

## 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.

The screenshot shows the 'Orbital Elements Manager' window. At the top, there are tabs for 'Comets' and 'Asteroids', with 'Comets' selected. Below the tabs is a toolbar with buttons: 'Get Web', 'Get Local', 'New', 'Edit', 'Delete', 'Favorite', 'Help', 'Find', and 'Reset'. The main area contains a table of comet data. The table has columns: Object, Source, Favorite, Date Created, Date Modified, Epoch, T, g, k, Peri, and a small icon column. The data rows list various comets, including 1P/Halley, 2P/Encke, 4P/Faye, 6P/d'Arrest, 7P/Pons-Winnecke, 8P/Tuttle, 9P/Tempel, 10P/Tempel, 11P/Tempel-Swift-LINEAR, 12P/Pons-Brooks, 13P/Olbers, and 14P/Wolf. Each row has a 'Favorite' checkbox, which is checked for all listed comets. The 'Date Created' and 'Date Modified' columns all show '01 Jun 2024 8:02 AM'. The 'Epoch' column shows dates like '2024/05/31' and '2026/09/13'. The 'T' column shows dates like '2061/09/13' and '2062/09/13'. The 'g' and 'k' columns show values like '4.00', '6.00', and '12.00'. The 'Peri' column shows values like '112.60700°', '187.28560°', and '159.17110°'. Below the table is an 'Update Status' section, which is currently empty. At the bottom of the window, there are two status bars: 'Total comets: 468, Favorites: 468' and 'Total asteroids: 294, Favorites: 294'.

Object	Source	Favorite	Date Created	Date Modified	Epoch	T	g	k	Peri
1P/Halley	MPC/Comet	<input checked="" type="checkbox"/>	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2061/09/13 6:237	4.00	6.00	112.60700°
2P/Encke	MPC/Comet	<input checked="" type="checkbox"/>	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2023/10/22 5:285	11.50	6.00	187.28560°
4P/Faye	MPC/Comet	<input checked="" type="checkbox"/>	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2021/09/09 1:152	8.00	6.00	207.10240°
6P/d'Arrest	MPC/Comet	<input checked="" type="checkbox"/>	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2021/09/17 1:670	7.50	16.00	178.08320°
7P/Pons-Winnecke	MPC/Comet	<input checked="" type="checkbox"/>	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2021/05/26 7:977	10.00	6.00	172.47380°
8P/Tuttle	MPC/Comet	<input checked="" type="checkbox"/>	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2021/08/28 0:462	8.00	8.00	207.47250°
9P/Tempel	MPC/Comet	<input checked="" type="checkbox"/>	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2022/03/11 5:862	5.50	10.00	182.99340°
10P/Tempel	MPC/Comet	<input checked="" type="checkbox"/>	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2026/08/2 1:685	5.00	10.00	195.52220°
11P/Tempel-Swift-LINEAR	MPC/Comet	<input checked="" type="checkbox"/>	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2026/11/9 6:259	17.00	4.00	168.02900°
12P/Pons-Brooks	MPC/Comet	<input checked="" type="checkbox"/>	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2024/04/21 1:237	5.00	6.00	198.98880°
13P/Olbers	MPC/Comet	<input checked="" type="checkbox"/>	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2024/06/30 0:495	5.00	6.00	64.41820°
14P/Wolf	MPC/Comet	<input checked="" type="checkbox"/>	01 Jun 2024 8:02 AM	01 Jun 2024 8:02 AM	2024/05/31	2026/09/18 7:483	5.50	12.00	159.17110°

Update Status

Total comets: 468, Favorites: 468      Total asteroids: 294, Favorites: 294

**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.

**Orbital Elements Editor**

Object Name  
12P/Pons-Brooks

Passage through perihelion (T)  
Year: 2024, Month: 4, Day: 21.1237

Mean motion (n) in degrees per day  
0.01381770

Semimajor axis (a) in AU  
17.1993568

Eccentricity (e)  
0.9546040

Perihelion distance (q) in AU  
0.780782

Epoch of osculation (optional)  
Year: 2024, Month: 5, Day: 31.0

Argument of perihelion (w) in degrees  
198.98880

Longitude of ascending node (omega) in degrees  
255.85590

Inclination (i) in degrees  
74.19170

Total absolute magnitude (g)  
5

Total magnitude slope parameter (k)  
6 ☒ Favorite

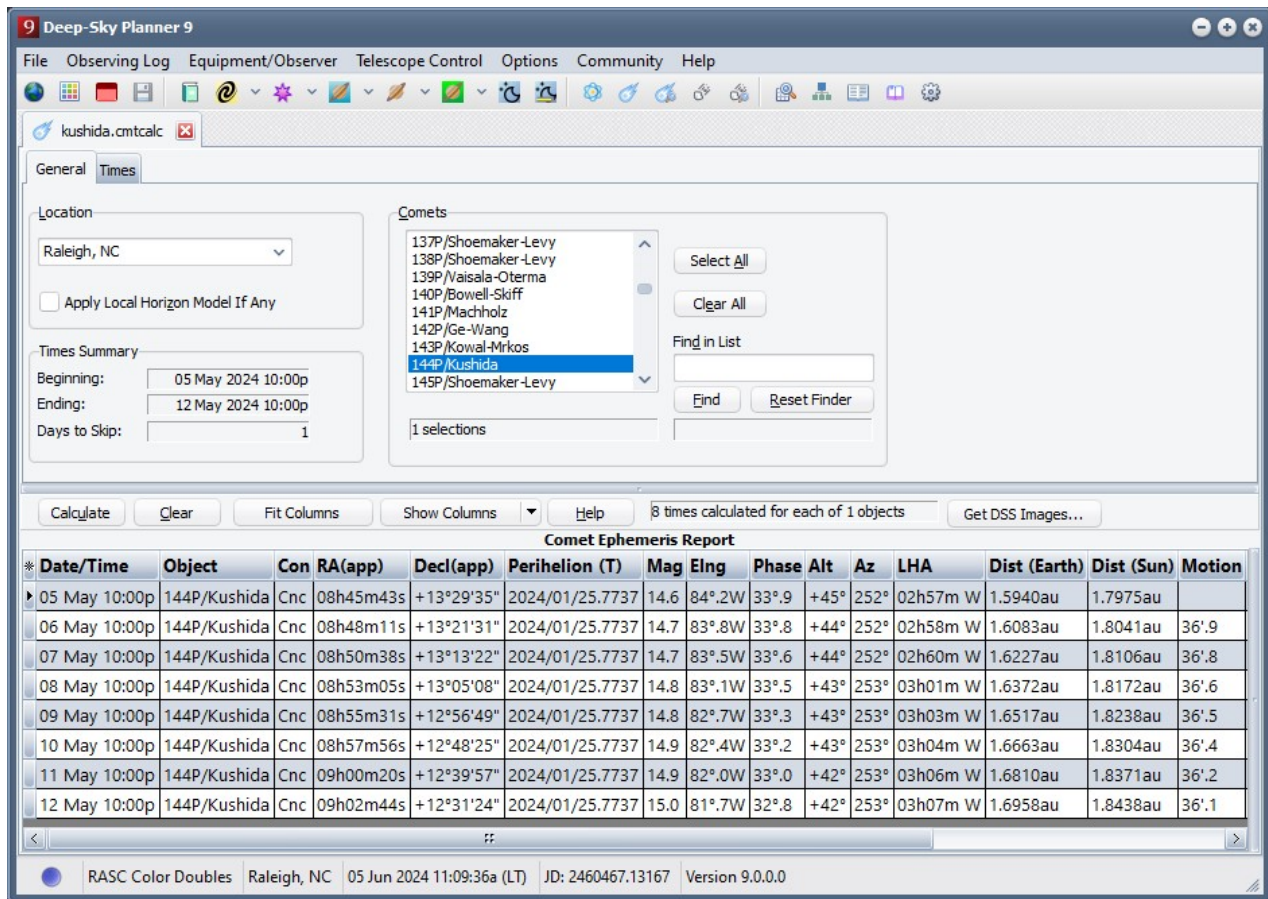
OK Cancel Help

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*.



**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**.



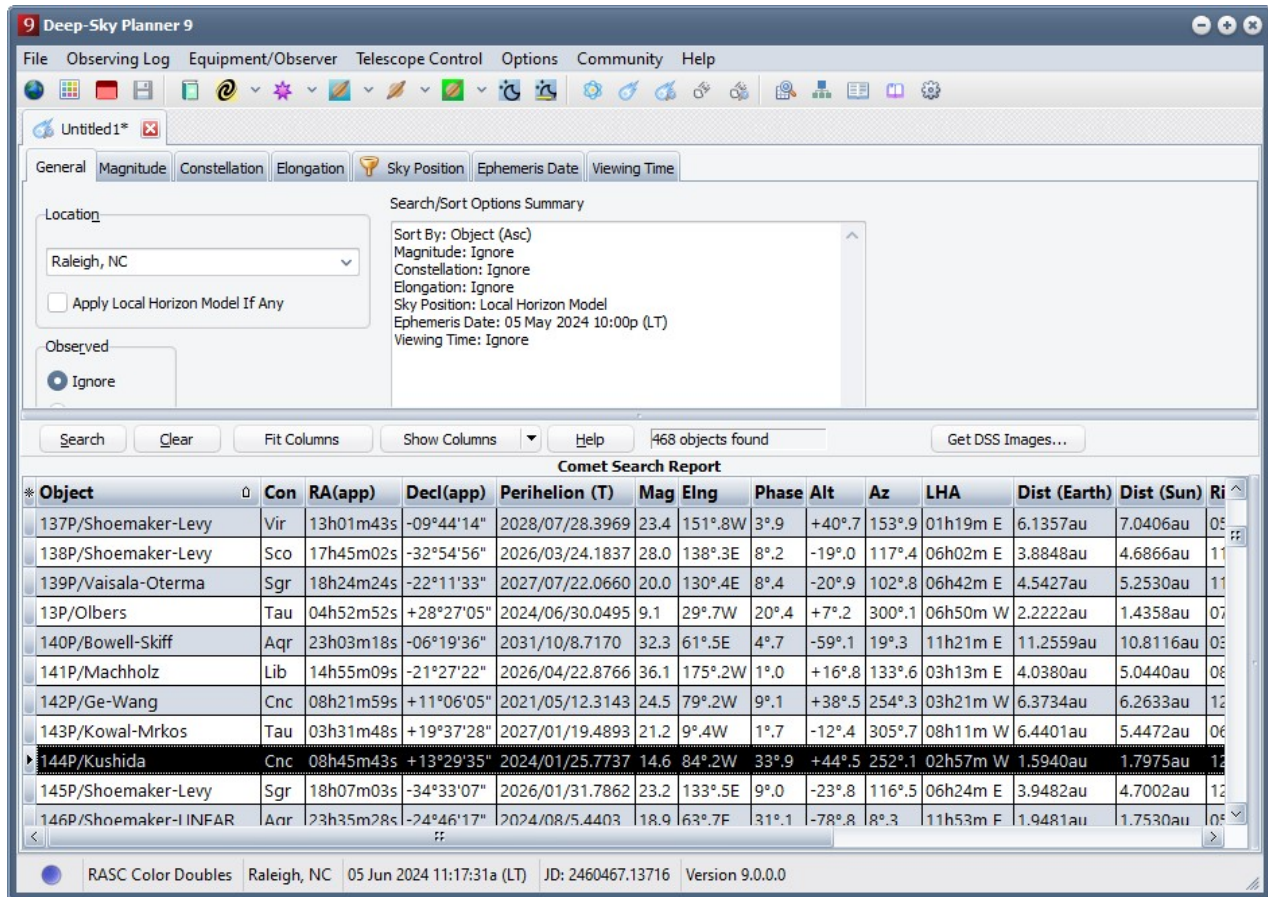


Figure 4: Comet Search document

## 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.



Object	Source	Favorite	Date Created	Date Modified	Epoch	H	G
(1) Ceres	MPC/Bright	<input checked="" type="checkbox"/>	05 Jun 2024 5:01 PM	05 Jun 2024 5:01 PM	2023/09/13	3.34	0.15
(2) Pallas	MPC/Bright	<input checked="" type="checkbox"/>	05 Jun 2024 5:01 PM	05 Jun 2024 5:01 PM	2023/09/13	4.12	0.15
(3) Juno	MPC/Bright	<input checked="" type="checkbox"/>	05 Jun 2024 5:01 PM	05 Jun 2024 5:01 PM	2023/09/13	5.17	0.15
(4) Vesta	MPC/Bright	<input checked="" type="checkbox"/>	05 Jun 2024 5:01 PM	05 Jun 2024 5:01 PM	2023/09/13	3.22	0.15
(5) Astraea	MPC/Bright	<input checked="" type="checkbox"/>	05 Jun 2024 5:01 PM	05 Jun 2024 5:01 PM	2023/09/13	7.00	0.15
(6) Hebe	MPC/Bright	<input checked="" type="checkbox"/>	05 Jun 2024 5:01 PM	05 Jun 2024 5:01 PM	2023/09/13	5.61	0.15
(7) Iris	MPC/Bright	<input checked="" type="checkbox"/>	05 Jun 2024 5:01 PM	05 Jun 2024 5:01 PM	2023/09/13	5.64	0.15
(8) Flora	MPC/Bright	<input checked="" type="checkbox"/>	05 Jun 2024 5:01 PM	05 Jun 2024 5:01 PM	2023/09/13	6.61	0.15
(9) Metis	MPC/Bright	<input checked="" type="checkbox"/>	05 Jun 2024 5:01 PM	05 Jun 2024 5:01 PM	2023/09/13	6.32	0.15
(10) Hygiea	MPC/Bright	<input checked="" type="checkbox"/>	05 Jun 2024 5:01 PM	05 Jun 2024 5:01 PM	2023/09/13	5.64	0.15
(11) Partheno	MPC/Bright	<input checked="" type="checkbox"/>	05 Jun 2024 5:01 PM	05 Jun 2024 5:01 PM	2023/09/13	6.73	0.15
(12) Victoria	MPC/Bright	<input checked="" type="checkbox"/>	05 Jun 2024 5:01 PM	05 Jun 2024 5:01 PM	2023/09/13	7.31	0.15

Update Status

Finished.

Total comets: 468, Favorites: 468      Total asteroids: 294, Favorites: 294

**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)**)

The screenshot shows the 'Orbital Elements Manager' window. The 'Asteroids' tab is selected. The table below lists 12 numbered asteroids with their orbital parameters. The 'Favorite' column has checkboxes, with (4) Vesta checked. The 'Update Status' section is empty. The status bar at the bottom shows: Total comets: 3852, Favorites: 3852; Total asteroids: 619999, Favorites: 4, Displayed: 56.

Object	Source	Favorite	Date Created	Date Modified	Epoch	H	G	M	Peri
(1) Ceres	SSD/Numbered	<input checked="" type="checkbox"/>	05 Feb 2023 3:50 PM	05 Feb 2023 3:51 PM	2023/02/25	3.33	0.10	17.21565°	73
(2) Pallas	SSD/Numbered	<input checked="" type="checkbox"/>	05 Feb 2023 3:50 PM	05 Feb 2023 3:51 PM	2023/02/25	4.12	0.10	357.84943°	310
(3) Juno	SSD/Numbered	<input checked="" type="checkbox"/>	05 Feb 2023 3:50 PM	05 Feb 2023 3:51 PM	2023/02/25	5.14	0.30	351.82412°	247
(4) Vesta	SSD/Numbered	<input checked="" type="checkbox"/>	05 Feb 2023 3:50 PM	05 Feb 2023 3:51 PM	2023/02/25	3.21	0.30	115.13299°	151
(5) Astraea	SSD/Numbered	<input type="checkbox"/>	05 Feb 2023 3:50 PM	05 Feb 2023 3:50 PM	2023/02/25	7.01	0.10	256.02914°	358
(6) Hebe	SSD/Numbered	<input type="checkbox"/>	05 Feb 2023 3:50 PM	05 Feb 2023 3:50 PM	2023/02/25	5.59	0.20	91.86528°	239
(7) Iris	SSD/Numbered	<input type="checkbox"/>	05 Feb 2023 3:50 PM	05 Feb 2023 3:50 PM	2023/02/25	5.62	0.10	154.48048°	145
(8) Flora	SSD/Numbered	<input type="checkbox"/>	05 Feb 2023 3:50 PM	05 Feb 2023 3:50 PM	2023/02/25	6.60	0.20	256.90410°	285
(9) Metis	SSD/Numbered	<input type="checkbox"/>	05 Feb 2023 3:50 PM	05 Feb 2023 3:50 PM	2023/02/25	6.32	0.10	291.84481°	5
(10) Hygiea	SSD/Numbered	<input type="checkbox"/>	05 Feb 2023 3:50 PM	05 Feb 2023 3:50 PM	2023/02/25	5.60	0.10	39.73549°	312
(11) Parthenope	SSD/Numbered	<input type="checkbox"/>	05 Feb 2023 3:50 PM	05 Feb 2023 3:50 PM	2023/02/25	6.73	0.10	277.86277°	195
(12) Victoria	SSD/Numbered	<input type="checkbox"/>	05 Feb 2023 3:50 PM	05 Feb 2023 3:50 PM	2023/02/25	7.34	0.20	160.44401°	69

Update Status

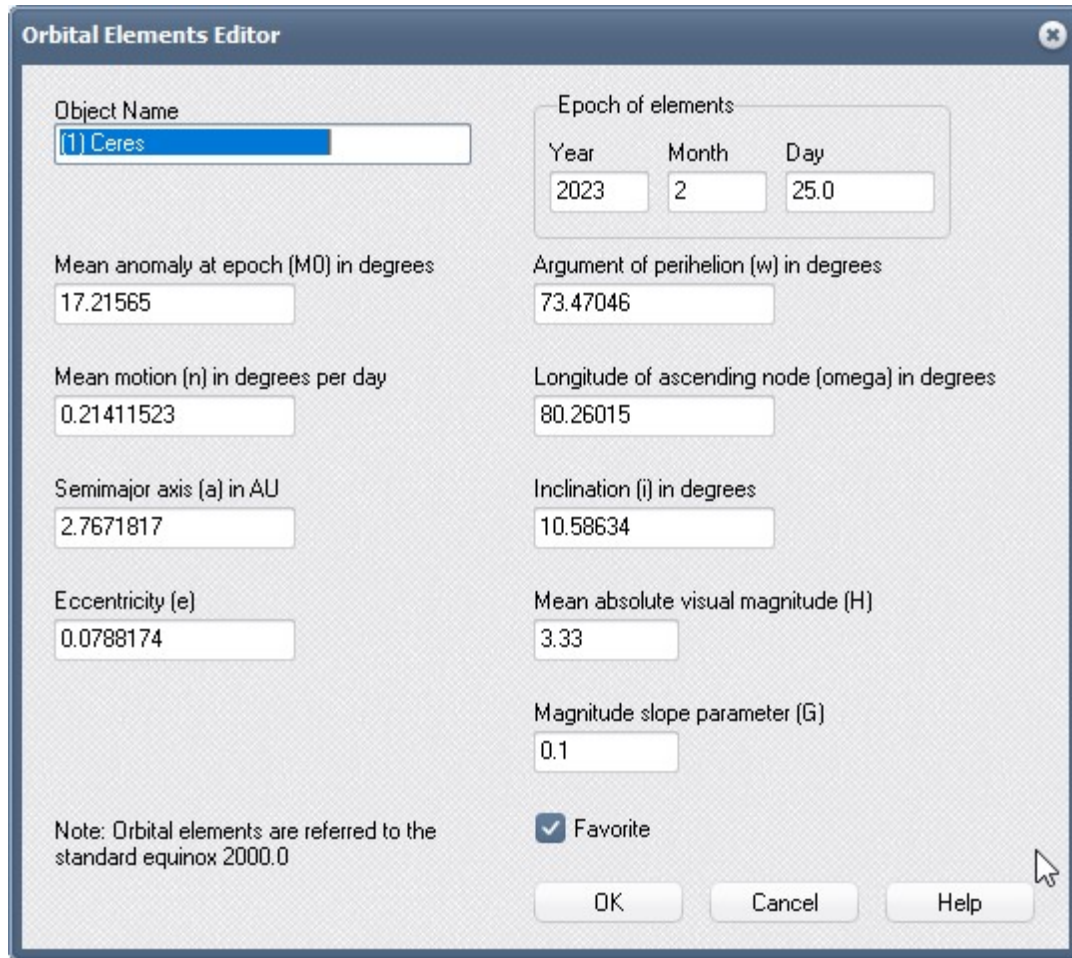
Total comets: 3852, Favorites: 3852      Total asteroids: 619999, Favorites: 4, Displayed: 56

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.



The screenshot shows a software window titled "Orbital Elements Editor". It contains two columns of input fields for orbital parameters. The left column includes fields for Object Name (set to "(1) Ceres"), Mean anomaly at epoch (M0) in degrees (17.21565), Mean motion (n) in degrees per day (0.21411523), Semimajor axis (a) in AU (2.7671817), and Eccentricity (e) (0.0788174). The right column includes a grouped box for "Epoch of elements" with sub-fields for Year (2023), Month (2), and Day (25.0); Argument of perihelion (w) in degrees (73.47046); Longitude of ascending node (omega) in degrees (80.26015); Inclination (i) in degrees (10.58634); Mean absolute visual magnitude (H) (3.33); and Magnitude slope parameter (G) (0.1). At the bottom left, a note states: "Note: Orbital elements are referred to the standard equinox 2000.0". At the bottom right, there is a checked checkbox labeled "Favorite" and three buttons: "OK", "Cancel", and "Help".

Parameter	Value
Object Name	(1) Ceres
Epoch of elements	
Year	2023
Month	2
Day	25.0
Mean anomaly at epoch (M0) in degrees	17.21565
Argument of perihelion (w) in degrees	73.47046
Mean motion (n) in degrees per day	0.21411523
Longitude of ascending node (omega) in degrees	80.26015
Semimajor axis (a) in AU	2.7671817
Inclination (i) in degrees	10.58634
Eccentricity (e)	0.0788174
Mean absolute visual magnitude (H)	3.33
Magnitude slope parameter (G)	0.1

Note: Orbital elements are referred to the standard equinox 2000.0

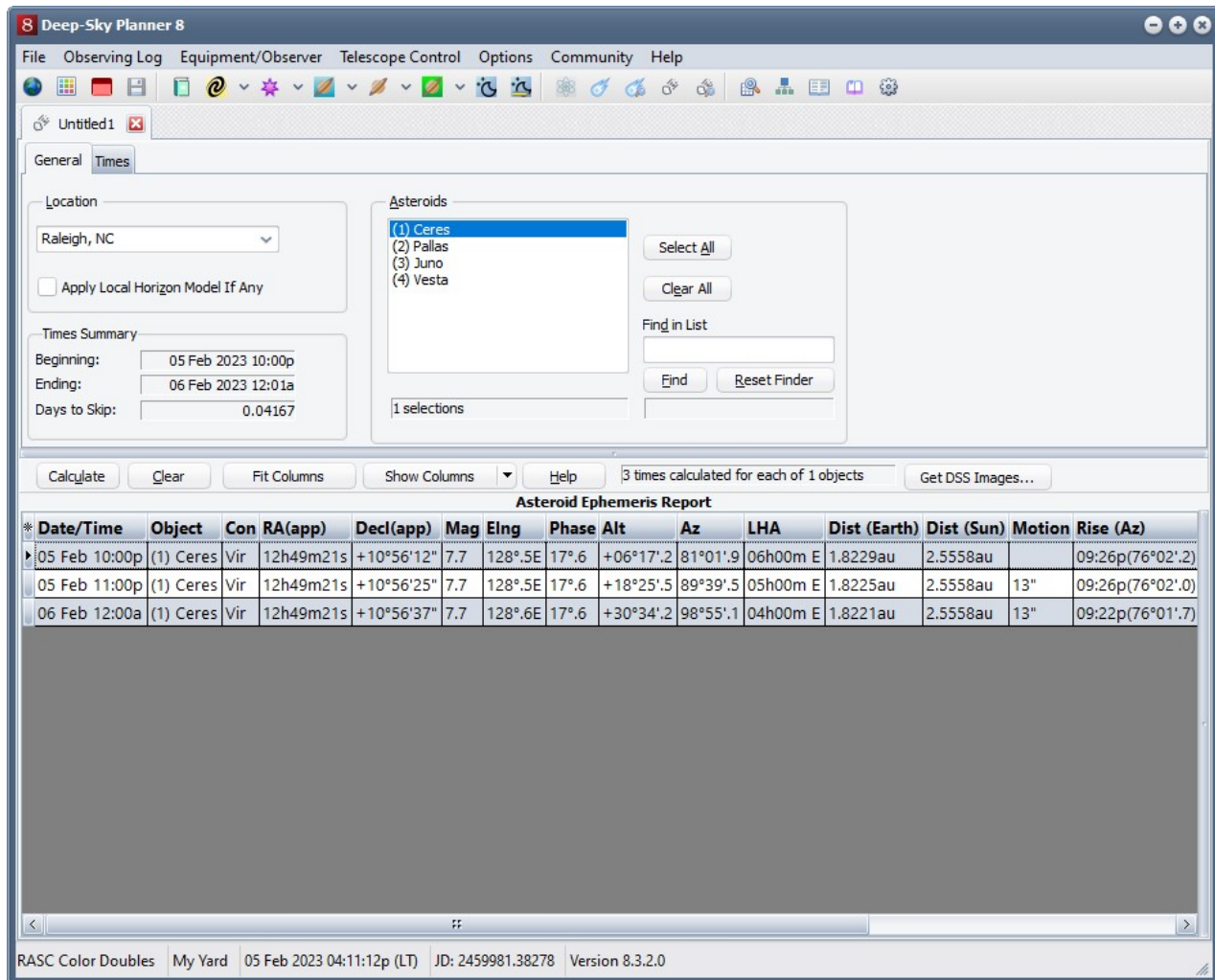
☒ Favorite

OK Cancel Help

## 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.



The screenshot displays the Deep-Sky Planner 8 application window. The top menu bar includes File, Observing Log, Equipment/Observer, Telescope Control, Options, Community, and Help. Below the menu is a toolbar with various icons. The main window has a tabbed interface with tabs for General, Magnitude, Constellation, Elongation, Sky Position, Ephemeris Date, and Viewing Time. The General tab is active, showing a Location dropdown set to 'Raleigh, NC' and an 'Apply Local Horizon Model If Any' checkbox. The 'Observed' section has radio buttons for 'Ignore' (selected), 'No', and 'Yes'. A 'Search/Sort Options Summary' box lists settings: Sort By: Object (Asc), Magnitude: Ignore, Constellation: Vir, Elongation: Ignore, Sky Position: Ignore, Ephemeris Date: 05 Feb 2023 11:00p (LT), and Viewing Time: Ignore. Below the tabs is a search bar with buttons for Search, Clear, Fit Columns, Show Columns, and Help. A status bar indicates '1 objects found' and a 'Get DSS Images...' button. The main display area shows an 'Asteroid Search Report' table with the following data:

* Object	Con	RA(app)	Decl(app)	Mag	Elong	Phase	Alt	Az	LHA	Dist (Earth)	Dist (Sun)	Rise (Az)	Set (Az)	Transit (Alt)
(1) Ceres	Vir	12h49m21s	+10°56'25"	7.7	128°.5E	17°.6	+18°.4	89°.7	05h00m E	1.8225au	2.5558au	09:26p(76°.0)	10:37a(284°.0)	04:03a(+65°.1)

The bottom status bar shows 'RASC Color Doubles', 'My Yard', '05 Feb 2023 04:25:25p (LT)', 'JD: 2459981.39265', and 'Version 8.3.2.0'.

Figure 7: Asteroid Search document