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## A2.3. Toolkit: Observing Asteroids with the Faulkes and LCO Robotic Telescopes

**Resource:** FTP- Europlanet gUG

**Book Captain:** Dr. Lothar Kurtze, Dr. Seda Özdemir-Fritz (FTP)

This manual provides comprehensive instructions for students on how to observe asteroids using the Faulkes and LCO Robotic telescopes, offering step-by-step guidance. It also includes how to get the orbital elements from the website of the Minor Planet Center.

**Language:** English

**Suitable for age:** 12-18 years

**Key words:** Asteroids, Robotic telescopes, Observing, Planning



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## Table of Contents

<b><i>SELECTING USFUL ASTEROIDS ON THE FTP-EUROPLANET WEBSITE .....</i></b>	<b>3</b>
<b><i>RECEIVING THE ORBITAL ELEMENTS FROM THE MINOR PLANET CENTER .....</i></b>	<b>4</b>
<b><i>LCO ROBOTIC TELESCOPE OBSERVATION PLANNING STEPS.....</i></b>	<b>6</b>



## SELECTING USEFUL ASTEROIDS ON THE FTP-EUROPLANET WEBSITE

### Preparation

Before you start with this activity, we highly recommend that you read the toolkit “A2.2.: Faulkes and LCO Robotic Telescope Handbook” with detailed instructions in utilizing your Faulkes Telescope account to access the Las Cumbres Observatory (LCO) interface in 'Basic' mode. You'll learn how to submit an observation request for an object of your choosing step-by-step. In case you do not have a telescope account, please apply for one.

### Selecting asteroids

The first step is selecting asteroids worth observing. This might be the case when a recently discovered asteroid has only been observed a few times, resulting in low orbit calculation accuracy. Similarly, an asteroid that hasn't been observed for an extended period falls into this category.

To assist schools in this selection process, the FTP-Europlanet gUG offers a monthly updated website listing useful targets for observation. You can find it here:

<https://ftp-europlanet.de/project-stand-asteroid-target-list>

This page not only includes selected asteroids, but also provides guidance on the required telescope type, number of images, exposure times and filters. These parameters are essential and need to be selected for programming the observations. See the example in Figure 1 below:

## Project StAnD – Asteroid Target List

A part of the [EU Erasmus+ Project StAnD](#) is the observation of asteroids with the [Faulkes Telescopes](#).

*Before you start observing asteroids, we recommend that you make yourself familiar how to program observations with the telescopes. The toolkit using the „basic mode“ to submit observations is available [here](#).*

Below, you can find a selection of asteroids useful to observe.

**Target List for May 2024:**

**Easy:**  
**2024 CR9**, a recently discovered PHA (Potentially Hazardous Asteroid), mag 17.9  
Exposure recommendation: 6× 100 sec., 1m Telescope, Filter: Bessel R

**Medium:**  
**2024 HP**, a recently discovered PHA (Potentially Hazardous Asteroid), mag 17.5, moving faster  
Exposure recommendation: 6× 30 sec., 1m Telescope, Filter: Bessel R

Figure 1 – Asteroid Target List



**Step 1:** Select the asteroid you want to observe from the FTP-Europlanet website. Please also note the recommended exposure time, number of images, telescope, and filter. This depends on the brightness and the speed of the asteroid moving against the background stars.

In this example, we select:

Asteroid 2024 CR9,  
Exposure recommendation: 100 sec.,  
Number of Images: 6  
Telescope: 1m Telescope  
Filter: Bessel R

## RECEIVING THE ORBITAL ELEMENTS FROM THE MINOR PLANET CENTER

Next step is searching for the orbital elements of the asteroid. This is the mathematic function which allows the telescope software to know where to find the asteroid at the time of the observation. For this, you need to visit this website of the Minor Planet Center:

<https://minorplanetcenter.net/iau/MPEph/MPEph.html>

See Figure 2 below.

The screenshot shows the website of the Minor Planet Center. The header includes the IAU logo and the text 'The International Astronomical Union Minor Planet Center'. There are navigation links for 'HOME', 'ABOUT', and 'HELPDESK'. A search bar labeled 'Search MPC' is also present. The main navigation menu has 'OBSERVERS' highlighted with a red box, along with 'DATA', 'NEW', and 'CONTACT'. Below this, there are sub-sections for 'STATUS', 'EXTERNAL', and 'DOCUMENTATION'. Under 'STATUS', there is a red dot next to the text 'Processing (Info)'. The main content area is titled 'Minor Planet & Comet Ephemeris Service' and contains a list of three purposes for the webpage.

**Figure 2 – Website of the MPC Ephemeris Service**



Under the OBSERVERS section (red rectangle) you will find Ephemeris Service. There, you scroll down, here there are many options which are not relevant for us. You just need to follow these steps:

**Step 2:** Enter the name of the selected asteroid in the field for the Objects, in Fig 3 e.g 2024 CR9. Please enter the name exactly as it is written in on the FTP-Europlanet website, do not leave out or add in any blanks. See Figure 3:

The screenshot shows a web form with two buttons at the top: "Get ephemerides/HTML page" and "Reset form". Below the buttons are three radio buttons: "Return ephemerides" (selected), "Return summary", and "Return HTML page". A text instruction reads: "Objects may be identified by designation or by name. Enter a list of designations or names below (one entry per line, excess entries will be ignored):". Below this is a text input field containing "2024 CR9", which is circled in red.

Figure 3 – Entering the object name.

**Step 3:** Next, you need to request the orbital elements in the right format for the telescope interface. When you scroll quite a bit further down, you will find “Format of elements output”. You need to select “MPC 8-line”, as shown in Figure 4:

The screenshot shows the "Format for elements output:" section. It contains a table of radio buttons for different output formats. The "MPC 8-line" option is selected and circled in red. Below the table, there is a checkbox for "Show residuals blocks" and a text input field. A note states: "If you select 8-line MPC format, you may display the residual block for the objects selected: Show residuals blocks. Show only residual lines containing observations from code [input field]". Another note says: "If you select 8-line MPC format the elements will be displayed with the ephemerides. If you select any format other than MPC format only the elements are returned. In such instances, your browser should download the elements file then save it to your local disk." At the bottom, there are two buttons: "Get ephemerides/HTML page" and "Reset form", both circled in red.

Figure 4 – Element Output Format.

**Step 4:** Now, you can click on “Get ephemeris/HTML page” and the latest orbital elements will be calculated for you (Fig. 4). It will look like in Figure 5.



**2024 CR9**

Number of variant orbits available: 11

Epoch 2024 Mar. 31.0 TT = JD<sub>T</sub> 2460400.5 MPC  
M 338.93488 (2000.0) P Q  
n 0.27242560 Peri. 0.00781 -0.04891073 +0.99590631 T = 2459156.36256 JD<sub>T</sub>  
a 2.3566990 Node 267.18871 -0.91638810 -0.07501751 q = 1.0585183  
e 0.5508471 Incl. 4.36484 -0.39729156 +0.05042807 Earth MOID = 0.04240 AU  
P 3.62 H 19.50 G 0.15 U 5  
From 144 observations 2024 Feb. 15-May 8, mean residual 0".41.

Last observed on 2024 Apr. 12. Perturbed ephemeris below based on elements from [MPEC 2024-IM0](#).

[Further observations?](#) Not necessary for orbit improvement. [PHA]

K24C09R		[H=19.50]											
Date	UT	R.A. (J2000)	Decl.	Delta	r	El.	Ph.	V	Sky Motion		Uncertainty info		
	h m s								"/min	P.A.	3-sig/"	P.A.	
2024 05 09	000000	13 33 56.8	-32 14 47	0.162	1.158	154.7	21.8	16.9	0.92	137.9	9	006.3 / <a href="#">Map</a> / <a href="#">Offsets</a>	
2024 05 10	000000	13 35 11.0	-32 31 25	0.157	1.153	154.3	22.3	16.9	0.99	135.5	10	004.6 / <a href="#">Map</a> / <a href="#">Offsets</a>	
2024 05 11	000000	13 36 34.5	-32 48 37	0.152	1.148	153.9	22.8	16.8	1.06	133.3	10	002.7 / <a href="#">Map</a> / <a href="#">Offsets</a>	
2024 05 12	000000	13 38 08.1	-33 06 24	0.147	1.144	153.4	23.3	16.7	1.15	131.1	11	000.8 / <a href="#">Map</a> / <a href="#">Offsets</a>	
2024 05 13	000000	13 39 52.9	-33 24 50	0.142	1.139	153.0	23.7	16.7	1.24	129.1	13	358.8 / <a href="#">Map</a> / <a href="#">Offsets</a>	

**Figure 5 – Output of the calculated orbital elements**

These orbital elements are required when we enter the asteroid data in the telescope interface. You need to keep this page open for copying the needed data later, see **Step 10**.

Now, you can finally log in to your telescope account and start programming the observation.

## LCO ROBOTIC TELESCOPE OBSERVATION PLANNING STEPS

In this tutorial, we will only show you the differences compared to programming observations in the “Basic Mode”, as explained in Tutorial A2.2. You should be familiar with this procedure before doing the following steps. Here, we use the “advanced mode” which has many functions and are not relevant for the asteroid observations at this stage. When some fields are not explained here, please be aware they are not related for our work and leave them unchanged.

**Step 5:** To submit an observation on the Faulkes Telescope using the LCO network, you will need to follow the link here: <https://observe.lco.global/> and login to your account. See tutorial A2.2.

**Step 6:** Asteroid observations are **not** possible using the basic mode of the interface. If you are able to see the ‘Basic’ mode by looking next to your name in the top right of the screen like in Fig. 6, this needs to be turned off. Do this by clicking on your **name**, then **profile** (Fig. 6) and **deselect “Use Basic Mode”** at the bottom of the page (Fig. 7).

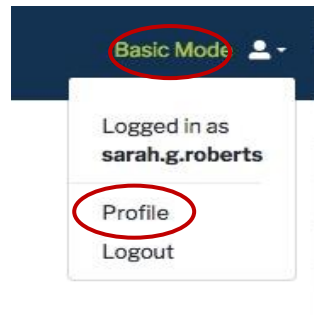


Figure 6 – Entering your profile in the LCO system.

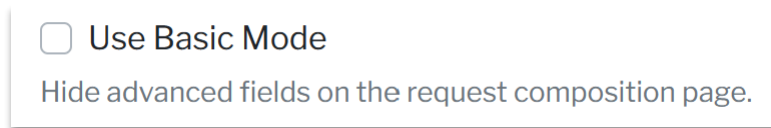


Figure 7 – Unselecting the basic interface option to use the advance mode.

Then click on “**Save**” at the bottom of the page.

You can also select “View authored requests only”, then you will only see your own requests on the main page, and not everybody’s observations (optional).

**Step 7:** You’ll now be taken to a page that displays a lot of information. You don’t need to worry about most of this, just simply select ‘**Submit Observation**’ to request your observation as shown in Figure 8.

User Info	State Info	# Requests / Pending / Failed / Complete			
<b>Cats Eye 2m RGB Ha O111 17July</b> scott_whitehouse FTPEPO2014A-004	PENDING 2017-07-17 11:30:03	1	1	0	0
<b>Freya7</b> gary_loveridge FTPEPO2014A-004	PENDING 2017-07-17 09:10:04	1	1	0	0
<b>Freya6</b> gary_loveridge FTPEPO2014A-004	PENDING 2017-07-17 08:58:01	1	1	0	0
<b>Pillars-PJW</b> peter_williamson FTPEPO2014A-004	PENDING 2017-07-17 07:51:37	1	1	0	0
<b>2012 FK70</b> matthias_penselin FTPEPO2014A-003	PENDING 2017-07-16 21:00:23	1	1	0	0

Telescope	-4 days	-3 days	-2 days	-1 day	Today
Siding Spring 0.4m A	19	94	38	62	

Figure 8 – Where to go to submit your observation.

Your screen should now display the Observation Request Form. The following steps will take you through each section of this form.

Don’t panic if you see a lot of red error messages on the page. These will remain until you have completed all the information boxes.



## General Information Section

This is the general summary section of your observation request (Fig. 9).

**Step 8:** In the ‘Name’ box you should give your observation a suitable title that you will remember. Best is the name of the asteroid you plan to observe. In this example “2024 CR9”.

**Step 9:** ‘Proposal’ refers to the telescope proposal you wish to take the observation time from. You should select ‘FTP Education – Queue’. The 2 fields below (Mode and IPP Factor, you can leave unchanged).

The screenshot shows a window titled "General Information". On the left, it displays "Duration of Observation Request:" with a question mark icon below it, and "0 hrs 0 min 0 sec". On the right, there are two input fields. The first is labeled "Name" and has a placeholder "Please provide a name." with an information icon. The second is labeled "Proposal" and has a placeholder "Please provide a proposal." with an information icon and a dropdown arrow.

Figure 9 – General information section of the observation request form

## Request Section

**Step 7:** Next, we have the Request section. These 4 values you can leave unchanged, as already suggested.

## Configuration Section

**Step 8:** Next, we have the Configuration section. Change “Instrument” to “1.0 meter Sinistro” and leave the other values unchanged, see Figure 10.

The screenshot shows a window titled "Configuration". On the left, there is a list of links: "More information about LCO instruments.", "For more information on the different options, see the 'Getting Started' guide in our Documentation section.", and "Dithered observations should be specified either by setting pattern parameters here or by manually setting Right ascension and Declination Offsets within the Instrumentation Configuration section." On the right, there are five settings: "Observation Type" set to "Image", "Instrument" set to "1.0 meter Sinistro", "Guiding?" with "Guide" selected and "Optional" checked, "Type?" set to "Exposure", and "Dither?" set to "None".

Figure 10 – Configuration section of the observation request form



## Instrument Configuration Section

**Step 9:** Next, we have the Instrument Configuration section. Set the “Exposure Count” , “Exposure time” (in Seconds) and “Filter” to the values suggested for the object (see **Step1**). The other values, you can leave unchanged. In our example, Exposure Count is 6, Exposure Time 100 seconds with the Filter “Bessel-R”, see Figure 11.

Field	Value
Exposure Count	6
Exposure Time?	100
Readout Mode	1M Sinistro Full Frar
Filter	Bessell-R
Defocus?	0
Offset Right Ascension?	0
Offset Declination?	0

Figure 11 – Instrument Configuration section of the observation request form

## Target Section

**Step 10:** In the Target section, please enter the Asteroid name, in our example 2024 CR9. And most important: change “Type” in the second box to “Non-Siderial”. Then the whole field changes to enable you to add in the orbital elements of the asteroid. Now you need to go back to Step 4 where you generated the orbital elements of the Asteroid on the Website of the Minor Planet Center.

The following data from *table A* below explains the values for the interface. Please copy the values from the MPC-website (Step 4) listed with the name in the left column to the fields in the interface as named in the right column.



Please note that the format for the Epoch is JD at the MPC and MJD at the interface, the conversion is:  $MJD=JD-2400000.5$

MPC	LCO interface
Epoch 2024 March. 31.0 TT = JDT 2460400.5	Epoch of Elements: 60400 ( $MJD=2460400.5-2400000.5= 60400$ )
Incl.	Orbital Inclination
Node	Longitude of Ascending Node
Peri.	Argument of Perihelion
e	Eccentricity
a	Semimajor Axis
M	Mean Anomaly
<i>not related to MPC, set to 0</i>	Fractional Ephemeris Rate

**Table A – Orbital elements at the MPV vs. LCO interface**

In case you are uncertain, please move your mouse to the little question mark in front of each input box. Then further information will pop up. In our example, the Target-section should look like in Figure 12:

Target

Could not find any matching objects

Name

Type

Scheme?

Epoch of Elements?

Orbital Inclination?

Longitude of Ascending Node?

Argument of Perihelion?

Eccentricity?

Semimajor Axis?

Mean Anomaly?

Fractional Ephemeris Rate?

**Figure 12 – Target section of the observation request form**



## Constraints Section

**Step 11:** The bright light of the moon may interfere with your observation, especially in case you have a small, faint asteroid to observe (which most of the new discoveries are...). To avoid lunar interference, you can set the second box “Minimum Lunar Separation” to 90 (degrees). The other values you can leave unchanged, see Figure 13.

Figure 13 – Constraints section of the observation request form

## Window Section

**Step 12:** Here you define the time window in which the portal scheduler can plan your observation. To optimize your chances, it is recommended you to set 6-7 days between “Start” and “End”. Then, several curves should appear as in Figure 14. If this is not the case, either the moon is too close to your object, then you need to extend the “End” date for some additional days. Or the object is already too close to the Sun. Then you need to choose another target. “Cadence” should not be changed.

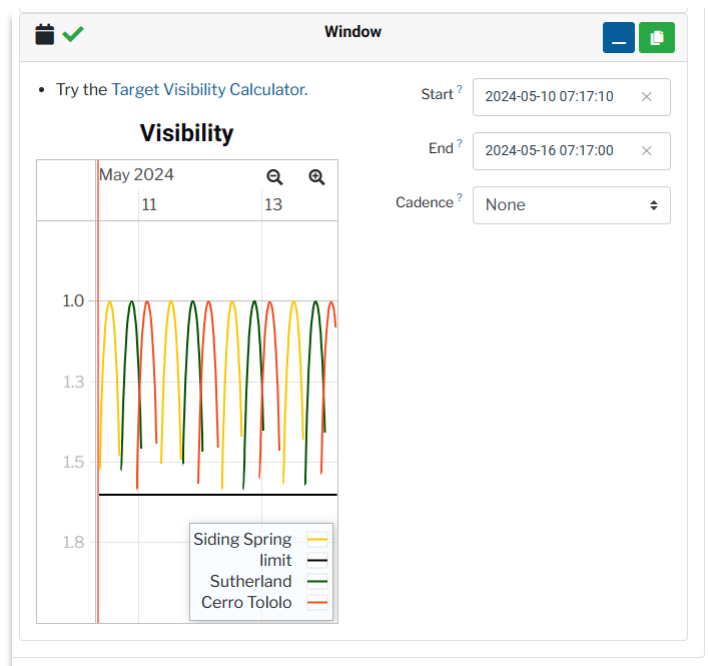


Figure 14 – Window section of the observation request form

**Step 13:** When you are happy with your requests and have completed to fill in the form, scroll back to the top of the page, and select the green **‘Submit Request’** button. This will process your request and it will go into the telescope network scheduler.

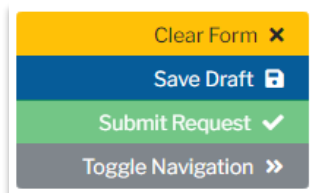


Figure 15 – Submitting your observation request form to the LCO telescope scheduler.

**Step 14:** This will cause a **pop-up** that asks if you are sure you want to submit your request, you should select **‘OK’**.  
If this message does not pop-up, you may need to enable pop-ups in your internet settings.

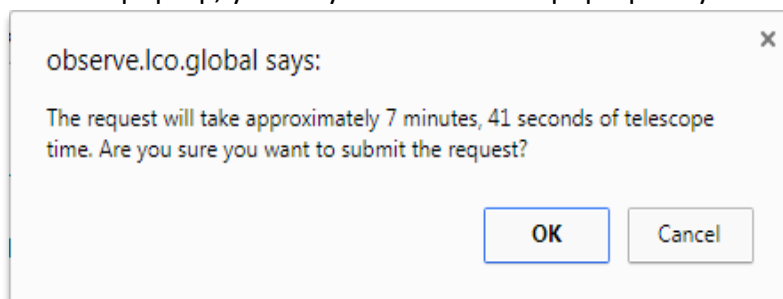


Figure 16 – The request submission pop-up



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All you need to do now, is log out and come back in a week's time (or how over long you set your time window as) to retrieve your images. You also receive an information email about the completion of the observation from [portal@lco.global](mailto:portal@lco.global).

**For further information, contact [support@faulkes-telescope.com](mailto:support@faulkes-telescope.com) or [support@FTP-Europlanet.eu](mailto:support@FTP-Europlanet.eu)**