About Orbital Elements:
Planning to Observe Comets and Asteroids with Deep-Sky Planner 9

Abstract

Calculating an accurate position for a comet or minor planet (asteroid) requires a set of parameters called orbital elements. Since there is a set of these parameters for every cataloged comet and asteroid, and they change over time, the parameters must be managed to give accurate calculations. Understanding how to maintain accurate parameters is necessary if you expect to get accurate data for comets and asteroids.

Orbits of Solar System Bodies

Solar system bodies have orbits described by various conical sections: ellipses, parabolas and hyperbolas. The major planets have elliptical orbits that are well understood; they can be described accurately with a set of equations. Asteroids also have elliptical orbits, but since their masses are small, more massive objects disrupt their orbital paths easily. This disruption is called perturbation and the effect on orbital calculations is that the parameters present in the equations change in a brief time due to perturbation. The situation with comets is even more interesting because their orbits can be elliptical, parabolic or hyperbolic in shape and their orbits are perturbed.

Orbital Elements

To address the need for accurate parameters, astronomers must make astrometric observations of comets and asteroids, and reduce the observations to a set of new parameters for each comet and asteroid. There are hundreds of comets and thousands of asteroids involved in this process with more being added constantly. The Minor Planet Center (MPC) and Solar System Dynamics Center (SSD) manage these efforts and publish the data for public use.

Managing Orbital Elements

Observers need to adopt a strategy for dealing with so much data changing on an irregular schedule. ***Deep-Sky Planner*** provides the capability to do so with its **Orbital Elements Manager**. The strategy that you employ really depends on which type of objects you want to observe.

Orbital Elements for Comets

The availability of orbital elements for comets has changed in recent years. The MPC makes elements available for commonly observed comets numbering in the hundreds. The SSD makes elements available for both commonly observed and newly discovered comets numbering in the thousands.

Data for each set of elements is available in a file that can be downloaded and imported into ***Deep-Sky Planner*** using the **Orbital Elements Manager.**

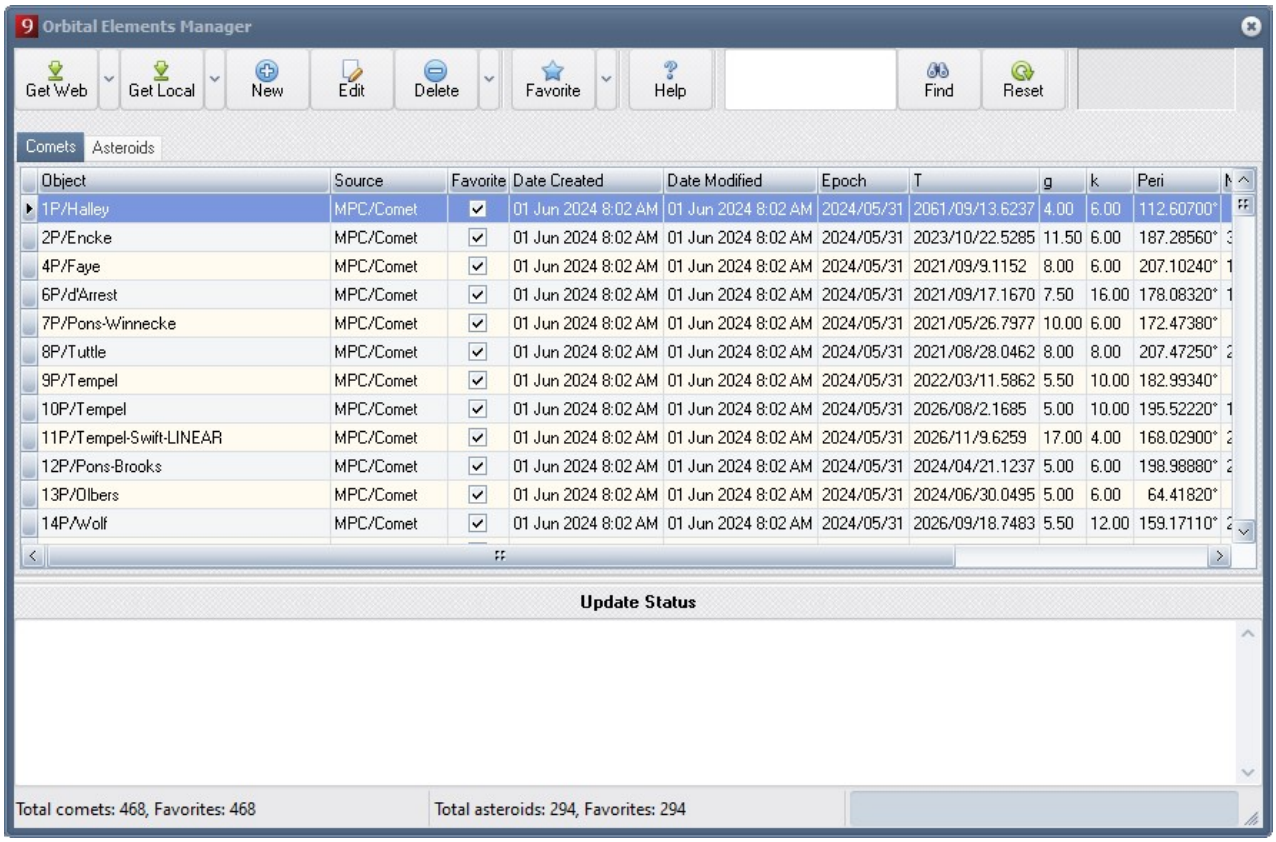
When a new comet is discovered, it takes some time to collate observations and reduce them to a reliable set of orbital elements, and to assign the comet an official designation. During this period of time, the MPC makes elements for the new comet available on an individual basis rather than adding them to the well-studied, commonly observed comets list. This data appears on the MPC's Comet Ephemeris pages accessible from https://minorplanetcenter.net/iau/Ephemerides/Comets/. Elements for new comets may be entered manually using the **Options | Orbital Elements Manager** in ***Deep-Sky Planner***.

You can download elements from either MPC or SSD using the **Orbital Elements Manager** (see below.) First click the **Comets** tab on the left edge of the **Orbital Elements** pane then click one of the Get buttons at the top of the pane:

- **Comets (MPC)**
- **Comets (SSD)**

Getting Orbital Elements for Comets from MPC or SSD

Open the **Orbital Elements Manager** (**Options | Orbital Elements Manager**) and select the **Comets** tab on the left edge of the **Orbital Elements** pane.



Object	Source	Favorite	Date Created	Date Modified	Epoch	T	g	k	Peri
1P/Halley	MPC/Comet	☑	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2061/09/13.6237	4.00	6.00	112.60700°
2P/Encke	MPC/Comet	☑	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2023/10/22.5285	11.50	6.00	187.28560°
4P/Faye	MPC/Comet	☑	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2021/09/9.1152	8.00	6.00	207.10240°
6P/d'Arrest	MPC/Comet	☑	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2021/09/17.1670	7.50	16.00	178.08320°
7P/Pons-Winnecke	MPC/Comet	☑	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2021/05/26.7977	10.00	6.00	172.47380°
8P/Tuttle	MPC/Comet	☑	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2021/08/28.0462	8.00	8.00	207.47250°
9P/Tempel	MPC/Comet	☑	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2022/03/11.5862	5.50	10.00	182.99340°
10P/Tempel	MPC/Comet	☑	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2026/08/2.1685	5.00	10.00	195.52220°
11P/Tempel-Swift-LINEAR	MPC/Comet	☑	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2026/11/9.6259	17.00	4.00	168.02900°
12P/Pons-Brooks	MPC/Comet	☑	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2024/04/21.1237	5.00	6.00	198.98880°
13P/Olbers	MPC/Comet	☑	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2024/06/30.0495	5.00	6.00	64.41820°
14P/Wolf	MPC/Comet	☑	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2026/09/18.7483	5.50	12.00	159.17110°

Figure 1: Orbital Elements Manager showing comets

The **Epoch** column shows the date for which the parameters are correct. MPC and SSD compute comet elements for a new Epoch about once a year, so if your elements are over a year old, you should download a new set of elements (see below.)

The **Date Modified** column shows the date that the parameters were added to or changed in the database. This tells you when you last updated elements for a specific comet.

The **T** column shows the date of perihelion – when the comet reaches its closest point to the sun.

The **Favorite** column shows whether a comet appears in the selection list of a Comet Ephemeris document, or whether it is included in a database search in a Comet Search document. Eliminating comets from a database search document improves performance. You can use the **Favorite** item to retain a comet's orbital elements for future use while excluding the comet temporarily from database searches and ephemeris calculations.

If you want to completely refresh comet elements, you should:

- Delete all displayed elements (**Delete All**)

- Download and import the latest elements from the MPC (**Get Web | Comets (MPC) | Periodic**) or the SSD (**Get Web | Comets (SSD) | Periodic**)

If you want to update only those elements that have been improved while retaining unimproved elements, you should:

- Download and import the latest elements from the MPC or SSD – elements for comets that are no longer on the MPC Observable Comets list will remain in your database. SSD usually retains elements for all known comets.

Adding Orbital Elements for a Newly Discovered Comets

From the **Orbital Elements Manager**, click  **New** to open the **Orbital Elements Editor**. Enter orbital elements for the new comet. Be sure to check **Favorite** if you want this comet to be included in comet ephemeris and search documents. Click **OK** to save the data.

You can modify the orbital elements for an object by right clicking on it in the **Orbital Elements Manager** and selecting **Edit** from the context menu.

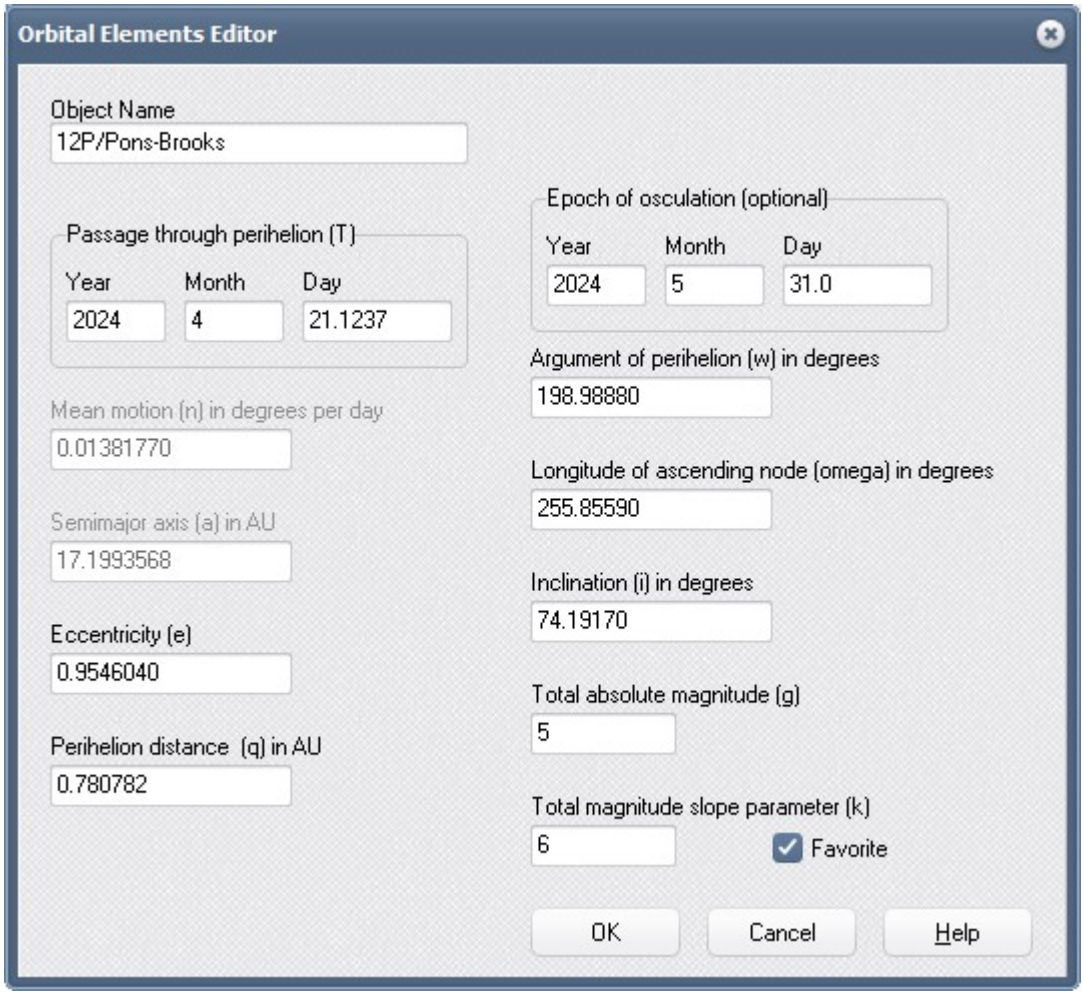
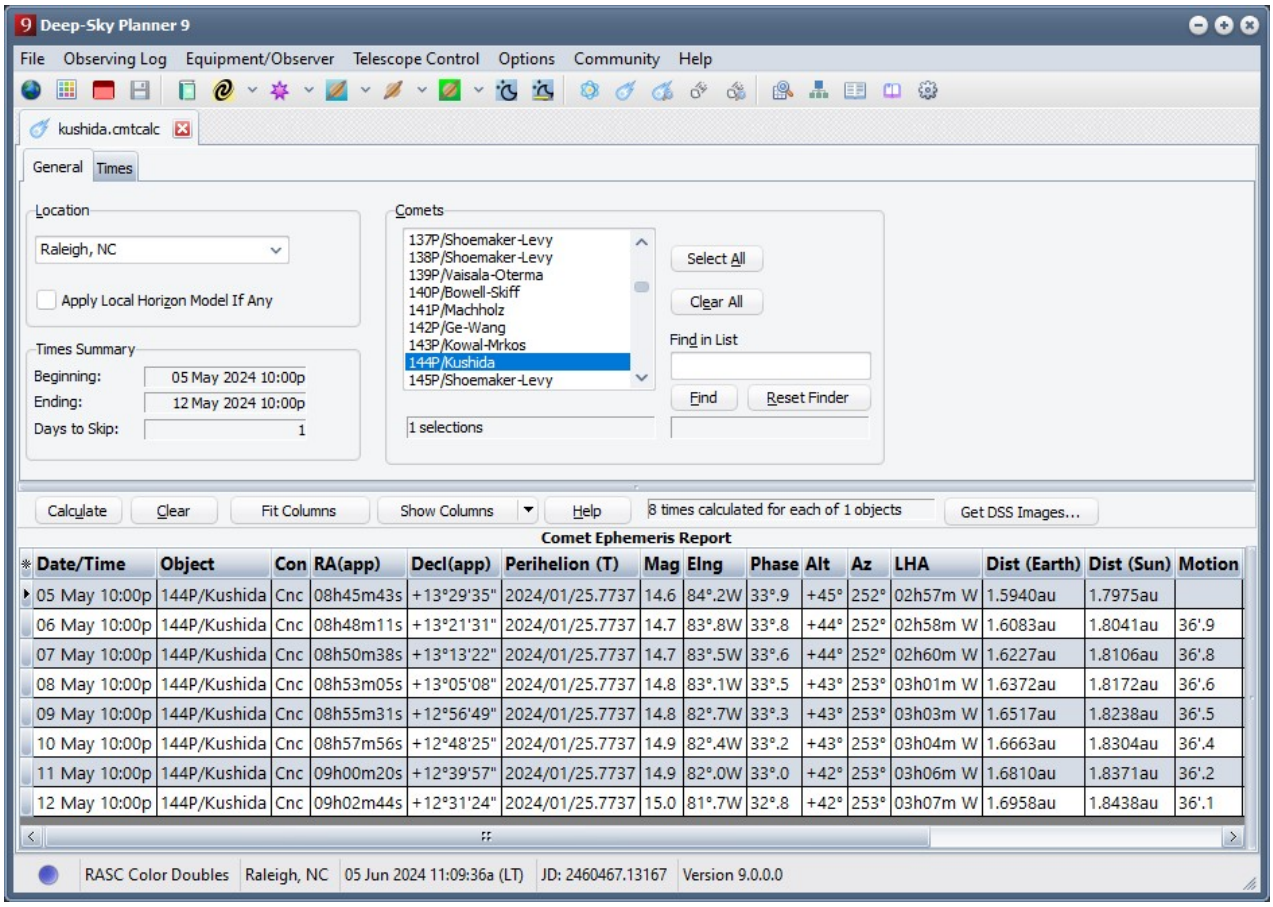


Figure 2: Orbital Elements Editor

Using the Comet Documents to Plan Your Observations

The two comet document types included in ***Deep-Sky Planner*** are for 2 distinct purposes.

When you know which comet(s) you want to observe, use the **Comet Ephemeris document** (shown below) to select these objects and compute ephemerides. Instructions for using the Comet Ephemeris document are in the main help file for ***Deep-Sky Planner.***



Date/Time	Object	Con	RA(app)	Decl(app)	Perihelion (T)	Mag	Elng	Phase	Alt	Az	LHA	Dist (Earth)	Dist (Sun)	Motion
05 May 10:00p	144P/Kushida	Cnc	08h45m43s	+13°29'35"	2024/01/25.7737	14.6	84°.2W	33°.9	+45°	252°	02h57m W	1.5940au	1.7975au	
06 May 10:00p	144P/Kushida	Cnc	08h48m11s	+13°21'31"	2024/01/25.7737	14.7	83°.8W	33°.8	+44°	252°	02h58m W	1.6083au	1.8041au	36'.9
07 May 10:00p	144P/Kushida	Cnc	08h50m38s	+13°13'22"	2024/01/25.7737	14.7	83°.5W	33°.6	+44°	252°	02h60m W	1.6227au	1.8106au	36'.8
08 May 10:00p	144P/Kushida	Cnc	08h53m05s	+13°05'08"	2024/01/25.7737	14.8	83°.1W	33°.5	+43°	253°	03h01m W	1.6372au	1.8172au	36'.6
09 May 10:00p	144P/Kushida	Cnc	08h55m31s	+12°56'49"	2024/01/25.7737	14.8	82°.7W	33°.3	+43°	253°	03h03m W	1.6517au	1.8238au	36'.5
10 May 10:00p	144P/Kushida	Cnc	08h57m56s	+12°48'25"	2024/01/25.7737	14.9	82°.4W	33°.2	+43°	253°	03h04m W	1.6663au	1.8304au	36'.4
11 May 10:00p	144P/Kushida	Cnc	09h00m20s	+12°39'57"	2024/01/25.7737	14.9	82°.0W	33°.0	+42°	253°	03h06m W	1.6810au	1.8371au	36'.2
12 May 10:00p	144P/Kushida	Cnc	09h02m44s	+12°31'24"	2024/01/25.7737	15.0	81°.7W	32°.8	+42°	253°	03h07m W	1.6958au	1.8438au	36'.1

Figure 3: Comet Ephemeris document showing daily motion of 144P/Kushida

When you don't know which comet(s) you want to observe, or you are trying to identify an object seen in the eyepiece or an image, use the **Comet Search document** (shown below) to find object(s) that fit your circumstances. Instructions for using the Comet Search document are in the main help file for ***Deep-Sky Planner***.

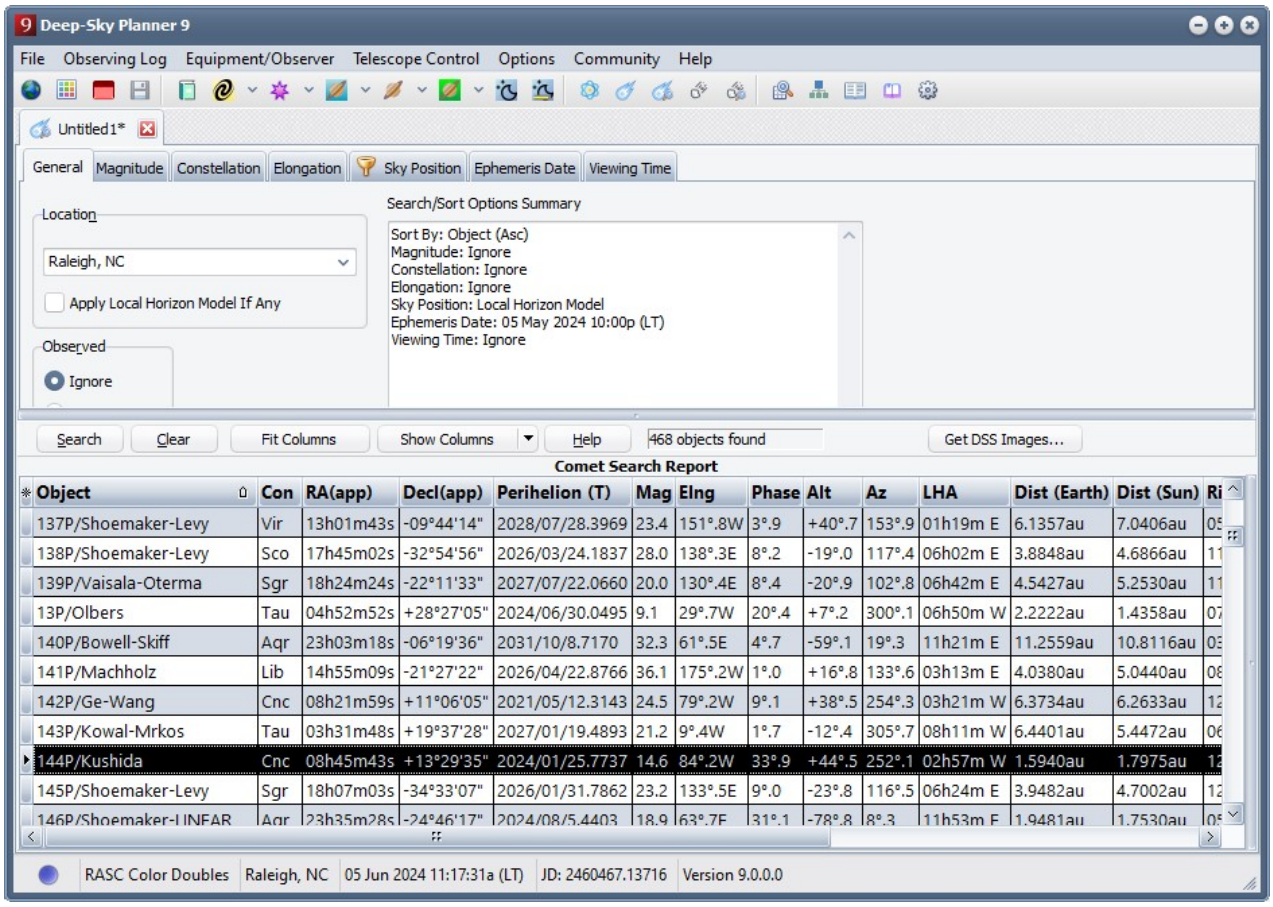


Figure 4: Comet Search document

Orbital Elements for Asteroids

The number of asteroids that are cataloged by the MPC and the SSD with orbital elements available is in the hundreds of thousands. There are large, comprehensive data sets available that are hundreds of megabytes in size. You can read about these at: https://www.minorplanetcenter.net/iau/MPCORB.html. ***Deep-Sky Planner*** can import these files, but because they are so large, performance of all tools becomes very slow. For this reason, Knightware suggests that you use any of the four smaller subsets that suit your interests. These can be downloaded and imported by ***Deep-Sky Planner.*** The following are the most popular data sets of asteroids (available from MPC):

- **Bright Asteroids** – objects reaching opposition during the current year, including the most familiar asteroids like Ceres, Pallas, Juno, Vesta, etc.
- **Critical List Asteroids** – the MPC needs additional astrometric observations for these objects so that their orbits may be refined
- **Distant Asteroids** – Centaurs and Transneptunian objects
- **Unusual Asteroids** - including the fast-moving Near Earth Objects (NEOs)

Two sets of data are available from the SSD:

- Numbered Asteroids – hundreds of thousands of objects
- Unnumbered Asteroids - hundreds of thousands of objects

Elements for bright asteroids are shipped with ***Deep-Sky Planner***. These should be updated at least once a year. The other three sets aren't shipped but can be downloaded and added to the database at any time. Each of these sets contains elements for hundreds of objects.

Like comets, when a new asteroid is discovered, it takes some time to collate observations and reduce them to a reliable set of orbital elements. Elements for new asteroids must be entered manually using the **Orbital Elements Manager** in ***Deep-Sky Planner***.

Getting Orbital Elements for Asteroids

Open the **Orbital Elements Manager** (**Options | Orbital Elements Manager**) and select the **Asteroids** tab on the left edge of the **Orbital Elements** pane.

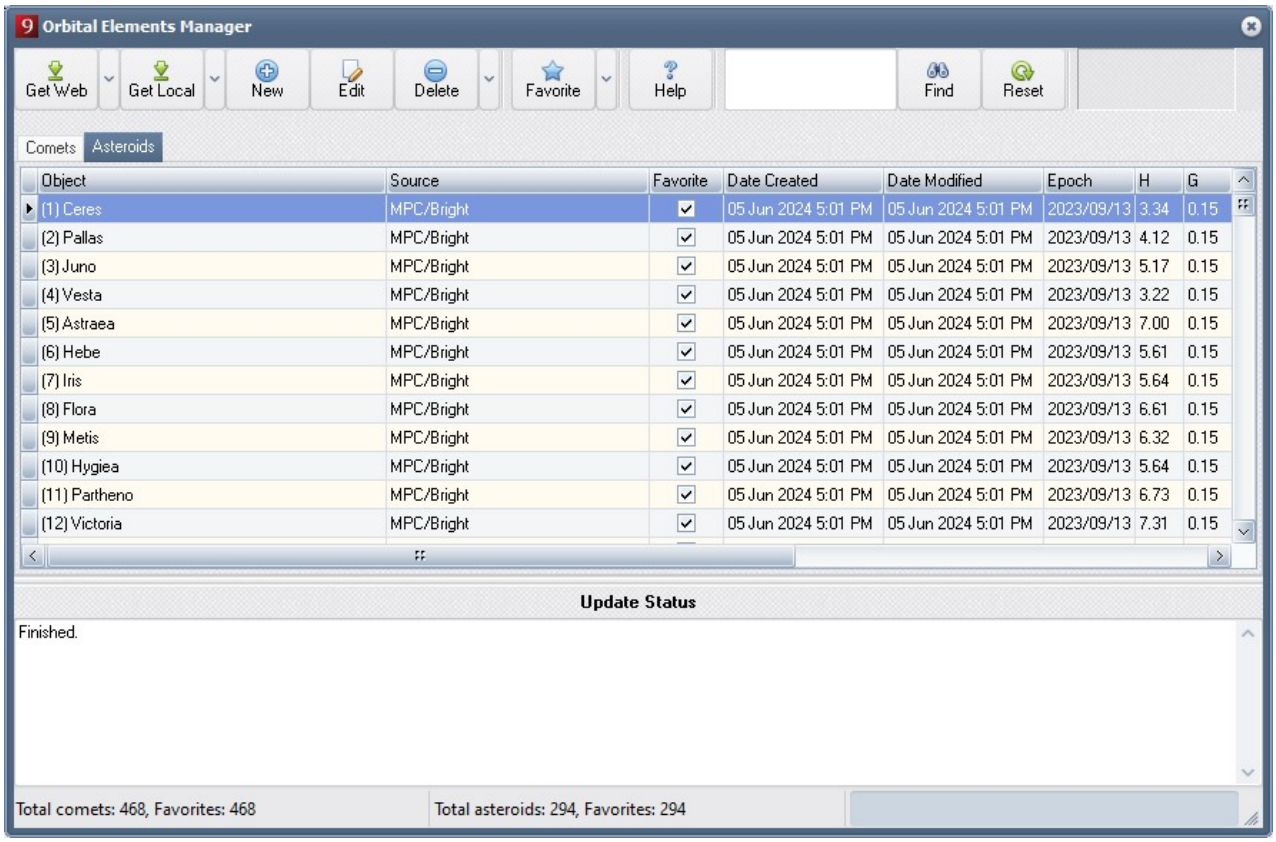


Figure 4: Orbital Elements Manager showing bright asteroids only

The **Epoch** column shows the date for which the parameters are correct. The MPC and SSD compute elements for a new Epoch about once a year, so if your elements are over a year old, you should download a new set of elements (see below.)

The **Date Modified** column shows the date that the parameters were added to or changed in the database. This tells you when you last updated elements for a specific object.

The **Favorite** column shows whether an asteroid appears in the selection list of an Asteroid Ephemeris document, or whether it is included in a database search of an Asteroid Search document. Eliminating objects from a database search document improves performance. You can use the **Favorite** item to retain an asteroid's orbital elements for future use while excluding it temporarily from database searches and ephemeris calculations.

If you want to completely refresh elements for all asteroids, you must delete all asteroids (click the **Delete All** button at the top of the **Orbital Elements** pane) before downloading new elements. The remaining discussion uses the Numbered Asteroids data set, but the technique applies equally to any of the sets. Note that none of the asteroids in a large data set are marked 'Favorite' – you should do that on a per-object basis.

- Select the **Asteroids** tab at the top of the **Orbital Elements** pane to display only those objects.
- Delete all asteroids elements (**Delete All**)
- Download and import the latest elements for Numbered Asteroids from the SSD (**File | Update from Internet | Numbered Asteroids (SSD)**

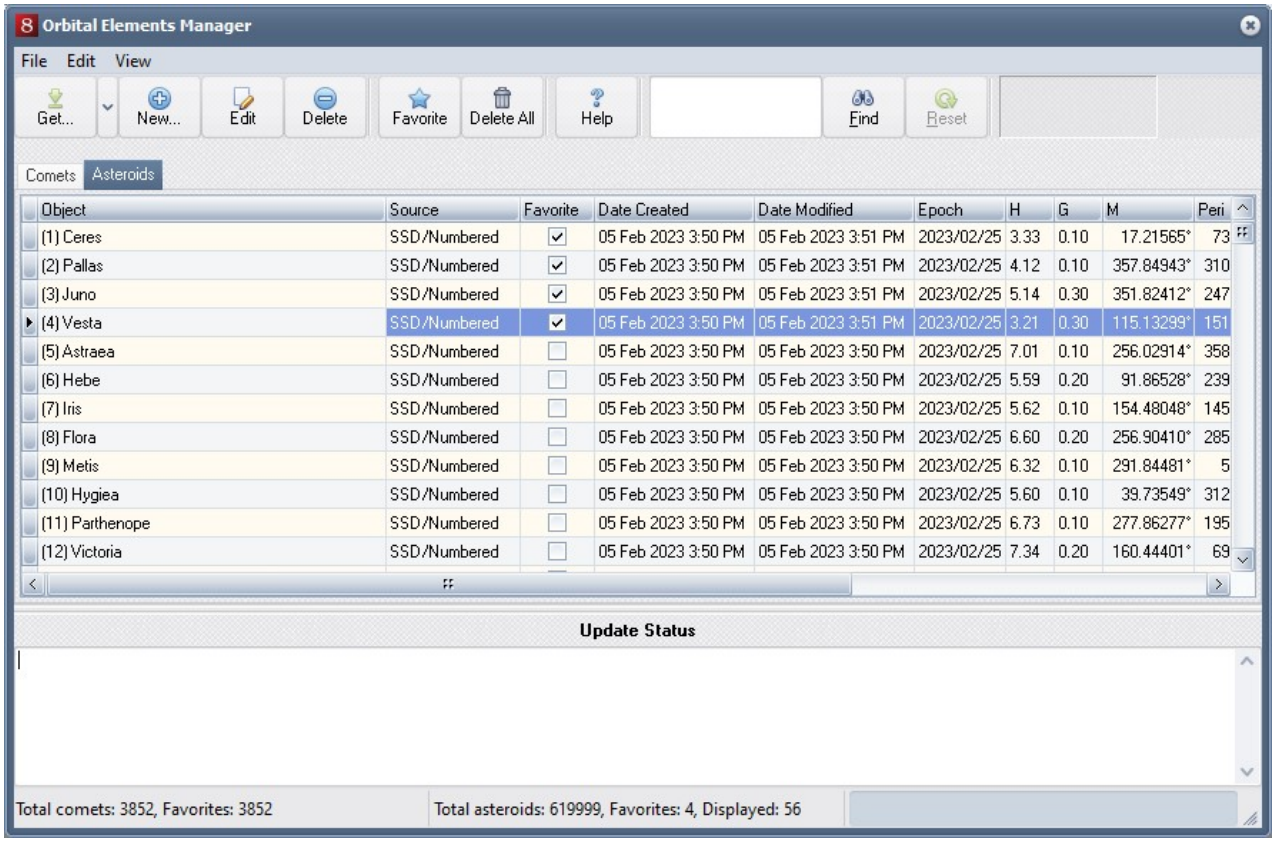
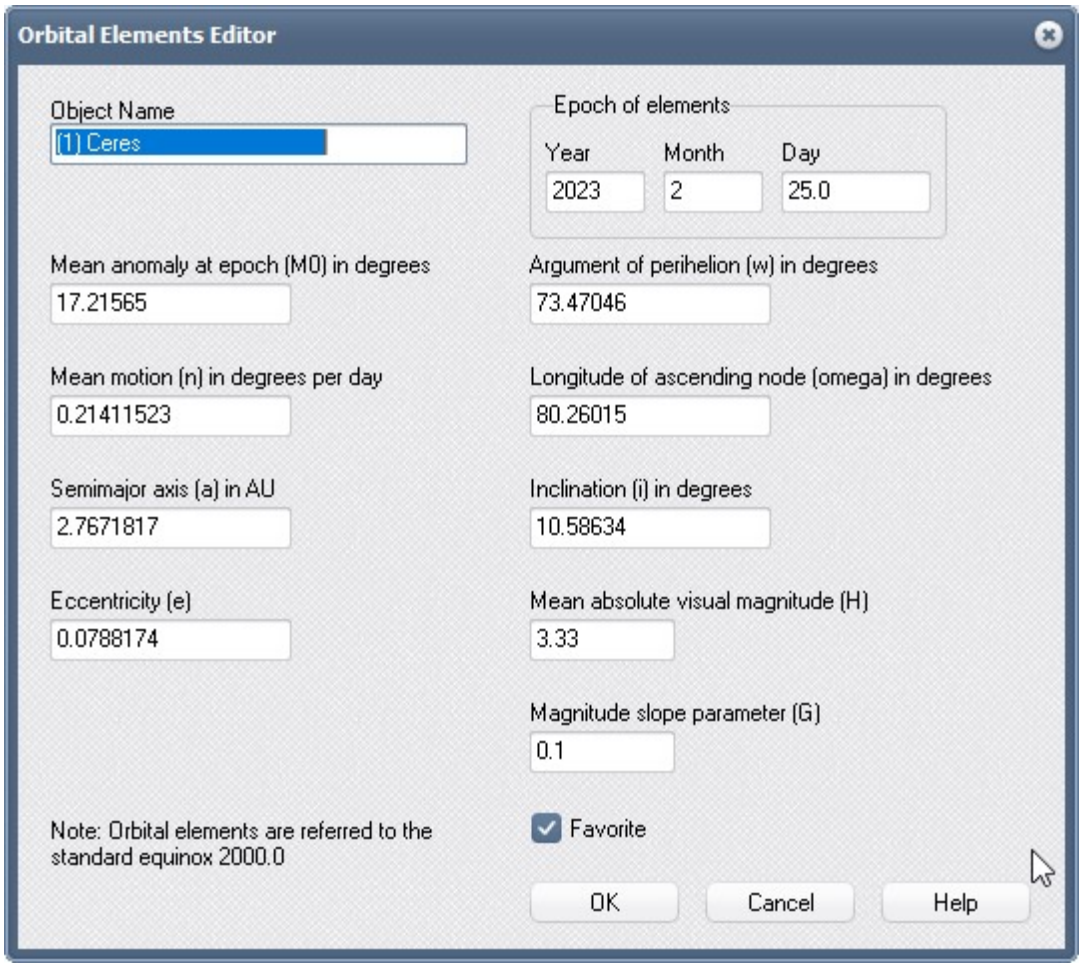


Figure 5: Results of downloading only Numbered Asteroids

Adding/Editing Orbital Elements for Newly Discovered Asteroids

From the **Orbital Elements Manager**, open the **Orbital Elements Editor** (**File | New**) and enter orbital elements for the new asteroid. Be sure to check **Favorite** if you want this object to be included in asteroid ephemeris and asteroid search documents. Click **OK** to save the data.

You can modify the orbital elements for an object by right clicking on it in the **Orbital Elements Manager** and selecting **Edit** from the context menu.



Using the Asteroid Documents to Plan Your Observations

The two asteroid document types included in ***Deep-Sky Planner*** are for 2 distinct purposes.

When you know which asteroid(s) you want to observe, use the **Asteroid Ephemeris document** to select these objects and compute ephemerides. Instructions for using the Asteroid Ephemeris document are in the main help file for ***Deep-Sky Planner***. You can open this help page by clicking the **Help** button as shown below.

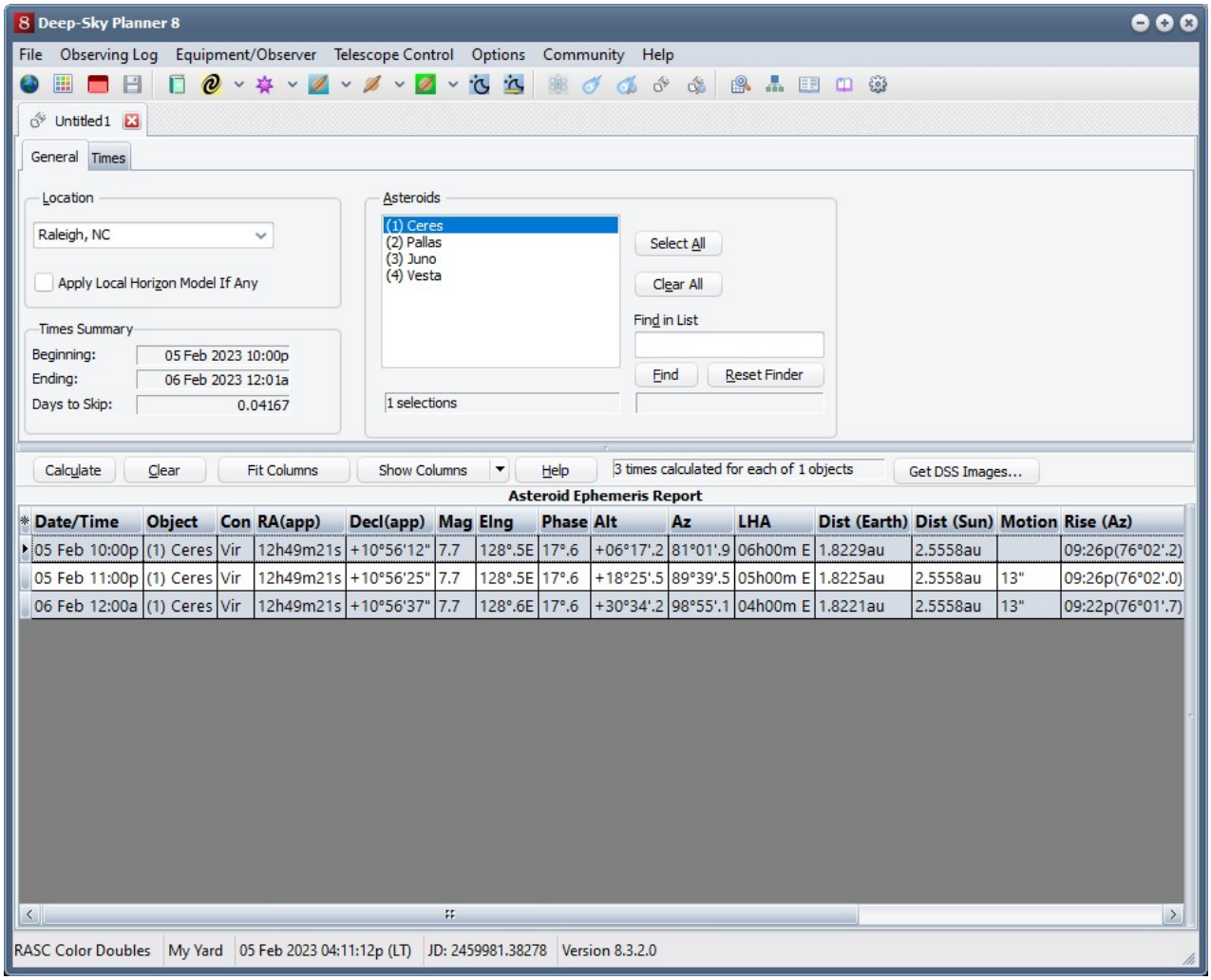


Figure 6: Asteroid Ephemeris document for (1) Ceres

When you don't know which asteroid(s) you want to observe, or you are trying to identify an object seen in the eyepiece or an image, use the **Asteroid Search document** to find object(s) that fit your situation. Instructions for using the Asteroid Search document are in the main help file for ***Deep-Sky Planner***. You can open this help page by clicking the **Help** button as shown below.

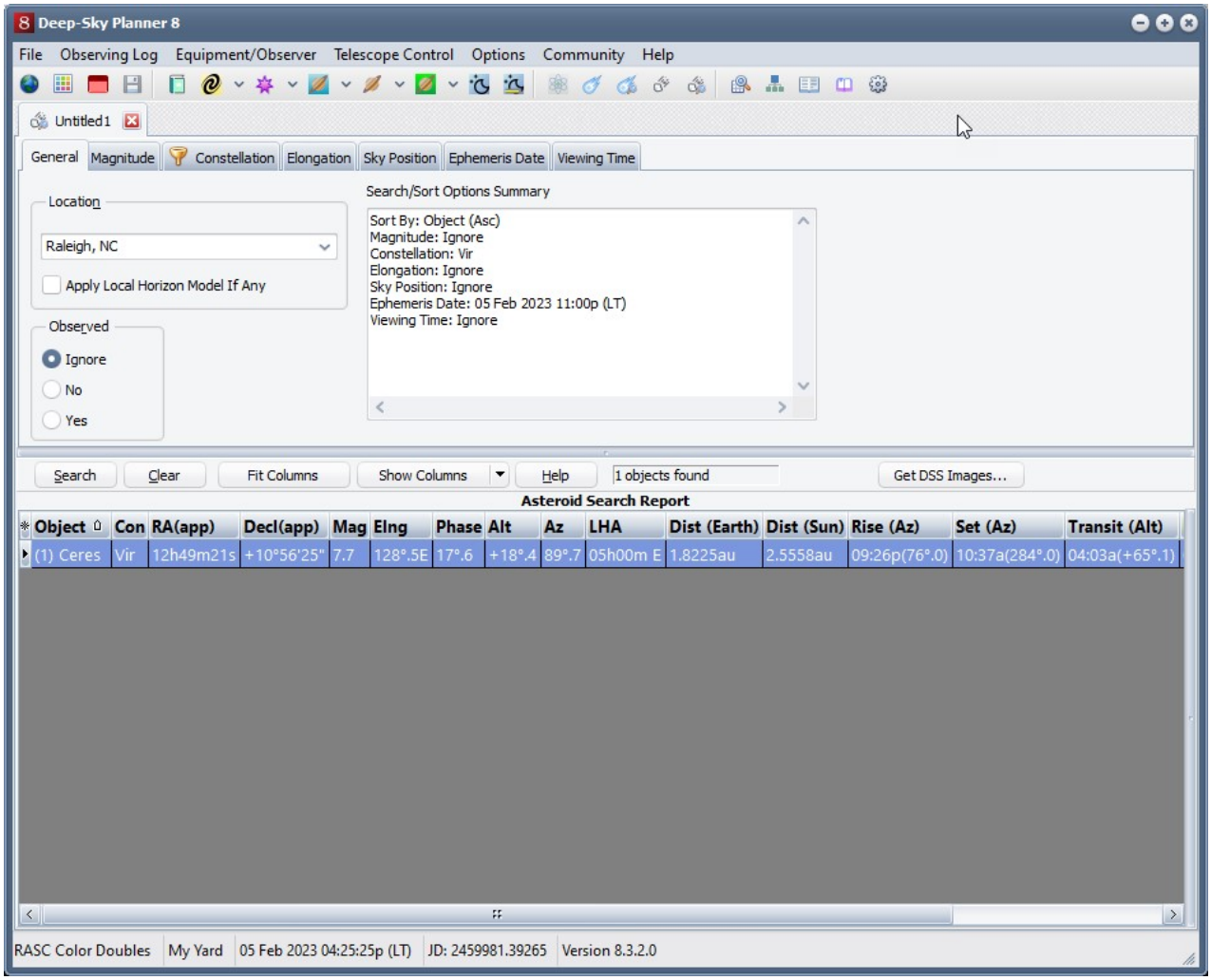


Figure 7: Asteroid Search document

