

Occultations

(Last updated: 2019 February 07) . (Updated Introduction and Predictions – 2026 June 30)

Introduction (EAON is Superseded by IOTA)

Introduction to [Observing and recording](#) by the Assistant Director (external page).

An [Occultation Primer](#) written by G .Viscome (IOTA-US). Pdf download.

Information on observing occultations can be found on the [Introduction](#) and [Circulars](#) pages on the European Asteroid Occultation Network (EAON) website. The EAON site should be considered the prime source of information on all matters relating to occultations. If there are differences between this site and theirs then please assume EAON are correct.

From time to time during the course of its orbit around the Sun, an asteroid will appear to pass in front of a star or another solar-system body as seen from Earth. Such a passage is referred to as an occultation. As the asteroid passes in front of the star, the latter will appear to dim or disappear altogether. The track width of such an occultation is very narrow – approximately the same width as the asteroid, i.e. typically no more than ~100 km or so. When the track intersects the Earth there will be only very few potential observers able to witness a positive occultation situated along it. Every observation whether positive or negative, is important in defining the limits of the track and hence the size and shape of the occulting body.

Occultations are the only way, apart from spacecraft missions to asteroids and radar observations of nearby objects, to determine the approximate size and shape of those bodies and are, of course, much cheaper and straightforward. They are an especially powerful way of studying small, very distant Trans-Neptunian objects, by watching stars, the light from which is blocked by the TNO for a few seconds. The [Lucky Star project](#) led by Bruno Sicardy in collaboration with groups from Paris, Meudon, Granada and Rio de Janeiro, provides [predictions](#) and oversees worldwide observing campaigns for the larger TNOs.

[The International Occultation Timing Association \(IOTA\) website](#)

[International Occultation Timing Association/European Section \(IOTA/ES\) website](#)

Predictions

Predictions of possible occultations are available from [IOTA call 4 observation](#) and [Steve Preston's website](#). Predictions are necessarily only approximate as the orbits of most asteroids and the positions of most stars are not known to the required level of precision to accurately define occultation tracks well ahead of time. The margin of uncertainty has improved enormously in recent years, thanks to the Gaia astrometry, and is typically better than +/-50 km so that the probable area of visibility is accurate in general terms. Uncertainty is now rarely greater than +/-100 km in most cases. The predicted times will be more accurate and the probable error is of the order of +/-10 seconds.

Astrometry is sometimes requested prior to the event to allow the predicted track and time of occultation to be refined. Particularly for Near Earth Asteroids (NEA). E.g [Didymos and Dimorphos](#)

Worldwide Predictions from the current BAA Handbook

Here are the predictions as listed in the 2019 Handbook of the BAA (Example).

OCCULTATIONS OF STARS BY ASTEROIDS AND DWARF PLANETS

Occultation events for 2019 were selected by Tim Haymes from a world list of events computed and published annually by Edwin Goffin of the VVS (Flemish Astronomical Association). The BAA is very grateful to Mr Goffin for permission to publish his predictions in the Handbook. These continue to be a valuable resource.

In the table of predictions below:

Time = UT of closest geocentric approach.

Region of Visibility codes (RoV):

1 = North and Central America,

2 = South America,

3 = Europe, North Africa and the Middle East,

4 = South Africa,

5 = Russia,

6 = Pakistan, India, and SE Asia,

7 = Japan, China and Taiwan,

8 = Australia and New Zealand.

ASTEROID OCCULTATIONS										
REGIONAL PREDICTIONS										
Date 2019	Time h m	Minor Planet No.	Name	Diam (IRAS)	Star ID	V	Max. Dur. sec.	Mag. drop	RoV	
Jan.	4 3 8.2	271	Penthesilea	0.05	PPMX 5017717	11.09	5.3	2.8	1, 3	
	4 3 13.2	479	Caprera	0.08	TYC 0758-01699-1	11.09	7.8	1.6	1, 3	
	4 23 20.1	90	Antiope	0.07	TYC 1868-00281-1	10.83	8.7	2.6	1, 3	
	17 18 22.4	25	Phocaea	0.05	TYC 4791-00936-1	11.13	5.9	1.6	3, 5, 7	
	25 20 10.8	46	Hestia	0.09	TYC 0634-00468-1	10.27	7.1	2.8	3	
	28 19 2.8	667	Denise	0.07	TYC 4792-01753-1	10.77	6.3	2.4	3	
Feb.	2 3 16.8	145	Adeona	0.08	TYC 5618-01134-1	10.37	6.3	3.2	3	
	2 5 3.3	260	Huberta	0.04	HIP 78503	9.71	4	5.8	3, 7	
	12 20 15.3	571	Dulcinea	0.04	UCAC5 532-047602	9.5	3.5	5.4	3	
	19 2 42.5	186	Celuta	0.04	TYC 2501-00455-1	10.47	3.9	2.5	1, 3	
	21 21 31.9	1977	Shura	0.04	TYC 0833-00142-1	10.72	4.5	4.6	3, 5	
	22 1 1.8	623	Chimaera	0.05	TYC 0239-01406-1	9.75	4	4.2	1, 3	
Mar.	7 4 57.5	108	Hecuba	0.04	TYC 0841-00363-1	11.11	5.4	1.7	3	
	8 3 31.7	788	Hohensteina	0.07	UCAC5 417-056707	10.62	15.7	2.4	3, 5	
	28 20 23.6	663	Gerlinde	0.06	TYC 0155-02781-1	10.49	7.1	4	3	
Apr.	1 20 23.4	80	Sappho	0.05	TYC 1299-01931-1	9.9	3.2	3.1	3	
	7 3 31.2	155	Scylla	0.04	TYC 4973-00045-1	9.71	3.6	5.7	1, 3	
May	22 0 31.1	914	Palisana	0.09	TYC 6282-00100-1	9.48	7.1	2.3	3, 4	
	28 0 20.1	225	Henrietta	0.09	TYC 0355-00548-1	10.24	10.7	2.8	3	
Jun.	7 18 48.8	121	Hermione	0.10	UCAC5 401-055242	10.66	23.1	2.6	3, 5	
	12 1 30.6	487	Venetia	0.04	UCAC5 440-055388	9.73	8.6	3.2	1, 3	
	23 1 19.2	130	Elektra	0.12	TYC 5239-01435-1	10.99	21.2	1.4	3	
Jul.	26 0 18.5	489	Comacina	0.09	TYC 5157-01423-1	11.02	10.8	2.2	3	
	26 4 48.9	94	Aurora	0.10	TYC 1216-00604-1	10.48	9.9	2.8	3	
	29 19 18.7	234	Barbara	0.04	UCAC5 447-056858	11.07	3.9	2	3	
Aug.	16 3 39.2	759	Vimifera	0.06	TYC 0582-00408-1	9.95	5	3.3	3	
	17 0 12.5	709	Fringilla	0.04	TYC 2418-01109-1	9.5	3	5.3	3	
	17 23 59.2	759	Vimifera	0.06	UCAC5 488-134811	10.68	5	2.6	3	
	26 0 40.4	1015	Christa	0.06	UCAC5 426-001328	10.09	15.7	3.8	3, 5	
	28 3 20.9	624	Hektor	0.04	TYC 5246-00764-1	10.16	7.8	4.5	1, 3	
Sep.	7 23 48.3	888	Parysatis	0.04	HIP 4643	10.72	4.9	2.4	3	
	11 20 34.6	91	Aegina	0.06	TYC 6816-00286-1	10.63	7.5	3.7	3	
	18 19 26.1	200	Dynamene	0.07	UCAC5 314-167327	11.04	11.6	2.6	3	
	24 22 24.3	113	Amalthea	0.04	TYC 0040-00504-1	10.93	5.3	1.7	3	
Oct.	2 19 57.9	795	Fini	0.05	TYC 4672-00259-1	10.67	5.2	3.2	3, 5	
	6 4 49.1	120	Lachesis	0.07	TYC 1943-00184-1	11.07	6.1	2.8	3	
	8 0 55.2	419	Aurelia	0.05	TYC 0816-00536-1	10.44	4.9	4.1	3	
	9 21 43	547	Praxedis	0.06	UCAC5 433-107716	10.93	6.8	2.8	3	
	10 22 16.4	578	Happelia	0.05	HIP 17043	7.27	9.3	6.5	3, 5	
	14 2 41.5	1048	Feodosia	0.04	TYC 1875-00091-1	11.09	9.8	4.3	3	
	15 6 36.3	144	Vibilia	0.12	TYC 1896-01786-1	10.94	13.2	1.7	1, 3	
	18 2 36.5	508	Princetonina	0.06	TYC 1949-01606-1	10.61	6.4	3.7	3	
	29 23 43.6	87	Sylvia	0.11	TYC 1932-00469-1	10.05	21.8	3.3	3, 5	
Nov.	4 1 10	567	Eleutheria	0.05	UCAC5 591-039832	10.92	13.3	3.8	3, 5	
	9 0 21.7	480	Hansa	0.04	TYC 0176-01146-1	10.38	4.9	2.6	3	
	27 20 56.5	445	Edna	0.07	TYC 2905-01262-1	11.16	7.1	2.4	3, 5, 7	
Dec.	3 0 54.5	154	Bertha	0.08	TYC 0885-00412-1	9.64	6.4	3.8	3, 5	
	5 20 21.1	1390	Abastumani	0.06	UCAC5 686-045133	11.09	7.9	3.7	3, 6	
	10 23 54.4	309	Fraternitas	0.04	TYC 1804-00682-1	9.19	4.8	5.2	3	
	12 1 39.4	87	Sylvia	0.13	TYC 1947-00290-1	10.98	29	2	1, 3, 5	
	19 2 49	329	Svea	0.07	UCAC5 439-039297	10.67	10.5	3	1, 3	
	24 7 8	159	Aemilia	0.05	TYC 5555-00367-1	10.21	4.1	3.9	3	

ASTEROID OCCULTATIONS

TNO GLOBAL PREDICTIONS

Date 2019	Time h m	Minor Planet No.	Name	Diam (IRAS)	Star ID	V	Max. Dur. sec.	Mag. drop	RoV
29	1 28.6	743	Eugenisis	0.04	TYC 0806-01299-1	10.44	5.8	3.6	3
Jan. 11	14 30.7	944	Hidalgo	0.03	UCAC5 850-010266	14.8	5.6	0.6	1,5
Mar. 9	9 22.2	136472	Makemake	0.12	UCAC5 572-047492	14.59	181.6	2.6	1,2
Mar. 13	8 35.8	10370	Hylonome	0.01	UCAC5 357-160286	14.8	6.1	7.3	2
May 20	12 11.1	38628	Huya	0.02	UCAC5 420-063781	14.23	20.1	5.2	7
Jun. 14	17 38.4	28978	Ixion	0.03	UCAC5 304-133829	12.77	31.9	6.8	4,8
Jul. 8	9 7.7	38628	Huya	0.02	UCAC5 420-063419	12.51	26.5	7	8
Jul. 15	0 41.6	10370	Hylonome	0.01	UCAC5 357-155269	14.06	4.6	7.8	2
Jul. 17	12 44.1	134340	Pluto	0.1	UCAC5 340-173206	12.91	98.4	1.8	7
Jul. 24	1 25.4	83982	Crantor	0.01	UCAC5 350-178947	14.44	3.3	7.2	2
Aug. 8	21 42	10199	Chariklo	0.02	UCAC5 323-192195	15	12.3	3.8	2,4
Sep. 5	14 57.5	134340	Pluto	0.1	UCAC5 339-167569	13.42	186.1	1.6	6,7
Sep. 13	23 23	66652	Borasisi	0.01	UCAC5 435-113798	13.81	11.1	8.3	5
Dec. 16	5 16.1	32532	Thereus	0.01	UCAC5 427-047196	13.51	5.7	6.8	2

MAJOR PLANET PREDICTIONS

Date 2019	Time h m	Planet Name	Diam "	Star ID	V	Max. Dur. sec.	RoV
Feb. 27	23 51	Mars	5.3	TYC 1215-01062-1	9.97	190	1
Mar. 9	10 28	Mars	5.1	UCAC5 536-004707	9.86	183	7
Apr. 10	11 55	Mars	4.5	HIP 20038	8.24	163	8
Jun. 3	19 33	Jupiter	45.9	HIP 84543	9.4	8762	3,6,7,8
Oct. 21	11 49	Jupiter	34.1	HIP 84936	8.75	4639	6,8
Oct. 13	8 19	Neptune	2.3	UCAC5 418-145773	12.4	2531	1,8

Using the tables

In the table of predictions : Time = UT of closest geocentric approach.

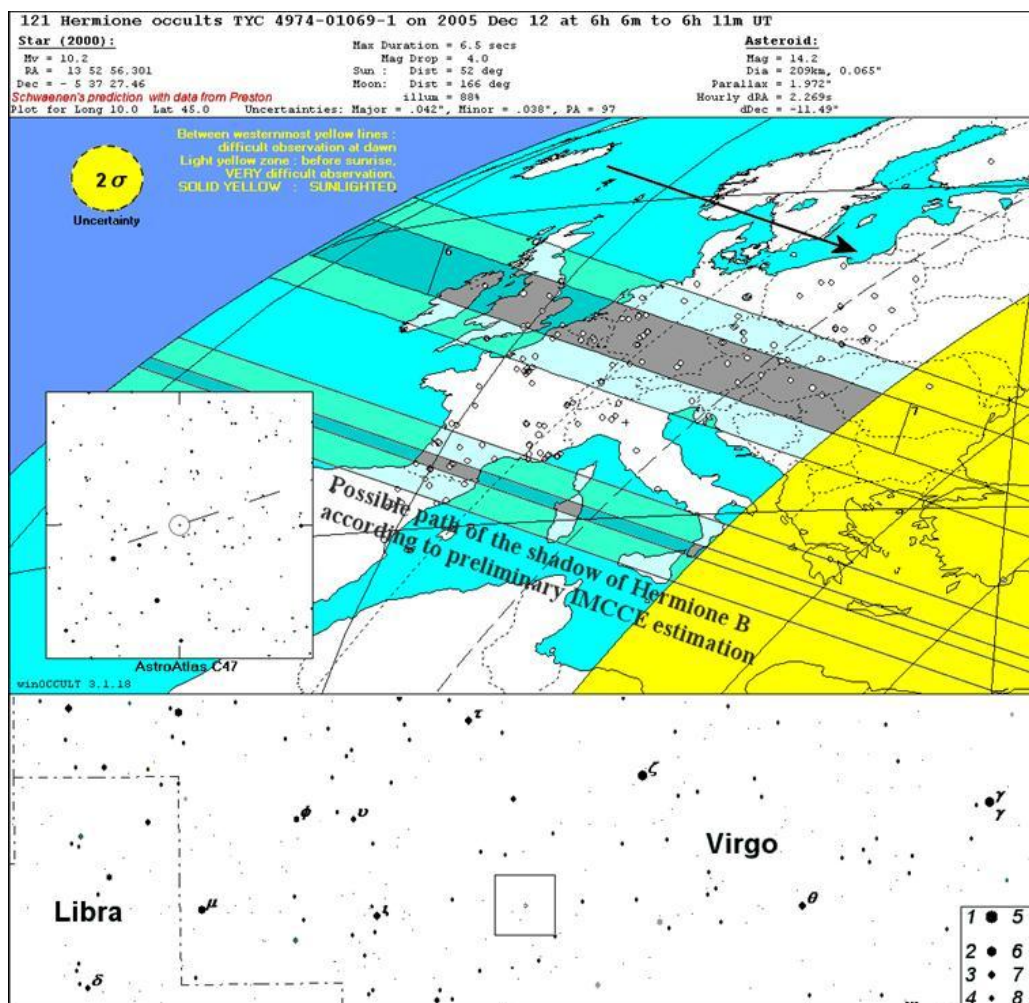
Region of Visibility codes (RoV): 1 = North and Central America
 2 = South America
 3 = Europe, N. Africa and the Middle East
 4 = South Africa
 5 = Russia
 6 = Pakistan, India, and SE Asia
 7 = Japan, China and Taiwan
 8 = Australia and New Zealand

Where diameters are not listed in the IRAS catalogue, an assumed value of A, the geometric albedo, has been used to calculate a value for the asteroid diameter. Predictions computed by Edwin Goffin. Track details are available from the Flemish Astronomical Association ftp site:

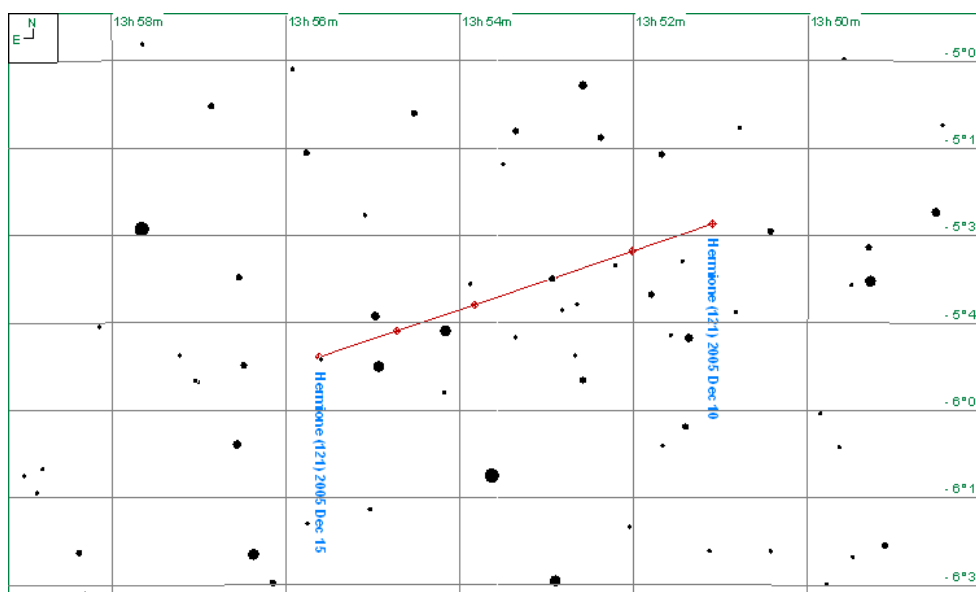
<http://bedekkingen.vvs.be/predictions/Asteroids2018>

Example of an EAON chart.

An example of an EAON chart is shown below. It includes star and asteroid data, duration of occultation, drop in magnitude of the star, time of the occultation, the track and finder charts. **For current predictions** refer to Occult Watcher Cloud ([OWC](#))



I would strongly recommend obtaining the latest orbital elements for the asteroid from the [Minor Planet Center's Minor Planet and Comet Ephemeris Service](#) and plotting its predicted track on a planetarium program such as [Megastar](#) or [GUIDE](#). Using a program with which you are familiar greatly reduces the chances of observing the wrong star. The example below shows the track of the asteroid from 10 – 15 Dec with the asteroid occulting the target star on 12 Dec.



Observing and timing the occultation

Spending several minutes staring at a star field through a telescope can be quite tiring and the eyes start to play tricks. This is particularly the case if the target star is difficult to see due to for example; its faintness, thin cloud or a bright sky background.

Practicing before the event is therefore to be recommended. You may find out that some obstacle is blocking your view of the event particularly if the target star is low down. It will also help you to identify the correct star field and, if the asteroid is bright enough, see it moving towards the target star. Such practice will also enable you to set the eyepiece in such a position that the event can be viewed from a comfortable sitting position if at all possible.

An alarm clock with two alarms is extremely helpful. Set the first alarm to one minute before the predicted time and the second for the end of the observing period. This way you can increase your concentration nearer the predicted time and know when to stop.

At the telescope, monitoring of the target star should commence some minutes before the predicted time and continue for at least the same period after it (the occultation prediction data will usually include a suggested time period). At the instant of occultation the brightness will reduce by the predicted amount, which depends on the relative brightness of the asteroid and star being occulted. Beware also when making an occultation observation of so-called secondary events which may happen some time either side of the primary occultation. Although termed 'secondary', such an event may also produce a dip in brightness virtually identical in magnitude to that of the primary event. Any secondary event may represent an occultation by a satellite of the minor planet.

See [EAON Circular #5, Parts two, three and four](#) for detailed explanations of various methods of recording the time of the occultation.

Time keeping

A radio controlled clock which uses the broadcast time signals to update the display will indicate the time to the necessary degree of accuracy. One's error, or Personal Equation (PE), can be calculated and the occultation timings modified accordingly.

See also EAON [Circular #5, Part Five, Short notes about time-keeping sources](#).

Timing example

An example of timing using a stop watch (with lap timing feature) and a radio controlled clock and assuming a 'Positive' result.

Activity	Stopwatch	Stopwatch time	
Star dims or winks out completely	Press Start	0	7 2 (
Star returns to normal brightness	Press Lap	6.5 secs	2 (
Radio controlled clock indicates a complete minute eg; 21:06:00	Press Stop	6 mins 12 secs	

Personal Equation

One's reaction time or Personal Equation (PE) should be calculated and subtracted from the times reported. The PE can be estimated using a stop watch as follows;

- cover the seconds, tenths and hundredths of second's digits
- start the stopwatch
- press stop when the next full minute is indicated

The indicted seconds and fractions of seconds will be your reaction time. Repeat the exercise say thirty times and take the average (mine was 0.3 secs). See [EAON circular #5, Part one, Personal equation and accuracy](#) for a more detailed explanation with examples.

Here is a [link to a simulation of an occultation allowing the observer to determine their 'Personal Equation'](#) . And a [more amusing example](#).

Recent advances in recording, timing and analysis

The use of sensitive video cameras was demonstrated in the UK by the late Andrew Elliott in the 1990's. (ARPS Assistant Director, Occultations 1990-2010). Section members now tend to use video where possible and record onto videotape. This though is being superseded by digitisation to a PC using a USB (A/D) converter and free software such as *Virtual Dub*.

Digital recordings (known as AVI) are not affected by the observers eye / watch coordination which can be problematic for faint events. 80% of predictions are magnitude 11 or fainter.

Video alone does not produce a time for the event. Frame counting will produce an accurate duration for an occultation, but the start and end time of the recording or the event, needs to be managed. This is effectively carried out using a Time-Text overlay on the video output before recording. Examples are listed in the Table 2. Table 1 lists typical video cameras used in occultation work:

Camera	Exposure
Mintron 12V1C-EX	1/50 to 5 sec
SCB-2000N	1/50 sec
WAT-120N	1/50 to 10 sec
WAT-120N+	1/2000 to 10 sec
WAT-902H	1/50 sec
WAT-902H2 Ultimate	1/50 sec (high gain)
WAT-910HX	1/2000 to 5 sec (replaces the WAT 120N+)

Table 1 – Examples of video cameras available in the UK or second-hand

Unit	Type / Distributor
Voltek CT230	UT Date generator (Manual synchronization *)
GPSBOXSPRITE2	GPS generated text overlay made by BlackBoxCamera **
IOTA VTI	Video Time Inserter made by Video Timers for IOTA. **

Table 2 – Time Text Overlay

[* 1 sec time resolution, ** 0.001 sec time resolution on every frame]

Type	General Description of Method
CCD drift scan	See Peter Birtwhistle's webpages under 'Gallery' / 'Occultations' and also John Broughton's detailed discussion of the technique
DSLR / Refractor	Drift Scan using stopwatch and time signal (brighter stars)
ASI120, ASI585	Multiple exposures (eg 100ms) saved as SER file (12-bit)
QHY174mGPS (cooled)	SER or FITS (12bit) with 2×2 binning (and ROI is possible) with GPS time on frame (needs SharpCap)

Table 3 – CCD Cameras and Webcams

[Serial file, is a packaged sequence of images, ROI = region of interest, sub frame]

Advantages of CCD or video

- 1) Exposure can be increased to detect fainter stars or TNOs, or allow use of smaller telescopes.
- 2) Occultations where the magnitude drop is too small to see by eye can be recorded (0.1-1.0 mag)
- 3) Permanent record created that can analysed by easy-to-use software (esp. *TANGRA-3* by Hristo Pavlov)
- 4) No personal equation and no errors.

Analysis techniques

TANGRA 4 [software](#) (free download, then update to v4) will analyse star brightness in an AVI or SER file and produce a light curve with timings. This application is the basis of most results. DRIFT scan requires some additional analysis (see the photometry/astrometry sub-section). Examples of asteroid occultation light curves and reports can be found on Tim Haymes' webpage at: <http://www.stargazer.me.uk/index.htm>

Observation Planning in the 21st Century

Note that there are two software applications to assist observers select and prepare for events:

1) [Occult Watcher](#), and 2) [C2A](#) (computer-aided astronomy-) planetarium charting software.

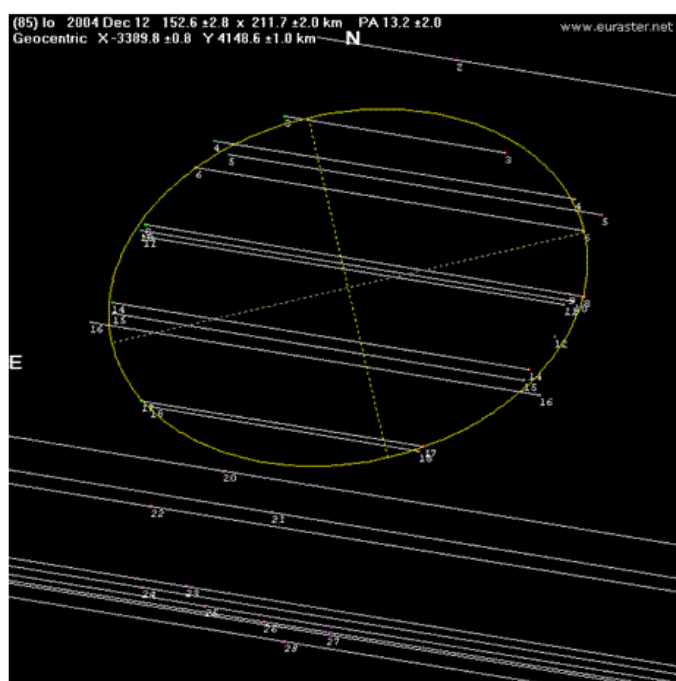
Occult Watcher is especially useful as it runs in the background and provides a real-time comprehensive listing of occultation events potentially observable from your own location. You can also register your observing station with others on an interactive GoogleMap.

Reporting

By joining the PLANOCULT mailing list (use link on the [Euraster](#) site) observers can see the occultation reports submitted by other observers. The ARPS Director, Richard Miles, and ARPS Occultation Coordinator, Tim Haymes, are members of PLANOCULT and can advise on reporting. Reports are now submitted to [SODIS](#).

Information about the sizes, shapes and positions of asteroids comes from the occultation observations. Each positive observation gives a chord length across the minor planet and its precise position at that time. It is well worth attempting to observe the occultation if your site is close to but not on the predicted track. Such negative observations (ie; no occultation observed) help to set limits on the size of the asteroid. If poor weather prevents observation then a report should **not** be submitted.

Below is an example of how the approximate shape of an asteroid was derived from a number of observations. The importance of ‘Negative’ results are clearly illustrated. Observers 2 and 20 (and some others) didn’t see the occultation but their results put limits on the size of the asteroid.



Results

European reports 1998 to 2022 can be found on the [Euraster archive](#)

UK report summary can be seen here: [Log File](#) (external page)

Conclusion

You have to be fairly dedicated to do this stuff. There used to be the 'Rule of Ten' i.e. for every 10 occultations you prepare for, the weather will wash out 9 of them and for every 10 you actually observe you may get one 'Positive'. Now that predictions are much more accurate, the chances of observing a positive occultation are substantially higher (1 in 3), but of course the weather still prevents observations in a lot of cases—! Remember for those observing close to the edge of the predicted track, 'Negatives' are just as important as 'Positives'. With predictions continuing to improve, the ratio of 'Positives' to 'Negatives' is steadily increasing. So please do get involved as the more observers there are, the more clearly we can derive the shape and size of these distant objects.

Hopefully the foregoing will motivate you to give it a try. Just remember that the greater the effort put in, the more rewarding is the actual success when it comes – Good luck.

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