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**PreviSat**  
Satellite tracking  
for everyone

# User manual V3.5

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## I. Overview

PreviSat is free open source software to track artificial satellites on a world map. It is developed in C++/Qt and available on Windows, GNU/Linux and Mac OSX operating systems. Its simple and intuitive interface is designed to meet both the needs of the neophyte to those of the casual observer. PreviSat allows to know the position of the satellites in several coordinate systems (cartesian, equatorial, horizontal). To do this, it uses the SGP4 orbital model - revised in 2006 by David Vallado - and orbital elements called TLE provided by Celestrak or the Space-Track. It also displays the position of the Sun and the Moon.

SGP4 model takes into account only the principal natural disturbances acting on the satellite (first terms of the Earth potential irregularities, simplified model of atmospheric drag, lunisolar disturbances or resonance phenomena), it is necessary to regularly reactualize the orbital elements of the satellites in order to guarantee an optimal precision on the position and the speed of the satellites, in particular when there is an orbital correction manoeuvre. The orbital elements placed at the disposal on the site [www.celestrak.com](http://www.celestrak.com) and also on the site [www.space-track.org](http://www.space-track.org) in the form of text files are presented in the following way, for example for the ISS (see "Satellite informations" tab to know the meaning of each parameter) :

```
ISS (ZARYA)
1 25544U 98067A   08289.55379628   .00014092   00000-0   10869-3 0   4451
2 25544 051.6421 119.2525 0003675 219.8593 192.3484 15.72261275567472
```

PreviSat has 2 operating modes : real-time mode and manual mode. The first mode allows to monitor in real time the evolution of the position of the satellites. The second mode allows the satellites for dates other than the system date.

Osculating Elements tab contains instantaneous orbital parameters of the orbit of the selected satellite. This allows in particular to estimate the size and shape of the satellite orbit. Satellite Information tab details the various components of TLE and also provides information on the satellite itself (dimensions, maximum magnitude ...).

PreviSat calculates the satellite pass predictions for a given place of observation, with the possibility of setting many parameters (selection of the place of observation, minimum height of the satellite, height of the Sun ...). PreviSat is able to determine quickly and accurately flares produced by the Iridium satellites, which can reach a magnitude of -8.3, which is 30 - 40 times brighter than Venus.

Many display options to customize the GUI are available (zone of visibility of satellites, ground track, Sun, shadow of the Earth, Moon ...). The graphical interface allows easy management of places of observation. A special category of places of observation, called "My Favorites" allows you to group most used observation sites. Two management utilities of TLE are available in the software (TLE updating or creating a TLE file from an existing file).

There are also three features making prediction calculations :

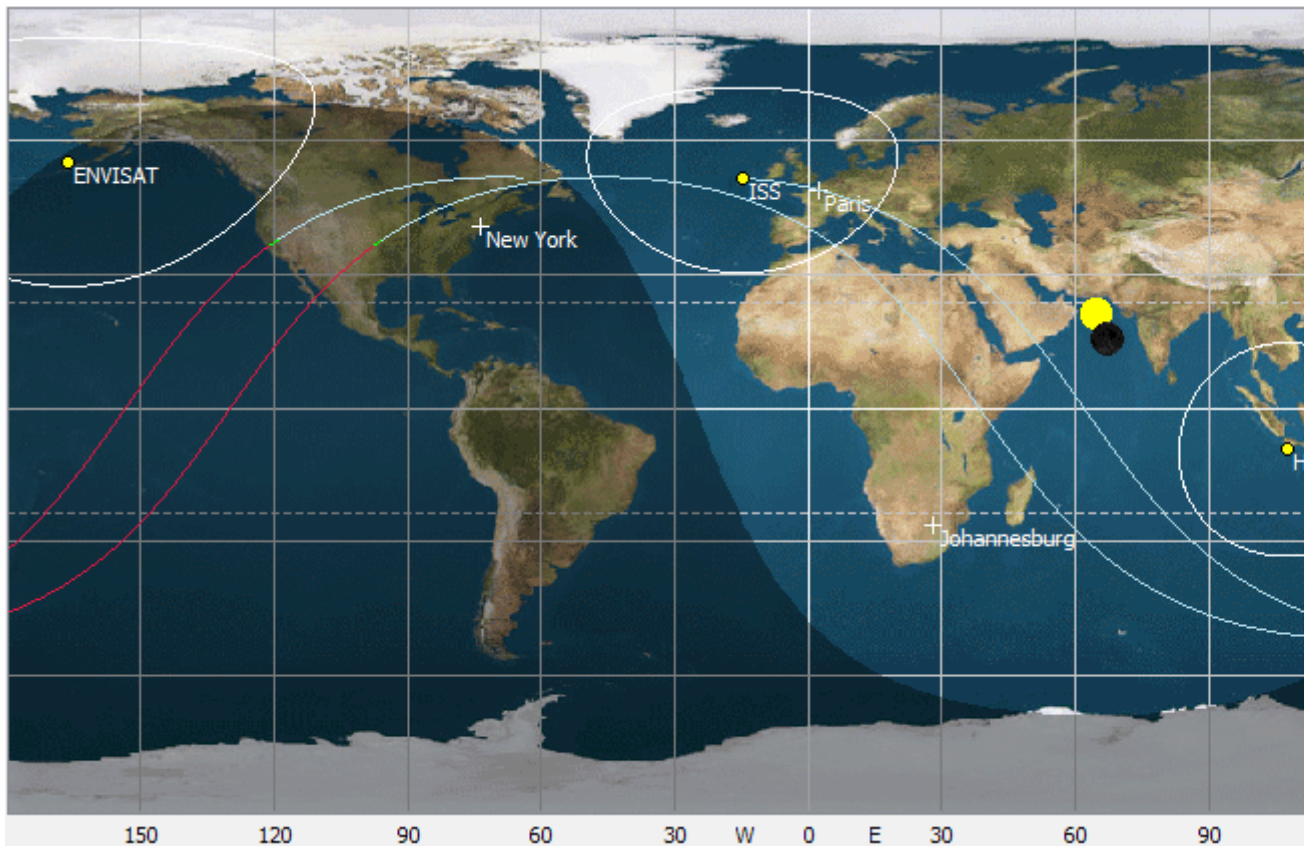
- Calculation of orbital events determines the dates of shadow/penumbral/light transitions, apogee/perigee, transits to nodes of the orbit, etc.,
- Calculation of the ISS transits to the Moon or the Sun,
- Calculation MetOp and SkyMed flares.

PreviSat has a display "Wall Command Center" resembling as closely as possible to the ISS command control center of NASA. This visualization allows particular view live streaming video of the ISS.

## II. Graphical interface

### 1. World map

When displayed, the **world map** is the main visual element of the graphic interface.



On this, many elements appear of which most important are the places of location, represented by a white cross, and the satellites, represented by a small coloured disc. Labels are assigned respectively with these two elements. The color of the disc representing the satellite varies according the illumination of the satellite :

- the disc is yellow if the satellite is illuminated by the Sun,
- the disc is green if the satellite is in the penumbra of the Earth
- the disc is red if the satellite is in the shadow of the Earth.

The white contour around the satellite represents the **foot print**, so the satellite is visible of the assembly of points of the globe located at the interior of this zone. In reality, the shape of the foot print is always a circle (abstraction made from the flatness of the terrestrial globe), but the projection on the planisphere can produce various forms.

We also draw the **ground track** of the future orbits of the default satellite. The color of this curve is clear blue when the satellite is illuminated by the Sun, green when the satellite is in the penumbra of the Earth, and red when the satellite is in the shadow of the Earth.

The **Sun** is drawn by a yellow disc on the maps. For a place of observation whose geographical coordinates merge with the center of the disc representing the Sun, this latter is found at the zenith of the considered place of location.

The **zone of shade** is the area of the globe located during the night. One can observe the evolution of the zone of shade during the day (day/night alternation) and of its shape during the year (seasons).

The **Moon** is also displayed on the maps, and its phase is drawn as it appears in the sky of the observer.

It is important to note that the size of the elements (Sun, Moon or satellites) is not representative of the reality.

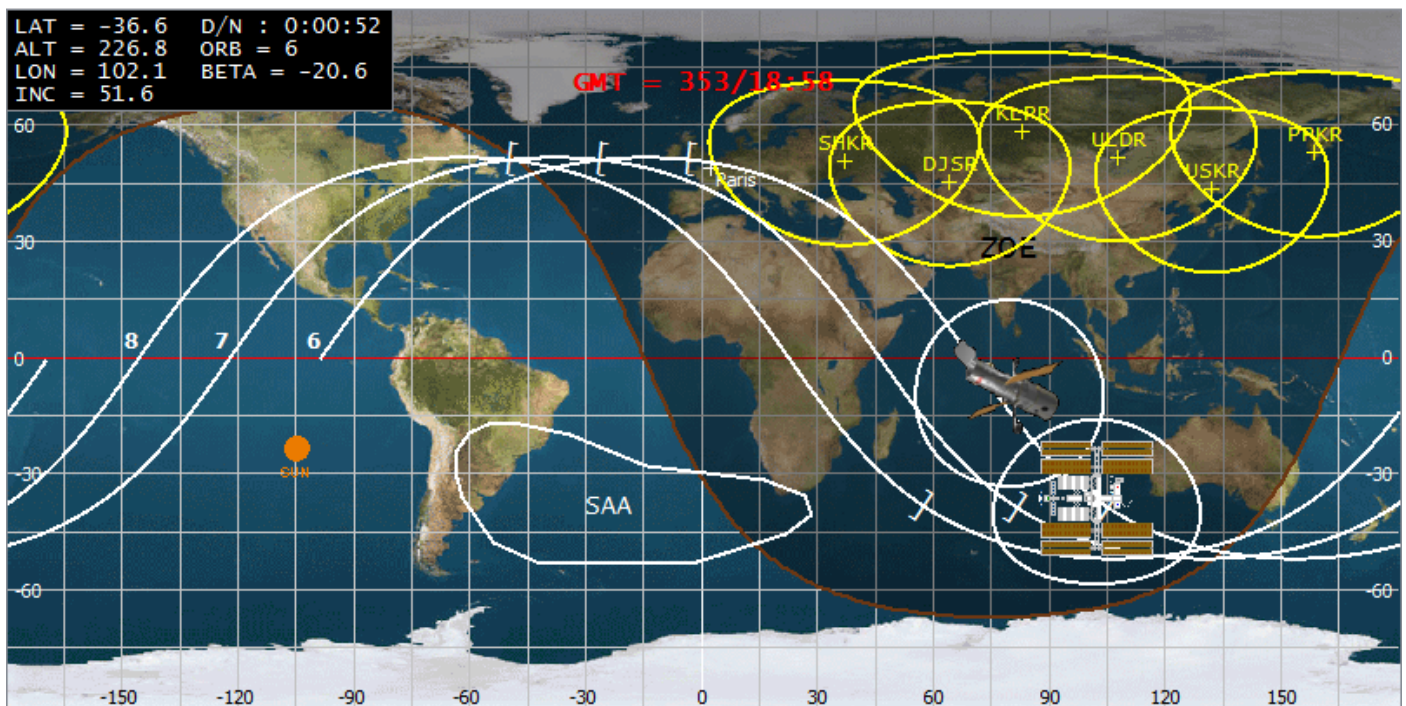
Also displayed on the world map is the grid of the geographical coordinates graduated in steps of 30 degrees, and also the tropics. The meridian at the center of the world map is the meridian line of Greenwich.

All elements described above (except the default place of location) can be made nondisplayable by de-selecting the boxes of the Options/Settings tab.

It is possible to select the default satellite by clicking on his disc on the maps or on the radar, or by right clicking on the list of satellites.


## 2. "Wall Command Center" visualization

When the "ISS Live" box is checked, the representation of the world map is changed.



It is then possible to view the live video stream of the ISS by clicking on the "NASA" button. Most of the time, the camera on board the ISS is pointing towards the ground. Sometimes it shows inside of the station, and you may see the crew. During a spacewalk (EVA), the camera is placed on the helmet of an astronaut.



You can double-click on the video in order to display it in fullscreen, or  click on the button to have it in a separate window.

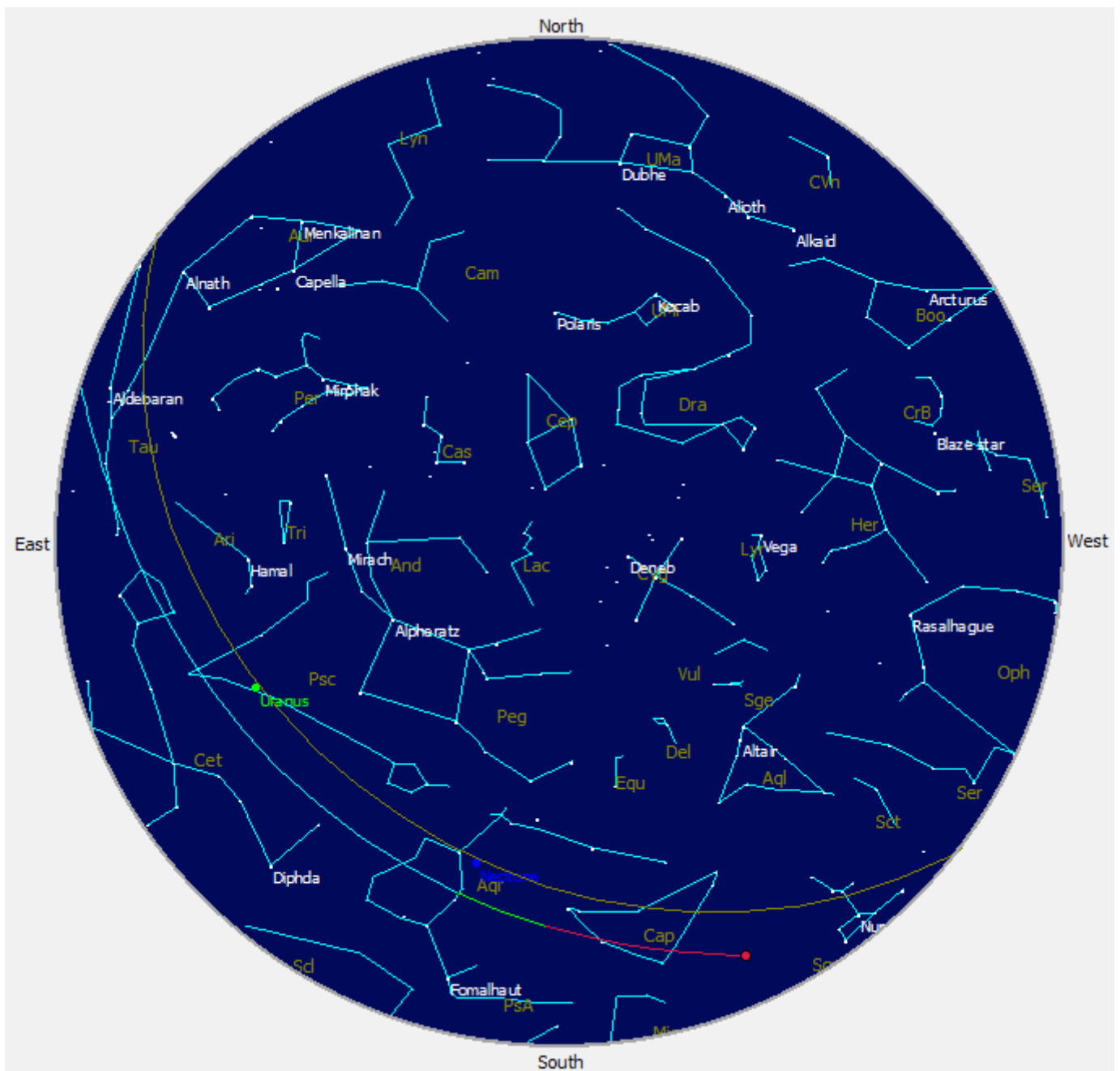
Note : because there is some delay in the broadcast of Live ISS stream, times of eclipses observed on the video are not simultaneous with values displayed by PreviSat.



### 3. Sky map

The **sky map** represents the sky seen the place of observation selected at the given instant.

When they have a positive elevation, satellites, the Sun, the Moon, the main planets (from Mercury to Neptun) and stars are displayed



On this image taken the July 19th, 2015, we can see the satellite ISS near the South-West horizon and it will across the sky. Along the ecliptic (in yellow), we can see Neptun in the Water Bearer constellation (Aqr) and Uranus in the Fishes constellation (Psc).



#### 4. Mode of use : Real time / Manual mode

By default and with each starting, PreviSat is in the Real-time mode, that is to say that the display of the elements of the maps, as well as the numeric data of the Main and Osculating elements tabs, follow the system hour. Various time steps ranging between 1 and 60 seconds can be selected in the drop-down list in the Real time mode for the update of the curves on the maps and the data on the tabs.

The **Manual mode** can be activated by several different manners :

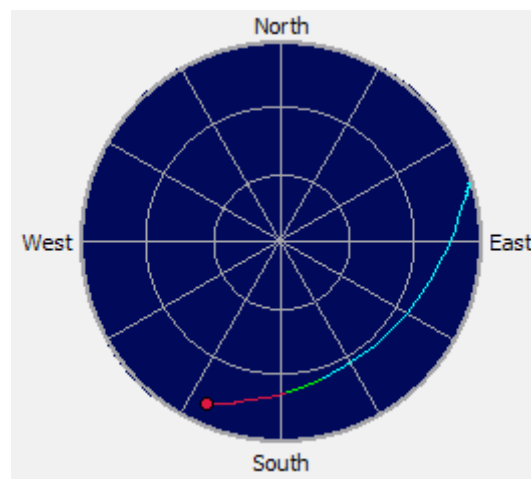
- By selecting the manual mode in the choice list,
- By pressing the keys :
  - F10 : jump between Real-time and Manual mode and vice versa.
  - F11 : move back in time by time step specified in the drop-down list.
  - F12 : move up in time by time step specified in the drop-down list.
- By double-clicking the date in the **Main** or **Osculating elements** tab.

One can also use the manual mode by modifying the value(s) of the date of the **Main** tab or the **Osculating elements** tab (month, day, year, hour, minutes or seconds).

When the manual mode is activated, a toolbar appears on the **Main** tab making it possible to move automatically during time, from any date.

#### 5. Radar

The radar represents the sky of the observer projected on a plan.



The external circle reproduces the (ideal) horizon of the observer and the center of the radar is the zenith of the place. The other concentric circles are the circles of a height of 30 and 60 degrees. The azimuths are graduated by steps of 30 degrees. It is drawn on the radar, when they are in the sky of the observer, the Sun, the Moon and the selected satellites. The color of the radar is purely indicative and should not represent exactly the color of the sky.

6.

Key	Shortcuts
<b>F1</b>	Displays the help file.
<b>F8</b>	Screenshot of main window.
<b>F9</b>	Toggle world map / sky map.
<b>F10</b>	Toggle Real-time / Manual mode.
<b>F11 (F6 on MacOS X)</b>	Previous step.
<b>F12 (F7 on MacOS X)</b>	Next step.
<b>Ctrl + M</b>	Maximization / Minimization of the map.
<b>Ctrl + N</b>	Night vision.
<b>Ctrl + O</b>	Open a TLE file.
<b>Ctrl + S</b>	Save the tab data in a text file.
<b>A...Z</b>	Allows to move in the list of satellites when this one is active.

Key

shortcuts

### III. "Main" tab

The **Main** tab contains all necessary information to know the position of the satellite with regards to the place of observation.

Main	Osculating elements	Satellite informations	Predictions	Iridium flares	Options	Tools
Date : Saturday August 31, 2013 08:59:23 UTC + 02:00						
Name of location : Paris		Conditions : Day		Sun coordinates :		
Longitude : 002° 20' 43" East		Latitude : 48° 51' 39" North		Altitude : 60 m		Elevation : +17° 42' 42"
Name : ISS		Time elapsed since epoch : 0.78 days				Azimuth (N) : 097° 18' 42"
Longitude : 131° 18' 35" East		Elevation : -34° 24' 44"		Right ascension : 16h 00m 37s		Range : 1.009 AU
Latitude : 47° 51' 28" North		Azimuth (N) : 032° 55' 34"		Declination : +01° 43' 00"		Right ascension : 10h 38m 41s
Altitude : 420.1 km		Range : 7922.8 km		Constellation : Ser		Declination : +08° 35' 23"
Direction : Descending		Satellite not visible (26%)				Constellation : Leo
Orbital velocity : 7.665 km/s		Orbit # 84635				Moon coordinates :
Range rate : +4.722 km/s		Next AOS : 08/31/2013 11:46:35 (in 02h 47min). Azimuth : 198° 30'				Elevation : +57° 32' 17"
						Azimuth (N) : 155° 44' 54"

First of all, the current date is indicated, which can be that of the system or that chosen by the user. It is possible to pass from the Real-time mode to the Manual mode by double-clicking on the label containing the date. We then point out the coordinates of the default place of observation (name, longitude, latitude, altitude). We also give the **conditions of observation**, that is an indication about the Sun's elevation ( $H_s$ ) :

- Day ( $H_s > 0^\circ$ ),
- Civil twilight ( $-6^\circ < H_s < 0^\circ$ ),
- Nautical twilight ( $-12^\circ < H_s < -6^\circ$ ),
- Astronomical twilight ( $-18^\circ < H_s < -12^\circ$ ),
- Night ( $H_s < -18^\circ$ ).

We then give the name of the default satellite, as well as the time elapsed since the epoch of the TLE. The color assigned to the age of the TLE give an approximative indication about its accuracy (the green color indicates a recent TLE, instead of the red color indicates an old TLE).

Then, we grouped the coordinates of the satellite in various reference frames :

- **Longitude, latitude and altitude :**

They are the terrestrial coordinates over flown by the satellite, where the altitude is calculated compared to the sea level by taking into account the flatness of the terrestrial globe. Longitude and latitude over flown are thus the point of the globe where the satellite passes to the zenith.

- **Elevation, azimuth and range :**

They are undoubtedly the most useful coordinates for the observation, since they are related to the place of observation. The elevation, also called site angle, is the angle counted vertically between the horizon and the satellite. This angle is between 0 and

90° when the satellite is above the horizon, and negative when it is below the horizon<sup>1</sup>. The azimuth is the angle counted horizontally from North and increasing towards the East. This angle, ranging between 0 and 360°, is that which one finds on compasses (North = 0°, East = 90°, South = 180°, West = 270°). Finally, we put the range between the satellite and the place of observation (taking into account of the flatness of the Earth).

- **Right ascension, declination and constellation :**

These coordinates are used to locate the satellite among stars. The right ascension, of which the origin is the vernal point located in the constellation of Fishes, is counted by convention from 0 to 24h and increasing towards the east along the celestial equator. The declination is the angle measured in degrees from one side of the celestial equator to the other (from 0 to +90° in the boreal celestial hemisphere, and from 0 to -90° in the southern celestial hemisphere).

- Given next is various information concerning the motion of the satellite, that is to say the **direction** of the satellite on its orbit (ascending as it moves from South to North, and descending in the contrary case), the **orbital velocity** and the **range rate** (negative if the satellite is approaching the observer).
- One provides, when the satellite has a positive elevation and is not eclipsed, the **magnitude** and the **illumination** (in %). The magnitude value is followed by an asterisk when the satellite is in the penumbra of the Earth, which supposes a weakening of the glare of the satellite.

The **number of orbits** carried out since the launch is then displayed (number increased each time the satellite passes to the ascending node).

Finally, we show the **next AOS** date (Acquisition of signal), that is to say the next date when the selected satellite will be above the horizon of the location. The next **LOS** (Loss of signal) is the time when the satellite passes below the horizon. We also give the delay of the AOS (resp. LOS) relative to the current date, and the azimuth where the satellite will appear (resp. disappear).

We then give the coordinates of the Sun and the Moon<sup>2</sup> in the following reference frames :

- Elevation, azimuth, range,
- Right ascension, declination, constellation.

The range given here is the range to the observer, which is generally different from geocentric range. We also give the informations about the Moon phase, its illuminated fraction (in %) and its magnitude.

1 The elevation, when it is positive, is corrected by the atmospheric refraction by the formula given in the **Astronomical Algorithms** 2<sup>nd</sup> edition, by Jean Meeus, p. 106.

2 The Sun and Moon positions are calculated from simplified models (**Astronomical Algorithms** 2<sup>nd</sup> edition, by Jean Meeus), there can thus be differences compared to precise ephemeris (about thirty arcseconds for the Sun).

It is possible to record in a text file the values provided in this tab by clicking on the **Save** item in the main menu or with the shortcut Ctrl + S.

## IV. "Osculating elements" tab

The **Osculating elements** tab contains the data concerning the position and the velocity of the satellite.

Main	Osculating elements	Satellite informations	Predictions	Iridium flares	Options	Tools
Date : Friday, November 13 2015 07:42:44 UTC + 01:00						
Name : <b>ISS</b>						
1 25544U 98067A 15315.52068756 .00012053 00000-0 18319-3 0 9990						
2 25544 51.6449 68.7539 0006638 129.5613 291.4123 15.54983950970961						
State vector <span>ECEF</span>		Osculating elements <span>Keplerian parameters</span>			Signal	
x : -735.779 km		Semi-major axis : 6786.0 km			Doppler@100MHz : -1484	
y : +6606.746 km		Eccentricity : 0.0015397			Free-space loss : 152.6	
z : -1333.047 km		Inclination : 51.6624°			Delay : 33.92	
vx : -4.213139 km/s		True anomaly : 54.8748°			Apogee (Altitude) : 6796.4 km (418.3 km)	
vy : -1.634951 km/s		Eccentric anomaly : 54.8026°			Perigee (Altitude) : 6775.5 km (397.4 km)	
vz : -5.826651 km/s		Field of view : ±19.84°			Orbital period : 1h 32m 32s	

In this tab, we recall the date, which is identical to that of the Main tab, then the name of the satellite and the 2 lines of the orbital elements of the TLE. These orbital elements are known average, that is to say they do not represent the real orbit at the instant of epoch of the TLE. The osculating elements, true characteristics of the orbit at a given moment, vary with time and represent the orbit that the satellite would follow if all the disturbances which the satellite undergoes disappeared suddenly.

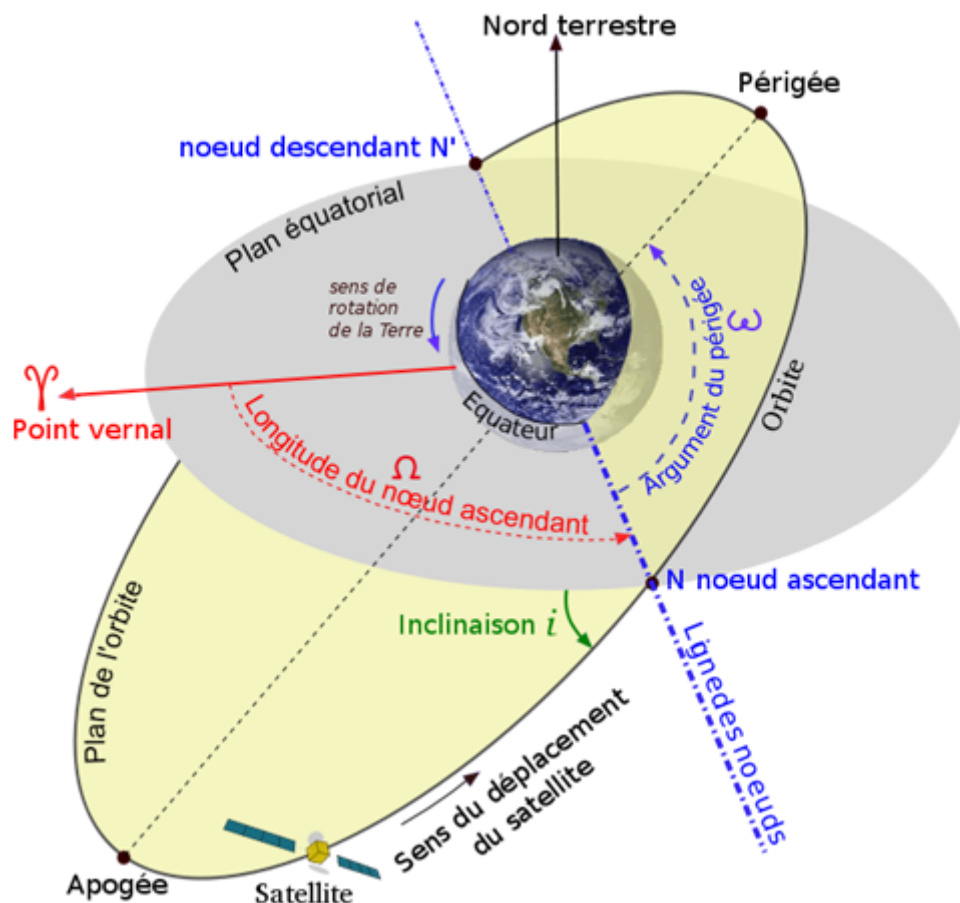
We give first of all under the name of **state vector** the results provided by the SGP4 model, namely the components of the position vector and the velocity vector in the ECI frame (Earth Centered Inertial). It is possible to have components of the position vector and the velocity vector in the ECEF frame (Earth Centered, Earth Fixed). Then starting from the components given in the ECI frame, we calculate the following osculating elements<sup>3</sup> :

- The **semi-major axis (a)** of the ellipse, characterizing the size of the orbit,
- The **eccentricity (e)**, characterizing the shape of the ellipse,
- The **inclination (i)** of the orbit measured from the celestial equator, always ranging between 0 and 180°. The types of orbit according to the value of the inclination are the following :
  - The equatorial orbits have an inclination of 0° or 180°,
  - The direct orbits have an inclination ranging between 0 and 90°,
  - The retrograde orbits have an inclination ranging between 90° and 180°,

<sup>3</sup> The formulas used here are from **Fundamental of Astrodynamics and Applications**, 2<sup>nd</sup> edition, by David Vallado.

- The polar orbits have an inclination of  $90^\circ$ .
- The **right ascension of ascending node ( $\Omega$ )** is the angle measured between the vernal point and the ascending node of the orbit (point where the satellite crosses the celestial equator plane from the South to the North) and counted along the celestial equator.
- The **argument of perigee ( $\omega$ )** is the angle counted along the orbital plane between the ascending node and the perigee (point where the radius vector passes to a minimum).
- The **mean anomaly ( $M$ )** is the angle counted from the perigee to the mean position of the satellite, considering a mean circular orbit.
- The **true anomaly ( $v$ )** is the angle counted from the perigee to the true position of the satellite.

One deduces from the preceding osculating elements, the perigee (minimum of the radius vector), the **apogee** (maximum of the radius vector), the **orbital period** as well as the **field of view**.





Note : read "right ascension of the ascending node" (ascension droite du nœud ascendant) instead of "longitude of the ascending node" (longitude du nœud ascendant)

Other orbital elements are available for circular and/or equatorial orbits. For a circular orbit, we define the following elements :

$$\begin{aligned} & a \\ e_x &= e \cos \omega \\ e_y &= e \sin \omega \\ & i \\ & \Omega \\ \alpha &= \omega + M \end{aligned}$$

$\alpha$  is named position on orbit.

For an equatorial orbit, we define :

$$\begin{aligned} & a \\ & e \\ i_x &= \tan\left(\frac{i}{2}\right) \cos \Omega \\ i_y &= \tan\left(\frac{i}{2}\right) \sin \Omega \\ \tilde{\omega} &= \omega + \Omega \\ & M \end{aligned}$$

$\tilde{\omega}$  is named longitude of perigee.

For a circular equatorial orbit, we define :

$$\begin{aligned} & a \\ e_x &= e \cos(\omega + \Omega) \\ e_y &= e \sin(\omega + \Omega) \\ i_x &= \tan\left(\frac{i}{2}\right) \cos \Omega \\ i_y &= \tan\left(\frac{i}{2}\right) \sin \Omega \\ l &= \omega + \Omega + \nu \end{aligned}$$

/ is named true longitude argument.

It is possible to record in a text file the values provided in this tab by clicking on the **Save** item in the main menu or with the shortcut Ctrl + S.

## V. "Satellite informations" tab

The **Satellite informations** tab provides the mean orbital elements of the TLE.

Main	Osculating elements	Satellite informations	Predictions	Iridium flares	Options	Tools
Name : <b>ISS</b>						Satellite data search...
1 25544U 98067A		15315.52068756	.00012053	00000-0	18319-3 0	9990
2 25544 51.6449		68.7539 0006638	129.5613	291.4123	15.54983950970961	
NORAD number :		25544	Mean motion :	15.54983950 rev/day	Launch date : 11/20/1998	
COSPAR Designation :		98067A	n' / 2 :	0.00012053 rev/day <sup>2</sup>	Orbital category : LEO/I	
Epoch (UTC) :		11/11/2015 12:29:47	n" / 6 :	0.00000000 rev/day <sup>3</sup>	Country/Organization : ISS	
Pseudo-ballistic coef :		0.00018319 (1/Er)	Orbit # at epoch :	97096		
Inclination :		51.6449°	Mean anomaly :	291.4123°		
RA of ascending node :		68.7539°	Std/Max magnitude :	-0.5v/-2.5		
Eccentricity :		0.0006638	Propagation model :	SGP4 (NE)		
Argument of perigee :		129.5613°	Dimensions/Section :	Cylindrical. L=30.0 m, R=20.0 m / 348.00 m <sup>2</sup>		

We point out first of all the name of the satellite and the élines composing the TLE. We give successively :

- The **NORAD number** : identification number assigned sequentially by North American Aerospace Defense Command. Each NORAD number refers to a single object (satellite, debris).
- The **COSPAR Designation** (COmmittee on SPace Research) : provides the year of launching, the number of the launch in the year, as well as one to three letters indicating a piece of the launch.
- The **epoch** of the TLE is given peculiar format : the 2 first digits refers to the year, the following digits are the number of days (with decimals) elapsed since January 1<sup>st</sup>. The epoch is given in Universal Time Coordinated (UTC).
- The **pseudo-ballistic coefficient** characterizes the atmospheric drag and its dimension is given in reverse of the Earth radius. SGP4 model uses this value to estimate the atmospheric drag.
- The **mean motion**, expressed in number of revolutions per day.
- The **first time derivative of mean motion divided by 2**, expressed in revolutions per day squared, represents the acceleration or the deceleration of the satellite. It's generally a question of acceleration, when the satellite descends to a slightly lower orbit; a deceleration can occur at the moment of a satellite manoeuvre (this parameter is not used in SGP4 model).

- The **second time derivative of mean motion divided by 6** is expressed in revolutions per day cubed (this parameter is not used in SGP4 model).
- The **revolution number at epoch** (from the TLE).
- The mean **inclination**.
- The **right ascension of the ascending node**.
- The mean **eccentricity**.
- The mean **argument of perigee**.
- The "mean" **mean anomaly**.
- The **standard magnitude** and the **maximum magnitude**. The standard magnitude is issued from an internal file in PreviSat. The letter which follows its value indicates how this latter has been determinate; **d** it is calculated according to dimensions of the satellite; **v** it is estimated according to visual observations. The maximal magnitude is evaluated starting from the standard magnitude and semi-major axis and eccentricity.
- The **propagation model** used (SGP4). For the satellites whose orbital period is inferior to 225 minutes, we precise "NE" (Near earth); on the contrary, we indicate "DS" (Deep Space).
- The **dimensions of the object** and the **radar cross section** issued from an internal file.
- The **launch date**.
- The **orbital category** (cf. table 1 below).
- The **country** or **organization** (cf. table 2 below).

By clicking on the **Search satellite** data, we access to the informations for all satellites listed by the Space-track. It is possible to make a search from the name of the object, or from the NORAD number, or from the COSPAR designation.

Main	Osculating elements	Satellite informations	Predictions	Iridium flares	Options	Tools
------	---------------------	------------------------	-------------	----------------	---------	-------

Search

Name : 
NORAD : 
COSPAR :

Satellite informations

Found objects (62) :

SPUTNIK 1	Name : SPUTNIK 1	Std/Max magnitude : ??
SPUTNIK 2	NORAD number : 00002	Propagation model : SGP4 (NE)
SPUTNIK 3	COSPAR Designation : 1957-001B	Dimensions/Section : Unknown
SPUTNIK 4	Launch date : 1957/10/04	Apogee (Altitude) : 7323 km (945 km)
SPUTNIK 4 CABIN	Decay date : 1958/01/04	Perigee (Altitude) : 6605 km (227 km)
SPUTNIK 4 DEB	Orbital category : LEO/I	Orbital period : 1h 36m 06s
SPUTNIK 4 DEB	Country/Organization : CIS	Inclination : 65.00°
SPUTNIK 4 DEB	Launch site : TTMR	

It is possible to record in a text file the values provided in this tab by clicking on the **Save** item in the main menu or with the shortcut Ctrl + S.

Designation	Signification	Period h	Inclination °	Eccentricity	Perigee km	Apogee km
<b>ATM</b>	Atmospheric	-	0.0 - 180.0	0.0 - 1.0	<80	0 - 80
<b>TAO</b>	Trans-atmospheric	-	0.0 - 180.0	0.0 - 1.0	0-80	>80
<b>SO</b>	Suborbital	-	0.0 - 180.0	0.0 - 1.0	<0	>80
<b>LEO/E</b>	Equatorial low orbit	1:26 - 2:00	0.0 - 20.0	0.0 - 0.21	80 - 1682	80 - 3284
<b>LEO/I</b>	Intermediate	1:26 - 2:00	20.0 - 85.0	0.0 - 0.21	80 - 1682	80 - 3284
<b>LEO/P</b>	Polar	1:26 - 2:00	85.0 - 95.0	0.0 - 0.21	80 - 1682	80 - 3284
<b>LEO/S</b>	Sun-synchronous	1:26 - 2:00	95.0 - 104.0	0.0 - 0.21	80 - 1682	80 - 3284
<b>LEO/R</b>	Retrograde	1:26 - 2:00	104.0 - 180.0	0.0 - 0.21	80 - 1682	80 - 3284
<b>MEO</b>	Medium	2:00 - 23:00	0.0 - 180.0	0.0 - 0.5	80 - 34680	1682 - 55209
<b>HEO</b>	Highly elliptique	4:03 - 23:00	0.0 - 180.0	0.5 - 0.92	80 - 14331	13000 - 69280
<b>HEO/M</b>	Molniya	11:30 - 12:30	62.0 - 64.0	0.5 - 0.77	80 - 7294	19489 - 41854
<b>GTO</b>	GEO Transfer	10:00 - 12:30	0.0 - 85.0	0.5 - 0.77	-	-
<b>GEO/S</b>	Stationary geosynchr.	23:55.5 - 23:56.5	0.0 - 2.0	0.0 - 0.01	35353 - 35795	35775 - 36217
<b>GEO/I</b>	Inclined GEO	23:55.5 - 23:56.5	0.0 - 20.0	0.0 - 0.05	33667 - 35795	35775 - 37903
<b>GEO/T</b>	Synchronous	23:55.5 - 23:56.5	0.0 - 180.0	0.0 - 0.85	80 - 35795	35775 - 71510
<b>GEO/D</b>	Drift GEO	23:00 - 25:00	0.0 - 2.0	0.0 - 0.05	32628 - 37028	34681 - 39198
<b>GEO/ID</b>	Inclined drift GEO	23:00 - 25:00	0.0 - 20.0	0.0 - 0.05	32628 - 37028	34681 - 39198
<b>GEO/NS</b>	Near-synchr.	23:00 - 25:00	0.0 - 180.0	0.0 - 0.85	80 - 37028	34681 - 73976
<b>DSO</b>	Deep Space	>25:00	0.0 - 180.0	0.0 - 0.50	>15325	>37028
<b>DHEO</b>	Deep Eccentric	>25:00	0.0 - 180.0	0.50 - 1.00	>80	>58731
<b>CLO</b>	Cislunar		0.0 - 180.0	0.0 - 1.00		>318200
<b>EEO</b>	Earth Escape					
<b>HCO</b>	Heliocentric					
<b>PCO</b>	Planetocentric					
<b>PEO</b>	Planetary escape trajectory					
<b>SSE</b>	Solar system Escape					

Table 1 : Orbital categories  
(<http://planet4589.org/space/log/orbits.html>)

Designation	Signification
<b>AB</b>	Arab satellite communications organization
<b>AC</b>	Asiatsat corp
<b>ALG</b>	Algeria

<b>ARGN</b>	Argentina
<b>ASRA</b>	Austria
<b>AUS</b>	Australia
<b>AZER</b>	Azerbaijan
<b>BELA</b>	Belarus
<b>BRAZ</b>	Brazil
<b>CA</b>	Canada
<b>CHBZ</b>	Peoples republic of China/Brazil
<b>CHLE</b>	Chile
<b>CIS</b>	Commonwealth of independent states
<b>COL</b>	Columbia
<b>CZCH</b>	Czechoslovakia
<b>DEN</b>	Denmark
<b>ECU</b>	Ecuador
<b>EGYP</b>	Egypt
<b>ESA</b>	European Space Agency
<b>ESRO</b>	European Space Research Organization
<b>EST</b>	Estonia
<b>EUME</b>	European organization for the exploitation of meteorological satellites
<b>EUTE</b>	European telecommunications satellite organization (EUTELSAT)
<b>FGER</b>	France/Germany
<b>FR</b>	France
<b>GER</b>	Germany
<b>GLOB</b>	Globalstar
<b>GREC</b>	Greece
<b>HUN</b>	Hungary
<b>IM</b>	International maritime satellite organization (INMARSAT)
<b>IND</b>	India
<b>INDO</b>	Indonesia
<b>IRAN</b>	Iran
<b>IRID</b>	Iridium
<b>ISRA</b>	Israel
<b>ISS</b>	International Space Station
<b>IT</b>	Italy
<b>ITSO</b>	International telecommunications satellite organization (INTELSAT)
<b>JPN</b>	Japan
<b>LUXE</b>	Luxembourg
<b>MALA</b>	Malaysia
<b>MEX</b>	Mexico
<b>NATO</b>	North Atlantic Treaty Organization (NATO)
<b>NETH</b>	Netherlands
<b>NICO</b>	New Ico
<b>NIG</b>	Nigeria
<b>NKOR</b>	North Korea
<b>NOR</b>	Norway
<b>O3B</b>	O3B Networks
<b>ORB</b>	Orbital telecommunications satellite (GLOBALSTAR)
<b>PAKI</b>	Pakistan
<b>POL</b>	Poland
<b>POR</b>	Portugal
<b>PRC</b>	Peoples republic of China
<b>RASC</b>	Regional african satellite communications organization
<b>ROC</b>	Republic of China (Taiwan)
<b>ROM</b>	Romania
<b>RP</b>	Republic of Philippines



<b>SAFR</b>	South Africa
<b>SAUD</b>	Saudi Arabia
<b>SEAL</b>	Sea Launch Demo
<b>SES</b>	Société européenne des satellites
<b>SING</b>	Singapore
<b>SKOR</b>	South Korea
<b>SPN</b>	Spain
<b>STCT</b>	Singapore/Taiwan
<b>SWED</b>	Sweden
<b>SWTZ</b>	Switzerland
<b>THAI</b>	Thailand
<b>TURK</b>	Turkey
<b>UAE</b>	United Arab Emirates
<b>UK</b>	United Kingdom
<b>US</b>	United States of America
<b>USBZ</b>	United States/Brazil
<b>VENZ</b>	Venezuela
<b>VTNM</b>	Vietnam

Table 2 : Countries or organizations

Designation	Signification
<b>AFETR</b>	Air Force Eastern Test Range, Florida, USA
<b>AFWTR</b>	Air Force Western Test Range, California, USA
<b>CAS</b>	Canaries Airspace
<b>DLS</b>	Dombarovskiy Launch Site, Russia
<b>ERAS</b>	Eastern Range Airspace
<b>FRGUI</b>	Europe's Spaceport, Kourou, French Guiana
<b>HGSTR</b>	Hammaguira Space Track Range, Algeria
<b>JSC</b>	Jiuquan Space Center, PRC
<b>KODAK</b>	Kodiak Launch Complex, Alaska, USA
<b>KSCUT</b>	Kagoshima Space Center, University of Tokyo
<b>KWAJ</b>	US Army Kwajalein Atoll (USAKA)
<b>KYMSC</b>	Kapustin Yar Missile and Space Complex, Russia
<b>NSC</b>	Naro Space Complex, South Korea
<b>OREN</b>	Orenbourg, Russia
<b>PKMTR</b>	Plesetsk Missile and Space Complex, Russia
<b>PMRF</b>	Pacific Missile Range Facility
<b>SADOL</b>	Submarine Launch from Barents Sea, Russia
<b>SEAL</b>	Sea Launch Platform (mobile)
<b>SEM</b>	Semnan Satellite Launch, Iran
<b>SNMLP</b>	San Marco Launch Platform, Indian Ocean (Kenya)
<b>SRI</b>	Satish Dhawan Space Center, (India), formerly Sriharikota Launching Range)
<b>SVOBO</b>	Svobodnyy Launch Complex, Russia
<b>TNSTA</b>	Tanegashima Space Center, Japan
<b>TSC</b>	Taiyuan Space Center, PRC
<b>TTMTR</b>	Tyuratam missile and Space Center, Kazakhstan also known as Baikonur cosmodrome
<b>UNKN</b>	Unknown

<b>WLPIS</b>	Wallops Island, Virginie, USA
<b>WOMRA</b>	Woomera, Australia
<b>WRAS</b>	Western Range Air Space, USA
<b>XSC</b>	Xichang Space Center, PRC
<b>YAVNE</b>	Yavne Launch Facility, Israel
<b>YUN</b>	Yunsong, North Korea

Table 3 : Launch sites

## VI. "Predictions" tab

The **Predictions** tab allows to make predictions of passes for one or more satellites above a given place of observation.

It is necessary to supply the initial and final dates and hours, the calculation step as well as the place of location. By default, the initial date is the current date and the initial hour is the current hour truncated to the minute; the date by default is initial date increased by 7 days. The calculation step is initially fixed at one minute.

It is possible to take into account of the magnitude of the satellite by ticking the **Maximal magnitude** box and by indicating the desired magnitude. This option will only apply to the satellites of which the standard magnitude is known.

Then, it is possible to regulate the minimal elevation which the satellite must have for the calculation of the predictions (for example, if the horizon of your place of observation is masked by a building, a mountain or luminous urban pollution). If you choose 'Other' in the drop-down list, you are then invited to select a positive integer value in the adjacent text field.

In the same way, you can parameterize the elevation of the Sun following the criteria below :

- Horizon (0°),
- Civil twilight (-6°), default value,
- Nautical twilight (-12°),
- Astronomical twilight (-18°),
- Indifferent, all passes will be displayed, including those of day,
- Other..., you are then invited to select an integer value ranging between -90° and +90° in the adjacent text field.

By default the list of satellites dedicated to predictions is filled by the satellites of the main list of satellites. It is possible to add or to eliminate satellites. By right clicking on

the list, we can check all the satellites or none. Then just click on the **Run** button to run the search.

Once calculations are finished, an explicit message appears in the task bar and the button **Show results** appears. By clicking on this button, one can display the results obtained and then have the possibility to save them in a text file.

In the first tab of result window, the passes are written in the form of columns as shown in the following example.

### Calculation for ISS and only for one day

PreviSat 3.5 / Astropedia (c) 2005-2015

Location : Paris 002°20'55" East 48°51'12" North 30 m  
 Timezone : Local time  
 Conditions of observations : Maximal elevation of the Sun = -6°  
 Minimal elevation of the satellite = 0°  
 Range unit : km  
 Age of the TLE : 0.13 days (at 05/30/2014 08:03:00)

ISS											
Date	Hour	Sat Azimuth	Sat Elev	RA Sat	Decl Sat	Const	Magn	Altitude	Range	Sun Azim	Sun Elev
2014/05/30	23:27:00	084°05'02"	00°28'42"	20h26m14s	+04°14'59"	Del	+9.9*	417.4	2347.7	326°39'55"	-12°35'54"
2014/05/31	01:00:00	105°20'41"	31°55'49"	19h33m45s	+14°30'24"	Aql	-1.0*	417.5	735.6	348°12'46"	-18°28'06"
2014/05/31	01:01:00	086°22'39"	19°31'45"	21h01m43s	+16°54'45"	Del	+0.1*	417.9	1040.1	348°27'17"	-18°30'05"
2014/05/31	01:02:00	078°02'33"	11°23'20"	21h50m24s	+16°24'00"	Peg	+1.3	418.3	1409.7	348°41'49"	-18°32'02"
2014/05/31	01:03:00	073°35'26"	05°47'59"	22h20m30s	+15°07'51"	Peg	+3.1	418.6	1803.8	348°56'22"	-18°33'56"
2014/05/31	01:04:00	070°52'48"	01°39'27"	22h41m05s	+13°43'20"	Peg	+6.9	418.8	2208.0	349°10'55"	-18°35'48"
2014/05/31	02:33:00	268°08'57"	14°31'46"	12h00m16s	+09°41'30"	Vir	+0.7*	417.6	1242.5	010°57'29"	-18°34'11"
2014/05/31	02:34:00	274°33'19"	25°36'50"	12h14m41s	+21°52'47"	Com	-0.5*	418.0	864.3	011°12'02"	-18°32'17"
2014/05/31	02:35:00	294°38'41"	46°48'58"	12h50m25s	+47°27'48"	CVn	-1.7	418.3	559.1	011°26'34"	-18°30'21"
2014/05/31	02:36:00	018°13'56"	57°08'34"	20h22m37s	+76°19'11"	Cep	-2.0	418.6	492.1	011°41'06"	-18°28'22"
2014/05/31	02:37:00	056°17'25"	32°15'46"	23h20m52s	+45°17'49"	And	-0.9	418.9	732.3	011°55'37"	-18°26'20"
2014/05/31	02:38:00	065°34'18"	18°09'00"	23h45m10s	+29°32'52"	Peg	+0.4	419.0	1092.4	012°10'07"	-18°24'16"
2014/05/31	02:39:00	069°36'03"	10°09'22"	23h57m15s	+21°00'37"	Peg	+1.7	419.1	1486.8	012°24'37"	-18°22'10"
2014/05/31	02:40:00	071°54'29"	04°47'29"	00h05m45s	+15°27'26"	Peg	+3.7	419.2	1893.1	012°39'06"	-18°20'01"
2014/05/31	02:41:00	073°26'55"	00°51'47"	00h12m22s	+11°27'54"	Psc	+8.8	419.2	2303.7	012°53'35"	-18°17'50"
2014/05/31	04:08:00	285°00'21"	03°05'10"	12h13m54s	+12°09'39"	Vir	+4.9	418.4	2053.4	033°00'47"	-12°42'00"
2014/05/31	04:09:00	287°27'45"	07°47'22"	12h19m58s	+17°19'08"	Com	+2.3	418.7	1647.3	033°13'56"	-12°36'37"
2014/05/31	04:10:00	291°28'58"	14°25'19"	12h27m17s	+24°53'35"	Com	+0.9	418.9	1250.8	033°27'03"	-12°31'11"
2014/05/31	04:11:00	299°31'38"	25°04'25"	12h37m47s	+37°47'43"	CVn	-0.3	419.1	879.5	033°40'10"	-12°25'43"
2014/05/31	04:12:00	322°42'32"	43°47'43"	13h07m26s	+64°01'42"	Dra	-1.4	419.1	586.7	033°53'15"	-12°20'14"
2014/05/31	04:13:00	033°08'11"	51°12'19"	23h40m31s	+68°46'01"	Cep	-1.7	419.2	527.6	034°06'20"	-12°14'42"
2014/05/31	04:14:00	070°59'20"	30°44'58"	00h22m16s	+34°41'45"	And	-0.7	419.1	759.1	034°19'23"	-12°09'09"

2014/05/31 04:15:00	082°10'11"	17°38'26"	00h33m51s	+18°16'41"	Psc	+0.5	419.0	1112.0	034°32'26"
-12°03'34"									
2014/05/31 04:16:00	087°10'57"	09°54'19"	00h41m36s	+09°17'17"	Psc	+1.9	418.9	1502.2	034°45'27"
-11°57'57"									
2014/05/31 04:17:00	090°03'42"	04°38'06"	00h48m02s	+03°26'53"	Psc	+3.9	418.7	1905.8	034°58'27"
-11°52'18"									
2014/05/31 04:18:00	091°58'14"	00°45'31"	00h53m30s	-00°43'30"	Cet	+9.3	418.5	2314.6	035°11'26"
-11°46'37"									

Elapsed time : 0.01s

We point out in the header of the results file the place of location, the time zone, as well as the conditions of observation (here, conditions by default).

We then display for each satellite the list of its passes (here 4 passes), separated one from another by a line jump. Each pass is made up, as we can see, from date and hour, followed by its characteristics. First of all, the azimuth and the elevation of the satellite, then the right ascension, the declination and the constellation. If the standard magnitude of the satellite is known, the visual is then calculated by means of the following formula :

$$m=m_{std}-15.75+2.5\cdot\log\left(\frac{d^2}{I}\right)$$

where  $d$  is the range to the observer and  $I$  the illumination. The magnitude is sometimes followed by an asterisk, meaning that the satellite is in the penumbra of the Earth. If standard magnitude is not known, the magnitude column only contains question marks (????). In the case that the satellite illumination is not required, for the instants where the satellite is in the shadow of the Earth, the magnitude column only contains dashes (----).

Next is given the altitude and the range to the satellite, then horizontal coordinates of the Sun (azimuth and elevation).

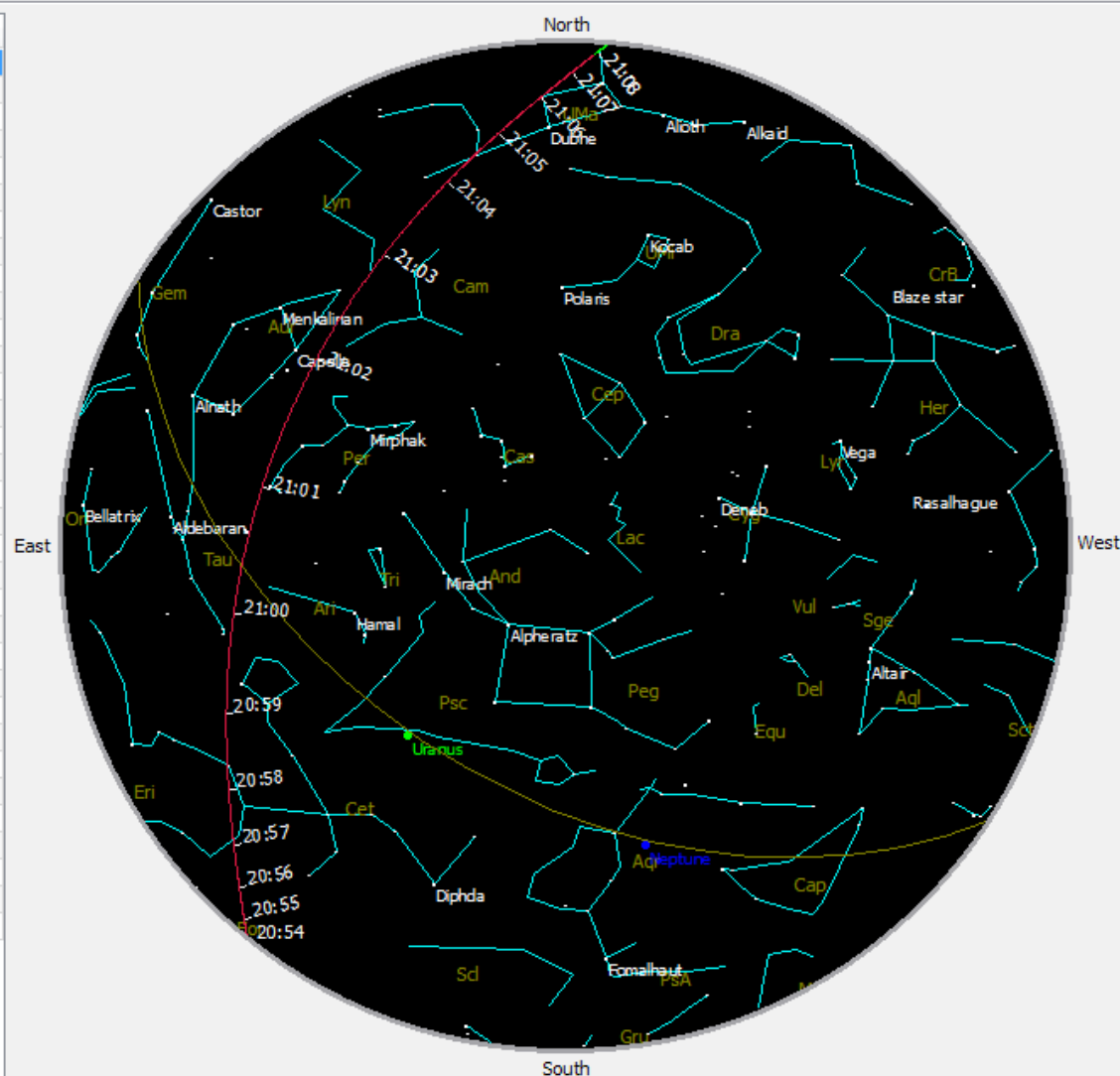
The nonvisible satellites for the search period are not mentioned in the result file.

Finally the time necessary to carry out the search is specified. This time depends in particular on the machine and the availability of its resources, as well as quality of search algorithm. This time is lengthened if one chooses a long time interval and/or a short calculation step and/or a great number of satellites.

In the second tab, the table summarizes each satellite pass. By clicking on a table row, we display the corresponding passage in the sky map.

Text file Predictions of passes

Satellite	Start date	Finish date	Max Elevation	Magn	Sun Elevation
ENVISAT	2015/11/11 21:08:00	2015/11/11 21:08:00	02°04'43"	+11.8*	38°52'19"2
ENVISAT	2015/11/12 20:31:00	2015/11/12 20:31:00	01°47'45"	+12.3*	32°25'37"2
ENVISAT	2015/11/13 19:54:00	2015/11/13 19:54:00	00°47'13"	+14.6*	25°52'57"2
HST	2015/11/12 18:10:00	2015/11/12 18:17:00	05°06'23"	+7.4	07°42'55"2
HST	2015/11/12 19:49:00	2015/11/12 19:53:00	09°19'35"	+5.7*	25°33'09"2
HST	2015/11/13 18:03:00	2015/11/13 18:08:00	06°21'34"	+6.9	06°19'34"2
HST	2015/11/13 19:40:00	2015/11/13 19:44:00	09°45'06"	+5.6*	24°04'17"2
HST	2015/11/13 21:20:00	2015/11/13 21:20:00	00°05'00"	+15.6*	41°17'47"2
HST	2015/11/14 19:30:00	2015/11/14 19:35:00	09°46'29"	+5.6	22°35'11"2
HST	2015/11/14 21:11:00	2015/11/14 21:11:00	00°16'59"	+14.6*	39°52'01"2
HST	2015/11/15 19:21:00	2015/11/15 19:27:00	09°23'12"	+5.7	21°05'57"2
HST	2015/11/15 21:02:00	2015/11/15 21:02:00	00°19'21"	+14.5	38°24'54"2
HST	2015/11/16 19:12:00	2015/11/16 19:18:00	08°54'57"	+5.9	19°25'56"2
HST	2015/11/16 20:53:00	2015/11/16 20:54:00	01°40'53"	+10.6*	37°07'20"2
HST	2015/11/17 19:03:00	2015/11/17 19:10:00	08°11'07"	+6.1	17°56'47"2
HST	2015/11/17 20:45:00	2015/11/17 20:45:00	01°03'23"	+12.0	35°38'04"2
HST	2015/11/18 18:53:00	2015/11/18 19:02:00	07°07'20"	+6.5	16°27'49"2
HST	2015/11/18 20:36:00	2015/11/18 20:37:00	00°49'06"	+12.6*	34°18'45"2
ISS	2015/11/12 04:58:00	2015/11/12 05:00:00	10°52'49"	+1.4*	30°02'33"2
ISS	2015/11/12 06:31:00	2015/11/12 06:36:00	25°17'03"	-0.5	13°07'49"2
ISS	2015/11/13 04:07:00	2015/11/13 04:07:00	00°47'19"	+8.9*	39°21'29"2
ISS	2015/11/13 05:40:00	2015/11/13 05:43:00	20°54'08"	-0.1	22°38'46"2
ISS	2015/11/13 07:12:00	2015/11/13 07:14:00	15°10'19"	+0.7	06°00'59"2
ISS	2015/11/14 04:49:00	2015/11/14 04:50:00	06°34'59"	+2.7*	32°03'46"2
ISS	2015/11/14 06:22:00	2015/11/14 06:27:00	20°48'40"	-0.1	15°18'30"2
ISS	2015/11/15 05:31:00	2015/11/15 05:34:00	13°14'08"	+1.0	24°39'58"2
ISS	2015/11/15 07:03:00	2015/11/15 07:11:00	19°52'01"	+0.2	07°48'07"2
ISS	2015/11/16 04:40:00	2015/11/16 04:40:00	02°51'25"	+5.1	34°04'33"2
ISS	2015/11/16 06:12:00	2015/11/16 06:17:00	18°45'41"	+0.2	17°18'30"2
ISS	2015/11/17 05:21:00	2015/11/17 05:24:00	13°47'53"	+0.8*	26°51'47"2
ISS	2015/11/17 06:54:00	2015/11/17 07:01:00	23°08'47"	-0.2	09°56'01"2
ISS	2015/11/18 04:30:00	2015/11/18 04:31:00	03°23'12"	+4.6*	36°15'35"2
ISS	2015/11/18 06:03:00	2015/11/18 06:08:00	20°22'26"	-0.0*	19°29'08"2



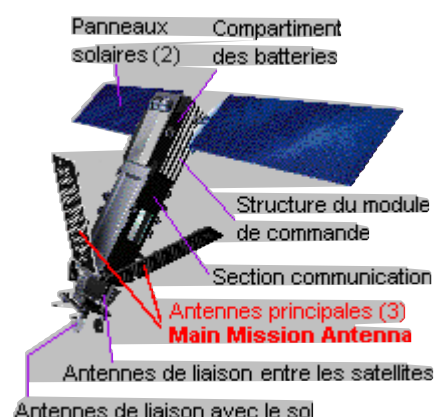


## VII. "Iridium flares" tab

The **Iridium flares** tab allows to carry out of Iridium flares search, including those of day.

Main	Osculating elements	Satellite informations	Predictions	Iridium flares	Options	Tools																
Start date : 11/11/2015 20:53:00 Finish date : 11/18/2015 20:53:00 Sun elevation : Civil twilight (-6°) Name of location : Paris Minimal elevation of satellite : 10°		Erase hours TLE file : iridium.txt Maximal magnitude (night) : 2.0 Maximal magnitude (day) : -4.0 Maximal angle of reflexion : 5.0		Output display <input type="radio"/> 1 line <input checked="" type="radio"/> 3 lines		Default settings <table border="1"> <thead> <tr> <th>Satellite</th> <th>Status</th> </tr> </thead> <tbody> <tr> <td>Iridium 02</td> <td>Non Op.</td> </tr> <tr> <td>Iridium 03</td> <td>Op.</td> </tr> <tr> <td>Iridium 03</td> <td>Op.</td> </tr> <tr> <td>Iridium 04</td> <td>Non Op.</td> </tr> <tr> <td>Iridium 05</td> <td>Op.</td> </tr> <tr> <td>Iridium 05</td> <td>Op.</td> </tr> <tr> <td>Iridium 06</td> <td>Op.</td> </tr> </tbody> </table>	Satellite	Status	Iridium 02	Non Op.	Iridium 03	Op.	Iridium 03	Op.	Iridium 04	Non Op.	Iridium 05	Op.	Iridium 05	Op.	Iridium 06	Op.
Satellite	Status																					
Iridium 02	Non Op.																					
Iridium 03	Op.																					
Iridium 03	Op.																					
Iridium 04	Non Op.																					
Iridium 05	Op.																					
Iridium 05	Op.																					
Iridium 06	Op.																					
<input type="checkbox"/> Only operational satellites <input checked="" type="checkbox"/> Chronologically sorting <input checked="" type="checkbox"/> Include solar panels flares				<input type="button" value="Run"/> <input type="button" value="Show results"/>																		

Initially, satellites of the Iridium constellation were satellites dedicated to telecommunications. They have 3 very reflective antennas (Main Mission Antenna, see diagram below) which are at the origin of the flares. The latter can reach magnitude -8, which is 30 to 40 times more luminous than Venus (magnitude about -4). A flare can last from a few seconds to about thirty seconds.





Flare of Iridium 37 satellite in the constellation of Queen on December 9<sup>th</sup>, 2014 at 17h34 UT in Toulouse, France (magnitude -6.8 flare from a MMA)

It is necessary to give the initial and final dates and hours. You have to specify the path of the file containing Iridium satellites (it can be a file containing only the Iridium satellites or a file containing them amongst other).

Just like for the Predictions tab, it is necessary to indicate the minimal elevation of the satellite (by default 10°) and the elevation of the Sun, which will make possible to determine the day/night transition. By default, the maximum magnitude for a night-time flare is equal to 2, while for a day-time flare, it is -4. We can also take into account the maximum angle of reflexion of the antennas (by default 5°).

Flares are calculated for the operational satellites, that is to say for which 3-axe stabilization is assured (at least in theory). Spare satellites, placed on higher orbits, can produce flares. To take into account the spare satellites, de-select the box 'Only the operational satellites'. The satellites which have lost attitude control are not taken into account in the calculation.

We can choose to publish the results in the form of one line (the moment when the magnitude value passes by a minimum), or in three lines (the moment of the value of the minimum is surrounded by the dates corresponding to the limiting conditions imposed by the preceding maximum magnitudes or the angle of reflexion). It is possible to classify the results either by satellites, or by chronological order (usual case).

In the first tab of result window, the results are displayed in the form of columns, as shown in the example below (one day calculation only) :

Location : Paris 002°20'55" East 48°51'12" North 30 m  
Local time - UTC offset : Local hour  
Conditions of observations : Maximal elevation of the Sun = -6°  
Minimal elevation of the satellite = 10°  
Range unit : km  
  
Age of the most recent TLE : 0.25 days (at 2015/09/23 21:46:00)  
Age of oldest TLE : 0.60 days

Ir	Date	Hour	Sat Azimuth	Sat Elev	RA Sat	Decl Sat	Cst Ang	Mir Magn	Alt	Range	Sun Azim	Sun Elev	Max Long	Max Lat	Range	Max Magn
1	Long Max	Lat Max	Distance	Magn Max												
56	2015/09/24	06:31:51.5	200°09'05"	56°05'35"	04h05m51s	+16°17'00"	Tau 3.45	G +2.0	783.5	921.8	076°39'56"	-11°49'24"	001.9874 E	48.8081 N	27.0 (W)	-6.8
56	2015/09/24	06:32:01.1	197°38'23"	52°35'04"	04h08m43s	+12°32'20"	Tau 1.56	G -0.4	783.4	956.6	076°41'49"	-11°47'52"				
56	2015/09/24	06:32:10.7	195°39'21"	49°16'10"	04h11m17s	+09°02'45"	Tau 3.23	G +2.0	783.3	994.8	076°43'42"	-11°46'19"				
43	2015/09/24	21:00:43.9	001°52'51"	38°03'42"	06h51m49s	+79°07'23"	Cam 1.26	G +2.0	785.7	1177.1	284°35'02"	-13°08'27"	002.0527 E	48.8997 N	22.3 (W)	-3.2
43	2015/09/24	21:00:47.5	001°56'18"	37°08'51"	06h53m02s	+78°12'35"	Cam 1.06	G +1.4	785.7	1196.1	284°35'45"	-13°09'02"				
43	2015/09/24	21:00:51.7	002°00'10"	36°06'18"	06h54m13s	+77°10'03"	Cam 1.31	G +2.0	785.8	1218.6	284°36'35"	-13°09'42"				
68	2015/09/24	21:16:58.8	128°42'18"	31°04'48"	22h27m29s	+02°05'00"	Peg 4.36	S +2.0	783.3	1339.3	287°50'00"	-15°42'40"	002.5202 E	48.8078 N	13.6 (E)	-2.6
68	2015/09/24	21:17:16.3	132°44'35"	28°27'42"	22h20m51s	-01°56'00"	Aqr 0.32	S -2.3	783.1	1415.8	287°53'32"	-15°45'25"				
68	2015/09/24	21:17:34.6	136°20'22"	25°50'31"	22h14m46s	-05°44'58"	Aqr 4.13	S +2.0	782.9	1502.2	287°57'14"	-15°48'17"				
21	2015/09/24	21:24:45.4	103°16'33"	50°37'48"	22h47m12s	+29°05'50"	Peg 4.02	D +2.0	784.3	979.7	289°24'57"	-16°55'31"	003.2834 E	48.7987 N	68.9 (E)	-7.5
21	2015/09/24	21:24:52.4	107°37'37"	49°38'13"	22h41m45s	+26°24'23"	Peg 3.24	D +1.3	784.2	991.5	289°26'23"	-16°56'36"				
21	2015/09/24	21:24:59.4	111°40'36"	48°30'42"	22h36m43s	+23°46'15"	Peg 3.98	D +2.0	784.1	1005.5	289°27'49"	-16°57'42"				

Temps elapsed : 0.46s

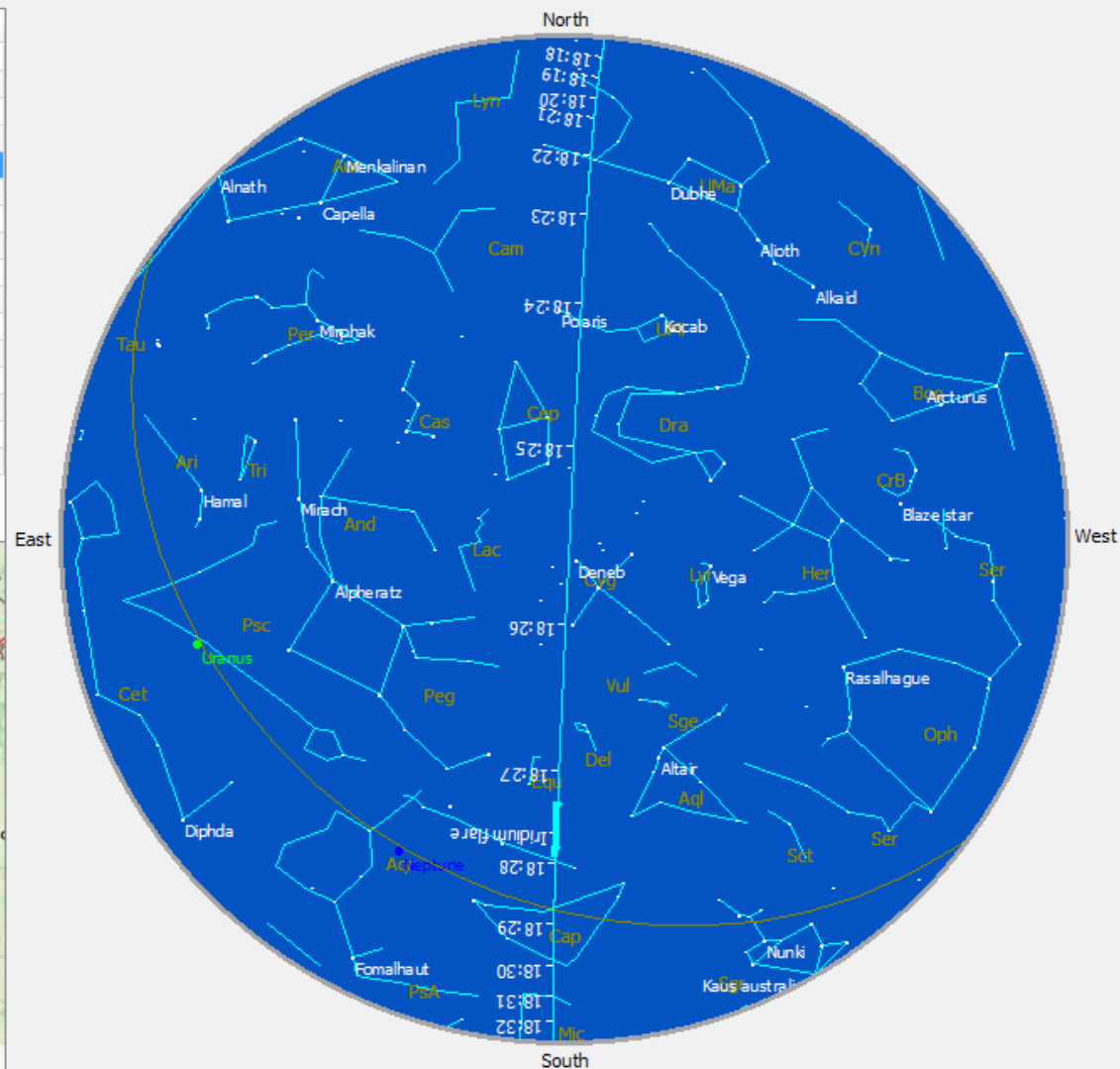
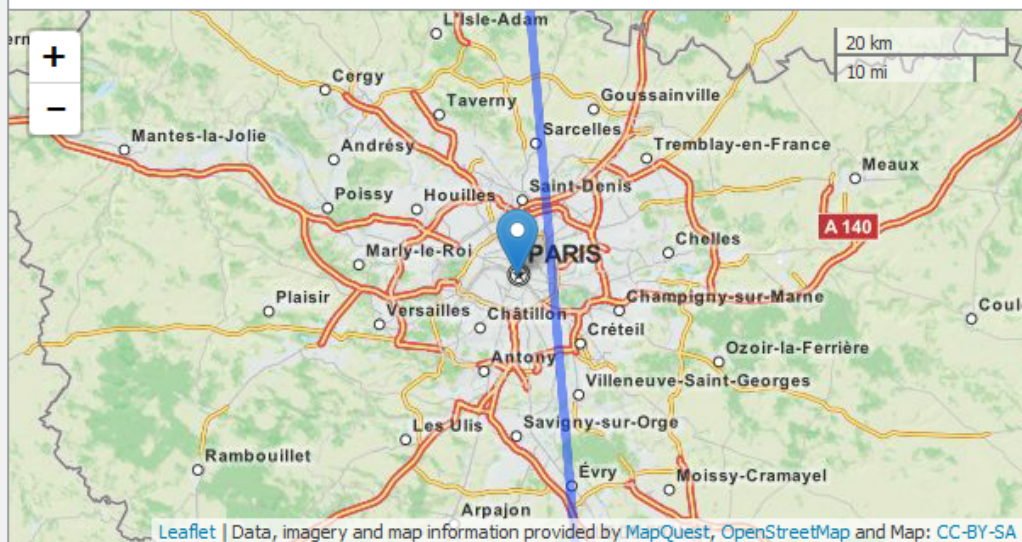
The first column gives the number of the Iridium satellite responsible of the flare. Then, successively, there is the date, the hour, the coordinates of the satellite and the constellation. One then give the angle of reflection of the antenna, as well as the concerned antenna ("F" = Front, "R" = Right, "L" = Left, "S" = solar panel). Next are specified the visual magnitude of the flare, the altitude and the range to the satellite, and the coordinates of the Sun. Finally, we give the terrestrial coordinates where the reflection angle reaches a minimum, the distance (at the East or at the West to the observer) and its visual magnitude.

**Note concerning the observation of Iridium satellites :**

Calculation uses an internal file which provides the status of the satellites, to know if the satellite is operational, spare or having lost its attitude control. In general, the operational satellites produce flares such as they are envisaged by PreviSat. However, there can exist an angular offset between the true attitude of the satellite and the theorical attitude (manoeuvres for example), which can result in a magnitude modification. The result provided by PreviSat is thus an estimate of the magnitude of the flare (in general, represented rather well). Thus, one should not be surprised if a flare is lower than hoped, or even did not take place.

Under the second tab, the table summarizes each Iridium flare. By clicking on a table row, we display the corresponding passage in the sky map, and a map centered on the place of observation showing where the maximum flare produces.

Satellite	Start date	Finish date	Max Elevation	Magn	Mir	Sun Elevation
Iridium 62	2015/11/12 05:05:38.3	2015/11/12 05:06:16.5	15°39'05"	+1.2	D	27°43'22"0
Iridium 47	2015/11/12 07:05:58.0	2015/11/12 07:06:06.0	59°39'09"	+0.8	D	08°11'47"0
Iridium 59	2015/11/12 09:08:29.3	2015/11/12 09:08:32.0	85°09'57"	-6.9	D	09°24'32"2
Iridium 19	2015/11/12 11:10:52.3	2015/11/12 11:10:56.2	51°27'34"	-6.6	D	20°57'56"2
Iridium 94?	2015/11/12 18:27:19.8	2015/11/12 18:27:53.5	42°39'14"	-6.5	D	12°04'36"0
Iridium 11	2015/11/13 06:59:54.5	2015/11/13 07:00:04.8	59°27'17"	-0.5	D	09°22'16"0
Iridium 68	2015/11/13 17:28:54.1	2015/11/13 17:28:57.0	21°37'44"	-5.3	A	03°09'20"0
Iridium 23?	2015/11/13 18:21:18.8	2015/11/13 18:21:50.4	41°32'56"	-1.4	D	11°17'31"0
Iridium 20	2015/11/14 18:15:22.8	2015/11/14 18:15:38.5	39°00'22"	+1.6	D	10°31'15"0
Iridium 62	2015/11/15 17:07:42.8	2015/11/15 17:07:46.4	25°42'22"	-5.9	A	00°09'20"0
Iridium 22	2015/11/15 18:18:29.0	2015/11/15 18:18:57.5	38°29'01"	-0.1	D	11°10'42"0
Iridium 25	2015/11/16 18:12:28.3	2015/11/16 18:12:58.4	37°22'09"	-0.8	D	10°23'13"0
Iridium 47	2015/11/17 18:06:25.1	2015/11/17 18:06:57.7	37°19'53"	-5.3	D	09°35'24"0
Iridium 11	2015/11/18 18:00:28.0	2015/11/18 18:00:42.1	35°36'39"	+1.7	D	08°48'38"0
Iridium 59	2015/11/18 19:35:59.1	2015/11/18 19:36:35.2	40°41'25"	-3.6*	D	24°12'04"0
Iridium 60	2015/11/18 19:43:49.4	2015/11/18 19:44:05.3	70°05'26"	-0.9*	S	25°29'26"0

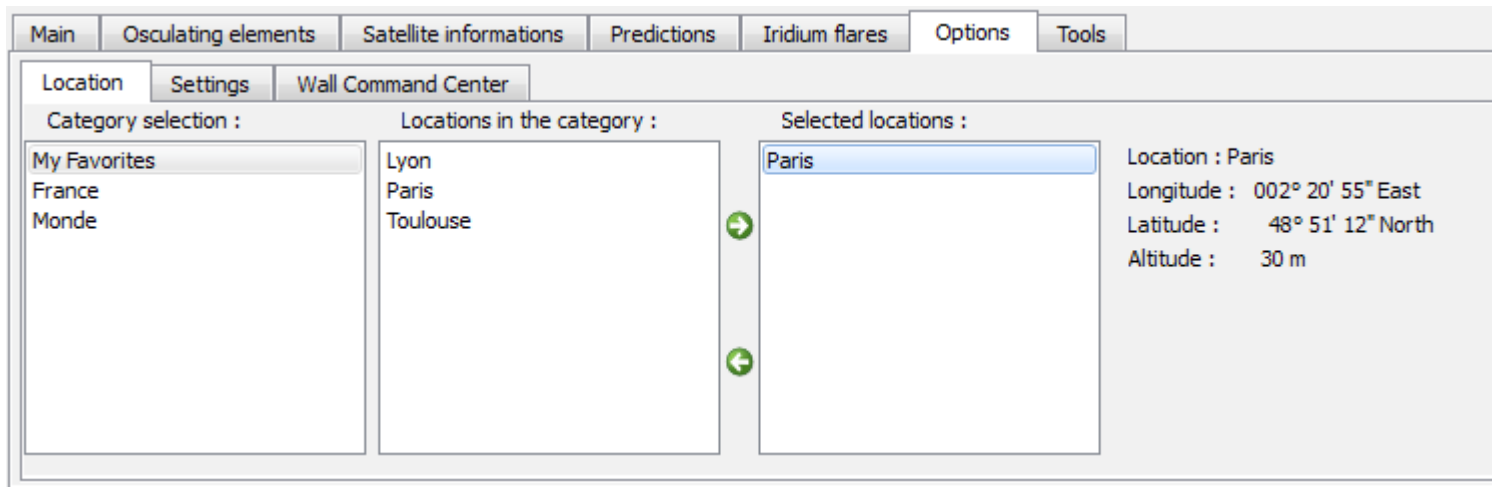




## VIII. "Options" tab

The **Options** tab allows to carry out the adjustments of PreviSat (place of observation, settings, Wall Command Center).

### 1. "Location" tab



The first list in the **Location** tab contains the various categories of places of observation (initially France, World and My Favorites).

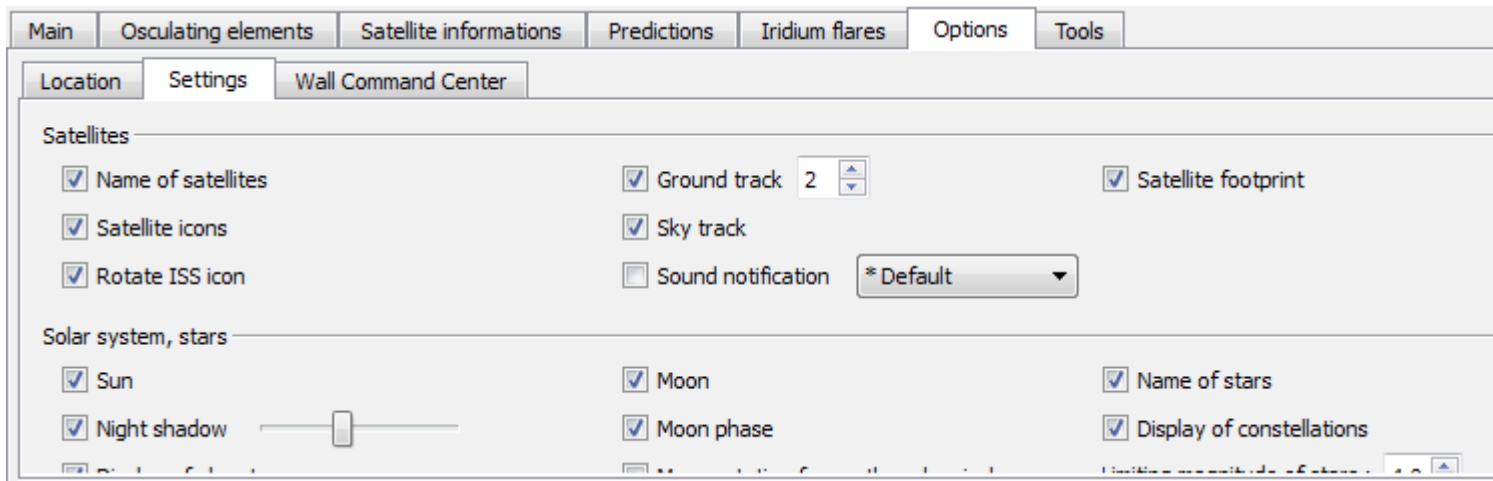
- The category **France** comprises the main towns of Metropolitan France.
- The category **World** contains the coordinates of almost 1700 cities in the world.

While clicking on an element of this first list, one reveals in the second list the names of the places of the category. When a place of observation is selected, its coordinates are displayed on the right-hand side of the tab. While clicking on the small arrows, one can select the locations for the application.

By right-clicking on an element in the **Location in the category** list, one can choose to remove it or to add it in the **My Favorites** category. For the manual addition of a place in a category, it is necessary to seize the name of the place of observation, its longitude and its latitude. (given for example by a GPS device). The altitude can be neglected if it is not known because its value has small effect on calculations.

It is possible to create or remove a category (except the category **My Favorites**), or to download new categories by right-clicking on the list **Selection of the category**.

## 2. "Settings" tab



This tab contains a list of checkboxes allowing to display (or not to display) elements in the graphic interface. Some checkboxes have 3 possible states :

### **Name of satellites** box :

- **Checked** : the names of selected satellites are displayed,
- **Partially checked** (the display of the box varies with the system requirements) : the name of default satellite is displayed,
- **Unchecked** : the display of the names of satellites is disabled.

### **Foot print** box :

- **Checked** : the foot prints of all selected satellites display,
- **Partially checked** : the foot print of the default satellite displays,
- **Unchecked** : the display of foot prints is disabled.

### **Radar** box:

- **Checked**: the radar only displays if a satellite is present in the sky of the place of observation,
- **Partiellement coché** : the radar displays permanently,
- **Unchecked** : the display of the radar is disabled.

### **Display of constellations** box :

- **Checked** : when the sky map is maximized, the constellation lines and names of constellation are displayed,
- **Partially checked** : constellation lines are displayed,
- **Unchecked** : the display of constellation lines and names of constellations are disabled.

## Name of locations box :

- **Checked** : the names of all places of observation are displayed,
- **Partially checked** : the name of the default location displays, the other locations are represented by a white cross,
- **Unchecked** : the name of the default location displays.

A first choice list makes it possible to choose the units displayed in PreviSat. For the satellites as well as the Moon, the unit can be either kilometers, or miles (1 mile = 1.609344 km); the altitude of the place of observation and dimensions of the satellite are then expressed respectively in meters or feet (1 foot = 0.3048 m). The distance from the Sun is always given in astronomical units (1 AU = 149,597,870 km = 92,955,807 miles).

**Note** : After the entry of a new place of observation when the unit is the foot, the displayed altitude can slightly differ compared to the entered value, because PreviSat stores the altitude in meters and in a integer value. That does not affect any the calculations carried out by PreviSat.

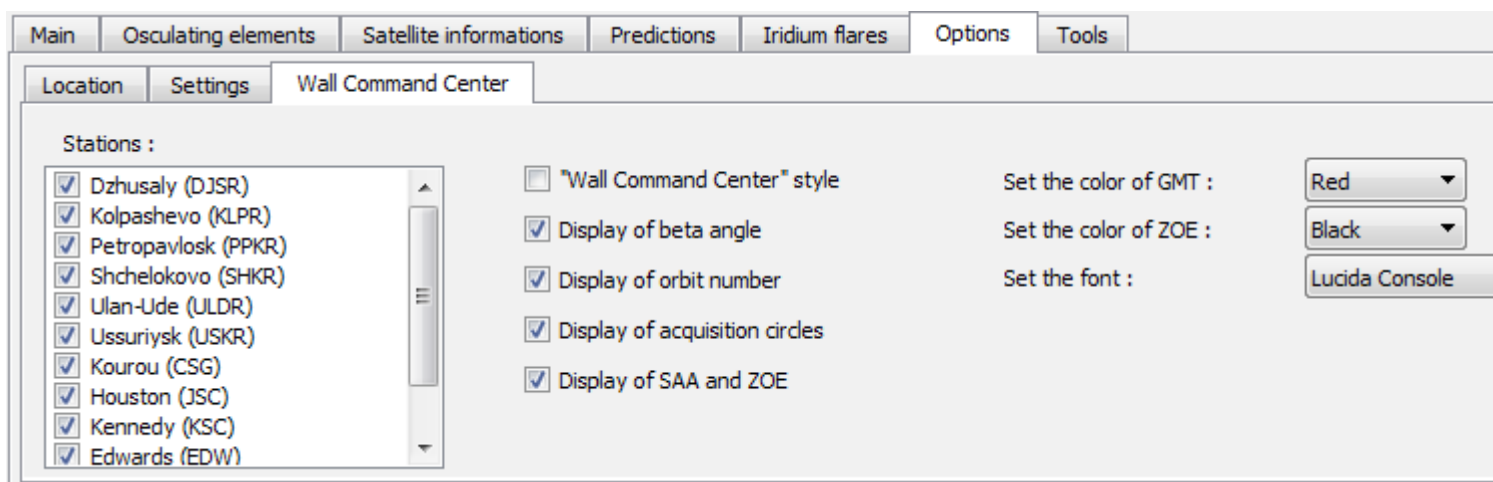
A second choice list allows to display hours at 24h format or at 12h format (AM/PM).

A third choice list makes it possible to select the Local time - UTC offset; one can changes the value of this offset. The **Auto** checkbox, when it is checked, allows to determine automatically this offset :

- If the **Auto** checkbox is checked at the time of closing of PreviSat, the offset will be given with the system value at the next starting of Previsat.
- If not, the offset will be given by the value indicated in the field, at the next starting of PreviSat.

### 1. "Wall Command Center" tab

This tab allows you to manage the display options when the Wall Command Center is activated (when the "ISS Live" box is checked).

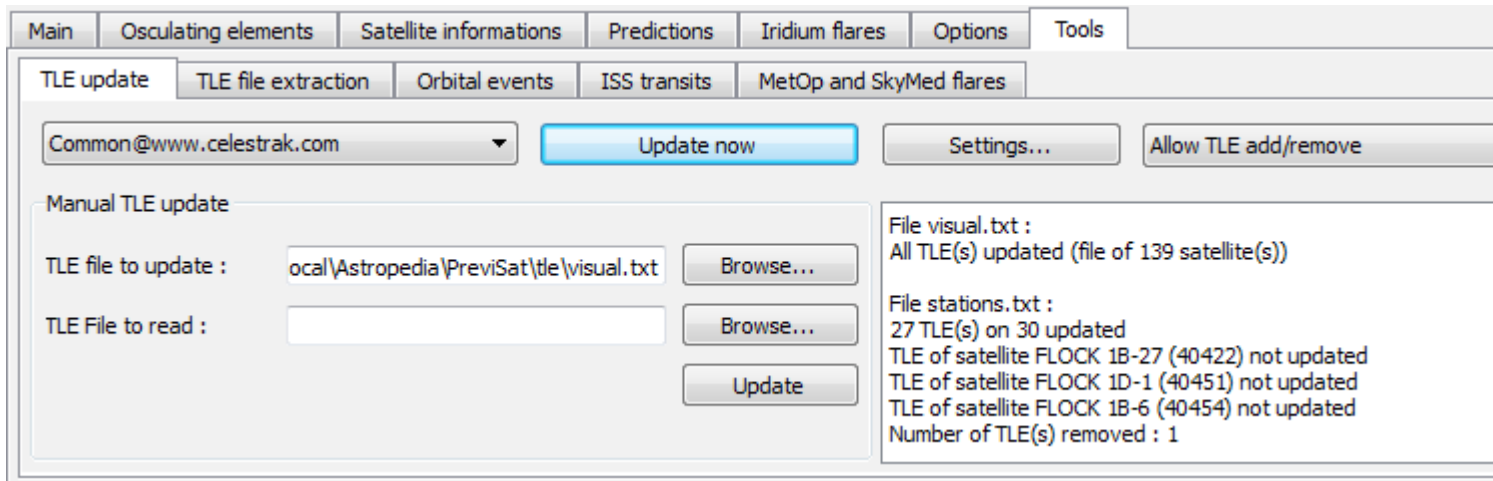




## IX. "Tools" tab

The **Tools** tab makes it possible to update TLE files and to create its own TLE files from other files. Two other calculations are provided : the calculation of orbital events and the transits of ISS with the Sun and the Moon.

### 1. "TLE update" tab



The first tab allows updating TLE files that PreviSat uses, in order not to carry out manually the handling of TLE files (decompression...). All that is carried out by this functionality. You may choose the category you want to update and click on the **Update now** button. PreviSat downloads the TLE files of the category and merges the files. When you launch the update, a report is displayed on the right-hand side of the tab.

You can create or modify categories by clicking on the **Settings** button : in the window displayed, it is possible to select categories that you want to update automatically at the starting of PreviSat, and define the expiry date. If the **TLE expiry date** is checked, the TLE updating is made automatically when the TLE are older than the value indicated. If not, the TLE updating is made every starting of PreviSat.

In the "Manual TLE update" section, you can update TLE files individually by indicating the TLE file to read (containing recent TLEs) and TLE file to update. The file to read can be in the gz format.

**Important :** the automatic updating of files of "tle" directory of PreviSat is done from the site [www.celestrak.com](http://www.celestrak.com). Only the TLE files with the same names are downloaded from celestrak.com

### 2. "TLE file extraction" tab

The second tab makes it possible to create its own TLE files according to various criteria. It is necessary to indicate the name of the file to be read and the name of the personal file. One can create a file according to the following criteria (between square brackets, entries by default, which are also the tolerated maximum values) :

- The NORAD number [All],
- The right ascension of the ascending node [From 0 to 360°],
- The eccentricity [From 0 to 1] (value 1 is excluded),

- The number of revolutions per day [From 0 to 18],
- The inclination [From 0 to 180°] (it is possible to define 2 intervals),
- The argument of perigee [From 0 to 360°],
- And the maximum magnitude [99] (The value 99 indicates that the magnitude is not a selection criteria).

The screenshot shows a software interface with a tabbed menu at the top: Main, Osculating elements, Satellite informations, Predictions, Iridium flares, Options, and Tools. The 'TLE file extraction' tab is selected. Below the tabs, there are several input fields and buttons. On the left, there is a 'TLE File to read' field with a 'Browse...' button next to it. Below this are dropdown menus for 'NORAD number' (set to 'All'), 'RA of ascending node' (set to 'From 0° to 360°'), 'Eccentricity' (set to 'From 0 to 1'), and 'Inclination' (set to '1 interval' with a range from 0 to 180 degrees). To the right of these are input fields for 'Number of revolutions per day' (from 00.000000000 to 18.000000000), 'Argument of perigee' (set to 'From 0° to 360°'), and 'Maximal magnitude' (set to 99). At the bottom, there is a 'Name of personal file' field with a 'Browse...' button and a 'Search' button.

For example, one wants to build a file containing the most luminous those of which the standard magnitude is known. One can retain the following criteria :

- NORAD number : All
- Right ascension of the ascending node : From 0 to 360°
- Eccentricity : From 0 to 0.001 (slightly eccentric; one could tolerate satellites of which the orbit is more eccentric and to take from 0 to 0.2)
- Number of revolutions per day : From 14 to 18 (to keep the satellites at low altitude, potentially most luminous)
- Inclination : From 35 to 145° (so as to be visible in temperate zones of the northern hemisphere of the Earth)
- Argument of perigee : From 0 to 360°
- Maximal magnitude : 4 (all the satellites where the minimal magnitude is lower than 4 will be kept)

### 3. "Orbital events" tab

The screenshot shows the 'Orbital events' tab of a software application. At the top, there are tabs: 'Main', 'Osculating elements', 'Satellite informations', 'Predictions', 'Iridium flares', 'Options', and 'Tools'. Below these, there are sub-tabs: 'TLE update', 'TLE file extraction', 'Orbital events' (selected), 'ISS transits', and 'MetOp and SkyMed flares'. The 'Orbital events' section contains a 'Start date' dropdown set to '11/11/2015 20:46:00' and a 'Finish date' dropdown set to '11/18/2015 20:46:00', with an 'Erase hours' button. Below these are checkboxes for various events: 'Passes to nodes', 'Passes to shadow/penumbra/light', 'Passes to quadrangles', 'Day/night transitions', and 'Passes to apogee/perigee'. All these checkboxes are checked. On the right side, there is a list of satellites with checkboxes: 'ERS-2', 'GENESIS 1', 'GENESIS 2', 'H-2A R/B', 'H-2A R/B', 'HST' (checked), 'IDEFIX & ARIANE 42P R/B', 'INTERCOSMOS 24', 'INTERCOSMOS 25', 'ISIS 1', and 'ISS' (checked). At the bottom, there are buttons for 'Default settings', 'Run', and 'Show results'.

The third tab allows to determine the orbital events of the selected satellites. We can choose the events :

- The passes of the satellite to ascending and descending nodes (equatorial crosses),
- The passes to quadrangles (at position =  $90^\circ$  and  $270^\circ$ ), that is to say the passes to the maximal latitudes,
- The passes to shadow/penumbra/light,
- The passes to apogee/perigee,
- And the day/night transitions, that is to say the passes of the satellite over the day/night limit.

### 4. "ISS Transits" tab

The screenshot shows the 'ISS transits' tab of the same software application. The top tabs are the same. Below them, the sub-tabs are 'TLE update', 'TLE file extraction', 'Orbital events', 'ISS transits' (selected), and 'MetOp and SkyMed flares'. The 'ISS transits' section contains a 'Start date' dropdown set to '11/11/2015 20:52:00' and a 'Finish date' dropdown set to '11/18/2015 20:52:00', with an 'Erase hours' button. Below these is a 'Name of location' dropdown set to 'Maison'. To the right, there is a 'Body' section with checkboxes for 'Sun' and 'Moon', both of which are checked. Below the location dropdown, there is a 'TLE file' dropdown set to 'visual.txt', a 'TLE age' field showing '0.31 days', and a 'TLE maximal age' spinner set to '2.0'. To the right of these, there is a 'Minimal elevation of satellite' dropdown set to '5°' and a 'Maximal elongation with the body' spinner set to '5.0'. At the bottom, there are buttons for 'Default settings', 'Run', and 'Show results'.

The fourth tab allows calculating the conjunctions and the transits of the ISS with the Sun and/or the Moon. It is necessary to give the initial and final dates and hours, the place of location and the TLE file containing the orbital elements of ISS. You have to specify which bodies you want to calculate the transits (Sun and/or Moon), the minimal elevation of satellite and the maximal elongation between ISS and the body.

The file containing the results shows in its header the conditions of observations. The results are provided under the form of columns which contain the date and hour, and then the

coordinates of ISS (azimuth, elevation, right ascension, declination and constellation). We then give the angular separation between ISS and the center of the considered body, the phenomenon type (C = Conjunction; T = Transit), the body (S = Sun; M = Moon), and also the illumination of ISS (Ill = Illuminated; Pen = Penumbra; Ecl = Eclipsed). We finally give the altitude and the range of the satellite, and the topocentric coordinates of the Sun.



## 2. "MetOp and SkyMed flares" tab

The **Flashes MetOp and SkyMed flares** tab allows to calculate flares produced by MetOp and COSMO-SkyMed satellites.

The screenshot shows the 'MetOp and SkyMed flares' tab in a software application. The interface includes a top menu bar with options like 'Main', 'Osculating elements', 'Satellite informations', 'Predictions', 'Iridium flares', 'Options', and 'Tools'. Below this is a sub-menu bar with 'TLE update', 'TLE file extraction', 'Orbital events', 'ISS transits', and 'MetOp and SkyMed flares'. The main panel contains several input fields: 'Start date' (11/11/2015 20:49:00), 'Finish date' (11/18/2015 20:49:00), 'Name of location' (Paris), 'Sun elevation' (Civil twilight (-6°)), and 'Minimal elevation of satellite' (10°). There is an 'Erase hours' button and a 'TLE file' dropdown (flares-spctrk.txt). An 'Output display' section has radio buttons for '1 line' and '3 lines' (selected). A 'Maximal magnitude' spinner is set to 3.0. A 'Chronologically sorting' checkbox is checked. At the bottom right are 'Run' and 'Show results' buttons.

MetOp satellites (for instance MetOp-A et MetOp-B are orbiting) are big size meteorological satellites (deployed dimensions : 17.6 x 6.6 x 5.0 m), developed by ESA and EUMETSAT. These satellites have an instrument named ASCAT (Advanced Scatterometer) which some antennas can produce flares. The ASCAT instrument measure wind speeds and their direction over oceans. There are 6 of these antennas, 3 pointing left to the ground track, and 3 pointing to right. Those pointing left to the ground track are never illuminated by the Sun and then can't produce flares. MetOp flares can reach a -5 magnitude. MetOp satellites are sun-synchronous, which implies some particularities :

- there are no flares during winter (except for high latitudes),
- flares produced by central antenna are visible in early spring (and will be visible to the tropics during summer),
- flares produced by the forward surface of the left antenna are only visible from the Northern hemisphere, while those produced by the backward surface of the left antenna are visible from the Southern hemisphere.

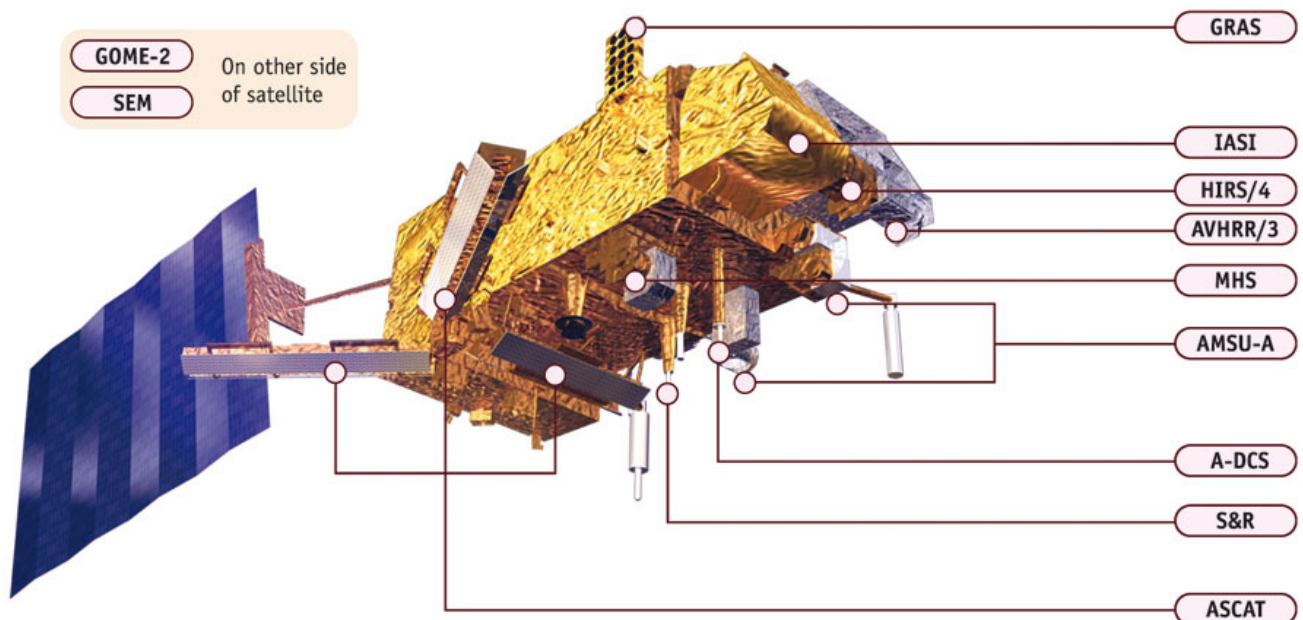
More informations on MetOp satellites are available on the EUMETSAT web site :

<http://www.eumetsat.int/website/home/Satellites/CurrentSatellites/Metop/index.html>





MetOp satellite model at Cité de l'Espace in Toulouse (Source FD)



Instruments of MetOp satellite (Source EUMETSAT)

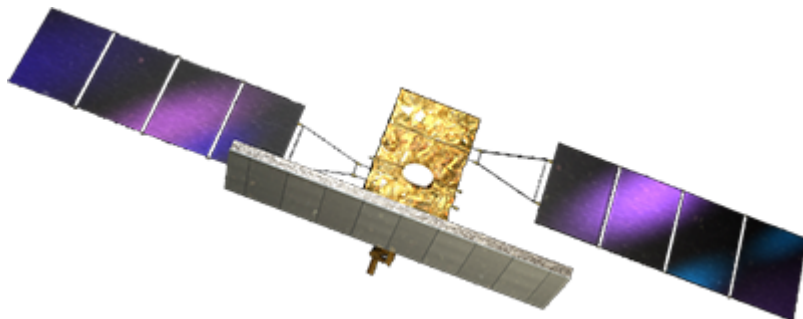


ASCAT instrument (Source EUMETSAT)

COSMO-SkyMed satellites, 4 in number, are managed by the Italian Space Agency (ASI). Placed on a sun-synchronous orbit with a right ascension of the ascending node next to  $90^\circ$  (an approximately 6am local time), they are never in the shadow of the Earth. They are equipped with a synthetic aperture radar (SAR), producing flares when sunlight is reflecting off the surface of the instrument. SkyMed flares can reach a-4 magnitude.

More informations are available on Earth Observation Portal web site :

<https://directory.eoportal.org/web/eoportal/satellite-missions/c-missions/cosmo-skymed>



COSMO-SkyMed satellite and its SAR antenna (Source : [www.e-geos.it](http://www.e-geos.it))

Setting the calculation of MetOp and SkyMed flares is practically identical to that of Idium flares. By default, the used TLE file is flares-spctrk.txt, which contains the 2 MetOp satellites and the 4 SkyMed satellites. The obtained results are exactly in the same form, only the denomination of antennas responsible of flares is changing ("Mir" column).



For MetOp flares, there are 3 antennas which can produce flares :

- the central antenna "C",
- the forward left antenna "F",
- the backward left antenna "B".

For SkyMed flares, the denomination of the antenna responsible of the flare is given by "S" letter (SAR).

# Annexes

## Annex 1 : List of constellations

Designation	Latin	English	French
<b>And</b>	Andromeda	Princess	Andromède
<b>Ant</b>	Antlia	Air Pump	Machine Pneumatique
<b>Aps</b>	Apus	Bird of Paradise	Oiseau de Paradis
<b>Aql</b>	Aquila	Eagle	Aigle
<b>Aqr</b>	Aquarius	Water Bearer	Verseau
<b>Ara</b>	Ara	Altar	Autel
<b>Ari</b>	Aries	Ram	Bélier
<b>Aur</b>	Auriga	Charioteer	Cocher
<b>Boo</b>	Bootes	Herdsman	Bouvier
<b>Cae</b>	Caelum	Chisel/Burin	Burin
<b>Cam</b>	Camelopardalis	Giraffe	Girafe
<b>Cap</b>	Capricornus	Sea Goat	Capricorne
<b>Car</b>	Carina	Keel	Carène
<b>Cas</b>	Cassiopeia	Queen	Cassiopée
<b>Cen</b>	Centaurus	Centaur	Centaure
<b>Cep</b>	Cepheus	King	Céphée
<b>Cet</b>	Cetus	Sea Monster/Whale	Baleine
<b>Cha</b>	Chamaeleon	Chameleon	Caméléon
<b>Cir</b>	Circinus	Compass/Dividers	Compas
<b>CMA</b>	Canis Major	Great Dog	Grand chien
<b>CMi</b>	Canis Minor	Small Dog	Petit Chien
<b>Cnc</b>	Cancer	Crab	Cancer
<b>Col</b>	Columba	Dove	Colombe
<b>Com</b>	Coma Berenices	Berenice's Hair	Chevelure de Bérénice
<b>CrA</b>	Corona Australis	Southern Crown	Couronne Australe
<b>CrB</b>	Corona Borealis	Northern Crown	Couronne Boréale
<b>Crt</b>	Crater	Cup	Coupe
<b>Cru</b>	Crux	Southern Cross	Croix du Sud
<b>Crv</b>	Corvus	Crow/Raven	Corbeau
<b>CVn</b>	Canes Venatici	Hunting Dogs	Chiens de Chasse
<b>Cyg</b>	Cygnus	Swan	Cygne
<b>Del</b>	Delphinus	Dolphin	Dauphin
<b>Dor</b>	Dorado	Dorado	Dorade
<b>Dra</b>	Draco	Dragon	Dragon
<b>Equ</b>	Equuleus	Colt	Petit Cheval
<b>Eri</b>	Eridanus	River Eridanus	Éridan
<b>For</b>	Fornax	Furnace	Fourneau
<b>Gem</b>	Gemini	Twins	Gémeaux
<b>Gru</b>	Grus	Crane	Grue
<b>Her</b>	Hercules	Hercules/Strong Man	Hercule
<b>Hor</b>	Horologium	Pendulum Clock	Horloge
<b>Hya</b>	Hydra	Water Serpent	Hydre Femelle
<b>Hyi</b>	Hydrus	Small Water Snake	Hydre Mâle

<b>Ind</b>	Indus	Indian	Indien
<b>Lac</b>	Lacerta	Lizard	Lézard
<b>Leo</b>	Leo	Lion	Lion
<b>Lep</b>	Lepus	Hare	Lièvre
<b>Lib</b>	Libra	Scales	Balance
<b>LMi</b>	Leo Minor	Small Lion	Petit Lion
<b>Lup</b>	Lupus	Wolf	Loup
<b>Lyn</b>	Lynx	Lynx	Lynx
<b>Lyr</b>	Lyra	Lyre/Harp	Lyre
<b>Men</b>	Mensa	Table Mountain	Table
<b>Mic</b>	Microscopium	Microscope	Microscope
<b>Mon</b>	Monoceros	Unicorn	Licorne
<b>Mus</b>	Musca	Fly	Mouche
<b>Nor</b>	Norma	Carpenter Square	Équerre
<b>Oct</b>	Octans	Octant	Octant
<b>Oph</b>	Ophiuchus	Serpent Bearer	Ophiucus
<b>Ori</b>	Orion	Hunter	Orion
<b>Pav</b>	Pavo	Peacock	Paon
<b>Peg</b>	Pegasus	Winged Horse	Pégase
<b>Per</b>	Perseus	Perseus/Hero	Persée
<b>Phe</b>	Phoenix	Phoenix	Phénix
<b>Pic</b>	Pictor	Painter's Easel	Peintre
<b>PsA</b>	Piscis Austrinus	Southern Fish	Poisson Austral
<b>Psc</b>	Pisces	Fishes	Poissons
<b>Pup</b>	Puppis	Poop	Poupe
<b>Pyx</b>	Pyxis Nauticus	Ship's Compass	Boussole
<b>Ret</b>	Reticulum	Net	Réticule
<b>Scl</b>	Sculptor	Sculptor	Sculpteur
<b>Sco</b>	Scorpius	Scorpion	Scorpion
<b>Sct</b>	Scutum	Shield	Écu de Sobieski
<b>Ser</b>	Serpens	Serpent	Serpent
<b>Sex</b>	Sextans	Sextant	Sextant
<b>Sge</b>	Sagitta	Arrow	Flèche
<b>Sgr</b>	Sagittarius	Archer	Sagittaire
<b>Tau</b>	Taurus	Bull	Taureau
<b>Tel</b>	Telescopium	Telescope	Télescope
<b>TrA</b>	Triangulum Australe	Southern Triangle	Triangle Austral
<b>Tri</b>	Triangulum	Triangle	Triangle
<b>Tuc</b>	Tucana	Toucan	Toucan
<b>UMa</b>	Ursa Major	Great Bear	Grande Ourse
<b>UMi</b>	Ursa Minor	Little Bear	Petite Ourse
<b>Vel</b>	Vela	Sail	Voiles
<b>Vir</b>	Virgo	Maiden	Vierge
<b>Vol</b>	Volans	Flying Fish	Poisson Volant
<b>Vul</b>	Vulpecula	Fox	Petit Renard

## Annex 2 : Version history

### **Version 3.5 (revision 0) :** **September - December 2015**

- Management of large orbit number.
- Added altitude for marker in maps of Iridium/MetOp/SkyMed flares and ISS transits.
- Added solar panels Iridium flares.
- Added MetOp and SkyMed flares.
- Added sound notification for LOS and download of sound notifications.
- Added Satellite data search.
- Added signal informations.
- Added ISS icon rotation.

### **Version 3.4 (revision 5) :** **October 2014 - September 2015**

- Added the weather window for the observer location and for NASA bases.
- Removing the obsolete video stream of ISS Live.
- Changing the display of ISS Live for MacOS X platform.
- Added the magnitude of the Moon.
- Small improvements in source code.
- Corrections for display.
- Corrections in checking software update.
- Corrections in TLE manager.

### **Version 3.3 (revision 1) :** **November 2013 - September 2014**

- Added the ISS Live.
- Added the Wall Command Center visualization.
- Added the 12-clock/24-clock option.
- Added the map for predictions results.

- New calculation of satellite eclipses (with atmospheric refraction).
- Correction of local time offset in the calculations of predictions.
- Correction in TLE updating.

### **Version 3.2 (revision 1) :**

**July - November 2013**

- Modification for checking updates.
- Added more information on the satellites.
- Conservation of the list of satellites for each file of the TLE directory.
- Display of TLE age in ISS Transit tab.
- Display of Iridium satellites status.
- Calculation of Iridium magnitude in the main window.
- Minor correction in the prediction of passes.
- Standization of source code for Windows/Linux/MacOS X platforms.

### **Version 3.1 (revision 3) :**

**October 2012 - July 2013**

- Correction for low resolution screens.
- Modification of TLE files management in the user interface.
- Night vision mode.
- Calculation of adapted orbital parameters.
- Online setup.

### **Version 3.0 (revision 5) :**

**July 2011 - October 2012**

- C++/Qt development.
- New implementations for predictions of passes, Iridium flares, orbital events and ISS transits.
- Calculation of coordinates of the maximum for Iridium flares and ISS transits.
- Modifications in the graphic user interface : adding planets, display of the SAA (South Atlantic Anomaly).

### **Version 2.3 (revision 4) :**

**January - October 2011 :**

- Many internal modifications.
- Add the sky map (with the constellations and the name of main stars).
- Maximised display of world map or sky map.
- Add the simulation mode.
- Downloading of new locations and world maps, management of TLE downloading.
- Management of satellite names for TLE with 2 lines.

**Version 2.2 (revision 2) :**  
**October 2009 - November 2010 :**

- Sizeable main window.
- Display of the Moon.
- Management of several locations on the world map.
- Calculation of ISS transits with the Sun and the Moon.
- New display options.

**Version 2.1 (revision 8) :**  
**April - October 2009 :**

- SGP4 model with corrections from D. Vallado (use of oriented object programming).
- Multi-satellite management (calculation algorithms, display).
- New algorithm for Iridium flares, TLE updating and the creation of personal TLE files.
- Several modifications concerning display.
- Many improvements of source code (manual mode, Iridium flares, ...).
- Calculation of orbital events.
- Screen shot of the main window at JPEG or BMP format.
- Automatic download of orbital elements (TLE).

**Version 2.0 (revision 8) :**  
**January 2008 - April 2009 :**

- New graphical interface with VB2005, simplification of its use.
- Rewriting of all the procedures : adaptation to the language VB2005, translation in C language of the procedures containing many mathematical operations.
- New management of locations.
- Significant optimization of predictions and Iridium flares.

- New display options.
- Display of the zone of shade.
- Gradual variation of the radar coloured background according to the elevation of the Sun.
- New calculation of the satellite foot print and the zone of shade.

**Version 1.2 (revision 11) :**  
**June - December 2006 :**

- Modification of the layout of elements in the graphic interface.
- Add the radar.
- Creation of TLE personal files and their update.

**Version 1.1 (revision 15) :**  
**December 2005 - June 2006 :**

- Predictions of Iridium flares (personal algorithm concerning the magnitude).
- Add the sound notification and the satellite foot print.
- Add the Sun, the terminator and the list of satellites in the main window.
- Display of the future ground track of the satellite.
- Add the satellite Informations.
- Decompression of TLE files with gz format.

**Version 1.0 (revision 114) :**  
**September 2005 - February 2006 :**

- Developing the module calculating position and velocity with orbital models SGP4/SDP4.
- Numeric display of the position (vectors position and velocity, then in the various reference points).
- Calculation of the predictions of a satellite.
- Add the world map.
- Add shortcut buttons on the graphic interface.
- Add the Real-time mode, the status bar and of the calculation of osculating elements.



- Prediction of several satellites.
- Add the manual mode.
- Save results in a text file.
- Choice among several steps in manual mode.
- Optimization of the calculation of the predictions.

## Annex 3 : Technical features

### 1. Development

Software	Version	Comments
<b>PreviSat</b>	3.5.0.8	30,300 lines of source code
<b>Qt Creator</b>	3.5.1	IDE
<b>Qt Library</b>	4.8.7	GUI Library
<b>CppCheck</b>	1.71	Checking and analyzing of source code
<b>Inno Setup Compiler</b>	5.5.6 (a)	Installation setup for Windows
<b>Tortoise Hg</b>	3.6.1	Version control software
<b>UPX</b>	3.91	Executable file compression software
<b>zlib</b>	1.2.8	File compression/decompression library

### 5. Used Models and constants

Component	Reference	Author	Comments
<b>Propagation model</b>	SGP4, Spacetrack report n°3, Models for propagation of NORAD Element Sets	Hoots, Roehrich Vallado	1980 Revision of 2006
<b>Sun position</b>	Astronomical Algorithms 2 <sup>nd</sup> edition	Meeus	Simplified model. pp163-164
<b>Moon position</b>			Simplified model. pp337-342
<b>Planets positions</b>			Simplified model. pp209-216
<b>Sidereal time of Greenwich</b>			From the formula p88
<b>Osculating elements</b>	Fundamental of Astrodynamics and Application 2 <sup>nd</sup> edition	Vallado	
<b>Atmospheric extinction</b>	Magnitude corrections for atmospheric extinction, 1992	Green	
<b>Catalog of main stars</b>	Bright Star Catalog 5, 1991	Hoffleit	

Constant	Symb ol	Value	Origin
<b>Gravitational geocentric constant</b>	GM	398 600.8 km <sup>3</sup> .s <sup>-2</sup>	WGS-72
<b>Second zonal harmonic</b>	J2	0.001 082 6158	
<b>Third zonal harmonic</b>	J3	-0.000 002 538 81	
<b>Fourth zonal harmonic</b>	J4	-0.000 001	

<b>Flatness of Earth globe</b>	f	655 97	
<b>Terrestrial equatorial radius</b>	Re	1/298.26	
		6378.135 km	
<b>Astronomical unit</b>	AU	149 597 870 km	UAI 1976
<b>Solar equatorial radius</b>	$R_{\odot}$	696 000 km	
<b>Lunar equatorial radius</b>	$R_{\oplus}$	1738 km	
<b>Magnitude of solar disc center</b>		-26.98	

## Annex 4 : Thanks

I would like to thank :

- T.S. Kelso for the information he communicated to me and numerous information available on his site [www.celestrak.com](http://www.celestrak.com),
- David Vallado for the publication of corrected model SGP4 (2006) and the calculation methods present in his **Fundamental of Astrodynamics and Applications** (consult the site [www.celestrak.com](http://www.celestrak.com) to buy it),
- Jean Meeus, where the **Astronomical Algorithms** supplied the essential astronomical calculations (calculation of the julian day, Sun's position, sidereal time...),
- Michel Casabonne, whose support and contributions helped to bring new features and significant improvements to PreviSat,
- and people who helped me in the development of PreviSat, for their advice and their software tests (thanks Claudia, Yannis, Rémi, JB, Benoît, Maurice, Jean-Louis !).

I also address thanks to all the people who expressed to me their appreciations of the software.

### 1. Translations

**English** : Mr O'Donoghe

### 6. Graphics (icons, splashscreen)

Claudia Martinez

## Annex 5 : Contact - License

This software is under the GNU GPL license version 3. The numerical results can be distributed freely, as well as predictions (passes of the satellites, flares, orbital events and ISS transits) have no restrictions. The latest version of the software can be downloaded freely on the official release web site [sourceforge.net/projects/previsat/](https://sourceforge.net/projects/previsat/).

For any information, suggestion or in the event of a problem, send an e-mail to the author of the software at the following address : [astropedia@free.fr](mailto:astropedia@free.fr).