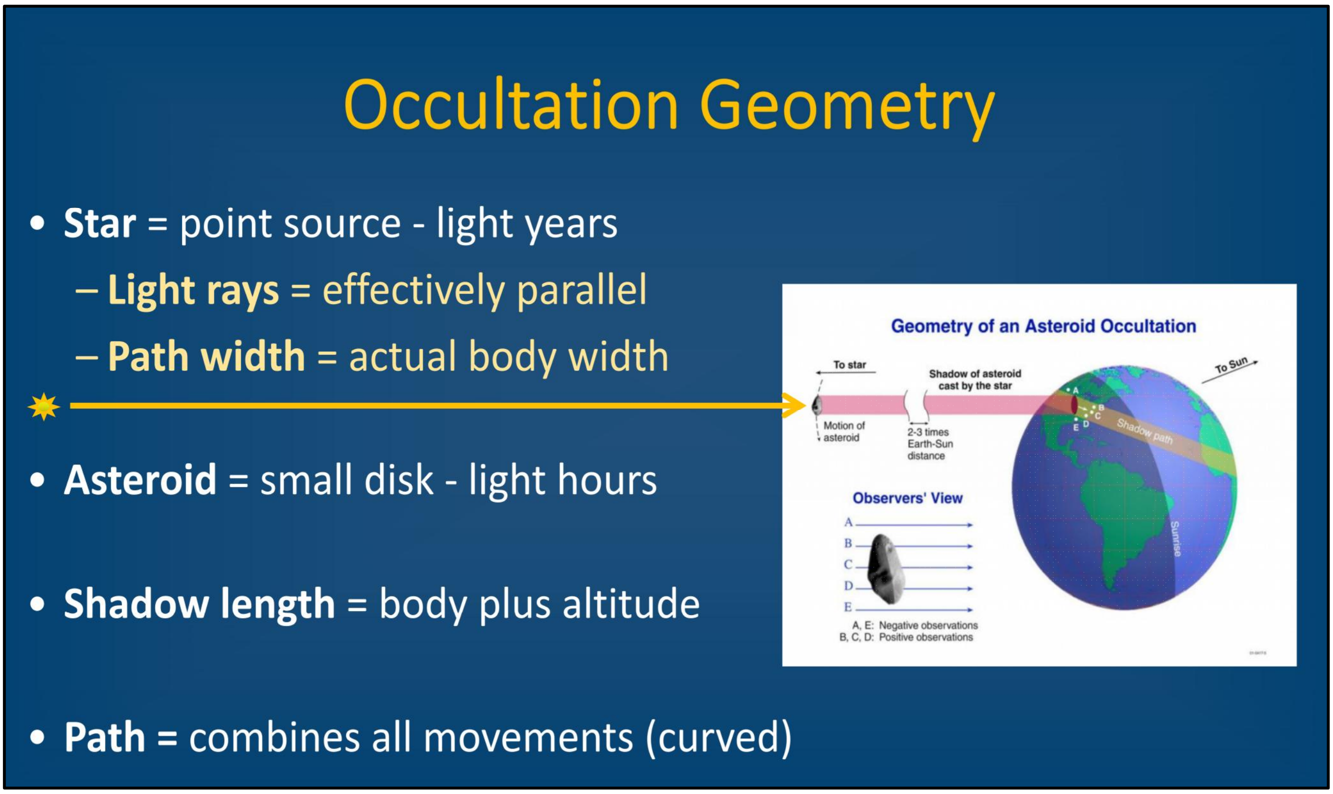
Why Do We Observe Occultations?

- They're amazing to watch!
- Contribute to science! Scientists need amateurs:
  - Paths fall randomly
  - Fixed observatories lack time
  - Scientists lack the tools & time
  - Amateurs are pre-positioned around the globe
  - Occultations are incredibly precise

image: http://netstevepr.com/iota/education/why-observe-occultations/

https://occultations.org/occultations/why-observe-occultations/

Observing occultations is valuable citizen science because professional astronomers are unprepared, unwilling, or unable to do this themselves. The paths fall randomly across the globe, so they must travel to record it. Professional observatories are busy with other tasks and cannot be diverted. However, an occultation can achieve higher precision for some measurements (asteroid size & shape, sometimes the orbit) than professional observatories.



To get a prediction, scientists take the locations and orbits of asteroids over a time span and then run simulations to see which asteroids can possibly occult stars as seen from somewhere on Earth. This data is passed to IOTA members, who run their software to see what tracks are within the range of their scopes and travel distances. The math behind this prediction is astounding

- The star is a point in the sky tens or hundreds of light years away.

  Its light is a laser with parallel beams, so the shadow of an event is the size of the asteroid.

  Its orbit and position are known within a certain amount of error.

- The asteroid is light hours from Earth and is at most a small disk visible as a point a few pixels across.

  Its orbit, rotation, size, and shape are known within a certain (sometimes very large) amount of error.

- The location of the observer is known within a few feet, but:

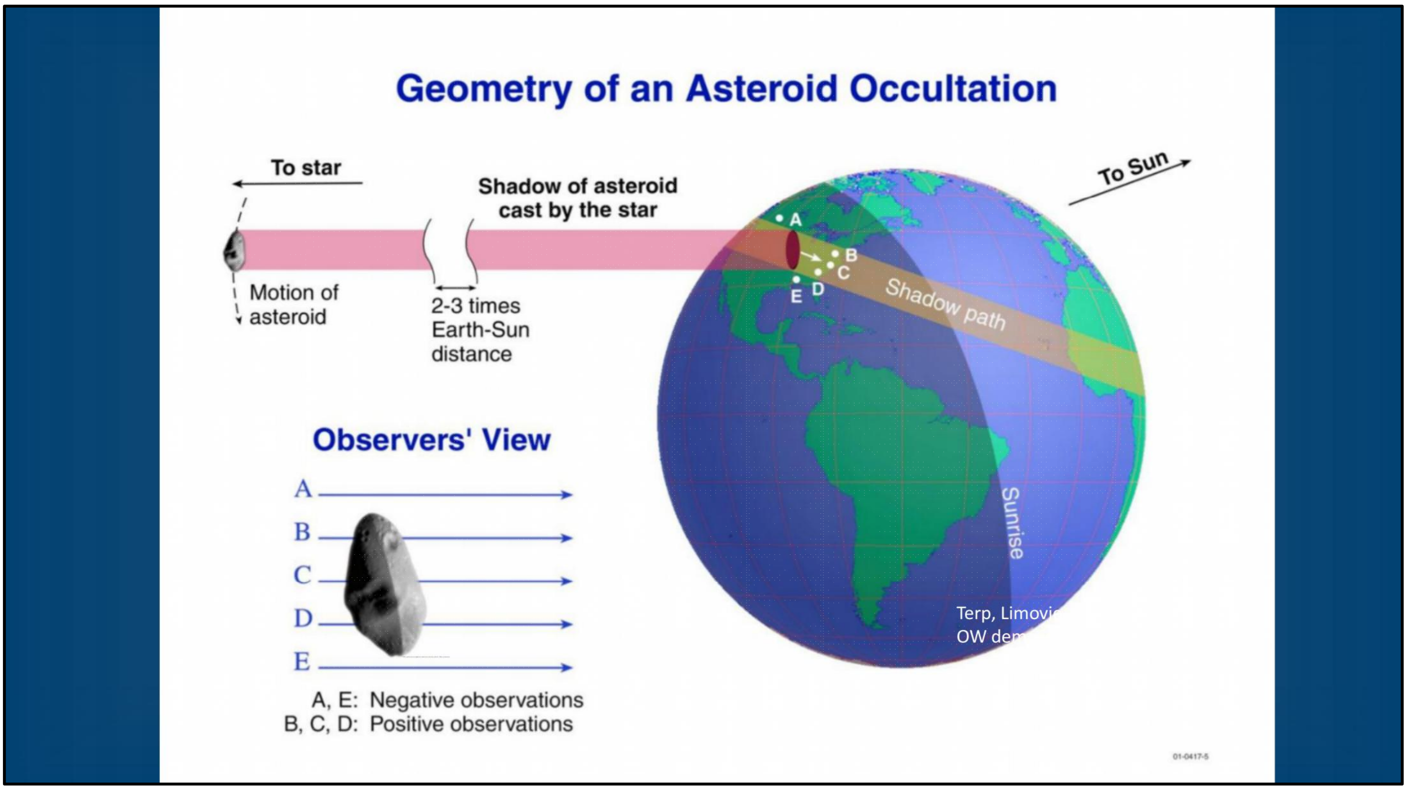
  The Earth is rotating a certain amount as the shadow moves.

  The altitude of that position affects the observer's chord.

  The atmospheric refraction affects the position of the star & asteroid, especially near the horizon.

- The combined motion of the three objects can cause tracks that curve or go in any direction.

However, since the starlight is usually coming from a precisely determined location running like a laser beam to the precisely known location and altitude on Earth, occultations can achieve 1-2 km precision on a 100 km asteroid!



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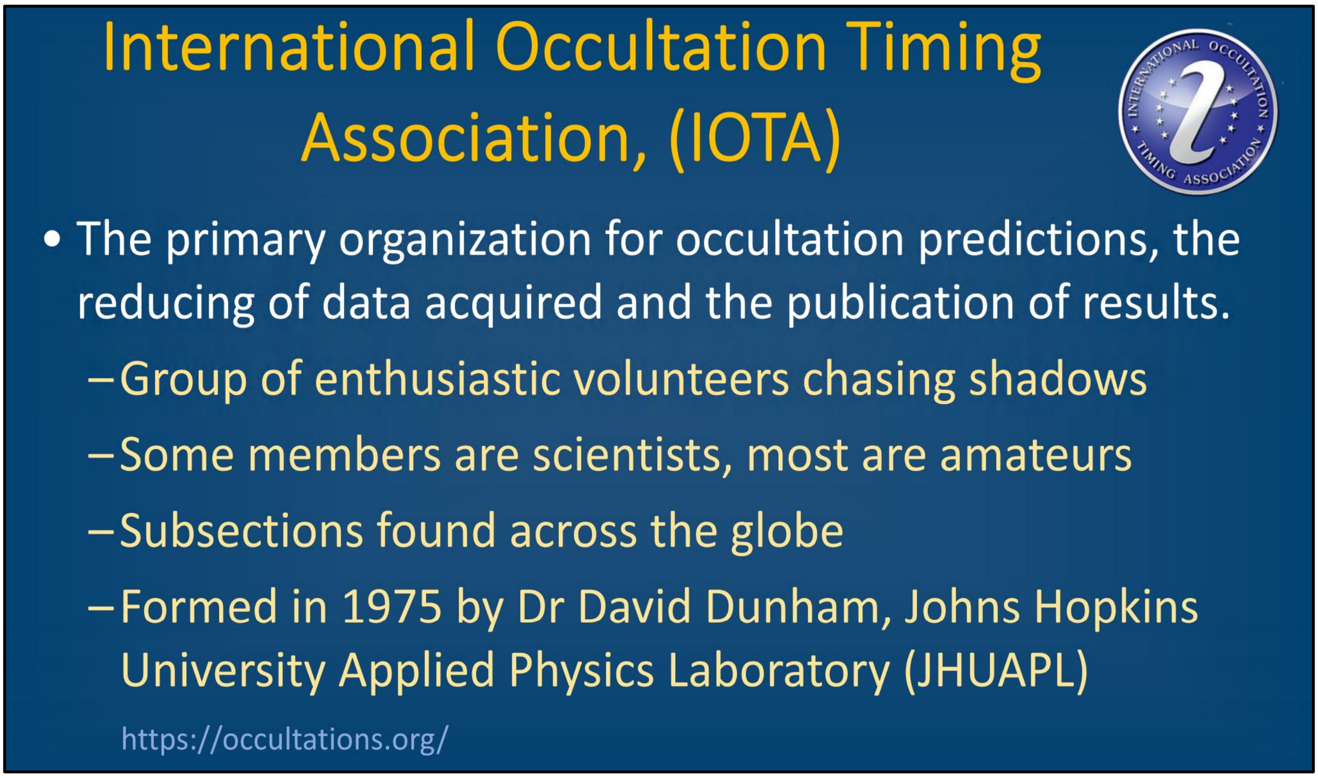
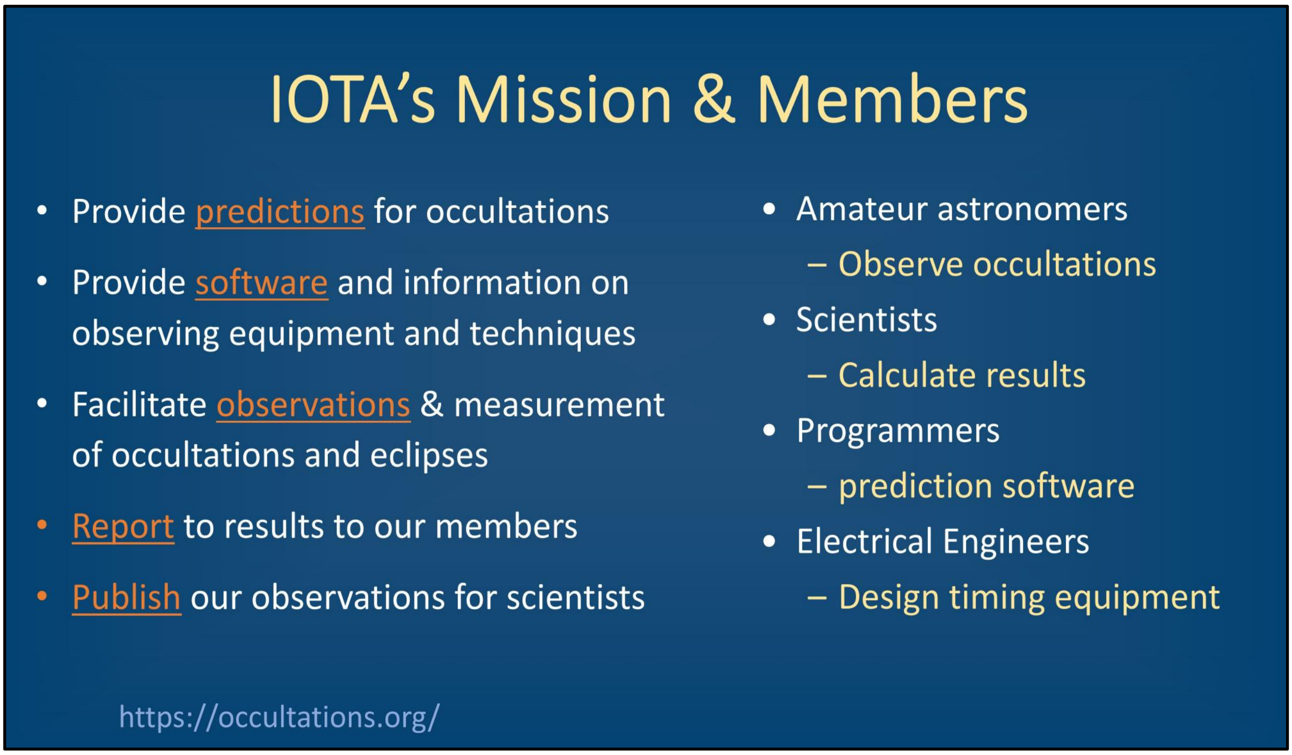
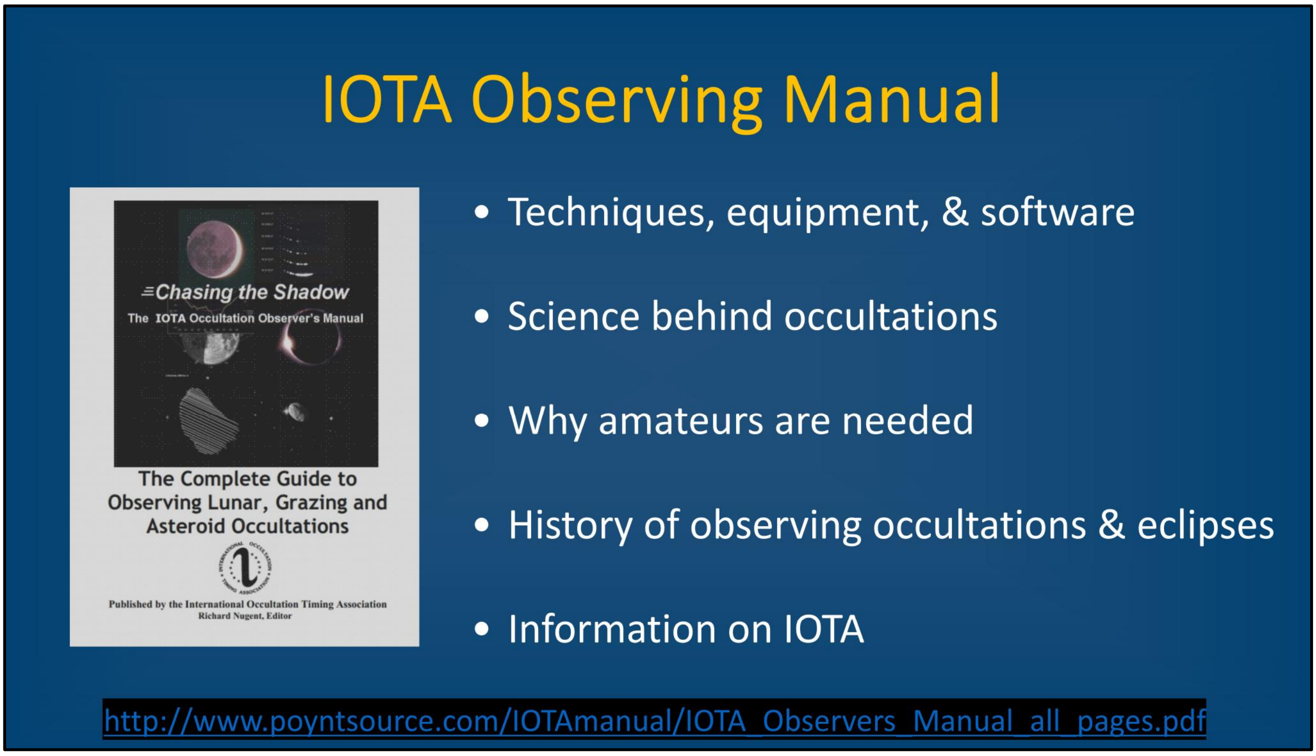


https://occultations.org/

I encourage you to view the web site and documents or contact me if you are interested in doing occultations and contributing to science!



IOTA is a collaboration between dedicated amateurs collecting data and scientists directing, reporting, and publishing results. There is one fine point - each amateur has the software available to do their own predictions based on your own needs, though IOTA Occult Watcher software does a pretty good job of allowing an observer to tune the predictions for their needs.



http://www.poyntsource.com/IOTAmanual/IOTA_Observers_Manual_all_pages.pdf

https://occultations.org/observing/

The observing manual is the IOTA bible that is updated to cover newer equipment and techniques. It's used by beginners and experienced observers alike. If you want to know what we do and don't mind reading how-to manuals, this is the book for you! You can also ask me!

Old School - Visual & Tape

- Fraction of a second precision
- Observe the event call out “start” and “end”
- Record voice and WWV

https://www.NIST.gov/pml/time-and-frequency-division/time-distribution/radio-station-WWV

I started with this very gear. The WWV radio station is a shortwave station at 2.5, 5, 10, 15, and 20 MHz. It’s probably the most boring radio station ever created with a monotonous bong every second and an announcement every minute. Listen to the WWV Simulator https://WWV.mcodes.org/ to hear it and imagine it running for an hour or more. Yeah...

To observe with this set, you set up the telescope, turn on the radio nearby, find your target, then test your recorder so you can hear both your voice and the radio. Just prior to the start, you center the scope, start the recorder, and put your eye to the scope. You make a call OFF and ON (or other clear words) when the the star disappears and reappears. You practice to know your personal reaction time, which factors into the reporting. You used common audio editing software to examine your calls and map out the time based on the WWV bongs in the background.

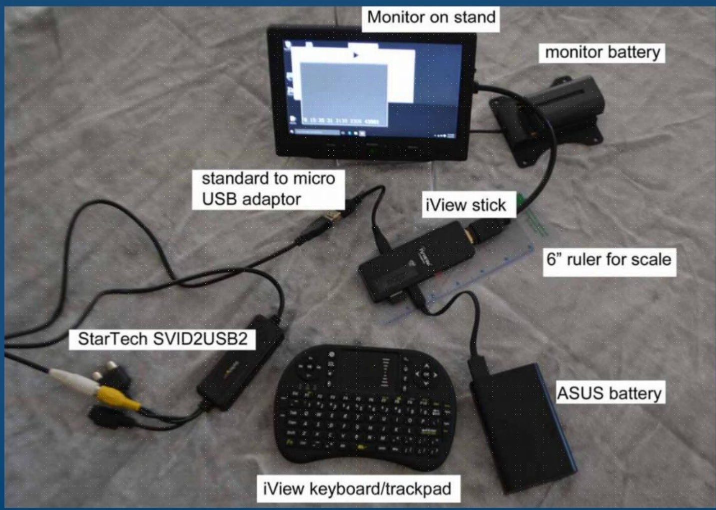
I started doing lunar occultations visually with this gear. After all, it’s really easy to find the Moon and the usually bright stars that are being occulted. I tried some bright asteroidal occultations as well, but I was not very good. In both cases, it’s difficult to keep an eye on a fairly dim star for a few minutes in the west Texas dusty wind! At least with a lunar occultation, you can often see the edge of the moon approaching the star, so you have an idea and that view is really eye-catching!

The Kiwi OSD on the left is the older model that I use. The VTI is the current model.

Both place the GPS time stamp on the video for msec precision down to the individual frame.

You use video editing software to look at each frame and graph the disappearance and reappearance. You then use the time codes printed on each frame to determine the timing.

Occ2 Recording System



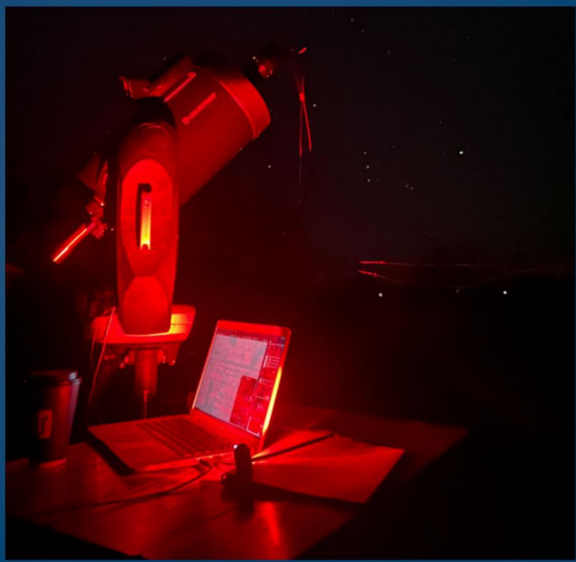
This is the most portable recording system, though some prefer an 11”laptop instead of individual pieces. I generally use old 13” laptops because I have them as surplus from supporting my parents, but small 11” laptops are inexpensive.

https://github.com/ChasinSpin/Astrid/blob/main/README.md

The Astrid was the camera I got just a week or two before the event. I spent the week leading up to the event getting camera, mount, and scope working together, then had more problems throughout the practice runs after my mount died and I had to borrow one from a friend. Everything worked during the event, but then I spend loads of time trying to get the results in a format the researchers could use. Fortunately, I did give them something they could use.

The Astrid is a miraculous instrument that combines GPS and plate solving to accurately give you directions (push-to) or control your mount (guiding) to ensure you're on target and to start the recording automatically. Even better, the camera eliminates the need for a laptop and runs with a much lighter tablet wirelessly. It will certainly get me more active in doing occultations!

SwRI systems



The SwRI system is a Celestron 11" SCT with Hyperstar camera at F/2. Complete with cases as a table, laptop, and more. Large manual for procedures for these campaigns. Images taken off Slack for this campaign.

Why use larger scopes?

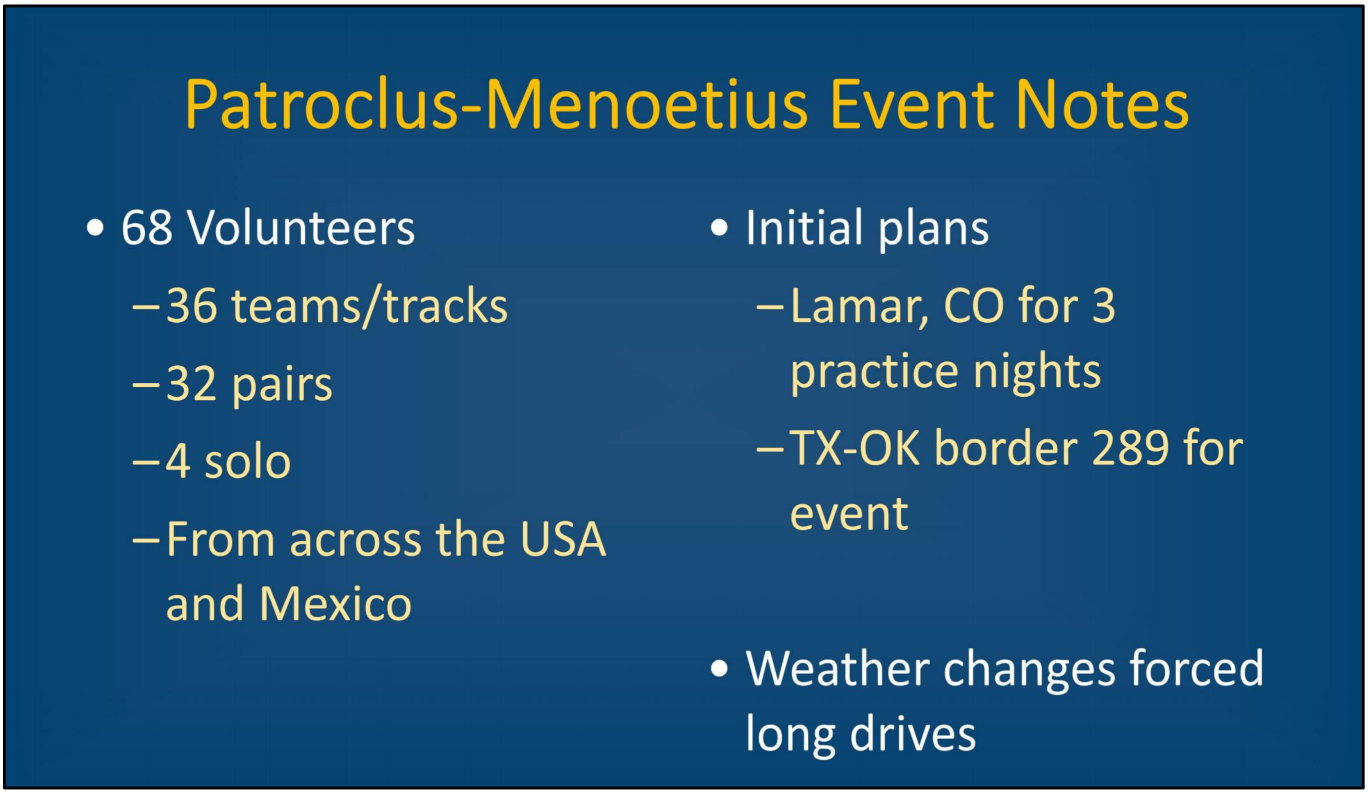
- +1 Magnitude
  = ~300% more stars!
- You can see 5,119 times the number of stars with a magnitude 14 scope than with the naked eye!

Mag	Stars in Range	Total Stars	Increase
-1	2	2	
0	6	8	400%
1	14	22	275%
2	71	93	423%
3	190	283	304%
4	610	893	316%
5	1,929	2,822	316%
6	5,946	8,768	311%
7	17,765	26,533	303%
8	51,094	77,627	293%
9	140,062	217,689	280%
10	409,194	626,883	288%
11	1,196,690	1,823,573	291%
12	3,481,113	5,304,685	291%
13	10,126,390	15,431,076	291%
14	29,457,184	44,888,260	291%

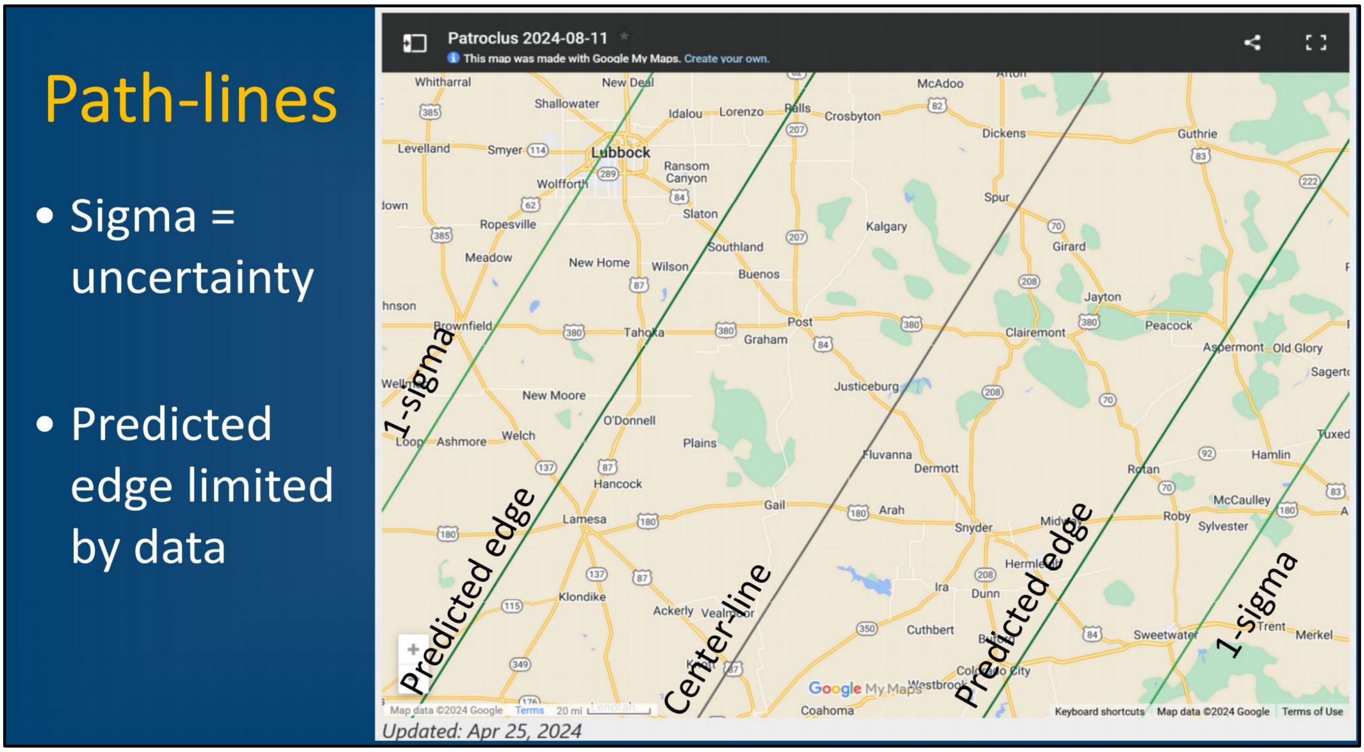
naked eye limit is approximately magnitude 6.5

Quite simply, the larger the scope and the more sensitive the camera, the more stars and therefore the more events you can see.

From http://www.stargazing.net/David/constel/howmanystars.html



The original event only meant travelling from Lubbock to Lamar, CO for three nights of practice, then driving down 287 to Childress as a loose group, then deploying to our individual sites across the 100km, and then returning to CO to return the SwRI gear. Unfortunately for us, mother nature drastically changed our plans!



Explanation of the path maps -

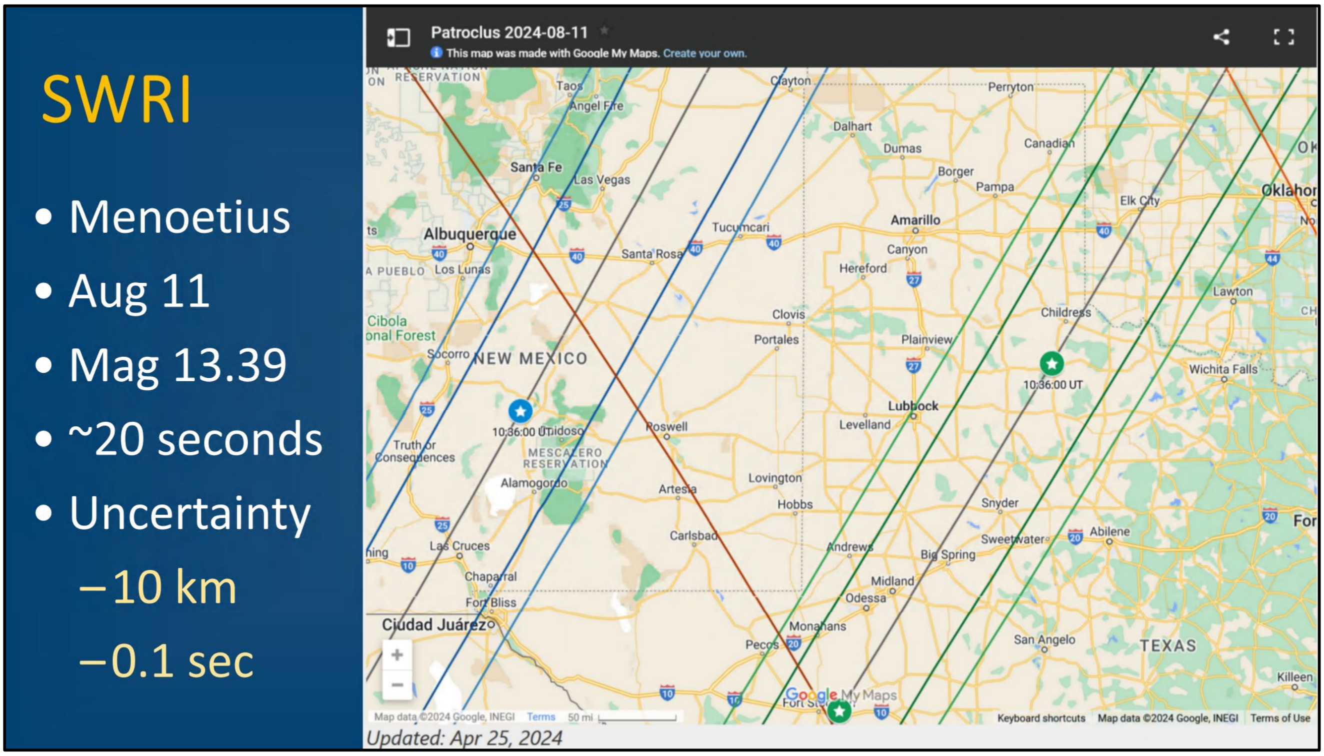
1) All lines are based on the best data we have for the star and asteroid.

2) Center-line will see the longest event.

3) The predicted edge is the best estimate of the edge based on the latest data. If you're near the edge, no event is good data that refines the edge. (That was my position.)

4) The span between the edges is the width of the asteroid, about 100km.

5) The 1-sigma represents the uncertainty in asteroid size and path. If you're positioned out there, a hit or a miss narrows the uncertainty.

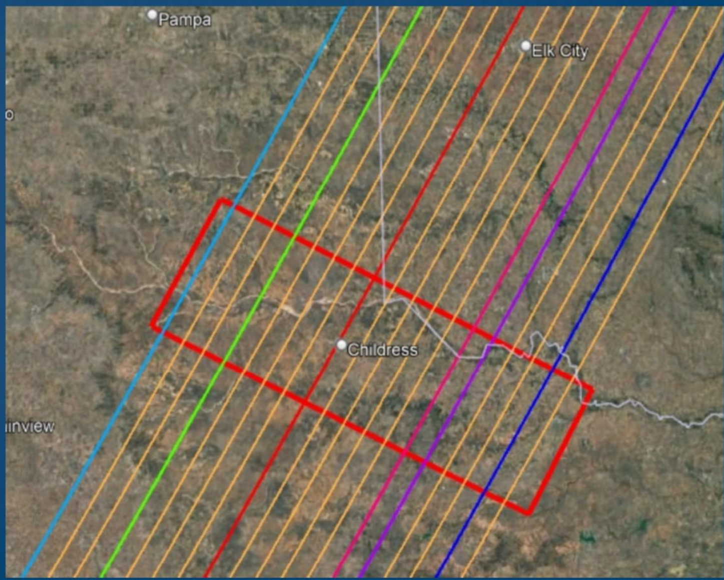


The group from Lubbock all did the Menoetius track and the original plan was to do the event centered around Childress, mostly deployed along US 287. the path is 115 KM or roughly 71.5 miles.

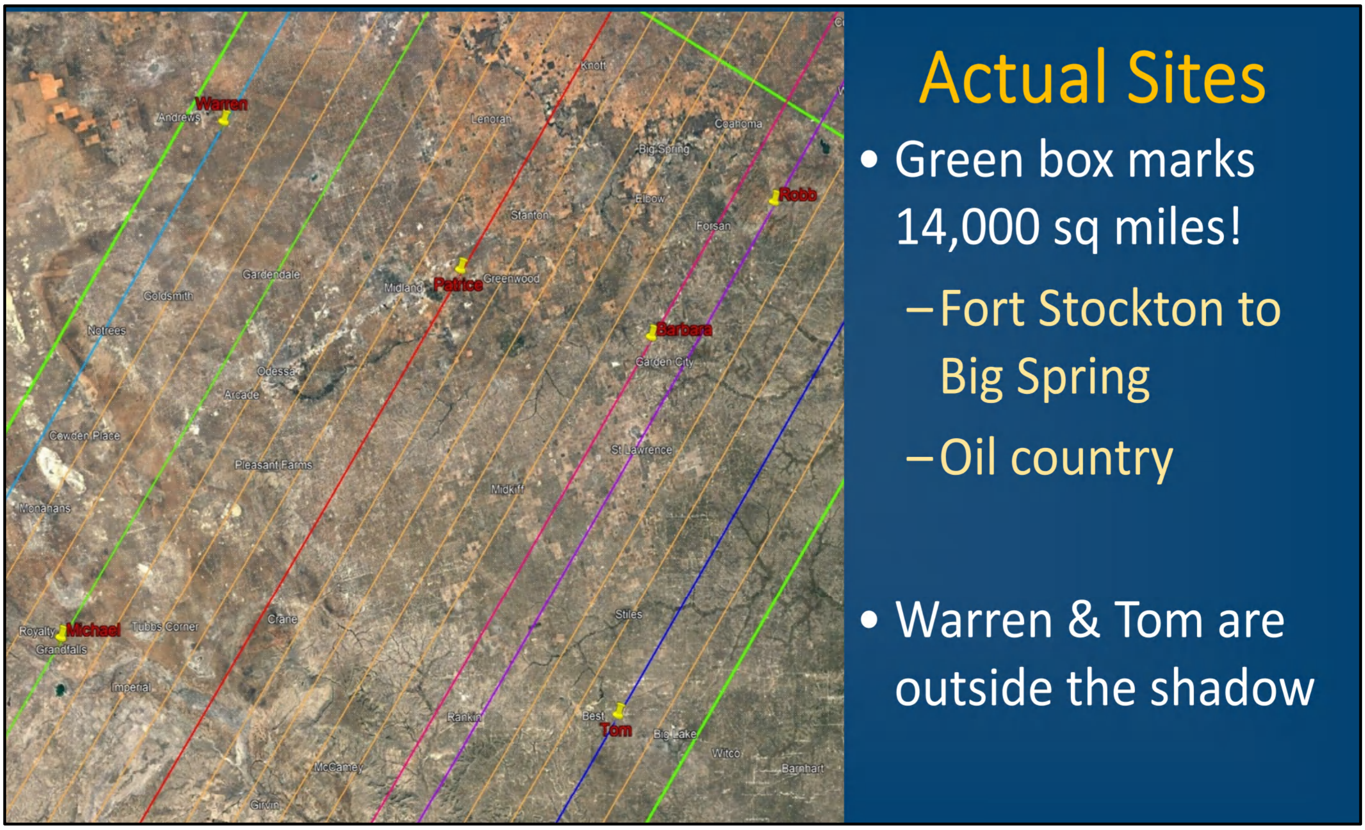
The weather caused great uncertainty and we didn't know the location of the next step until the following morning. We were constantly guessing on locations and watching the weather hoping that we'd eventually have clear skies for the event and hoping that space was somewhat close to home! The delay for the event was even worse in that we were instructed to head from Roswell to Plains, TX and they'd make a decision based on the weather at noon. The event was at 5:33 am, so once the area centered on Midland. The practices were at 3:30-5:30am. It took some dedication!

The Original Plan

- Chord Spacing
  - 5 miles
  - 8.5 km
- Allowed displacement
  - 375 m
  - 1,230 ft (1/4 mile)



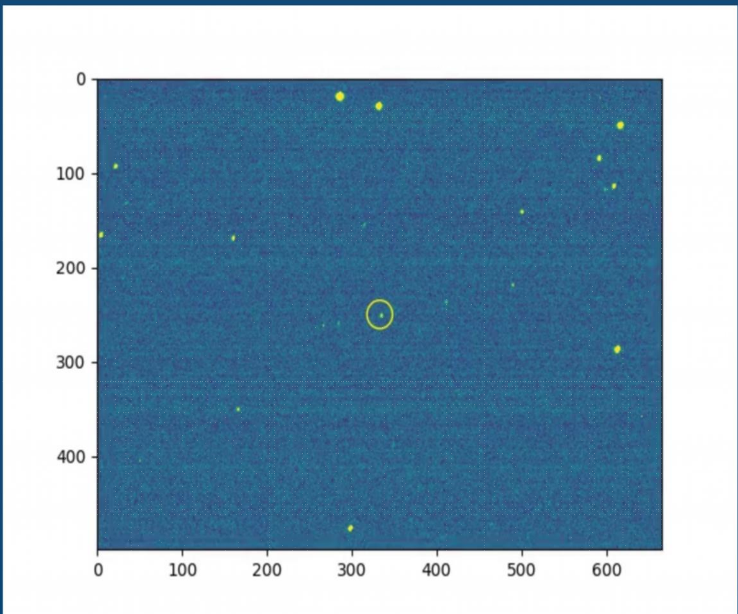
The original event area would be a convenient drive from the Lamar, CO. staging area. Each chord was spaced 5 miles apart and we were to pick a spot not more than 1/4 mile from the chord for our observing site to give the scientists the spacing they needed to collect the resolution they needed for the LUCY mission. We were all well aware of the importance of getting the data from every station!



Each of the teams found the site most suitable for their process within the large box. We took up hotels spread across the land as best suited our needs. I chose the Big Lake area because several areas to the north had few paved roads and appeared to have restricted access for large stretches down the chord. The Big Lake area had the best access with several highways and it turns out that Best, TX was a very good site with dark skies to the south, though I had a highway to the north with multiple good locations, too.

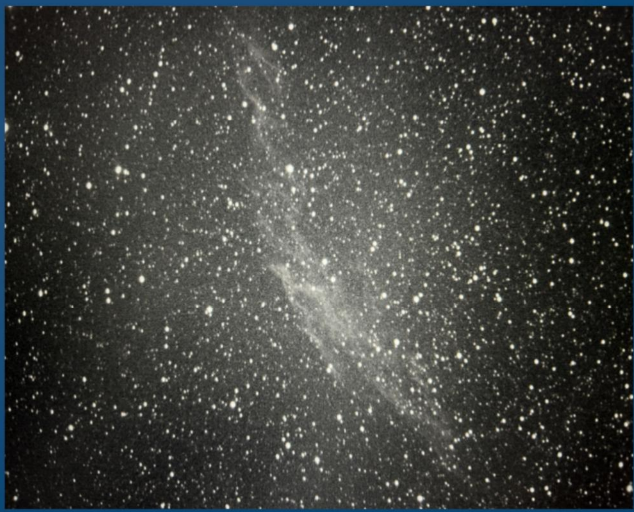
The path between I10 and I20 covered roughly 14,000 square miles!

The Event As Recorded

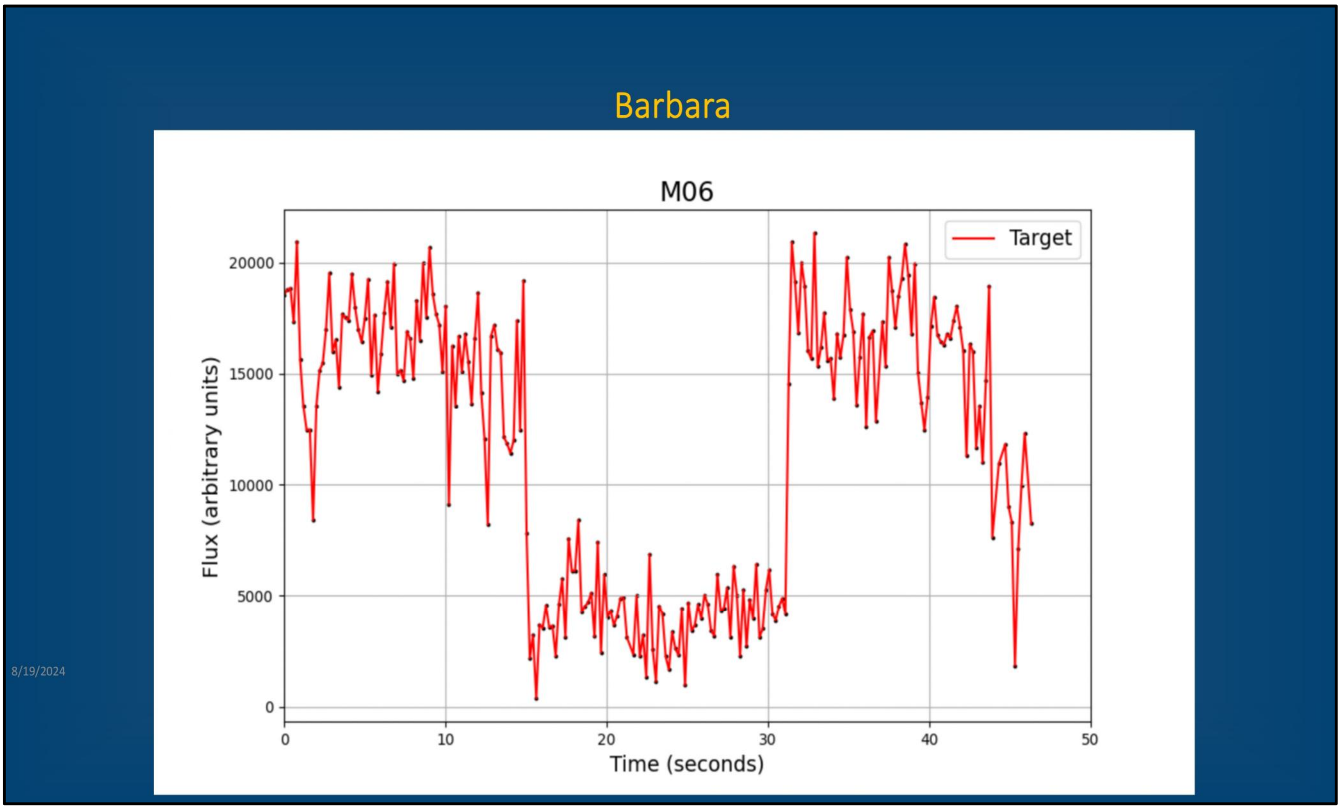


Movie from one of the stations showing the target star disappear. Note that with this scope and camera you can actually see (very dim) the star.

Cameras on other targets

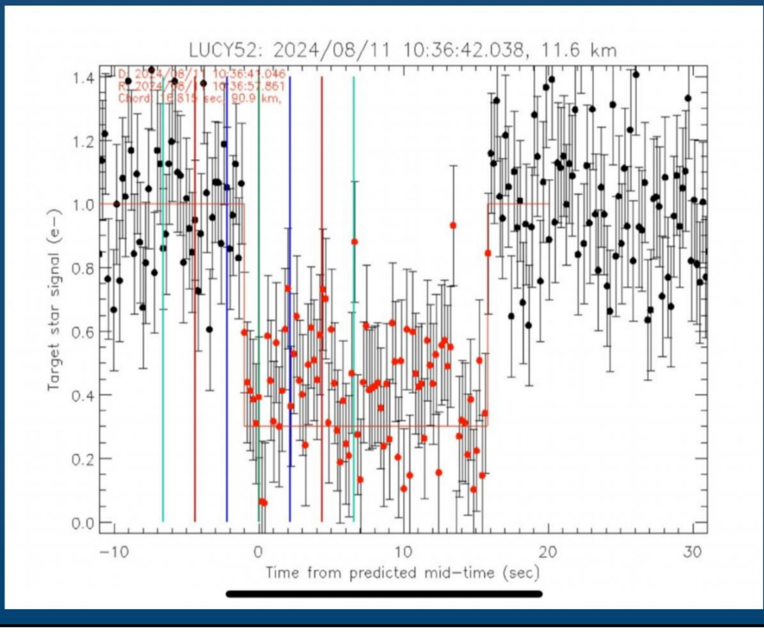


The hyper star cameras a capable of doing excellent astrophotography with guides scopes and an equatorial mount. These quick shots by one of the participants is just the start.



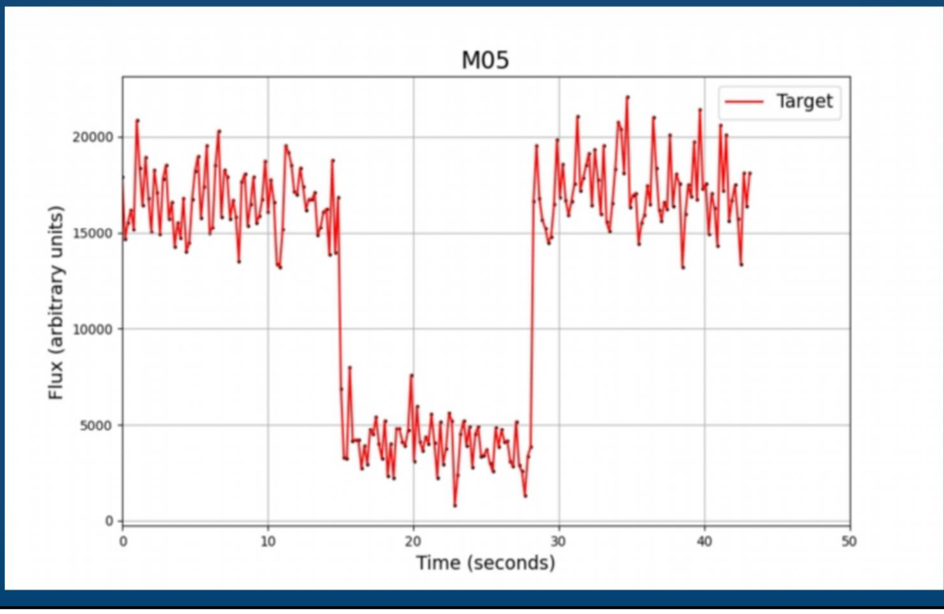
This shows the actual light curve of Barbara’s team near the center. 16 seconds.

Patrice

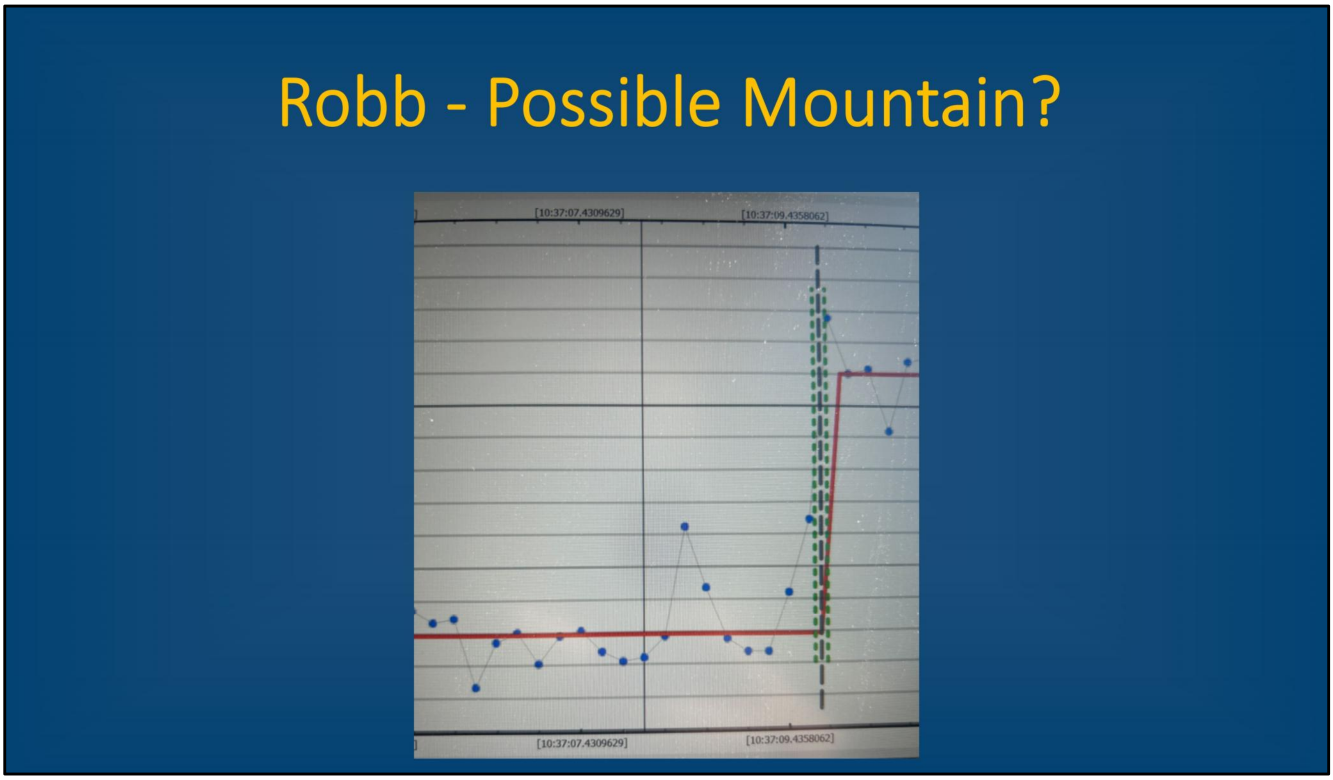


Patrice’s team encountered gusty winds that caused lots of shaking. However, the occultation is still clear despite the noise.

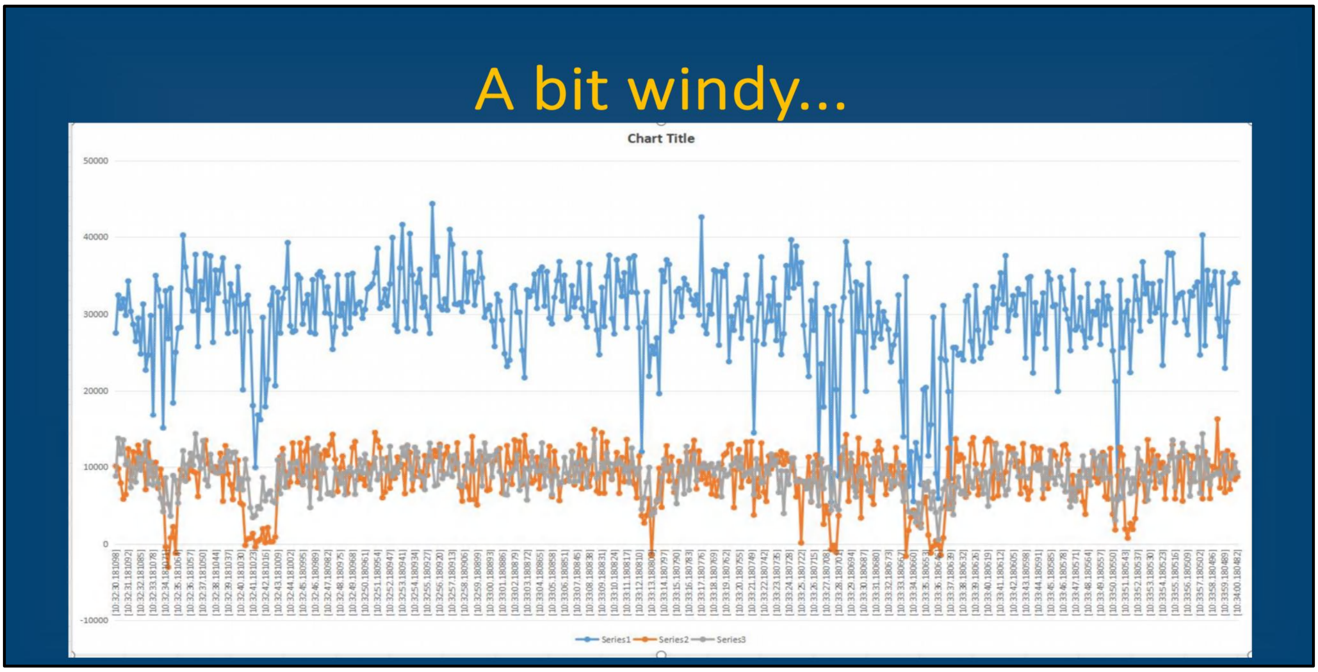
Robb



Robb’s team had a clean result!

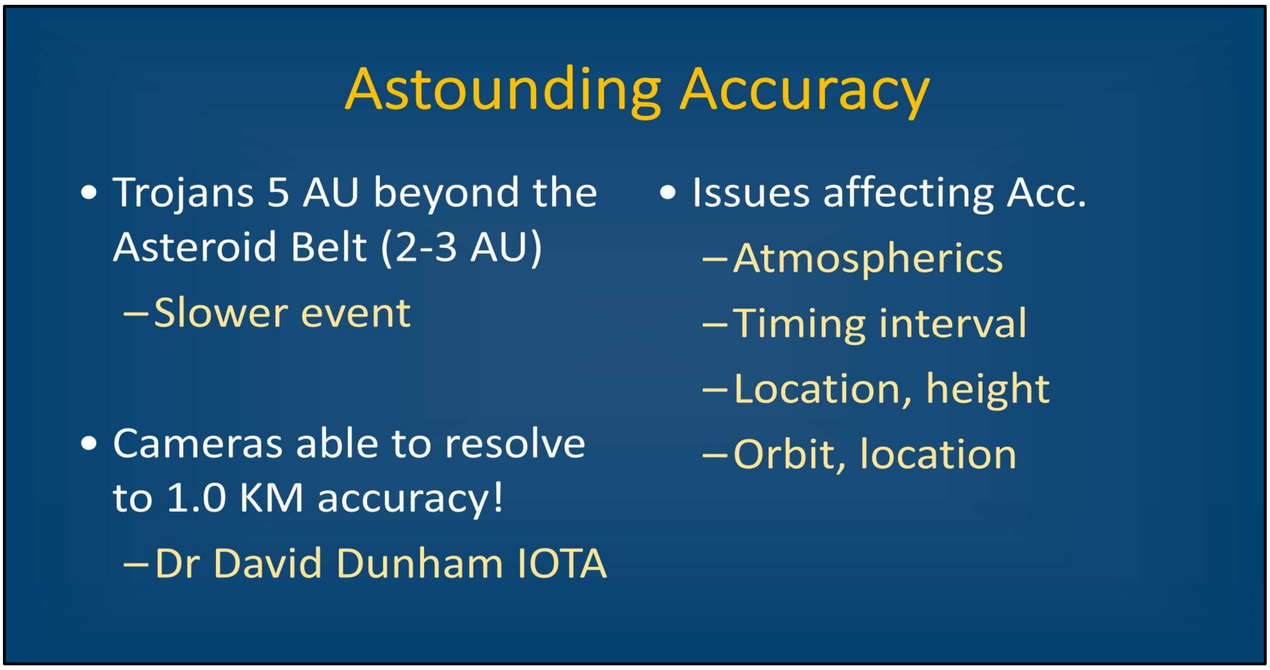


Robb’s team potentially had a large mountain at the edge or was it noise? (It would require a monitoring a second star roughly as bright as the target star and verifying that this wasn’t a variation in overall light levels.)



My position was just outside the shadow path, so I was expecting a flat light curve with a very brief, if any, dimming, but as dawn approached, the wind picked up. Closer to event time, it got very gusty, but I couldn't move my car to block the wind. The square camera at the end of the boom really caught the wind coming around a mesquite bush. The way we control for that is to monitor one or two "control" stars that are about the same brightness as the data star. Since my field of view is a little larger than the full Moon, any star in the field that's roughly the same brightness will work. The dip in the data without a dip of the same magnitude in the control stars is an event. As expected, there is no event at the event time.

Any dip in all three stars of about the same amount is wind shake or an atmospheric event like haze, dust, or clouds. Since there was visible dust or haze in the sky that would dim the stars occasionally, it's not a surprise to see some slow events like the big one on the right. The faster events like the two at the left are from wind shake, where the star's photons are spread across several wells, reducing brightness, even when the software tracks the movement.



The Patroclus system at 5 AU was more distant, but the motion for the Aug. 11th event was slower than usual. So although the star was relatively faint (mag. 13.4), most, if not all, stations that recorded the occultation were able to determine points on the sky plane to under 1.0 km accuracy; as Marc said on Slack, it's turning out to be a beautiful result.

David (Dr. David Dunham, IOTA)

So we were able to define the edge of a 100km body 8 AU distant to less than 1KM with modest equipment!

Links

- LUCY Mission SwRI Lucy.sari.edu/
- LUCY Mission NASA science.nasa.gov/mission/Lucy/

- LUCY occultation campaign Aug 11, 2025: Lucy.sari.edu/occ/predictions/20240811Patroclus/

- International Occultation Timing Association (IOTA) https://occultations.org/
- http://www.poyntsource.com/IOTAmanual/IOTA_Observers_Manual_all_pages.pdf

https://Lucy.sari.edu
https://science.nasa.gov/mission/Lucy

https://Lucy.sari.edu/occ/predictions/20240811Patroclus

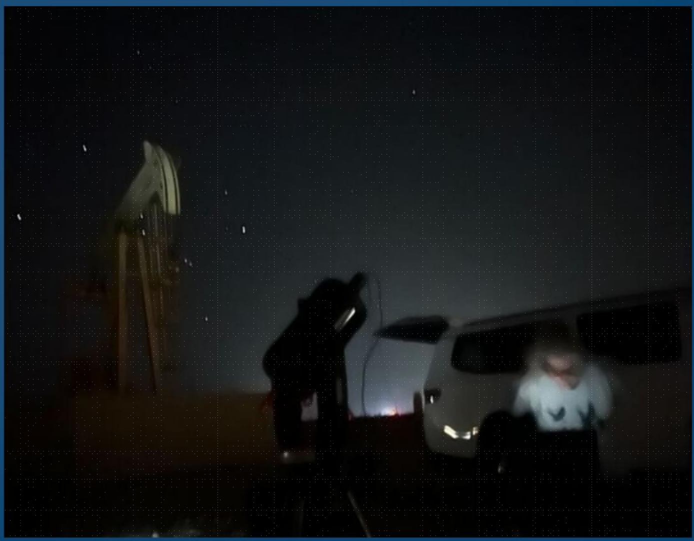
https://occultations.org
https://www.poyntsource.com/IOTAmanual/IOTA_Observers_Manual_all_pages.pdf

Fun Stuff!

Patrice photos

Barbara

Barbara



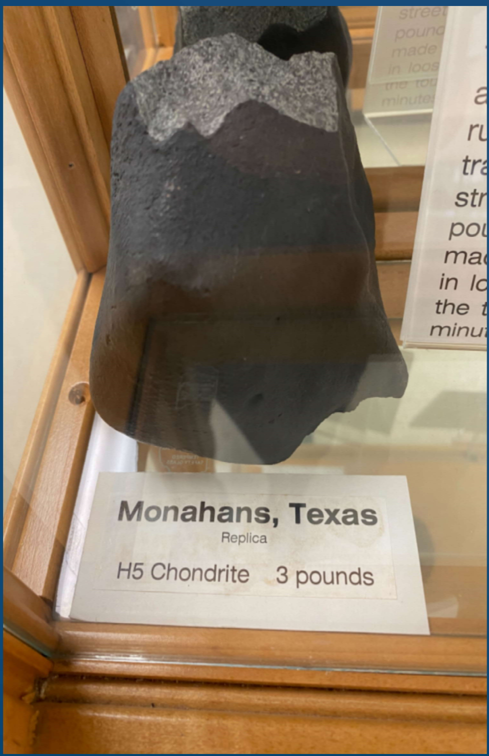
Michael

Michael shared a number of videos from his DropBox account:

https://www.Dropbox.com/scl/fo/vnuyr53hhgmzsm6b79aar/AKA-xk5tIYE4SprN7V1UpaM?dl=0&e=2&rlkey=z1p6lrg94aluhq5jqylhlp1uf&st=55a2xpat

Michael

Michael



Patrice

Patrice

Patrice

The Roswell UFO McDonald’s

Patrice

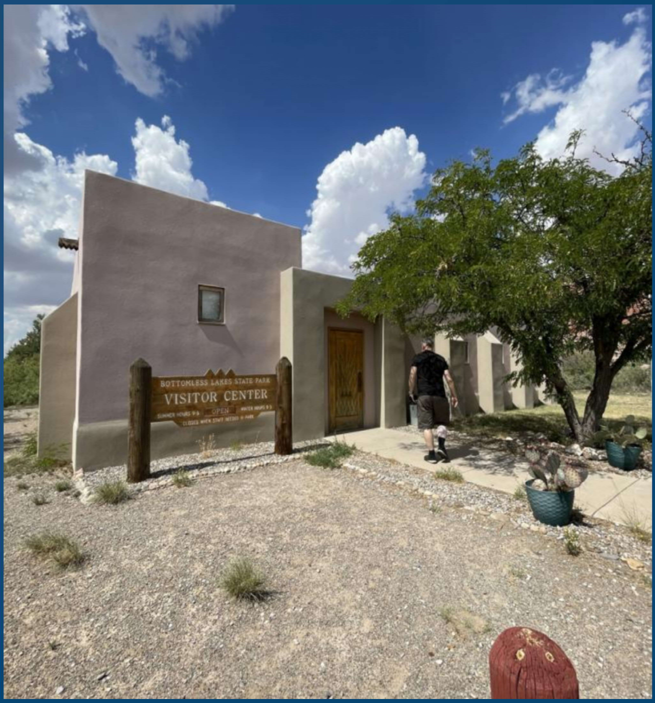
The UFO McDonald's Roswell, NM


MIDLAND
Feel the Energy!

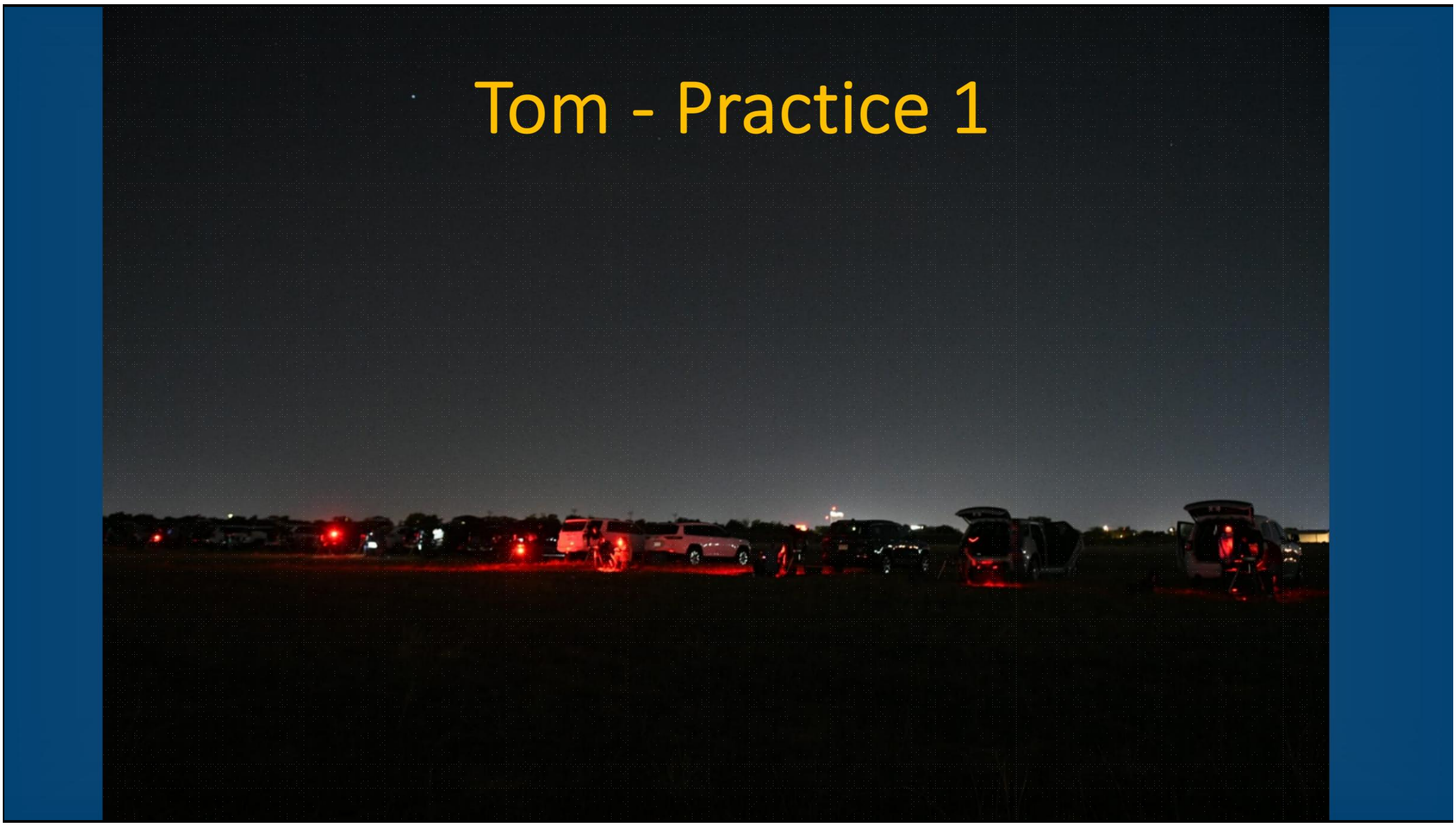
Patrice

Bottomless Lakes State Park, Roswell, NM

Patrice

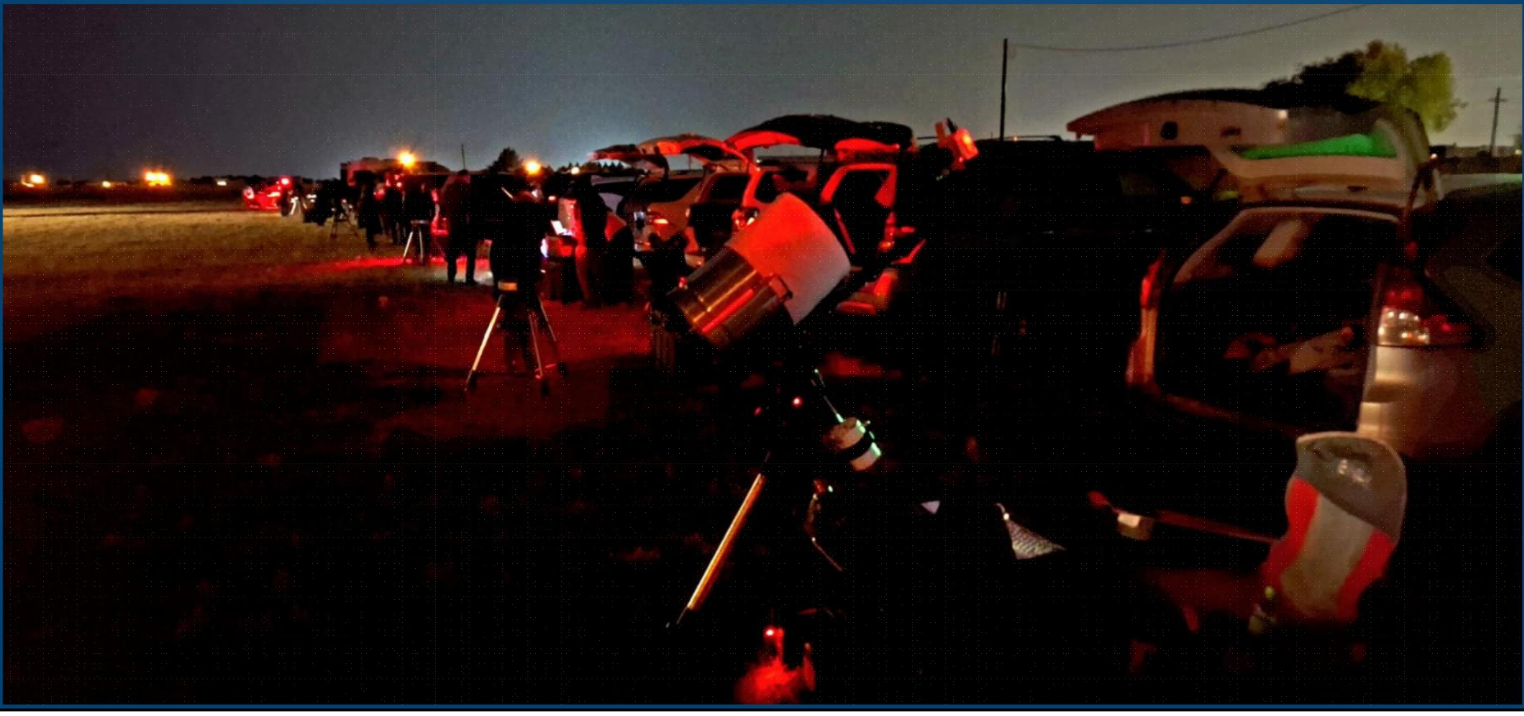


Robb



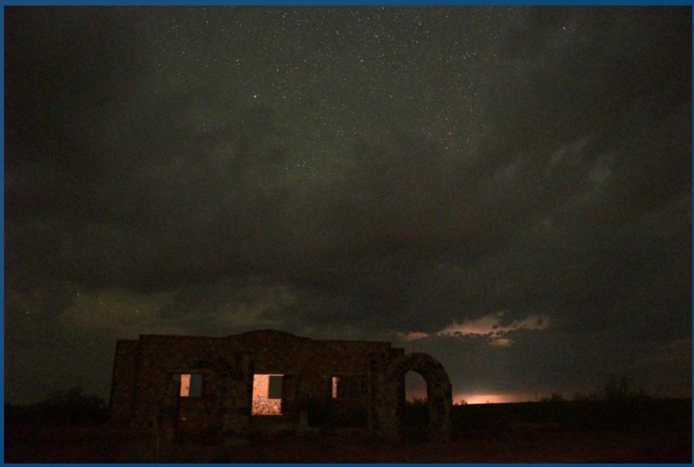
Amarillo practice field looking north at about 5am.

Tom Practice 2



Lubbock practice field - near Slide, TX

Tom - Roswell Storm



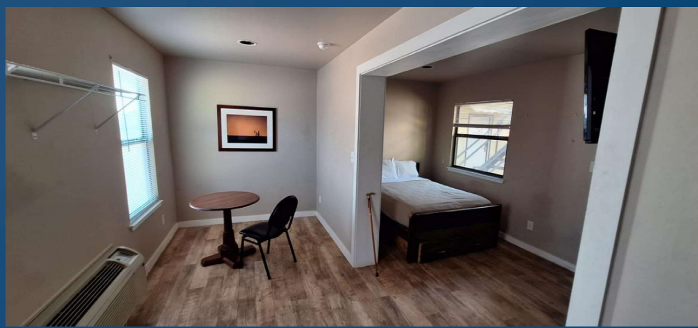
I arrived at Roswell pretty late from the southeast and noticed a storm receding to the north. I didn't stop at the hotel, but drove through the city and headed northeast towards Clovis following the storm. At one point, I took a dirt county road hoping I could see over the countryside to see the storm, but no luck. Back on the highway, it became obvious that I wasn't catching up. After a little more, I found a picnic area about 40 miles from Roswell and tried some shots, but never got a clear shot. Still, I like the barbed-wire fence stars, and storms shot.

On the way back, I noticed a site marked on Google Maps - The Frazier School, on the hill above the Pecos outside Roswell. I stopped, threw a light inside the abandoned school and took some shots of the clouds and stars. Fortunately for me, the storm threw off a few bolts to say goodbye.

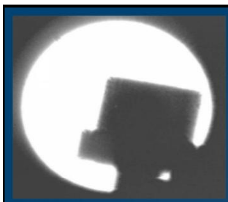
Tom

Bottomless lake practice. At the end of practice, I got out the camera for a few quick shots. I was tired enough that I didn’t notice the camera was focused on the foreground objects and the stars were out of focus. However, the larger disk of the stars emphasized the colors. Amy, one of the participants and an SwRI staff member asked if I would get a shot of her. It was really fun meeting like-minded crazy people. LOL!

Tom



This was the oilfield hotel in tiny Big Lake. Now I know why they didn't have outside shots on the web site. Yes, these are oilfield equipment shipping containers that are larger than the standard train, truck, and ship containers. The rooms were nice, well insulated, but rather spartan. Each block had four rooms with a catwalk and stairs for the upper two. They were pretty well soundproofed and I couldn't hear my upstairs neighbor walking around inside or on the catwalk. It was a bit expensive, as everything in the oil-patch tends to be, but it was only a few minutes away from my primary site.



Tom

10” f/4.8 (f/1.8 with reducer) and Astrid camera

My scope is quite different from the SwRI scopes. I put a 10” f/4.8 mirror inside a 12” menudo pot with a 1”square extruded tube frame leading to a boom holding the focuser over the mirror center with no secondary. I use a 0.37x focal reducer that brings it to f/1.8. Given the insane central obstruction of the 2” focuser and boxy camera (see the out-of-focus image at top right) and the very wide FOV, image quality isn’t this scope’s forte, but it does the job well enough for occultations. Collimation is super easy with a laser collimator, though I do need to move the focuser from time to time if the boom seats a little off. Once the laser hits the middle of the scope, I tweak the collimation bolts to return the laser beam into the collimator’s internal target.

The Astrid camera is a project by an IOTA member who used a Raspberry Pi 4, Sony camera chip, and GPS bits to create a fantastic system for occultations. The camera knows where it is in the sky and on land and when it is, so it can plate solve (identify the stars) and tell you or the mount how far to move to get to the target area. Once there, it will keep time and automatically record the event at the proper time, with enough time before and after to detect any unknown companions as well. It’s under development and a little rough, but a stunning achievement.

You control the camera wirelessly with a tablet or laptop - The image on the right is the remote image of the camera’s desktop and imaging software.

Warren

Warren

Lubbock practice

Roswell practice

Warren

Event night