

# Getting Started on the LCO Global Telescope Network

(August 2020 edition)

## Contents

[Purpose](#)

[Overview of the Las Cumbres Observatory \(in 2019\)](#)

[Supported Instruments](#)

[Functions of the LCO Observation Portal](#)

[Creating a User Account](#)

[Creating a Proposal](#)

[Elements of a Proposal](#)

[Observation Planning Tools](#)

[Creating an Observation Request](#)

[General Information](#)

[Request](#)

[Configuration](#)

[Instrument Configuration](#)

[Target](#)

[Constraints](#)

[Window](#)

[Features](#)

[Results of Submitted Observation Requests](#)

[Interactions with the Scheduler](#)

[Managing Proposals](#)

[Pipeline processing and access to data products](#)

[Communicating with LCO through APIs](#)

[Getting Additional Support](#)

[Appendix A: Intra-/Inter-Proposal Priority Factor](#)

[Appendix B: Observation Overheads](#)

[Appendix C: LCO site codes](#)

[Appendix D: The Cassegrain derotators on the 2m telescopes](#)

## Purpose

This document explains the basic procedures for interacting with the LCO Network through the user portal at <https://observe.lco.global/> . Its primary purpose is to describe to users how to making scientific observations with the network. If you are not an astronomer, the [information on LCO's website](#) may be more appropriate for you.

For a one-page “cheat sheet” to using the system, see the [LCO Network Jump Start](#).

## Overview of Las Cumbres Observatory (in 2019)

Las Cumbres Observatory (LCO) is a global telescope network consisting of two 2-meter telescopes, eleven 1-meter telescopes, and ten 0.4m telescopes.

The 2-meter network includes one telescope at Haleakala Observatory on Maui and one telescope at Siding Spring Observatory (SSO) in Australia.

The 1-meter network comprises three telescopes in the northern hemisphere and eight telescopes in the southern hemisphere. There are two telescopes at McDonald Observatory in Texas, three at Cerro Tololo Inter-American Observatory (CTIO) in Chile, three at South African Astronomical Observatory (SAAO) and two at Siding Spring Observatory in Australia. The 1-meter telescope at Wise Observatory in Israel became part of the network in 2019.

The 0.4-meter network includes ten telescopes: two at Haleakala Observatory on Maui, two at SSO, one at SAAO, two at CTIO, one at McDonald Observatory, and two at Teide Observatory on Tenerife in the Canary Islands.

The LCO network is dedicated to time-domain observations at optical and near-IR (silicon cutoff) wavelengths. The types of phenomena typically observed include supernovae, exoplanets, near-Earth objects, variable stars, and gamma ray bursts. LCO's technical capabilities and operations model are designed to enable observations for which a global network is uniquely suitable. Examples of specialized observation modes include 1. continuous monitoring over 24 hours, 2. rapid response to alerts, and 3. reliable long-term monitoring at any cadence. For details on the network, instrumentation, or science goals see [Las Cumbres Observatory Global Telescope Network](#) in Publications of the Astronomical Society of the Pacific, 125, 1031, July 2013, also available at <http://arxiv.org/abs/1305.2437> .

## Supported Instruments

The general system for requesting observations, tracking the status of requests, and viewing and downloading data is the same for all three telescope aperture classes. The instrumentation differs among the three aperture classes. Basic characteristics of the supported instruments are given in the table below. For additional information, consult the [Instruments](#) section of the LCO website.

| Telescope aperture class | Instrument                                   | Field of view              | Pixel size or wavelength range | Approximate magnitude range |
|--------------------------|--|----------------------------|--------------------------------|-----------------------------|
| 2-meter                  | Spectral (optical imager)                    | 10' × 10'                  | 0.31" (binned 2×2)             | 10-22                       |
| 2-meter                  | FLOYDS (low dispersion optical spectrograph) | 30" slit; width selectable | 320-1100 nm                    | 10-19                       |
| 1-meter                  | Sinistro (optical imager)                    | 26' × 26'                  | 0.39"                          | 8-19                        |
| 1-meter                  | NRES (high dispersion optical spectrograph)  | 3" diameter fiber          | 390-860 nm                     | 5-15                        |
| 0.4-meter                | SBIG STX-6303 (optical imager)               | 20' × 30'                  | 0.57" (binned 1×1)             | 6-18                        |

Exposure times and S/N ratios for the imagers can be estimated using the [exposure time calculator](#) (see the [Observation Planning Tools](#) section below).

## Functions of the LCO Observation Portal

The url for LCO's Observation Portal is <https://observe.lco.global/> . The Portal allows users to do the following tasks:

- Create a user account;
- Write and submit observation proposals;
- Plan, compose, and submit requests for observations for approved proposals;
- Track the status of submitted requests;
- Identify and download completed observations;
- Monitor the hours used for approved proposals;
- Report problems, ask questions, and make suggestions.

## Creating a User Account

Anyone may create a user account through the Portal. If you are eligible to use the network (check the description of [LCO's Time Allocation Process](#) for the eligibility requirements) and would like to submit a proposal, you should begin by creating a user account. Only registered users with an approved proposal (i.e. one to which time has been allocated) can submit requests for observations. Co-investigators on your proposal must also create user accounts before they can submit observation requests or retrieve data.

To create a new user account:

- Go to the URL for the [Portal](#), and click on the large green button that says “Register an Account”.
- Complete the registration form. The Username that you will select will be inserted into the `USERID` header variable of any data that are acquired for your approved proposals. Review LCO's [Terms of Service](#). Click the Register button.
- You will receive confirmation via e-mail.

## Creating a Proposal

Three types of proposals can be submitted through the Portal: Standard proposals, Key Project proposals, and proposals for Director's Discretionary Time. For information on the three types of proposals, and who is eligible to apply for network time, consult the description of LCO's [time allocation process](#) on the LCO website. Guidance on [writing proposals](#) is also available on the website.

To create a proposal in the Portal:

- Go to the [Portal](#) and login.
- Click on the “Manage Proposals” link in the header.
- The new page will show a list of Your Proposals (described in the [“Manage Proposals”](#) section below.) If you've never submitted a proposal before, the list will be empty. Click on the “Submit Proposal” link in the upper-right.
- The subsequent page lists all active Calls for Proposals. Select the Call for which you want to submit a proposal and click the corresponding “Apply” button.
- Fill out the form. A description of each element in the proposal form is given below.
- A draft proposal can be saved by clicking on the Save button. When you next login to the portal and click on the “Submit proposal” link, your draft will be shown in a “Your Proposals” list. Click on the title of the draft proposal to resume writing the proposal. Drafts for multiple proposals can be saved.
- The information in a draft proposal can be succinctly displayed (i.e. without the explanatory text of the proposal form) by clicking on the Preview button. The proposal can be viewed in its final format, i.e. the format that the TAC will actually read, by clicking the “View pdf” link in the upper-right corner of the preview.

- When the proposal is complete, click the Submit button. Confirm your submission in the popup window by clicking OK.
- After submission, the “Calls for Proposals” page will now include your proposal on the “Submitted Proposals” list. To view the completed proposal again, click on the pdf icon in the right-most column. To print the pdf of the proposal, click on the printer icon.

## Elements of a Proposal

For a standard proposal, information on all of the elements listed below must be included. Additional information on [Writing Proposals](#) is available on the LCO website.

### Title

Limit the proposal title to 100 characters.

### Abstract

Limit the proposal abstract to 1500 characters.

### Principal Investigator

If this is not the author, add the PI's email address, name, and institution.

### Co-investigators

Email addresses, names and institutions of the proposal's Co-Is.

### Observing Budget

Requested observing time in hours for the duration of the semester. If requesting time for more than one type of instrument, click “add another” for each new instrument. Time requested for Rapid Response and Time Critical observations (described below) must be listed separately.

The balance of the proposal should be included in a single file (pdf format). The style and formatting of the file is up to the author, but the file must conform to the following rules:

- The font size must be 11 pt or larger.
- The margins on all edges must be at least 1 inch.
- Line spacing must be 6 lines-per-inch or greater.

The file should include the following elements:

### Science Justification

Scientific justification for the time requested, which should include the scientific background, the goals of the project, and pertinent references (which should be listed in full at the end or on the figures page). The results of any previous time allocated for this project should be discussed.

### Experimental Design

A description of the observations and constraints, and justification for the amount

of Rapid Response or Time Critical hours requested. Rapid Response observations will interrupt regularly scheduled observations. Time Critical observations do not interrupt scheduled observations, so their use is restricted to cases where this is the only mode in which these targets can be observed. Time Critical mode is reserved for observations that must be made at tightly constrained times.

### **Related programs on other telescopes**

A concise account of other programs which relate to this proposal.

### **Report on past use of LCO in the last 3 years**

A concise account of time used on LCO network in the past 3 years.

### **Applicant's related publications**

Up to 10 relevant publications from past 3 years.

In the proposal form for discretionary time, several fields (Related programs, Report on past use, and Publications) are omitted. In their place is one additional field:

### **Justification of discretionary time**

An explanation of why the observations must be carried out immediately, rather than waiting for the next semester's proposal and review process.

## **Observation Planning Tools**

A variety of software tools have been created to assist in planning observations. The tools can be accessed through the [Observatory Tools](#) page of the LCO website or by clicking on the "Planning Tools" link in Portal header.

### **Exposure Time Calculator**

A tool for estimating the exposure time needed to achieve a particular S/N ratio on a target of known brightness. The calculator can be used for any filter on any of the imagers on the three telescope aperture classes. For estimating exposure times on the FLOYDS spectrographs, consult the [FLOYDS webpage](#).

### **Target Visibility Calculator**

A tool that displays the visibility of a (user-specified) set of coordinates from the LCO sites. The visibility can be displayed either as a range of UT hours over a range of dates ("Seasonal Visibility"), or as a range of altitude/airmass on a particular date ("Daily Visibility"). A version of the Daily Visibility plot is generated in the [Window section](#) of the Portal's Observation Request Form (see below).

## Network Contention Plots

A “pressure” plot shows the number of requests “competing” in the global schedule as a function of time from “now”, i.e. the time when the plot is generated. “Contention” plots for each telescope class show the total hours of requested observations broken down by target RA.

## LookUP

A simple tool for finding information about named (catalogued) targets: coordinates, proper motions, recent publications, and links to maps of nearby objects.

## Creating an Observation Request

Requests submitted to LCO are *most commonly* created for a single type of observation (image or spectrum) with a single instrument of a single target. Each observation is defined by four sets of information describing 1. the target, 2. the configuration of the instrument, 3. the time window, and 4. the observing constraints.

The target parameters determine the location on the sky to which the telescope is pointed. The configuration parameters identify the details of the type of observation, for example the filter, the number of exposures in a sequence and their duration, and the binning of pixels on the CCD. The time window parameters specify when the observation should occur. Lastly, requests can be defined by two constraints: the maximum airmass at which the observation can be scheduled, and minimum angular separation from the moon to which the telescope can be pointed when making the observation.




Requests on the LCO network do *not* identify specific sites or telescopes. The telescopes of each aperture class are identical. LCO’s scheduling software (or simply “the Scheduler”) assigns each observation request to the best telescope available, and reassigns it to the next available telescope if the initial attempt fails (due to weather or technical problems).

Although (as stated above) observation requests are *most commonly* created for a single target, it is possible to create multiple sub-requests to observe multiple targets. An advantage of doing so is that the statuses of the sub-requests are tracked together. However, the scheduling of the sub-requests is completely independent, and the overall request is not complete until either all sub-requests have been successfully completed or the time window has closed.

## The Observation Request Form: General Information

To compose a request for an observation, first login to the [Portal](#), then click on the “Submit



Observation” link in the header. The default display is the request composition form. The top section of the form, labeled “General Information”, is displayed in Figure 1. The tabs and buttons along the top of the form are described in the [Features section](#) below. The  in the upper-left corner indicates that the request is not ready to be submitted. When the request is complete, the  will be replaced by a .

The “Duration of Observation Request” shown in the General Information section is the amount of time that will be deducted from the science project’s allocation when the observation is complete. The duration includes the science exposures and all accompanying overheads. It is set to “0 hrs 0 min 0 sec” until details of the observation request are entered into the compose form.

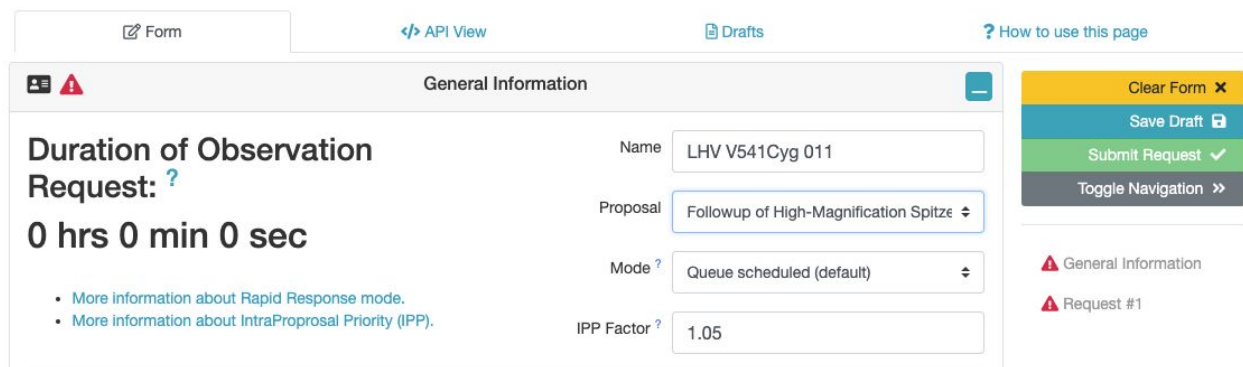


Figure 1.

**Name.** Begin by selecting a name for your request. In any image acquired for the request, the name will be recorded under the `GROUPID` keyword in the image header. Because this request will appear in lists of other requests, its name should be unique and meaningful. For example, a useful title might be “ABC V541Cyg 001”, where ABC are a PI’s initials, V541Cyg is the target, and 001 is a sequence number.

**Proposal.** Select the proposal for which you are making the request. In the drop-down menu, the titles of the active proposals for which you are the PI or a Co-I are displayed. Time expended for this request (even if the observations are not completed) will be deducted from the proposal that you select. Time is deducted when an exposure begins on a telescope, not before.

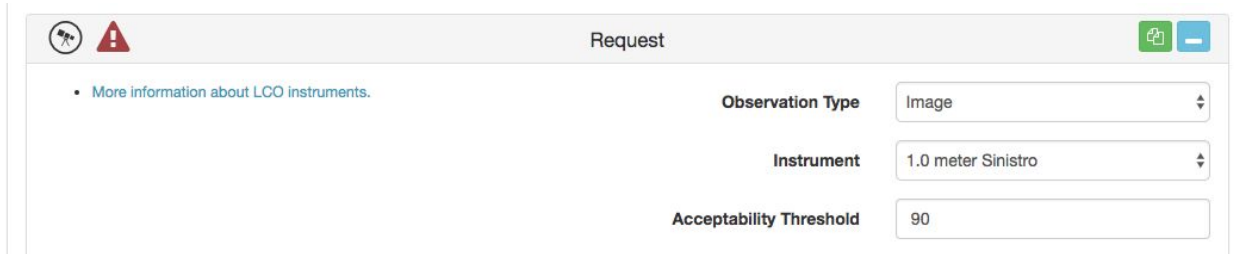
**Mode.** LCO offers two modes for processing observation requests: standard queue-scheduled mode and Rapid Response mode. LCO’s scheduler typically produces a new schedule in about 5 minutes. Rapid Response mode is reserved for observations for which this cycle time is not fast enough. Rapid Response requests circumvent the normal scheduling process and are carried out “immediately” upon submission. If a Rapid Response request cannot be executed immediately, it is executed as soon as possible, up to 24 hours after submission. For more information, please see the [Special Scheduling Modes page](#) in the [Documentation section](#) of the LCO website. Because Rapid Response observations are disruptive to network operations, you

may only select this mode if Rapid Response observations were approved for your research proposal.

**IPP Factor.** The Intra/Inter-Proposal Priority (IPP) Factor allows you to boost or demote the priority of your request, thereby communicating the relative importance of this request relative to other requests in your observing program to the Scheduler. If you are a novice LCO-user, it is best to leave the IPP Factor set to its default value. For more information on the IPP Factor, see [Appendix A](#).

## The Observation Request Form: Request

The next section in the composition form is the Request section (Figure 2). Fill out this section to specify the type of observation you want to make and the instrument you want to use.



The screenshot shows a web form titled "Request". At the top left, there are icons for a refresh button and a warning triangle. Below these is a link: "• [More information about LCO instruments.](#)". The form contains three input fields:

- Observation Type:** A dropdown menu with "Image" selected.
- Instrument:** A dropdown menu with "1.0 meter Sinistro" selected.
- Acceptability Threshold:** A text input field containing the number "90".

Figure 2.

**Observation Type.** The only options are Image and Spectrum.

**Instrument.** If you set the Observation Type to *Image*, then your options are the Spectral camera (on the 2m telescopes), the Sinistro camera (on the 1m telescopes), and the SBIG camera (on the 0.4m telescopes). If you set the Observation Type to *Spectrum*, then your options are FLOYDS (on the 2m telescopes) or NRES (on the 1m telescopes). Be careful to only select an instrument on the telescope class for which your proposal has been allocated time. If you select an instrument for which you have not been allocated time, your observation request will yield an error message that says, “You do not have sufficient time allocated on the resource you’re requesting for this proposal.” In other words, you’ve been granted 0 hours for the instrument you’ve selected.

**Acceptability Threshold.** If the observation is interrupted before all exposures are acquired, the request will still be marked “Complete” if the percentage of the acquired exposure time (relative to the total time requested) exceeds this threshold. In this case, you agree to accept the exposures already acquired as sufficient to meet the science goal of the request, and the request is not rescheduled. If, on the other hand, the percentage of the acquired exposure time does *not* exceed the threshold, then the request is marked "Failed", and it *is* rescheduled. The threshold should be specified as a percentage (between 0 and 100). The default value is 90%.

For FLOYDS observations, the default threshold is 100%, i.e. the science spectrum and all accompanying calibrations must be acquired.

The Acceptability Threshold is particularly relevant for requests of multiple exposures. It is intended to primarily benefit users who request long-duration (multi-hour) observations that might get interrupted. Users who would prefer to get, say, 90% of the full observation rather than have the full request rescheduled (and thus drain more time from the allocation) can communicate this preference to the scheduler with the Acceptability Threshold.

## The Observation Request Form: Configuration

Instructions for where the telescope should be pointed, how the instrument should execute the exposures and other details should be entered in the Configuration section and its three subsections: Instrument Configuration, Target, and Constraints. The appearance of each section will vary depending on whether your Observation Type is an *Image* or *Spectrum*. If you selected *Image*, then the options in the top-level Configuration section will be **Guiding** and **Type**, and it will look like Figure 3.

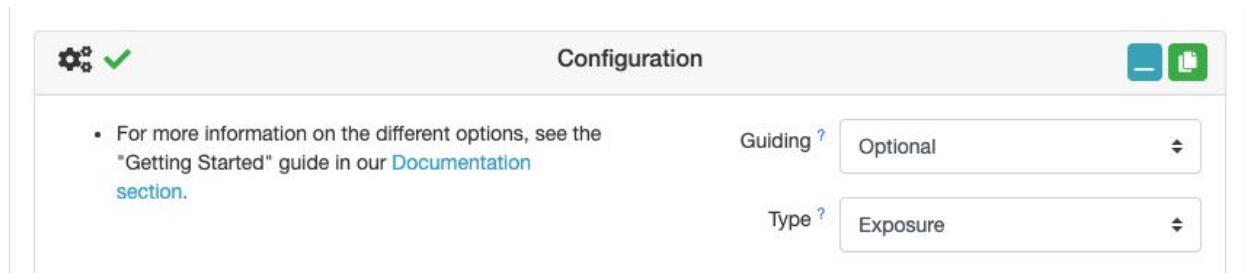


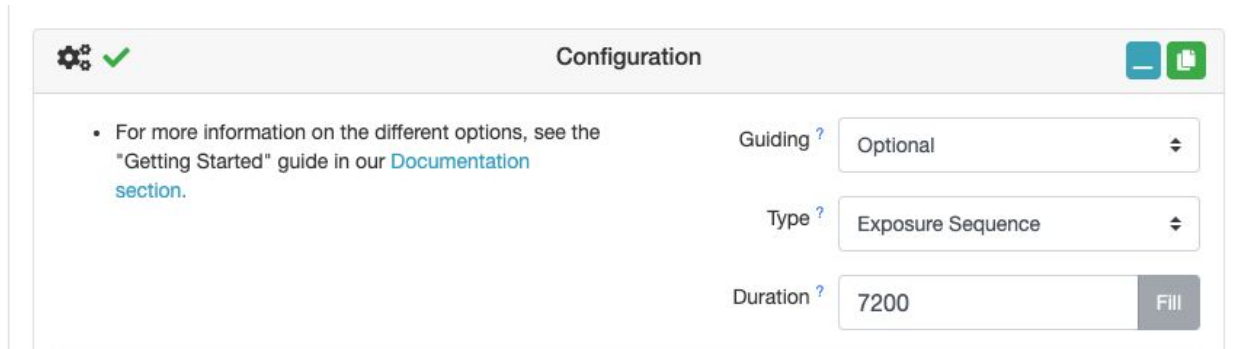
Figure 3. The Configuration section of the compose form when the Instrument is an imager.

**Guiding.** LCO’s telescopes are equipped with guide cameras. (On the 0.4m telescopes, the science cameras are used to acquire guide images.) When a telescope “guides,” an algorithm compares consecutive guide camera images and corrects the telescope’s pointing so that the pattern of sources in the images matches within a specified tolerance. The most common reason for guiding to fail is that there are too few stars in the guide camera’s field-of-view. For observations with imagers, guiding is not essential, but for exposures longer than approximately 5 minutes, we recommend that observations be guided. If the **Guiding** parameter is set to *Off*, then a guide image is never acquired, and exposures are carried-out without guiding. If **Guiding** is set to *On*, then the pattern-matching algorithm *must be successful* for the exposure to be carried-out. [For FLOYDS and NRES observations, guiding is required for the spectrographs to acquire a target, so guiding is automatically set to *On* when the Instrument (in the Request section) is a spectrograph.] If **Guiding** is set to *Optional* (the default), then guiding is attempted, but the observation is carried-out even if the pattern-matching algorithm fails.

**Type.** If the configuration type is set to *Exposure*, then the observation, as defined by the selections in the Instrument Configuration sub-section, will be executed once. If the

configuration type is set to *Exposure Sequence*, then the observation will be repeated, and an additional parameter (see Figure 4) must be specified:

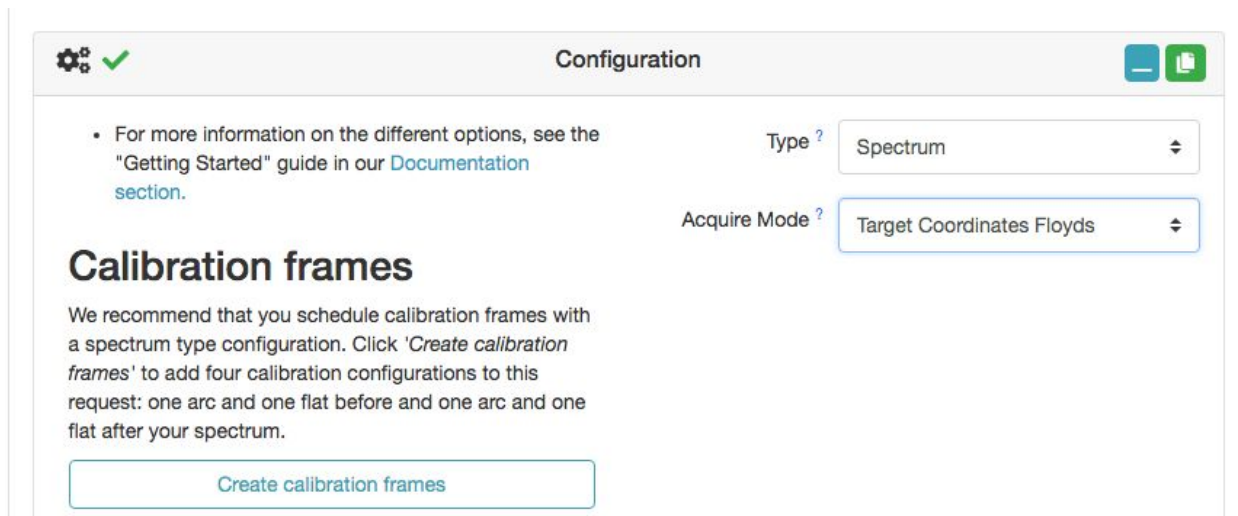
**Duration.** The period, in seconds, over which the Instrument Configurations are to be repeated. If the *Fill* button is clicked, the **Duration** is set to the longest interval over which the target is visible in the observing window. The start and end times of the observing window are specified in the Window section, further down on the form. The overheads for LCO instruments are listed in [Appendix B](#) below.



The screenshot shows a 'Configuration' panel with a settings icon and a checkmark. On the left, there is a link to 'Getting Started' guide. On the right, there are three dropdown menus: 'Guiding?' set to 'Optional', 'Type?' set to 'Exposure Sequence', and 'Duration?' set to '7200'. A 'Fill' button is located to the right of the 'Duration' field.

Figure 4. The Configuration section of the compose form when the *Exposure Sequence* type has been selected for an imager.

If the Observation Type in the Request section is set to *Spectrum* and the Instrument is set to *2.0 meter FLOYDS*, then the Configuration section will look like Figure 5, with two Configuration parameters.



The screenshot shows a 'Configuration' panel with a settings icon and a checkmark. On the left, there is a link to 'Getting Started' guide. On the right, there are two dropdown menus: 'Type?' set to 'Spectrum' and 'Acquire Mode?' set to 'Target Coordinates Floyds'. Below these, there is a section titled 'Calibration frames' with a paragraph of text and a 'Create calibration frames' button.

Figure 5. The Configuration section of the compose form when the Instrument is the FLOYDS spectrograph.

**Type.** FLOYDS exposures may be made either on a target in the telescope’s field-of-view (the *Spectrum* option), on a Tungsten-Halogen filament lamp (the *Lamp Flat* option), or on a HgAr wavelength calibration lamp (the *Arc* option). Typically, the science and calibration spectra

should be acquired in a series, with the science spectrum bracketed by flat and arc spectra. The Configuration parameters for all five of the spectra in this series (flat + arc + science spectrum + arc + flat) can be created by clicking on the “Create calibration frames” button on the left side of the Configuration section. To request multiple FLOYDS exposures on the target, the *Spectrum Sequence* option may be selected. In this case, spectra will be made, according to the parameters of the Instrument Configuration sub-section, until the **Duration** has elapsed. The **Duration** parameter works the same way as for an imaging observation: either it must be specified (in seconds), or the *Fill* button can be clicked to select the longest visibility interval within the observing window. Caution: for a *Spectrum Sequence*, the target will *not* be re-acquired between exposures.

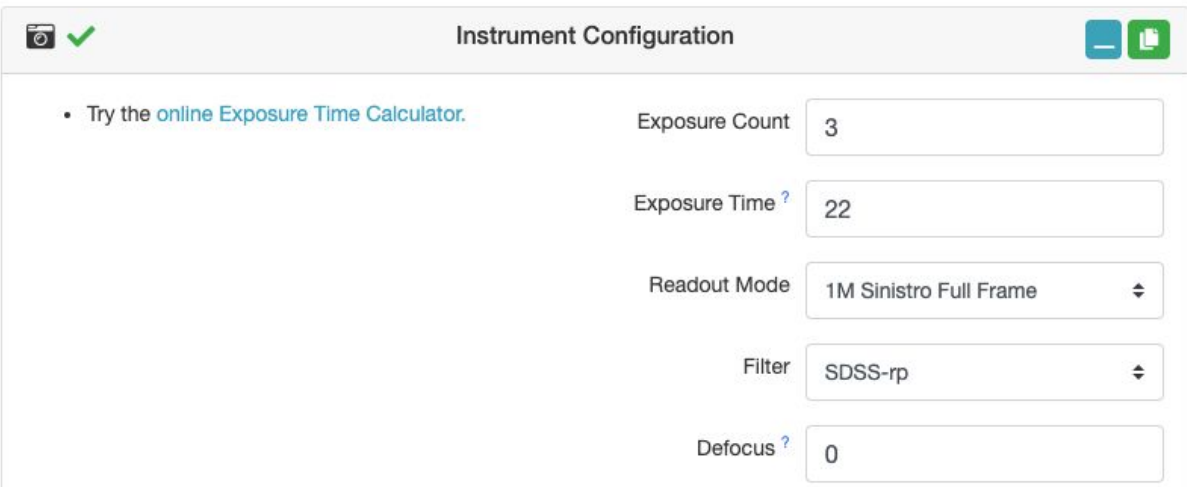
**Acquire Mode.** When set to *Target Coordinates* (the default), the slit is centered on the position of the target. The alternative mode, *Brightest Object*, places the slit on the brightest object near the target coordinates, and one additional parameter must be specified:

**Acquire Radius.** The radius (in arc-seconds) around the target coordinates within which to search for the brightest object.

If the Instrument in the Request section is set to *1.0 meter NRES*, the only **Type** options are *Spectrum* and *Spectrum Sequence*. These selections are similar to their FLOYDS counterparts (see above). For NRES spectra, the default Acquire Mode is to place the pinhole on the brightest object in the guide camera’s field-of-view. Only if the target doesn’t meet certain brightness criteria is the pinhole placed according to a WCS solution to the guider image.

## The Observation Request Form: Instrument Configuration

Instrument-specific instructions should be included in the Instrument Configuration section (Figure 6). The options vary, depending on whether the instructions are sent to an imager or a spectrograph. For all instruments, the **Exposure Count** and **Exposure Time** must be set.



The screenshot shows a web form titled "Instrument Configuration". At the top left, there is a camera icon and a green checkmark. At the top right, there are minus and plus icons. Below the title, there is a link: "Try the [online Exposure Time Calculator](#)." The form contains the following fields:

- Exposure Count: 3
- Exposure Time: 22
- Readout Mode: 1M Sinistro Full Frame
- Filter: SDSS-rp
- Defocus: 0

Figure 6. The Instrument Configuration section of the compose form.

**Exposure Count.** The number of exposures to be made.


**Exposure Time.** The open-shutter time for each exposure, in seconds. The time does not include overheads. The minimum is 0.01s.

For imaging observations, in addition to the exposure count and duration, the **Filter** and **Defocus** parameters must be set.

**Filter.** The desired filter for the exposure (or series of exposures). The pulldown menu displays only the filters available on the instrument chosen in the Request section. The set of filters for each instrument is uniform throughout the network. LCO's [filters page](#) lists which filters are available on which instruments.

**Defocus.** Photometric observations of bright targets may be deliberately defocused to prevent the CCD from saturating. The **Defocus** parameter controls the offset of the telescope's secondary mirror from the optimal focus position. The units are millimeters. Typical offsets are 1.0-2.0 mm; offsets of 3mm (the limit) will transform point sources into rings.

Moreover, for observations with the Sinistro imagers (on the 1m telescopes), the **Readout Mode** may be selected. The default, *Full Frame*, uses the full (4K x 4K) field-of-view and the pixels are not binned (1x1). The alternative, *Central 2x2k binned*, reads out the central 2K x 2K pixels and bins the pixels 2x2, resulting in a 1K x 1K pixel image.

It is possible to request multiple Instrument Configurations within the same Configuration by clicking on the  (copy) symbol to generate multiple Instrument Configuration sections.

For FLOYDS spectra, the Filter and Defocus parameters are not applicable. Instead, the additional fields are the Slit and position (Rotator Mode).

**Slit.** FLOYDS North and South have identical sets of slits with widths that project to 1.2, 1.6, 2.0, and 6.0 arcseconds on the sky.

**Rotator Mode.** The default (and most-commonly used) mode is *Parallactic Slit Angle*, which places the spectrograph slit at the parallactic angle at the start of the exposure and maintains that angle for the duration of the exposure. Fixing the slit at the parallactic angle minimizes the effect of atmospheric dispersion. The other possible mode is *Slit Position Angle*; if selected, the following field appears:

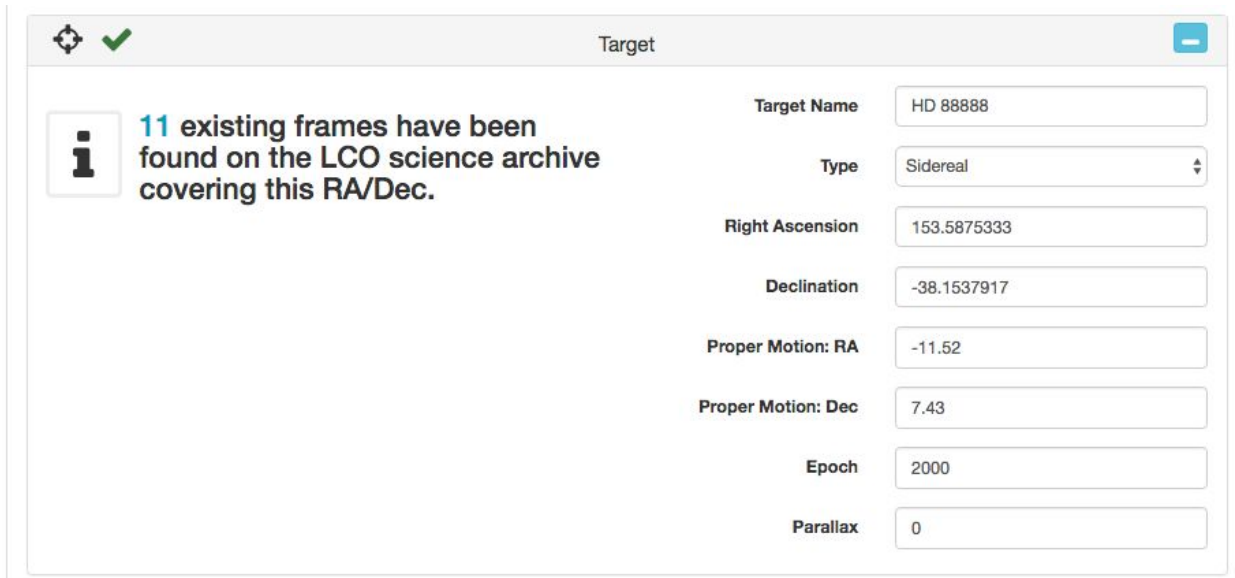
**Rotator Angle.** The user-specified fixed angle of the spectrograph slit. The Position Angle of the slit is measured in degrees East of North and is fixed for the duration of the exposure.



If multiple Instrument Configurations are created within a FLOYDS Configuration, the **Rotator Mode** must be identical for all Instrument Configurations.

## The Observation Request Form: Target

Details about the target to be observed should be entered in the Target section of the composition form (Figure 7).



The screenshot shows a window titled "Target" with a notification on the left and a list of input fields on the right. The notification reads: "11 existing frames have been found on the LCO science archive covering this RA/Dec." The input fields are:

|                    |             |
|--------------------|-------------|
| Target Name        | HD 88888    |
| Type               | Sidereal    |
| Right Ascension    | 153.5875333 |
| Declination        | -38.1537917 |
| Proper Motion: RA  | -11.52      |
| Proper Motion: Dec | 7.43        |
| Epoch              | 2000        |
| Parallax           | 0           |

Figure 7.

**Name.** The name may be anything, but if you enter a name that can be found in common astronomical databases, several of the subsequent fields will be populated automatically.

**Type.** The options are *Sidereal* or *Non-Sidereal*.

For **sidereal** targets, telescope pointing is determined according to the following parameters: Right Ascension, Declination, Proper Motion (in RA & DEC), Epoch, and Parallax. If parameters of known targets extracted from the database are out-of-date, they can be modified. Target coordinates are in the format HH:MM:SS.SS, +DD:MM:SS.SS. The Proper Motion terms are in units of milli-arcseconds per year, the Parallax term is in milli-arcseconds, and the Epoch is in Julian years.

For **non-sidereal** targets, a set of orbital elements must be specified, so the Target parameters section changes. The **Scheme** parameter is used to identify the target as either a Minor Planet, a Major Planet, or a Comet. LCO supports the set of elements given by the Minor Planet Center (MPC); these elements can be obtained from e.g. [http://www.minorplanetcenter.net/db\\_search](http://www.minorplanetcenter.net/db_search). The Epoch of the elements must be given as a Modified Julian Date (MJD). For the **Minor Planet** scheme, the orbital elements are Orbital Inclination (in degrees), Longitude of the

Ascending Node (in degrees), Argument of Perihelion (in degrees), Eccentricity, Mean Distance (Semimajor Axis in AU), and Mean Anomaly (in degrees). For the **Major Planet** scheme, one additional element, the Daily Motion (in degrees), must be specified. For the **Comet** scheme, the Mean Distance and Mean Anomaly terms are replaced by the Perihelion Distance (in AU) and the Time of Perihelion passage (Epoch of Perihelion in Modified Julian Date). Care must be taken to differentiate the *epoch of the elements set*, which is normally given as a Julian Date rounded to the nearest multiple of 200 days (e.g. 2457400.5), and the *epoch of perihelion*, which is not rounded-up (e.g. T = 2457462.77852 JDT). Both the ‘epoch JD’ and ‘perihelion JD’ given by the MPC must be converted to Modified Julian Dates by subtracting 2400000.5, giving an epoch of elements of 57400.0 and an epoch of perihelion of 57462.27852 for the above examples.

## The Observation Request Form: Constraints

Opportunities for scheduling requests may be further influenced by imposing constraints, as shown in Figure 8.



Figure 8. The Constraints section of an observation request.

**Maximum Airmass.** The maximum acceptable airmass at which the observation can be scheduled. A plane-parallel atmosphere model is assumed, so the airmass is the secant of the zenith angle. The default limit is 1.6, which corresponds to approximately 38.7 degrees above the horizon. The telescopes can track targets at 15 degrees above the horizon (airmass ~3.86). The 1-meter and 0.4-meter telescopes have Hour Angle limits of 4.6 hours east and west; the 2-meter telescopes have Alt-Az mounts, thus no hour angle limits.


**Minimum Lunar Separation.** The minimum acceptable separation angle between the target and the moon. The default limit is 30 degrees, independent of lunar phase. Observations will only be scheduled when the target is further from the moon than this limit.

Decreasing the maximum airmass or increasing the minimum lunar separation shortens the time window for the observation, thus decreasing the opportunities to schedule the observation. Ultimately, the constraints you choose should strike a balance: strict enough to insure that the data have satisfactory quality, and lenient enough to insure that the observations can be scheduled. For advice on setting the maximum airmass, read the [Airmass Limit webpage](#) on the LCO website.



## The Observation Request Form: Window

The final section of the form that must be completed before the request can be submitted describes the time window within which the observation should be made. An example is shown in Figure 9. The Scheduler will determine the rise and set times of the target for each available telescope within the time window. In general, an observation is scheduled at the earliest possible time. If an observation fails (due to, for example, bad weather or a technical malfunction), it is automatically rescheduled on another telescope at another time within the time window.

If the exact time of an observation is not critical (for example, to make an occasional measurement of the brightness of a target), create a single large time window. If, however, exact timing is critical (for example, to observe the ingress of an exoplanet transit), the time window must be made sufficiently narrow. It's also possible to request multiple time windows for the same observation by clicking on the  (copy) symbol to generate multiple Window sections. New **Start** and **End** times can be set for each new window. *In general, specifying a larger time window gives the Scheduler more opportunities to place the observation. Conversely, a narrow time window may restrict the observation to a single site or may even make it unschedulable.* Regardless of its duration, a time window must always include sufficient time for the observation itself *plus* the mechanical and software overheads. A description of the overheads associated with LCO observations, as well as example calculations, are presented in [Appendix B](#).

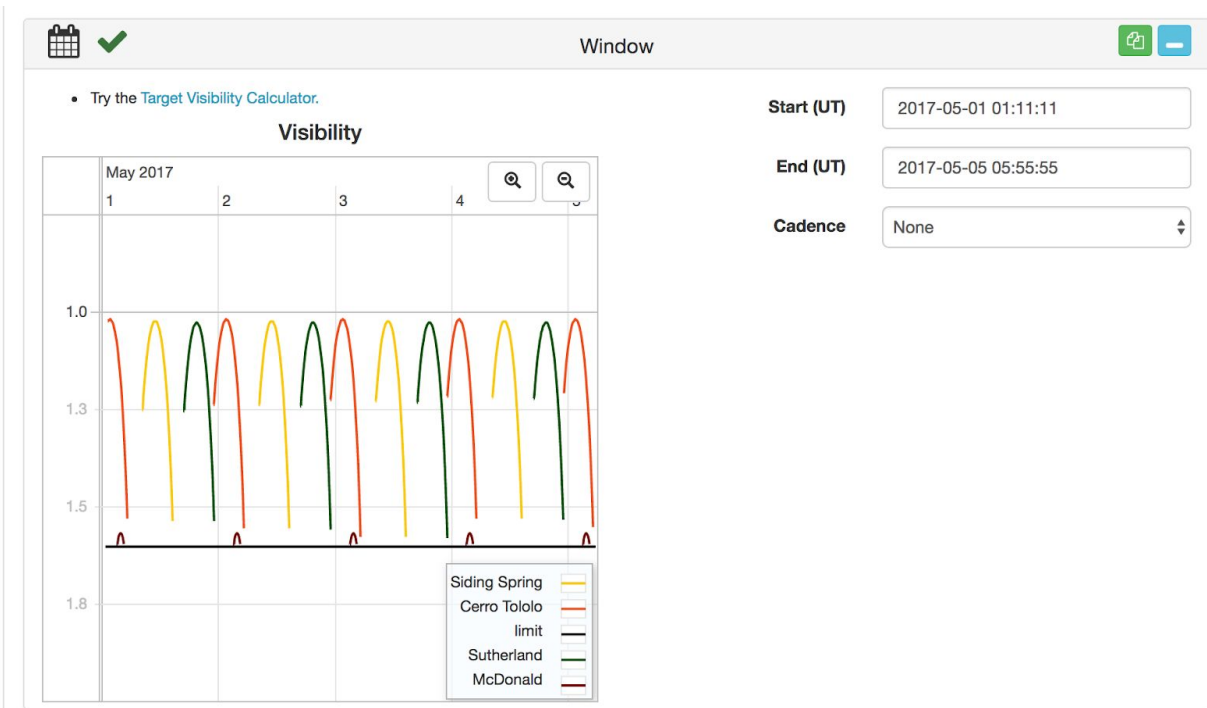


Figure 9.

**Start (UT).** The time at which the observing window opens. The start time can be specified either by writing it out (format = YYYY-MM-DD HH:MM:SS) or by selecting the date and the hour and minute from the pop-up calendar and clock. Times are in UTC, so no time zone conversion is necessary.

**End (UT).** The time at which the observing window closes.

It is advantageous for many science programs to observe a target repeatedly with an (approximately) fixed interval between observations. Rather than requiring users to create multiple time windows, the portal offers the **Cadence** feature. A cadence with a *Simple Period* is the only type currently supported. We plan to make other cadences available as science programs require them.

**Cadence.** When set to *None*, only a single observation (as described in the Configuration section) is carried out within the time window. Setting **Cadence** to *Simple Period* allows you to request multiple observations within the time window by specifying two new parameters:

**Period.** The time interval (in decimal hours) between individual observations, i.e. how often the observation should be rescheduled.

**Jitter.** The dispersion (in decimal hours) around the period during which it's acceptable to

schedule the observation. The jitter must be long enough to contain one observation request, including overheads.

Observations will be scheduled every  $(\text{Period} \pm \text{Jitter}/2)$  hours. For example, if the **Period** of the cadence is set to 18 hours and the **Jitter** to 4 hours, each observation may be scheduled to start as many as 2 hours before or 2 hours after the strict 18-hour period. Thus, the spacing between two successive observations may be as small as 16 hours or as great as 20 hours. Note: the *first* observation will have a window with a duration of  $\text{Jitter}/2$ , i.e. half the duration of the others, because the Jitter can't extend the window before the initial **Start (UT)** time.)

Clicking on the **Generate Cadence** button will produce a window (Figure 10) which shows blocks representing all of the time windows in the cadence. Depending on the phase offset between solar rise/set times and the cadence period, some of the windows may become too short for the observation and overheads to fit. These particular windows will be omitted from the cadence. If the cadence represented by the blocks is accepted, then the single request on the compose form will be replaced by a series of sub-requests (and affiliated sub-sections), one for each of the numbered blocks in the time window. The Start and End times of the overall time window vanish; the Window section for each sub-request in the series will have its own Start and End time. Parameters describing each sub-request in the series can be modified before the overall series of requests is submitted.

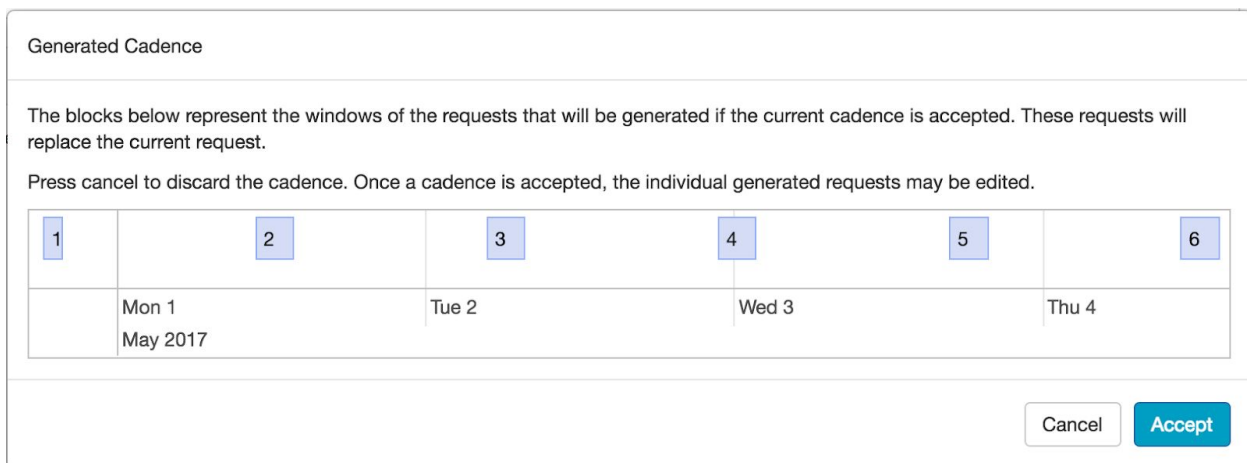








Figure 10.

## Features of the Observation Request Form



Any section on the request form (General Information, Request, Configuration, Instrument Configuration, Target, Constraints, Window) may be collapsed by clicking on the  in the upper-right corner of the section. When a section is collapsed, all values are arranged horizontally rather than vertically, allowing more of the compose form to be shown on screen. To expand a section again, click on the  appropriate for that section.


The contents of any section can be copied by clicking on the  symbol in the upper-right corner. All of the values in the original section will be duplicated in a new section with an incremented index number. For example, if you've completed the Instrument Configuration section to request three 22-second exposures with the Bessel-V filter, and you want to add three 22-second exposures with the Bessel-I filter (on the same target, within the same time window), you simply click the  icon in the Configuration section, and then select Bessel-I in the section labeled Configuration #2.


If you want to remove a duplicated section, click on the  button.

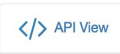
On the right edge of the page is an index of the sections in the compose form. (The index can be hidden by clicking . The section of the form on which you're currently working, i.e. where the cursor is located, is highlighted in blue. More importantly, if there is a problem with your request (and it therefore cannot be submitted), the index will show a  next to the section with the error. Moving the cursor to the problem section will cause an error message to be displayed in red. Common reasons why a request may not be valid are:

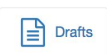
1. The target is not above the telescope's horizon limit during the time window;
2. The proposal does not have time allocated on the resource requested (for example, a request for an observation on a 2-meter telescope for a proposal that's only been granted 1-meter hours);
3. The requested observation requires more time than the proposal has remaining in its allocation;
4. The observing constraints are too restrictive (for example, the minimum lunar separation angle is set to 90 degrees, but the target will always be closer to the moon than this during the time window).

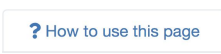
When the request is valid, then all fields in the index will have  next to them, and the request can be sent to the Scheduler by clicking  at the top-right corner of the compose form. After a request has been submitted, it can no longer be edited. Canceling the request must be done by selecting it from the list of submitted requests (see below).

An observation request can be saved at any time during the composition process by clicking the  button. Only the General Information section (Title and Proposal) must be filled out to save a draft. The draft does not have to be error-free.

The  button clears the entire form. This feature can be useful after you've loaded a draft (to see how you've done a particular observation before) but then decide you want to "start fresh" on a new target.

Clicking on the  tab will show you what an observation request looks like in JSON format (see Figure 11). This is the code that is sent to the Scheduler when the submit button is clicked. Many experienced LCO users obviate the Portal’s user interface by writing their own code to generate requests in JSON format and submit them through LCO’s web service API. All LCO users, but especially PIs of large programs, are encouraged to read the documentation describing the request service API, beginning with the [Data Format Definition](#).

Clicking on the  tab will show you a list of your draft observation requests. Submitted requests are removed from the Drafts list.

The  tab provides general information on the Compose Form, the API View and draft requests.

```

{
  "name": "Farquhar V541Cyg 002",
  "proposal": "LC02019B-117",
  "ipp_value": 1.05,
  "operator": "SINGLE",
  "observation_type": "NORMAL",
  "requests": [
    {
      "acceptability_threshold": 90,
      "configurations": [
        {
          "type": "EXPOSE",
          "instrument_type": "1M0-SCICAM-SINISTRO",
          "instrument_configs": [
            {
              "bin_x": 1,
              "bin_y": 1,
              "exposure_count": "3",
              "exposure_time": "22",
              "mode": "full_frame",
              "rotator_mode": "",
              "extra_params": {
                "defocus": 0
              },
              "optical_elements": {
                "filter": "Astrodon-UV"
              }
            }
          ],
          "acquisition_config": {
            "mode": "OFF",
            "extra_params": {}
          },
          "guiding_config": {
            "mode": "ON",
            "optional": true,
            "extra_params": {}
          }
        }
      ],
      "target": {
        "name": "V541 Cyg",
        "type": "ICRS",
        "ra": 295.6227279,
        "dec": 31.3278219,
        "proper_motion_ra": 3.677,
        "proper_motion_dec": -1.299,
        "epoch": 2000,
        "parallax": 0.7,
        "dailymot": null,
        "orbinc": null,
        "longascnode": null,
        "argofperih": null,
        "eccentricity": null,
        "perihdist": null,
        "meandist": null,
        "meananom": null
      },
      "constraints": {
        "max_airmass": "1.5",
        "min_lunar_distance": "50"
      }
    }
  ],
  "windows": [
    {
      "start": "2019-09-08 02:22:00",
      "end": "2019-09-09 22:22:00"
    }
  ],
  "location": {
    "telescope_class": "1m0"
  }
}

```

Figure 11. An example of the “API view” of a simple observation request.

## Results of Submitted Observation Requests

After an observation request is submitted, it’s re-displayed in a compact form (Figure 12). The full details can be viewed again by clicking on the (blue) request ID number. The Options button

in the upper-right corner can be used to either cancel the request, so that it is no longer considered by the Scheduler, or duplicate the request, so that it can be used as a template for another observation.

## Farquhar V541Cyg 001

Tracking # 393664

| State   | Last Update         | Submitted           | Proposal      | Submitter | IPP  | Options   |
|---------|---------------------|---------------------|---------------|-----------|------|-----------|
| PENDING | 2017-04-27 17:53:28 | 2017-04-27 17:53:28 | LCO2017AB-116 | nvolgenau | 1.05 | Options ▾ |

Sub-requests

|  |   |             |                                 |
|--|---|-------------|---------------------------------|
| # <b>1064393</b>   | PENDING   | View in API | No scheduling information found |
| <ul style="list-style-type: none"> <li>⌚ Duration: 288 seconds</li> <li>🚫 Fail Count: 0</li> </ul> | <ul style="list-style-type: none"> <li>📅 2017-04-27 17:53:28</li> </ul> |             |                                 |

Figure 12.

All of the submitted requests, for which the user is the PI or a Co-I, are listed on the user's home page. An example of (the top of) a list of submitted requests is shown in Figure 13. Each entry on the list displays the following:

- the Title;
- the ID of the user who submitted the request ( );
- the ID of the proposal for which the request was made ( );
- the status of the request: PENDING, CANCELED, SCHEDULED, COMPLETED, or WINDOW\_EXPIRED;
- the time when the request was submitted ( );
- and columns showing the number of sub-requests submitted, pending, failed, and completed.

To search for a particular request, click on the "Filter List" button in the upper-right. The window that pops up (Figure 14) allows you to refine the request list according to various filters:

- the State of the request (PENDING, SCHEDULED, etc.);
- the Title;
- the Proposal for which the request was made;
- the date and time at which the request was submitted;
- the ID of the user who submitted the request;
- the telescope class for which the request was made (2-meter, 1-meter, etc.).

## Submitted Observation Requests

Filter List

| User Info  | State Info                         | # Requests / Pending / Failed / Complete |   |   |   |
|--|------------------------------------|--|---|---|---|
| <b>Gaia17awv</b><br>roger_pickard<br>FTPEPO2014A-004   | ✓ COMPLETED<br>2017-04-03 15:24:09 | 1  | 0 | 0 | 1 |
| <b>MWSC 3301</b><br>roger_pickard<br>FTPEPO2014A-004   | ✓ COMPLETED<br>2017-04-03 15:03:26 | 3  | 0 | 0 | 3 |
| <b>Berkeley 86</b><br>roger_pickard<br>FTPEPO2014A-004 | ✓ COMPLETED<br>2017-04-03 14:40:36 | 3  | 0 | 0 | 3 |
| <b>IC4603</b><br>malcolm_beckford<br>FTPEPO2014A-004   | ✓ COMPLETED<br>2017-04-03 13:59:16 | 1  | 0 | 0 | 1 |
| <b>NGC 3521</b><br>ole_ahlgren<br>FTPEPO2014A-004      | ✓ COMPLETED<br>2017-04-03 11:41:58 | 1  | 0 | 0 | 1 |
| <b>M60</b><br>ole_ahlgren<br>FTPEPO2014A-004           | ✓ COMPLETED<br>2017-04-03 20:57:50 | 1  | 0 | 0 | 1 |

Figure 13.

When a particular request has been found, clicking on the request's Title opens a new page like Figure 12. Then, clicking on the (blue) request ID number reveals the full details of the scheduling and execution of that request, broken down into four sections: **Details**, **Scheduling**, **Visibility**, and **Data**.

**Details.** A compact display of the parameters entered into the observation request form: target coordinates, time window, constraints, etc.

**Scheduling.** A plot of the history of the times when the request was inserted into the network schedule. If the request has not yet been (or was never) scheduled, the plot will be blank. *The presence of a bar of any color indicates that the request was scheduled.* Each row of the plot shows the result of one run of the scheduling software. A new row is displayed, with its corresponding run number, only when the status of a scheduled request changes, i.e. it is scheduled with a new location or time. The length of a bar shows the duration of the observation request. The color of a bar indicates the status of the scheduled request (Figure 15). A request labeled as 'scheduled in the past' (brown) was scheduled before the next run of the scheduling



The screenshot shows a search filter interface with the following sections:

- State:** A dropdown menu with a refresh icon.
- Title Contains:** A text input field with the placeholder "Title contains" and a green 'x' icon to clear the field.
- Proposal:** A dropdown menu with a refresh icon.
- Submitted After:** A date input field with a calendar icon, the placeholder "Submitted after", and a green 'x' icon.
- Submitted Before:** A date input field with a calendar icon, the placeholder "Submitted before", and a green 'x' icon.
- Username Contains:** A text input field with the placeholder "Username contains" and a green 'x' icon.
- Telescope Class:** A dropdown menu with a refresh icon.

At the bottom of the form are two buttons: "Filter Results" (in blue) and "Clear All Fields" (in white).

Figure 14.

software, but information about whether the request was completed or failed hasn't yet been received, perhaps because of a disrupted internet connection. 'Superseded by a new schedule' (gray) indicates the normal operation of the scheduler to reschedule all pending blocks after each run.

**Visibility.** The *top* plot shows the visibility of the target at the eligible Network sites over the duration of the observing window. Visibility is shown as the change in airmass of the target with time, and each site is coded with a different color. "Eligible" sites are those that have the type of telescope (e.g. 2-meter) or instrument (e.g. Sinistro) requested by the user. Only telescopes with visibility above the airmass limit of the request (default = 1.6), and within the window of the request, are shown. The *bottom* plot shows the status of each eligible telescope over the duration of the observing window. The condition of each telescope is indicated by a color (Figure 16). The time when a request was actually carried out is coded in green.

**Data.** A list of the files, observing times, filters, and corresponding reduction statuses of all of the observations made as a result of the request (see Figure 17). The data can be downloaded directly from this page, without having to search in the Science Archive. Most users will click the "Download Selected" button after selecting the subset of files for which the reduction status is "reduced".

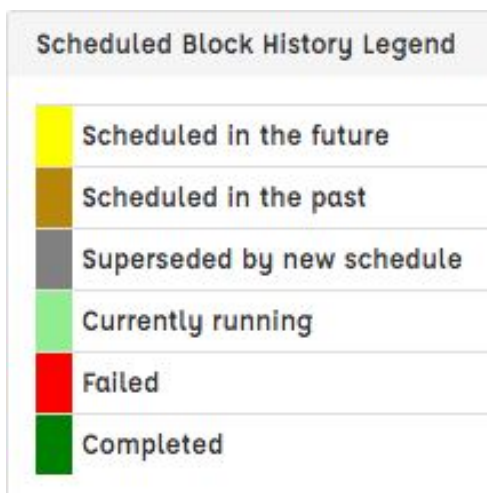


Figure 15.

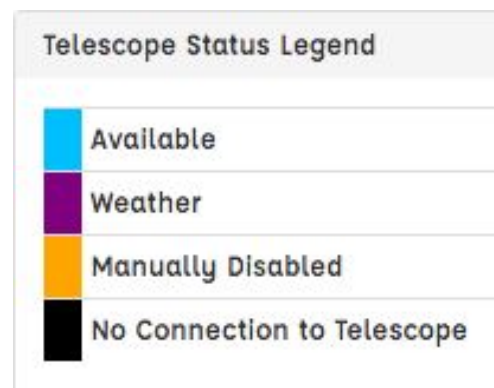


Figure 16.



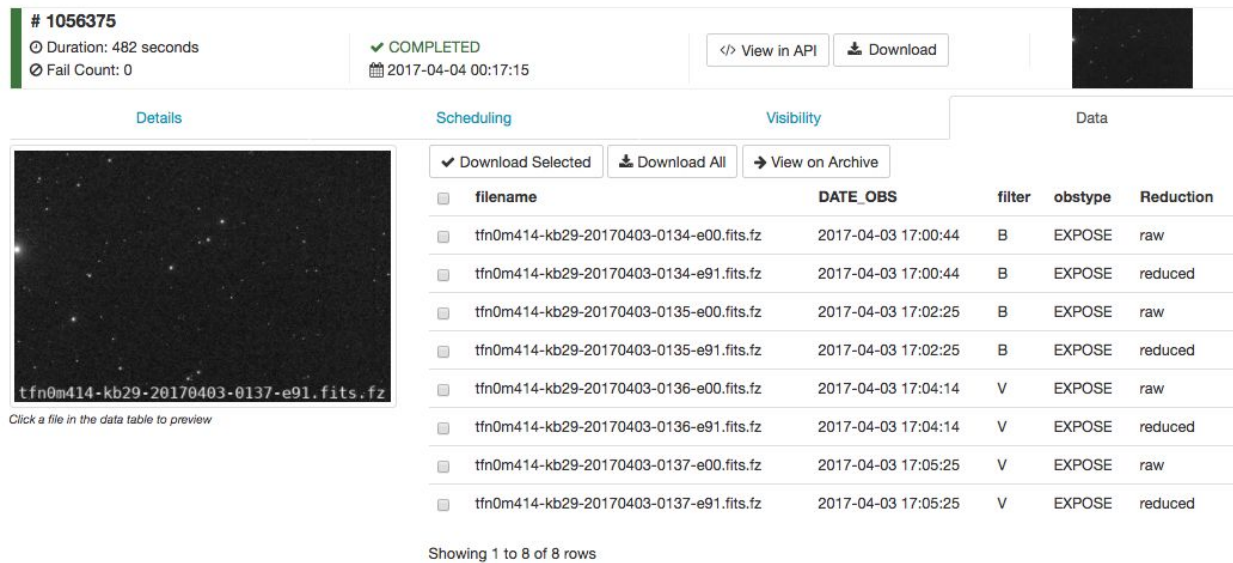


Figure 17.

## Interactions with the Scheduler

If the state of a request is PENDING, it does not mean that the observation is currently underway. It means that not all observations created as a part of that request have reached a final state.

Any submitted requests that haven't reached a final state (WINDOW\_EXPIRED or COMPLETED) can be canceled. Canceled requests can be copied, modified, and resubmitted.

If an observation is started but not completed, the request has failed, and the Scheduler will try to reschedule the entire observation again (if the time window hasn't closed). The rescheduling will be attempted *whenever the acceptability threshold is not met*, and will be repeated until either the acceptability threshold is met (i.e. the request is completed successfully) or the time window closes. Time is deducted from a science project's allocation every time a request is attempted, not when it's successfully completed. It is clearly in a user's interest to make sure that all requested exposures plus overheads (see Appendix B) can be completed in the time window. Users are also encouraged to monitor the status of their requests, and if they receive enough data for a request that fails, they can cancel the request and prevent further attempts.

## Managing proposals

To see a list of all of the proposals for which you are the principal investigator (PI) or a co-Investigator, click on the "Manage Proposals" link in the header. The default display shows

your “active” proposals, i.e. the proposals for which you may currently submit observation requests. You can switch to displaying “inactive” proposals (or all proposals), or proposals for a particular semester, using the drop-down menus in the upper-right corner, and then clicking the “Filter” button.

To see the summary of a particular proposal, click on the proposal code in the list. You can also get to the summary by clicking on the proposal code (👤) in the list of Submitted Observation Requests. The summary (Figure 18) displays the following information:

- proposal code;
- title;
- abstract;
- name and email of the PI;
- number of observation requests submitted for this proposal;
- number of hours used, broken down by semester, telescope class, and observation type;
- number of IPP hours still available (see [Appendix A](#)), also broken down by telescope class.

If you are the PI of the proposal, then you will also see a list of the names and email addresses of all Co-Is.

## NOAO2017AB-015 Physical Properties of Near Earth Asteroids

For over 15 years there has been clear evidence for an asteroid spin barrier, where asteroids larger than 150 m in diameter ( $H=22$ ) do not rotate faster than 11 rev/day ( $P=2.2$  hours). However, the asteroid population near the spin barrier has not been well studied because these objects are fainter than what the amateur community can typically observe. Additionally, until recently, there has not been enough meter-class telescope time available to conduct a large scale population study. This proposed work will almost double the number of quality rotational studies of asteroids between  $H=20$  (300 m) and  $H=23$  (100 m). The LCO network provides a unique opportunity to provide physical characterization of medium sized near Earth asteroids soon after discovery. While the discovery rate of these asteroids will greatly increase with LSST, the window available for their characterization will remain unchanged. Therefore, an infrastructure like the one proposed here is required to be able to process LSST alerts in real time and submit time domain observations.

### Total Observation Requests: 9

| Semester | Telescope Class | Hours          | Used/Allocated              |
|----------|-----------------|----------------|-----------------------------|
| 2017AB   |                 |                |                             |
|          | 1m0             |                |                             |
|          |                 | Standard       | 8.8/20.0                    |
|          |                 | Rapid Response | 0/0.0                       |
|          |                 | IPP            | Available: 10.0 Limit: 20.0 |
|          | 2m0             |                |                             |
|          |                 | Standard       | 0/20.0                      |
|          |                 | Rapid Response | 0/0.0                       |
|          |                 | IPP            | Available: 1 Limit: 2.0     |

Figure 18.

In the upper-right corner of the proposal summary page is a box labeled “Notifications enabled.” By checking the box and then clicking the “Save” button, you will receive an email every time an observation for this proposal is completed.

## Pipeline processing and access to data products

The raw data from the telescopes are brought back to LCO headquarters and processed through a pipeline that performs the standard steps to produce a reduced data set. The pipeline that processes data from the imagers is called [BANZAI](#). BANZAI runs twice for each raw

science frame: once, in a quick-look mode, immediately upon receipt of the raw frame at LCO headquarters, using the best-at-time calibration information, and then again, following the completion of the local night, when all the final calibration information has been suggested. In addition to an instrumental-signature-removed image, BANZAI produces an object catalog of detected sources and a bitmap image. These data, along with the master calibration frames that are produced by the pipeline are transferred to and ingested into the [LCO Science Archive](#), hosted in the Amazon Cloud.

Data from spectroscopic observations are processed through separate pipelines, one for [FLOYDS data](#) and one for [NRES data](#).

Data taken on the LCO Network is normally proprietary for 1 year from time of observation. This means that all users of a proposal will need to be registered with the Science Archive (which will be handled by LCO, based on the proposal information received) and be logged into the archive in order to see, manipulate, plot, and download data.

To access their data, users should open a link to the [Science Archive front page](#) in a separate tab in their browser and login with their email address and password. Once logged in, users can search for datasets using the archive front page - more detailed instructions are given in the archive [Users Guide](#). Alternatively, once logged into the archive, users can return to the Observation Portal and use the 'Image Archive' links to jump to the specific set of images for their observations on the LCO network.

## Communicating with LCO through APIs

The Portal interacts with computers at LCO's headquarters through a set of Application Programmable Interfaces (APIs). These APIs are described on LCO's [Developers website](#). Various pages there describe how to:

- Schedule observation requests,
- Obtain information on the status of a submitted request, and
- Retrieve data stored in the Science Archive.

Examples of (python) code that use the API endpoints are provided. We encourage users to write their own code to use the APIs and customize their communications with LCO.

## Getting Additional Support

Clicking on the "Help" link in the header takes you to an overview of the Portal, that includes many hyperlinks to various pages within the Portal itself and on the LCO website. The most important link on that page is the one at the bottom labeled "Email Science Support." Clicking on that button will open a compose page in your native email application.

To report a bug, make a suggestion, or ask a question, please send an email to LCO's Science Support team at [science-support@lco.global](mailto:science-support@lco.global). You should receive an acknowledgment of your email within 24 hours (on business days). *If you want to point out a problem with a particular observation request or a particular image, please include your proposal code and the tracking ID number of the observation request in your email.*

## Appendix A: Intra-/Inter-Proposal Priority Factor

Users have the ability to adjust the priority of their requests so that they have some control over the outcome. This is known as the Intra-/Inter-Proposal Priority (IPP), and it is controlled by a single multiplicative number (the IPP Factor) that is applied to each request. Over a semester, the increases and decreases have to average out, and the quantitative degree of change in priority is such that this value is mostly beneficial to users who have large target lists with a range of internal priority levels. A comprehensive explanation of how IPP works is given in the document [“Increased Flexibility for Prioritizing Targets at LCOGT”](#) by Iair Arcavi.

Allowed values for IPP are between 0.5 (decreasing a request's priority by a factor of 2) and 2.0 (increasing a request's priority by a factor of 2). For bookkeeping reasons, the default value is 1.05. The maximum and minimum value allowed will change as different IPP values are applied to requests during the semester to ensure that a proposal's priority averages to the value it received from its TAC review.

Users who don't want to tangle with the IPP Factor can just leave it at its default value.

## Appendix B: Observation overheads

Most observations will not need to consider overheads. It's good practice to create time windows that are sufficiently long to cover your observations. *The system does not deduct time based on the duration of a window, only by the duration of the actual observations made.*

However, if your observation requires a finite window (for example, a NEO passing into sunlight from behind the Earth), the start and end times must be set so that the time window accommodates the exposures times plus overheads.

The term “overhead” refers to the time required to set up for and complete an observation request. The minimum duration of a time window is the exposure time plus overhead. Calculating the overhead can be complicated; it depends on how complex a request is and how far the request is broken down by the Scheduler. **Note:** Exact overhead provisions are managed programmatically and are subject to change as equipment, processing, and other factors change.

The overheads for LCO's instruments are as follows:

**2.0-meter / Spectral imager**

|   |          |
|---|----------|
| Per-pointing setup time for slewing, etc. | 180 sec  |
| Per-configuration overhead                | 16 sec   |
| Per-frame filter change (minimum of 1)    | 2 sec    |
| Plus per-frame readout                    |          |
| 2x2 binning                               | 10.5 sec |
| Plus per-frame overhead time              | 8.5 sec  |

**2.0-meter / FLOYDS spectrograph**

|  |         |
|--|---------|
| Per-pointing setup time for slewing, etc.                            | 120 sec |
| Acquisition time   | 90 sec  |
| Configuration change overhead  | 60 sec  |
| (SPECTRUM+ARC+FLAT = 3 configurations)                               |         |
| “Per-molecule” (software) overhead                                   | 16 sec  |
| (SPECTRUM+ARC+FLAT = 3 molecules)                                    |         |
| Exposure times (70 sec for ARC, 20 sec for FLAT, X sec for SPECTRUM) |         |
| Plus per-frame readout (1x1 binning)                                 | 25 sec  |
| Plus per-frame overhead time   | 1 sec   |

**1-meter / Sinistro imager**

|   |        |
|---|--------|
| Per-pointing setup time for slewing, etc. | 90 sec |
| Per-configuration overhead                | 16 sec |
| Per-frame filter change (minimum of 1)    | 2 sec  |
| Plus per-frame readout                    |        |
| 1x1 binning                               | 27 sec |
| Plus per-frame overhead time              | 1 sec  |

**1.0-meter / NRES spectrograph**

|   |         |
|---|---------|
| Per-pointing setup time for slewing, etc. | 180 sec |
| Acquisition time (exposure + processing)  | 430 sec |
| Exposure time (X sec for SPECTRUM)        |         |
| Plus per-frame readout                    |         |
| 1x1 binning                               | 57 sec  |
| Plus per-frame overhead time              | 1 sec   |

**0.4-meter / SBIG imager**

|   |        |
|---|--------|
| Per-pointing setup time for slewing, etc. | 90 sec |
| Per-configuration overhead                | 16 sec |
| Per-frame filter change (minimum of 1)    | 2 sec  |

|                              |        |
|------------------------------|--------|
| Plus per-frame readout       |        |
| 1x1 binning                  | 13 sec |
| Plus per-frame overhead time | 1 sec  |

Example 1. For a request of 9 x 30s exposures on a Sinistro imager with a single filter, the observation time is:

|                             |                |
|-----------------------------|----------------|
| Setup                       | 90 sec         |
| Configuration overhead      | 16 sec         |
| Filter change               | 2 sec          |
| Exposure (9 exp x 30 sec =) | 270 sec        |
| Readout (9 exp x 27 sec)    | 243 sec        |
| Overhead (9 exp x 1 sec=)   | 9 sec          |
| <b>Total time =</b>         | <b>630 sec</b> |

Example 2. For a request for one 120 sec exposure on a Sinistro imager in each of the B, V and I filters, the observation time is:

|                                     |                |
|-------------------------------------|----------------|
| Setup                               | 90 sec         |
| Configuration overhead              | 16 sec         |
| Filter change (3 filters x 2 sec =) | 6 sec          |
| Exposure (3 exp x 120 sec =)        | 360 sec        |
| Readout (3 x 27 sec =)              | 81 sec         |
| Overhead (3 x 1 sec=)               | 3 sec          |
| <b>Total time =</b>                 | <b>556 sec</b> |

## Appendix C: LCO site codes

The filenames of all data acquired with LCO telescopes begin with the three-letter code for the site at which the telescope is located. For LCO staff, these site codes are part of the lingo used to discuss network operations. For LCO users, however, the codes can be cryptic. Here's a list of the codes and the Observatory sites to which they correspond:

- COJ = Siding Spring Observatory, near Coonabarabran, Australia
- CPT = South African Astronomical Observatory, near Sutherland, South Africa.
- TFN = Teide Observatory, on Tenerife, Canary Islands, Spain
- LSC = Cerro Tololo Inter-American Observatory, near La Serena, Chile
- ELP = McDonald Observatory, near Ft. Davis, Texas, United States
- OGG = Haleakala Observatory, on Maui, Hawaii, United States

## Appendix D: The Cassegrain derotators on the 2m telescopes

LCO's 2-meter telescopes have Alt-Az mounts, so as the telescope tracks a position on the sky,



the orientation of an image rotates as the telescope azimuth changes. To prevent objects from getting smeared-out in images, a derotator above the Cassegrain focus counters the telescope's azimuthal motion. The derotators have a range of motion slightly greater than one full rotation.

For FLOYDS spectra, users may specify a position angle; for Spectral images, position angle selection is not available. For most position angles, only one starting derotator position is possible, so the telescope control system is unable to prevent the derotator from tracking into a limit during long exposure sequences. LCO intends to add a derotator limit into the portal's visibility calculations in the future, but until that limit is imposed, *we advise users to break long series of exposures into multiple subrequests*. By breaking-up long observations, the telescope control system can unwrap the derotator between subrequests. We recommend that subrequests be limited to no longer than 1 hour.

## Revisions to this document

|  |            |
|--|------------|
| Added Data Archive access instructions.  | 2013 08 28 |
| Added line of instructions to data access description.   | 2013 08 28 |
| Major overhaul to capture beta comments, V1 orientation.   | 2013 10 31 |
| TAL: Moving objects are now supported. Changed links to website versions of documents and updated email addresses.               | 2014 01 23 |
| TAL: Update to reflect SBIG and Sinistro mixed network. Reworked overhead calculations. Documented moving object target support. | 2014 03 26 |
| TAL: Small tweaks for V1.0.  | 2014 04 15 |
| TAL: Updates for change of archive host from IPAC to Amazon. Add Comet examples, update overhead numbers.                        | 2016 03 23 |
| NV: Updated "Observatory Capabilities" section.  | 2016 05 11 |
| TYB: Combine 2m and 1m documents; add 0.4m; update to 2017   | 2017 01 30 |
| NV: Rewritten for Valhalla UI.   | 2017 04 28 |
| NV: Added NRES-specific information.   | 2017 07 28 |
| NV: Add Acceptability Threshold. Revise NRES overheads.  | 2017 10 16 |
| NV: Update Spectral imager overheads, NRES guiding requirement.  | 2018 01 17 |
| NV: Reduced 2.0-meter per-pointing setup time to 120s.   | 2018 03 06 |
| NV: Acceptability threshold for FLOYDS is 100%.  | 2018 08 21 |
| NV: Updated overheads for Sinistro, NRES, Spectral, SBIG.  | 2018 12 13 |
| NV: Increase "front padding" for Spectral.   | 2019 01 14 |
| NV: Sinistro camera readout time decreased from 37s to 27s.  | 2019 03 11 |
| NV: Add Appendix D.  | 2019 04 23 |
| NV: Description of Time Critical mode.   | 2019 05 23 |
| NV, EHJ: Updated for the new Observation Portal (new compose form, new request language).  | 2019 06 19 |
| EHJ, NV: Multiple Instrument Configurations  | 2019 11 01 |





Las Cumbres **Observatory**

NV: Add Exposure Sequence, Spectrum Sequence; remove NRES  
Acquire mode 2019 12 17

NV: Add configuration overhead; reduce filter change 2020 08 13