



# **Orbital Prediction and Overpass Tool (OPOT)**

## **User Guide**

**Version 1.1**

**June 2018**



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## 2 Introduction

The Orbital Prediction and Overpass Tool (OPOT) is a web application included in the ESA Atmospheric Validation Data Centre (EVDC) platform. It allows users to plan observation campaigns for a specific site providing the satellite's overpasses. An overpass is when the field of view of a satellite's instrument passes over an area of interest (AOI). Users can search for overpasses by satellite/instrument, as well as for joint overpasses between two satellites. They can then download the obtained overpasses or upload previous defined queries. The tool also allows users to define their own satellites, which they can then run queries against. This allows them to plan campaigns for satellites which have yet to launch.

The EVDC is managed by the EVDC team. Please, contact:

- NILU [nadirteam@nilu.no](mailto:nadirteam@nilu.no) for general assistance with the EVDC service, provision of login details (personal user accounts), GEOMS data conversion routines etc.
- Skytek: Paul Kiernan and Shane Carty: Contact: [info@skytek.com](mailto:info@skytek.com) (for OPOT)
- ICHEC: Alastair McKinstry: Contact: [support@ichec.ie](mailto:support@ichec.ie) (for Satellite Element)
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## 3 Getting started

This document provides a list of “HowTo” concerning the main tasks that the user can execute step-by-step. The OPOT is directly accessible (login not needed) from the:

EVDC Portal (<http://evdc.esa.int>) -> Overpass Tool (<http://evdc.esa.int/orbit/>)

1. Access to the EVDC portal <http://evdc.esa.int>
2. On the EVDC main menu click on the “Overpass Tool” button
  - The OPOT dashboard will appear

The OPOT dashboard is composed by four main parts:

- A. The (top-left) panel for Satellites and Instruments selection
- B. The (top-right) “3D Globe” to manually select location and to visualize the resulting Orbits and Overpasses
- C. The (bottom-right) panel to select location by coordinates, time window and to trigger queries for Predict Orbits, Get Spatial Overpasses, Get Temporal Overpasses, Search Satellite Data and to eventually add new satellites
- D. The (bottom-left) panel, which shows satellite information, as well as results from the queries.

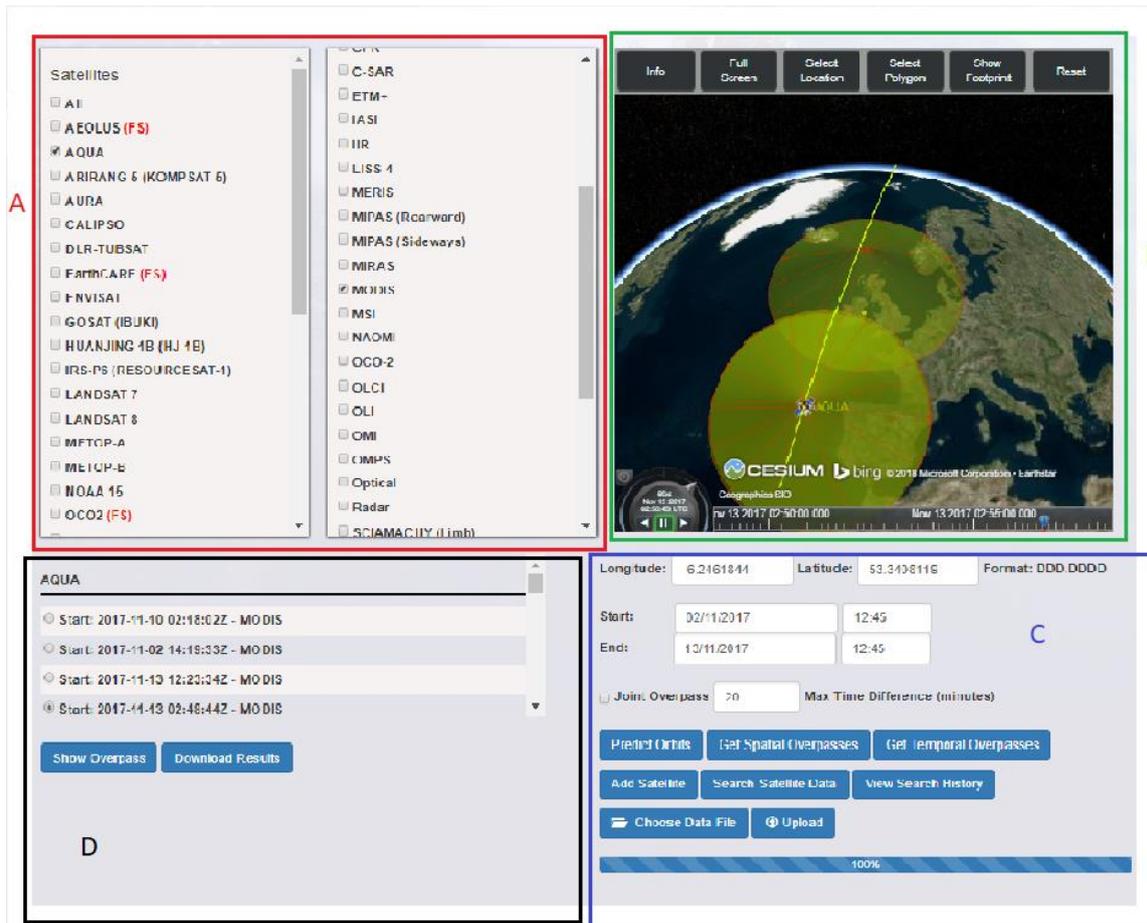


Figure 3-1 The OPOT main dashboard composed by four main parts

### 3.1 Satellites and Instruments

The top-left side (A) of the page contains a list of the available satellites. Clicking on a satellite name generates its orbit for the next 24 hours and displays it on the globe; it also shows the satellite information in a panel below the list. Each satellite has a checkbox beside its name for selecting as part of a query. Beside the satellite list is the list of all the instruments on board the satellites. Each instrument also contains a checkbox for adding to a query.

### 3.2 Globe

The upper right side (B) of the page contains the 3D globe. The globe is used to visualize orbits and overpasses, as well as for specifying the ground location of a query. The globe has several buttons; please hover over each button to find out their functions, these are:

- **Info** – Opens a popup which describes the functionality of the other buttons, and contains a download button for this guide.
- **Full Screen** - Shows the globe in full screen mode.
- **Select Location** - Once selected, the user can click on the globe to select a ground location for their query.
- **Show Footprint** – Once selected, the user can click a satellite on the globe to see its footprint displayed.
- **Select Polygon** - Once selected, the user can click on the globe to form a polygon. Their initial points should be left-clicked, and the final one right-clicked.
- **Reset** – Resets the globe and all input parameters.

### 3.3 Query Parameters

The bottom-right side (C) of the page contains the query input parameters, these are:

- **Longitude, Latitude** – This can be a single coordinate, or a series of coordinates denoting a polygon. These can be filled in by clicking on the globe with “Select Location” or “Select Polygon” button selected. The format for the longitude/latitude is decimal: DDD.DDDD
- **Start, End** – The time range of the query
- **Joint Overpass** – Selecting to run a joint overpass query
- **Max Time Difference** – Max time in minutes between overpasses for joint overpass query.

Below this is a number of buttons, these are:

- **Predict Orbits** – Submits an orbit prediction and visualisation query.
- **Get Over Passes** – Submits an overpass query
- **Add Satellite** – Opens a separate page to add a satellite to the OPOT.
- **Search Satellite Data** – Takes the query parameters and uses them as input to the Search Satellite Data page of EVDC.
- **Temporal Search** – Search for Joint Overpass by time range.
- **Choose Data File** – Selects a data file to use as inputs to an overpass query.
- **Uploads** - Uploads selected data file.

Below this is a loading bar, which keeps the user informed on the progress of their query.

### 3.4 Satellite Information/Overpass Results

The bottom left side (D) of the page contains different information based on the context. If a satellite's name has been clicked, this area contains:

- Satellite ID
- Onboard Instruments Name
- Instruments Swath Width
- Instruments Viewing Angle
- Satellites Latest TLE

While if an overpass query has been submitted, this area contains the list of overpass results, ordered by satellite and time of overpass, as well as the instrument of the overpass. Each overpass has a radio button beside its name, which are used to select which overpass to visualise or download. The user can select one overpass per satellite, and then click the following buttons:

- **Show Overpass** – Displays the selected overpasses on the 3D globe.
- **Download Results** – Opens a popup which gives the option to download the overpass results in JSON or CSV format.

## 4 How to get Satellite/Instrument info

It is possible to get information on a Satellite and corresponding Instrument. Once a satellite is selected all the corresponding instruments are automatically selected. Info concerning the Selected Satellite: NORAD ID, Instrument name, Swath Angle, Viewing angle, Viewing Direction and the latest TLE available

1. Select one Satellite on top-left panel
  - Corresponding Instruments are identified
  - All the info appears on the bottom-left panel (D)

The screenshot displays the EVDC interface with two selection panels at the top and an information panel at the bottom left.

**Satellite Selection Panel (Left):**

- HUANJING 1B (HJ-1B)
- IRS-P6 (RESOURCESAT-1)
- LANDSAT 7
- LANDSAT 8
- METOP-A
- METOP-B
- NOAA 15
- ODIN
- PROBA-V
- QUIKSCAT
- SENTINEL-1A
- SENTINEL-1B
- SENTINEL-2A
- SENTINEL-3A
- SENTINEL-5P
- SMAP

**Instrument Selection Panel (Right):**

- MIRAS
- MODIS
- MSI
- NAOMI
- OLCI
- OLI
- OMI
- OMPS
- Optical
- Radar
- SCIAMACHY (Limb)
- SCIAMACHY (Nadir)
- SeaWinds Scatterometer
- SLSTR (Nadir)
- SLSTR (Oblique)
- SMR
- TANSO-FTS
- TROPOMI
- VGT-P
- WVC

**Selected Satellite: SENTINEL-5P**

NORAD ID: 42969  
 Instrument 1: TROPOMI  
 Swath Width: 2600 km's  
 Viewing Angle: Nadir

Latest TLE: 2017-11-13 07:02:24

```
SENTINEL-5P
1 42969U 17064A 17317.29333373 .00000222 00000-0 12592-3 0 9998
2 42969 98.7112 255.1219 0001149 106.5961 253.5390 14.19556564 4375
```

Figure 4-1 Satellite, Instrument Info and TLE

## 5 How to “Predict Orbits”

This is a basic feature available for the OPOT. It allows users to visualise the orbits of one or more satellites over a given timeframe. To run this query, a user selects the satellites and enters the timeframe, then clicks the “Predict Orbit” button. The globe then refreshes to show the orbits of the selected satellites.

1. Select Satellites (one, two or more, or even All) from the top-left panel (A);
2. Select temporal window using “Start” and “End” boxes or leaving the default values
3. Click on “Predict Orbits” button
  - Satellite Orbits are shown on the Globe

The screenshot displays the OPOT interface with the following elements:

- Satellite Selection (Left Panel):** A list of satellites including CALIPSO, DLR-TUBSAT, ENVISAT, GOSAT (IBUKI), HUANJING 1B (HJ-1B), IRS-P6 (RESOURCESAT-1), LANDSAT 7 (checked), LANDSAT 8, METOP-A, METOP-B, NOAA 15 (checked), ODIN, PROBA-V, QUIKSCAT, SENTINEL-1A, SENTINEL-1B, SENTINEL-2A, SENTINEL-3A, SENTINEL-5P, SMAP, and SMOS.
- Instruments Selection (Middle Panel):** A list of instruments including All, Aladin, AMSU-A (checked), CCD, COSI (WS), C-SAR, ETM+ (checked), IASI, IIR, LISS-4, MERIS, MIPAS (Rearward), MIPAS (Sideways), MIRAS, MODIS, MSI, NAOMI, OLCI, and OLI.
- Top-Right Panel:** A 3D globe showing satellite orbits. The globe is labeled 'LANDSAT 7'. Above the globe are buttons for 'Info', 'Full Screen', 'Select Location', 'Select Polygon', 'Show Footprint', and 'Reset'.
- Bottom-Right Panel:** Input fields for 'Longitude: -6.2614447', 'Latitude: 53.34751', and 'Format: DDD.DDDD'. Below these are 'Start' and 'End' date/time fields (20/12/2017 13:08 and 21/12/2017 13:08). A 'Joint Overpass' checkbox is checked with a value of '20' and 'Max Time Difference (minutes)'. At the bottom are buttons for 'Add Satellite', 'Search Satellite Data', 'Choose Data File', and 'Upload'.
- Bottom-Center Panel:** A large blue button labeled 'Predict Orbits' with an arrow pointing to it. To its right are buttons for 'Get Spatial Overpasses' and 'Get Temporal Overpasses'.

Figure 5-1 Predict Orbits query

## 6 How to get spatial overpasses

The main query type of the OPOT is the overpass prediction query. This is what allows users to plan observation campaigns. The user selects the satellite, the ground location of interest, either by manually entering the coordinates or using the 3D globe, the timeframe, and then clicks the “Get Spatial Overpasses” button. This returns a list of overpasses in the bottom-left of the screen, panel (D). The user can then choose to visualise the overpass or download the corresponding file.

1. Select one satellite on top-left panel (A)
2. Select location on top-right panel (B) by “Select Location”, or by “Select Polygon” or directly entering coordinates (Longitude, Latitude)
3. Select time window “Start” and “End” time
4. Click on “Get Spatial Overpasses”
  - Once the process is completed (processing bar 100%), the overpasses are listed on the bottom-left panel (D)

Once the Overpasses are available on the bottom-left panel you can select one of them by the radio buttons, visualize and download

1. Select an Overpass on the bottom left panel (D)
2. Click on “Show Overpass”
  - The Overpasses is visualized on the Globe on top-right panel (B)
3. Click on “Download Results”
4. Click on the “JSON” button
  - The Overpass file is downloaded, the file includes a self-explanatory header

Please note that selecting a satellite will select all the corresponding on-board instruments, if the user knows the instruments of interest, he can search by these instead, along with the time, and location parameters. The OPOT will then only return overpasses by the selected instruments.

## 7 How to get joint overpasses by location

If this option is selected, then the query only returns pairs of overpasses between two satellites for a particular location. For example, if two satellites were selected for the query, the results will only contain overpasses for one satellite, which have a concurrent overpass by the other satellite. Whether two overpasses are concurrent depends on the “Max Time Difference” parameter, which specifies the maximum time between two satellites overpassing an area. When more than two satellites are selected, then each overpass for an individual satellite will have a concurrent overpass from at least one of the other satellites in the query. This query also takes instruments into account if selected.

1. Select two (or more) satellites on top-left panel (A)
  2. Select location on top-right panel (B) by “Select Location”, or by “Select Polygon” or directly entering coordinates (Longitude, Latitude)
  3. Select time window “Start” and “End” time
  4. Select Joint Overpasses and set the Max Time Difference (minutes)
  5. Click on Get Spatial Overpasses
- Once the process is completed (processing bar 100%), the overpasses are listed on the bottom-left panel (D)

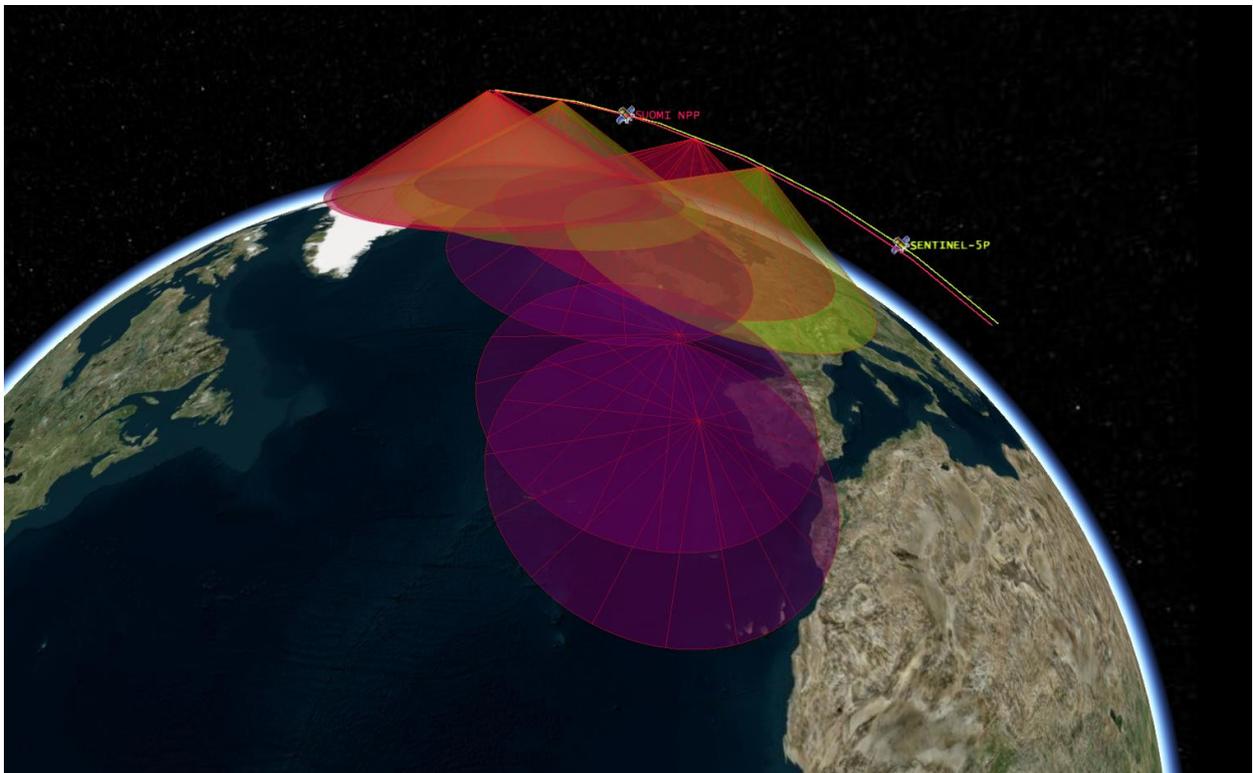


Figure 7-1 Visualization of joint overpasses over a location

## 8 How to get joint overpasses by time

This query allows the user to specify two satellites, along with a timeframe, and then it searches for locations where these two satellites overpass at the same time. This is useful for when the user wants to compare observations from two satellites, but are not concerned about the location being observed. This query is submitted using the “Get Temporal Overpasses” button, and it returns a list of times and locations where the two satellites field of view overlaps. The user can then click to view each joint overpass.

1. Select two satellites on top-left panel (A)
  2. Select time window “Start” and “End” time
  3. Click on Get Temporal Overpasses
- Once the process is completed (processing bar 100%), the overpasses are listed on the bottom-left panel (D)

The screenshot displays the EVDC Orbit and Predictor Tool interface. On the left, there are two panels for satellite selection. The first panel lists satellites such as METOP-B, NOAA 15, OCO2 (FS), ODIN, PROBA-V, QUIKSCAT, SENTINEL-1A, SENTINEL-1B, SENTINEL-2A, SENTINEL-2B, SENTINEL-3A, SENTINEL-3B, SENTINEL-5P, SMAP, SMOS, SPOT 6, SPOT 7, SUOMI NPP, and TERRA. The second panel lists instruments like NAOMI, OCO-2, OLCI, OLI, OMI, OMPs, Optical, Radar, SCIAMACHY (Limb), SCIAMACHY (Nadir), SeaWinds Scatterometer, SL STR (Nadir), SL STR (Oblique), SMR, TANSO-FTS, TROPOMI, VGT-P, VIIRS, and WVC. The central panel shows a 3D visualization of Earth with satellite orbits and footprints for Terra and Suomi NPP. The bottom-left panel displays 'Joint Overpass Results for TERRA and SUOMI NPP' with a list of overpass events: 2017-11-03 00:06:00, Longitude: -166.971, Latitude: 37.532; 2017-11-02 23:15:00, Longitude: 25.949, Latitude: -36.834; 2017-11-02 22:24:30, Longitude: -141.596, Latitude: 37.530; and 2017-11-02 21:34:30, Longitude: 50.189, Latitude: -40.310. The bottom-right panel contains input fields for Longitude (-6.2614447), Latitude (53.34751), Start (02/11/2017 12:45), and End (03/11/2017 12:45), along with a 'Joint Overpass' checkbox and a 'Max Time Difference (minutes)' field set to 20. Buttons for 'Predict Orbits', 'Get Spatial Overpasses', 'Get Temporal Overpasses', 'Add Satellite', 'Search Satellite Data', 'View Search History', 'Choose Data File', and 'Upload' are visible. A progress bar at the bottom indicates 100% completion.

Figure 8-1 Example of joint overpasses by time visualization

## 9 How to Search Satellite Data

The OPOT can be used to search for data from the “Search Satellite Data” portlet of EVDC. This is done by clicking the “Search Satellite Data” button in the bottom right of the main page. When this happens, EVDC takes the satellite, instrument, time range and ground locations selected in the OPOT, and uses them to fill the form fields in the “Search Satellite Data” portlet. This means when a user carries out a query, they can click the “Search Satellite Button”, and then click submit on the page which opens, to get back a list of actual data files from the satellite they are interested in. This currently works with the Sentinel-3A satellite and it will be made available for Sentinel 5P during E2 operational phase.

1. Select satellite, location and temporal window
2. Click on the “Search Satellite Data” in panel (C)
- The query parameters are reported in the Search Satellite Data, ready to be used

## 10 Sub-set Overpass Data

This feature allows users to sub-set the data a satellite gathered during an overpass. This means instead of downloading the entire orbit file, the user can download only the sub-set of data from their ground station or area of interest.

To use this feature, the user selects the satellite (this feature currently only supports Sentinel-5p), then they select the time frame (this should be a time frame in the past, as you cannot sub-set data which has yet to be gathered), then they click the “Get Spatial Overpasses” button. This should return a list of overpasses.

The user then selects the radio button beside the overpass they are interested in, then clicks the “Subset Overpass” button (this button only shows up in panel (D) for Sentinel-5p overpass results). This will bring the user to the satellite data results page, with the sub-setting tool parameters filled in. The user then selects the satellite data file they are interested in, (there will be several for each overpass, one for each of the different product types), and clicks the “Run Operation” button, to start the sub-setting operation. They can then check the “Recent Submitted Jobs” page, to download the results file.

**Note:** This feature is currently in Beta, so the “Subset Overpass” button will only show up for users who have been given access.

1. Select Sentinel-5p from list of satellites
2. Select “Start” and “End” for a time window in the past
3. Click on the “Get Spatial Overpasses” in panel (C)
- The list of overpasses are displayed in the panel (D)
4. Select the radio beside one of the overpass results
5. Click the “Subset Overpass” button
6. Select radio button beside one of the satellite data files
7. Click “Run Operation”
8. Click “Recent Submitted Jobs” page to download the result file

## 11 How to add satellite

OPOT gives users the ability to define their own satellite, by clicking on the “Add Satellite” button in the bottom right (C) of the page. This feature is meant for advanced users and for its

application is recommended to contact the EVDC team.

Once created, a satellite is added to the database, and can be used to run queries against like any other satellite. Satellites created this way have an “FS” beside their name, to indicate it’s a future satellite. There are three different ways to add a new satellite to the OPOT, which are described below.

### 11.1 Add by Parameters

Adding a satellite by parameters allows a user to customise the satellites orbit down to the last details. A satellites orbit is defined in a format known a Two Line Element (TLE). A TLE has attributes such as the eccentricity, inclination and mean motion. These define the size and shape of the orbit. It also encodes values for the drag encountered by a satellite, which depends on the size and orbital height of the satellite. This section allows the user to enter in values for these terms, which are then collected in a TLE, and used to predict the satellites orbit, and hence overpass queries. The page includes a link to an [article](#) to help users understand these values, however this feature is meant for advanced users.

When using this feature, the following fields are to be entered by the user:

- Name
- Epoch
- Bstar drag term
- Inclination
- Raan
- Eccentricity
- Argument of perigee
- Mean anomaly
- Mean motion

### 11.2 Add by Proxy

Adding a satellite by proxy is useful if there is already a satellite in orbit which has similar parameters to the satellite the user wants to add to the OPOT. For example some satellite series have similar orbits, so if a user wants to model a future satellite then they can use an existing one as a proxy, the method used is based on this [article](#).

The proxy satellite should have parameters very close to the planned parameters of the satellite, which has yet to launch. In particular, they should have the same orbital inclination, mean motion (orbits of the earth per day) and the same launch site and vehicle if possible. This feature leaves it up to the user to select a suitable proxy satellite, by entering its NORAD id. The user also enters the proxy satellites launch date, to allow the OPOT to find its initial TLE, as well as the projected launch date of the future satellite.

The following forms fields are to be entered by the user:

- Proxy Satellite Number – (NORAD ID)
- Future Satellite Name
- Future Satellite Launch Date

### 11.3 Add by TLE

The final method a user can use to add a satellite to the OPOT is by entering its TLE. This allows users to add existing satellites which have not already been submitted. A good source of TLE’s is the [website Celestrak](#), these can be copy-pasted from here by the user into the TLE text box. The user can also define an instrument for the satellite by its name and swath width. This allows users to run queries against the new satellite like any other.

The following forms fields are to be entered by the user:

- Satellite Name
- First Line of TLE
- Second Line of TLE
- Instrument Name
- Instrument Swath Width (km's)