

TLE ANALYSER

User Manual

TLE analysis / Satellite tracking and prediction / Export to GMAT, Celestia and Google Earth

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Stable Version - 2013

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1. What is TLE Analyser?

Every object in orbit around earth is referenced and checked by the American NORAD. This organisation provides orbital parameters of unclassified satellites in a specific format called TLE (Two Line Elements).

TLE Analyser first mission is to decode satellites TLE in order to extract the **osculating orbit** parameters and all other resulted data (velocities, altitudes, periods, precession movements...)

The second mission of *TLE Analyser* is to make prediction on satellite position. 3 *graphic* tracking modes are available (2D and 3D).

Third mission of TLE Analyser (and not the least) is to export TLE parameters to different 3D spatial applications (NASA GMAT, Celestia, Google Earth).

TLE Analyser provides data with reference to Simplified General Perturbations models (SGP4).

These models predict the effect of perturbations caused by the Earth's shape (spherical harmonics), drag, radiation, and gravitation effects from the Sun and Moon.

The SGP4 model has an error ~1 km at epoch and grows at ~1–3 km per day.

TLE Analyser can predict satellite position many years before and after TLE epoch but you should keep a range of +/- 10 days to have good prediction.

Internet connection must be effective (for TLE updater, Google Map and Earth visualization)

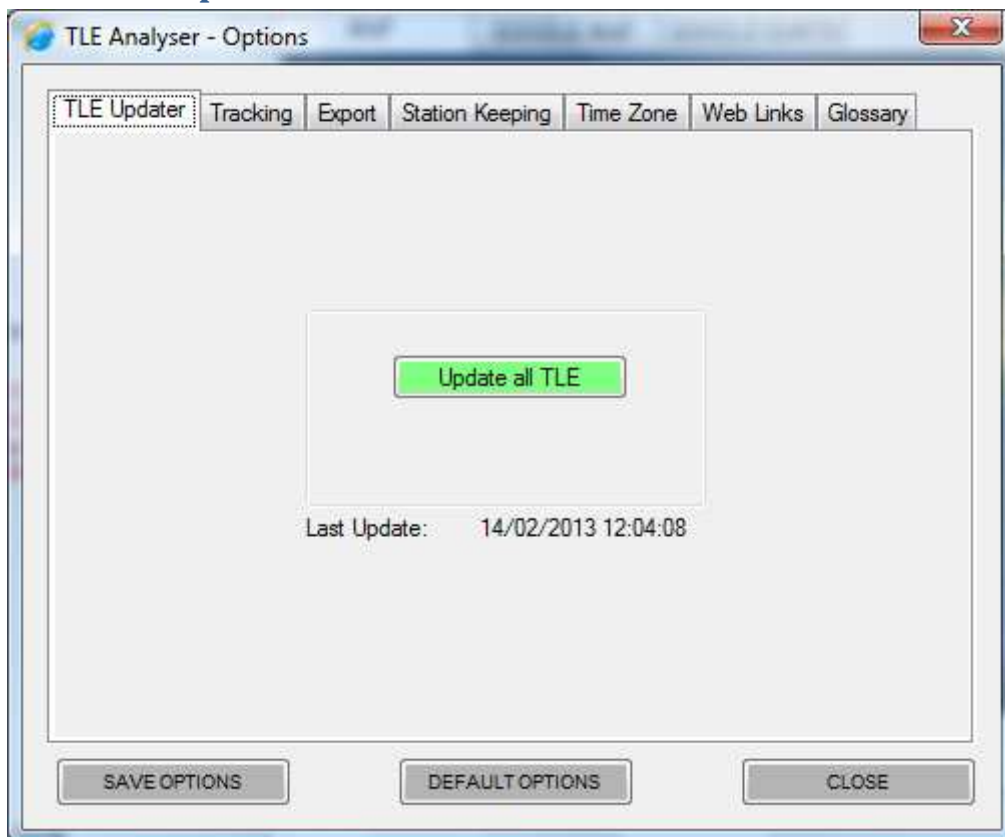
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2. TLE Analyser Setup and Options



- **TLE Updater**

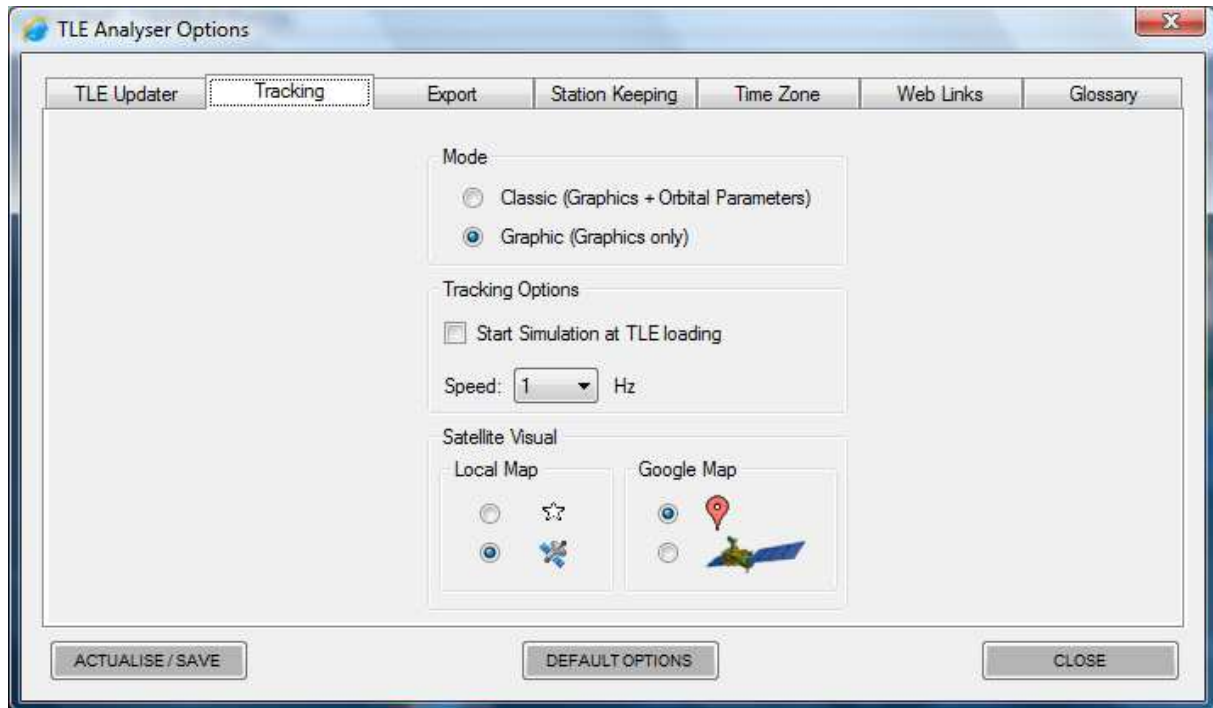


- **Update TLE option** allow to download last versions of all TLE used by TLE Analyser
 - TLE files are located in C:\TLEAnalyser\TLE\

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- **Tracking**

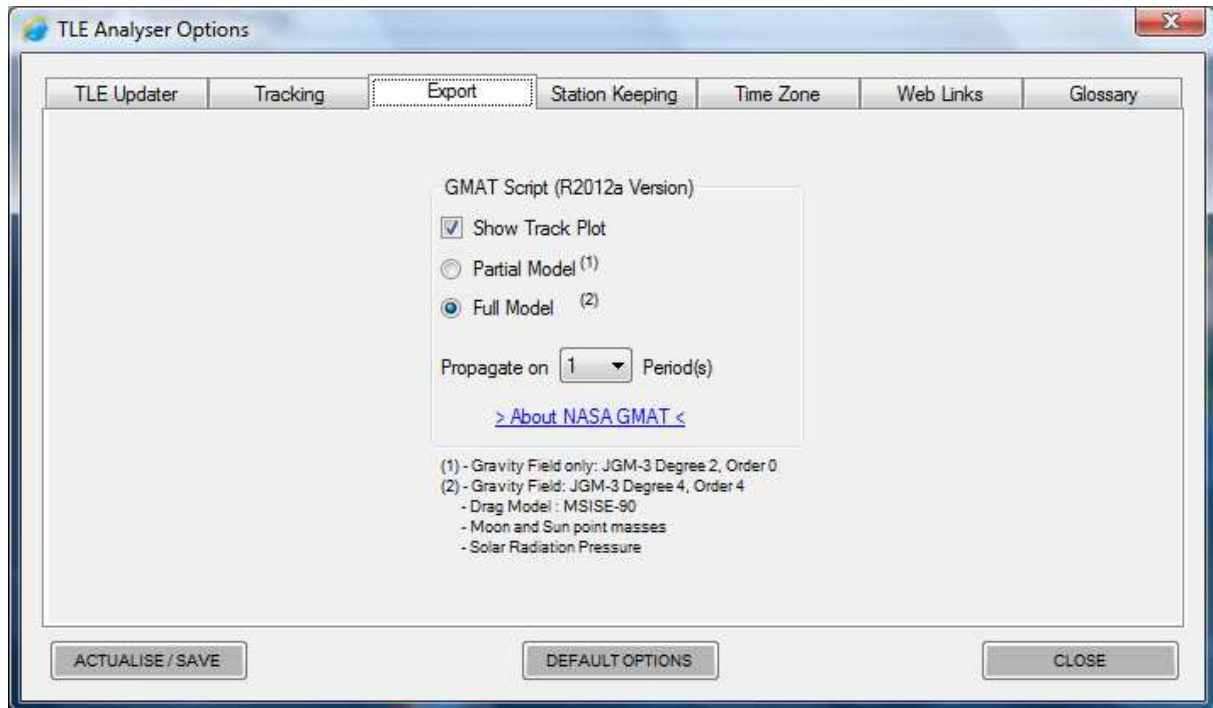


- **Mode:**
 - **Classic:** Display orbital parameters and low size maps
 - **Graphic:** Display bigger size map without main orbital parameters
- **Tracking options** allow to choose:
 - **Start Simulation at TLE Loading:** Simulation automatically starts when you import a TLE (with actual tracking parameters)
 - **Speed :** frequency of actuation:
 - 1= 1 step/s⁻¹ (1 sec. between each step)
 - 10= 10 steps/ s⁻¹ (0,1 sec. between each step)
 - 100= 100 steps/ s⁻¹ (0,01 sec. between each step)
- **Satellite Visual:**
 - Satellite icon on standard 2D map
 - Satellite icon on Google Map

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- **Export**

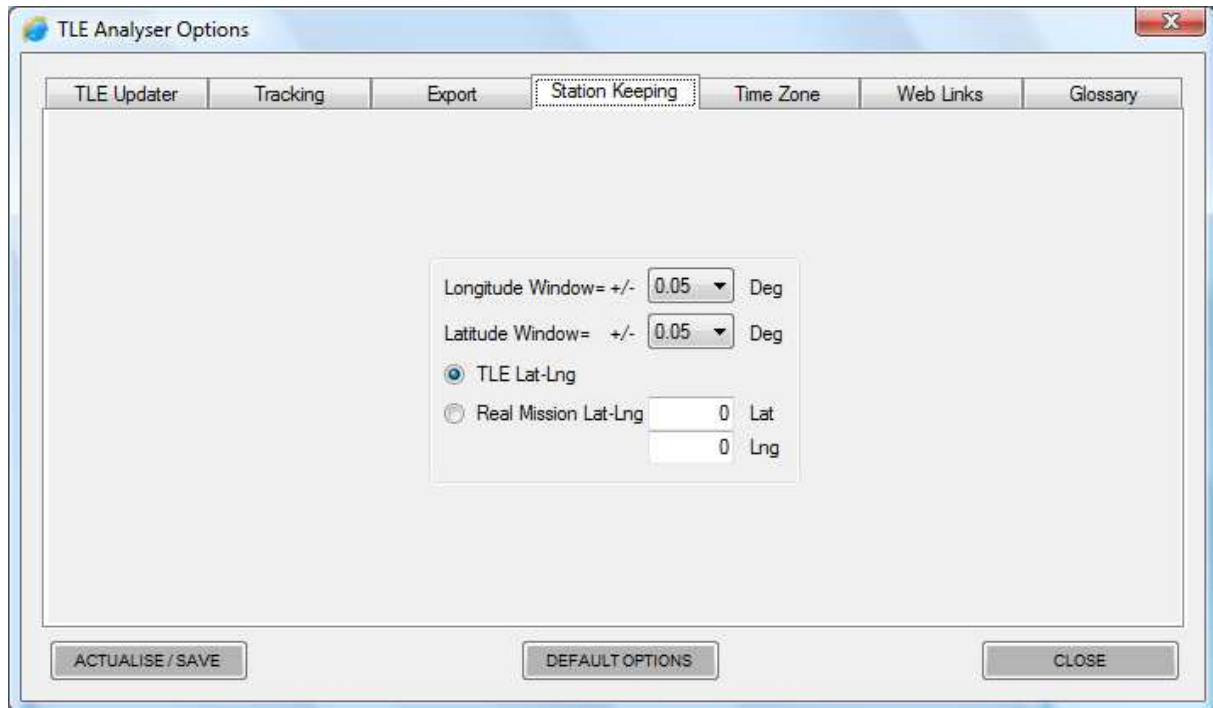


- **Export option** allow to choose (for GMAT .script only):
 - **Show Track Plot:** GMAT can display a 2D map of satellite propagation
 - **Partial or Full model:** choose among 2 options of force models
 - **Propagate:** propagate duration (based on Draconitic Period)

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- **Station Keeping**

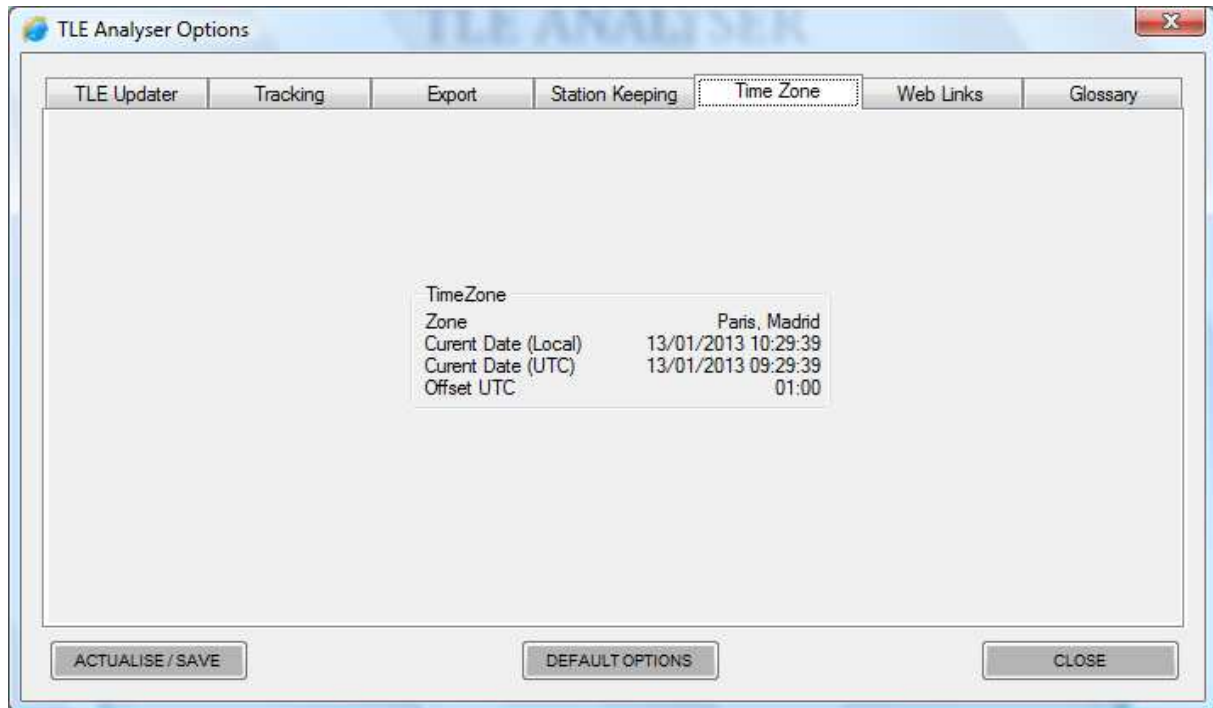


- **Station Keeping option** (for Geostationary Satellites) :
 - This option allow to generate a keeping window in longitude and latitude for Geostationary Satellites with following conditions:
 - $0,99 < \text{Mean Motion} < 1,01$
 - $\text{ECC} < 0,01$
 - $\text{INC} < 1$
 - The reference latitude and longitude can be:
 - TLE reference position
 - Real mission position (you can use **Catalogue Link** to check this data)

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- **Time Zone**

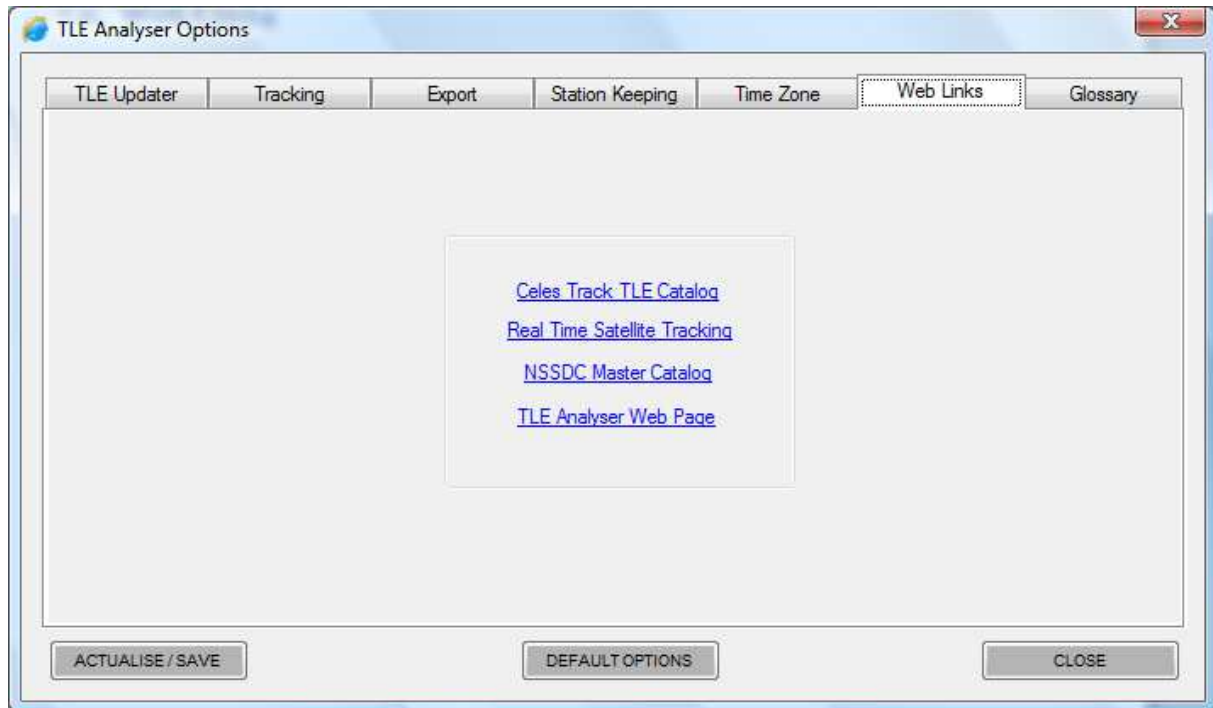


- **Time Zone option** provides some data about local Time Zone
 - Zone
 - Current Date
 - Current UTC Date
 - Offset UTC

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- **Web Links**

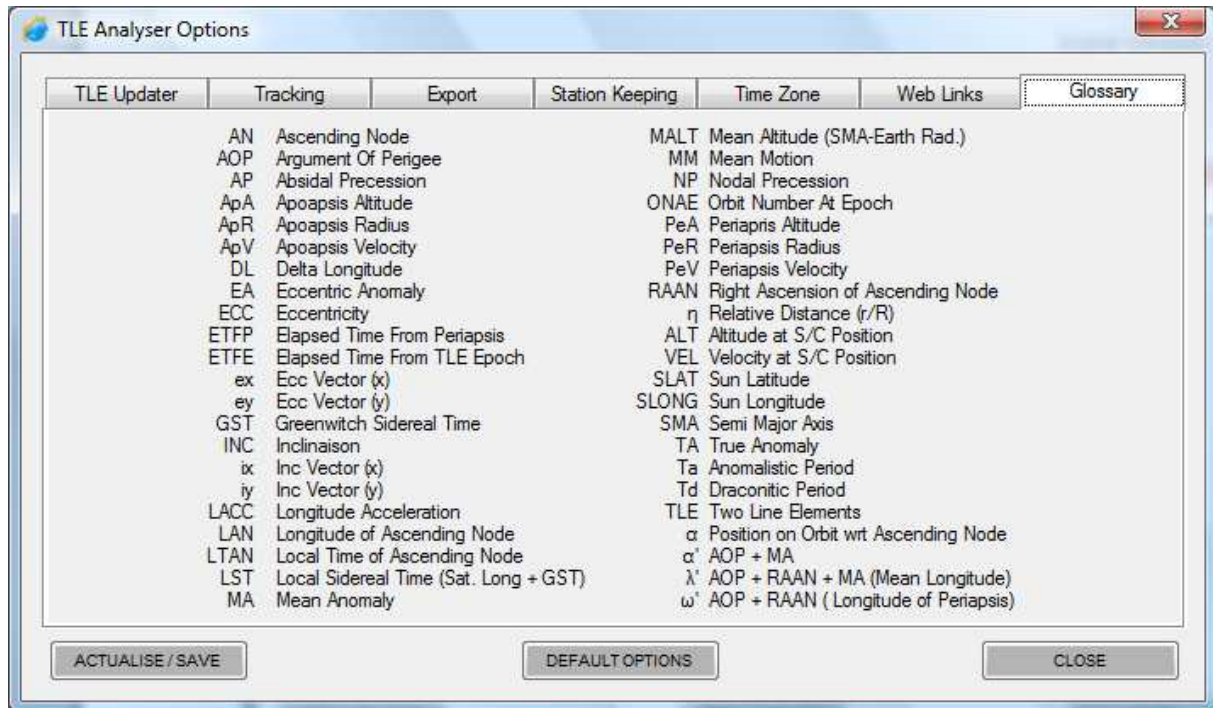


- **Web Links option** provides some links to useful websites:
 - CelesTrack TLE Catalog: Catalog of TLE used by TLE Analyser
 - Real Time Satellite Tracking: Satellite Tracking on the web (Google Map)
 - NSSDC Master Catalog: Here you can find some details of loaded satellites
 - TLE ANALYSER WEB SITE: Web Page of TLEA on Sourceforge.net

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- **Glossary**



- **Glossary** option provides a definition of each acronyms used in TLE Analyser

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3. Import/Modify a TLE

- Import a TLE:
 - Choose a satellite among those of the available lists.
 - Satellite is automatically imported at **Current UTC date**
 - Search option is available.
 - **NEW** option allows you to paste your own 2 lines, click on **IMPORT** button to accept the new TLE.

Two Line Elements
AAU CUBESAT SAT# **27846** CAT# **2003-031G**
1 27846U 03031G 12327.96287249 .00000312 00000-0 16282-3 0 4304
2 27846 98.6947 334.3496 0009927 98.4108 261.8207 14.21363724487560

NEW MODIFY TLE IMPORT SHOW DETAILS

Select TLE from list

- amateur.bt
- cubesat.bt
- dmc.bt
- education.bt
- engineering.bt
- galileo.bt
- geo.bt
- geodetic.bt
- globalstar.bt
- glo-ops.bt
- goes.bt
- gorizont.bt
- gps-ops.bt
- intelsat.bt
- indium.bt

2012-006D
2012-006H
2012-006J
AAU CUBESAT
AAUSAT-II
AUBIESAT-1
BEESAT
CANX-1
CANX-2
CAPE1
COMPASS-1
CSTB1
CUBESAT XI-IV (CO-57)
CUBESAT XI-V (CO-58)
CUTE-1 (CO-55)
CUTE-1.7+APD II (CO-6)
DELFI-C3 (DO-64)
DICE-F
DICE-Y
DTUSAT
E-ST@R
F-1

Find a S/C (1520 TLE)

Keplerian Elements

SMA 7205.012848 km
ECC 0.002032882
INC 98.68923856 deg
RAAN 334.3495997 deg
AOP 81.51399543 deg
MA 278.7175622 deg

Cartesian State

X 6492.989 km
Y -3117.9702 km
Z 0.1503 km
VX -0.5002 km/s
VY -1.0067 km/s
VZ 7.3548 km/s

Position

TA 278.4872 deg
EA 278.6024 deg
ETPF 78.5369 min
alpha 0.0012 deg
LAT 0.001 N deg
LONG -74.615 W deg

Adapted Parameter

SMA 7205.012848 km
ex 0.000299988
ey 0.002010626
INC 98.68923856 deg
RAAN 334.3495997 deg
alpha' 0.231557704 deg

Altitudes

ApA 841.5231 km
PeA 812.2292 km
ApR 7219.6598 km
PeR 7190.3659 km
ALT 824.6853 km
MALT 826.8762 km

Periods

Ta 101.4406 min
Td 101.4978 min

Ascending Node

LAN -74.6147 deg
LTAN 18:07:53.149

Mvmt - Precession

MM 14.1955 rev/day
NP 0.9825 deg/day
AP -2.8806 deg/day
DL 25.3747 deg

- Modify a TLE:
 - When a TLE is imported, click on **MODIFY TLE** to change Keplerian values in the **2nd** line.

Two Line Elements
AAU CUBESAT SAT# **27846** CAT# **2003-031G**
1 27846U 03031G 12327.96287249 .00000312 00000-0 16282-3 0 4304
2 27846 150.6947 334.3496 0009927 150.4108 261.8207 14.21363724487560

NEW MODIFY TLE IMPORT SHOW DETAILS

Find a S/C (1520 TLE)

- Be careful to respect characters positions (use **Show Details** to be sure)
- Click on **IMPORT** button to accept the new TLE.

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4. Tracking and Maps

- When a TLE is imported, the tracking tools are enabled and satellite position can be estimated with following options:

The screenshot displays the 'Tracking and Maps' section of the TLE ANALYSER software. It is divided into three main panels:

- Epoch (UTC):** Contains a 'Format' dropdown set to 'UTCGregorian', a 'Current Date' field showing '26/02/2013 19:18:45.000', and a table of orbital parameters:

GST	86.484	deg		ONAE	2488
LST	303.5361	deg		Eclipse	NO
TLE Epoch	13/02/2013 20:51:03.736				
- Simulation Mode:** Features a dropdown set to '1', a 'min' dropdown, and five navigation buttons (rewind, previous, play, next, fast forward). Below these is an 'Actualize Track' link.
- Track Options:** Includes checkboxes for 'Track on' (checked), 'Full Track' (unchecked), and 'Night Shadow' (checked). A dropdown next to 'Track on' is set to '1' with 'Per.' to its right.

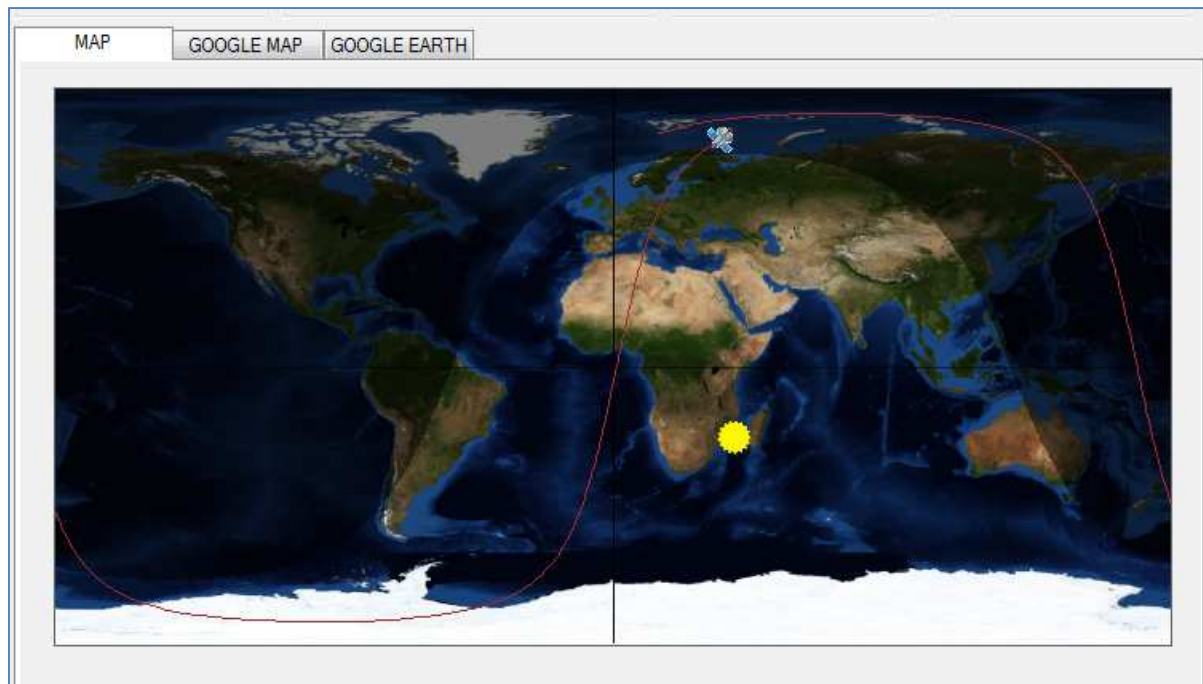
- **Epoch parameters:**
 - **Gregorian** and **Modified Julian Date** are available
 - Click on **Current Date** to use *Current UTC* Date
 - Use **Reload** button  in the menu bar to reload the TLE at the TLE Epoch.
 - TLE Epoch is also available
- **Simulation Mode:**
 - Allow to choose simulation parameters
- **Track Options:**
 - Allow to generate from 1 to 15 periods track.
 - Allow to generate **Full Track** (only for satellites phased on **15 days** max.)
 - Allow to display **Day/Night** on **Standard Map** and on **Google Earth**.
 - Allow to display **full grid** of meridians on standard Map.

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- **Standard Map (based on a Equirectangular projection)**

- You can visualise the satellite **track** on different periods (from 1 to 15)
- For satellite with phasing on 20 days max, you can visualise **full track**
- Positions of the Satellite and position of the Sun are available.



- More info about Phasing parameters:

Periods		
Ta	101.2358	min
Td	101.2931	min
Phasing	[14 ; 5 ; 26] 369	

- Phasing form is: **[n ; p ; q] r**
 - n = Entire part of the daily phasing frequency
 - p / q = Fractional part of the daily phasing frequency
- That mean:
 - The Satellite performs “r” revolutions in “q” days.
 - $n + (p/q)$ = Number of orbit per day
- These parameters are usually used for Low Orbit missions and especially for Sun Synchronous orbits.

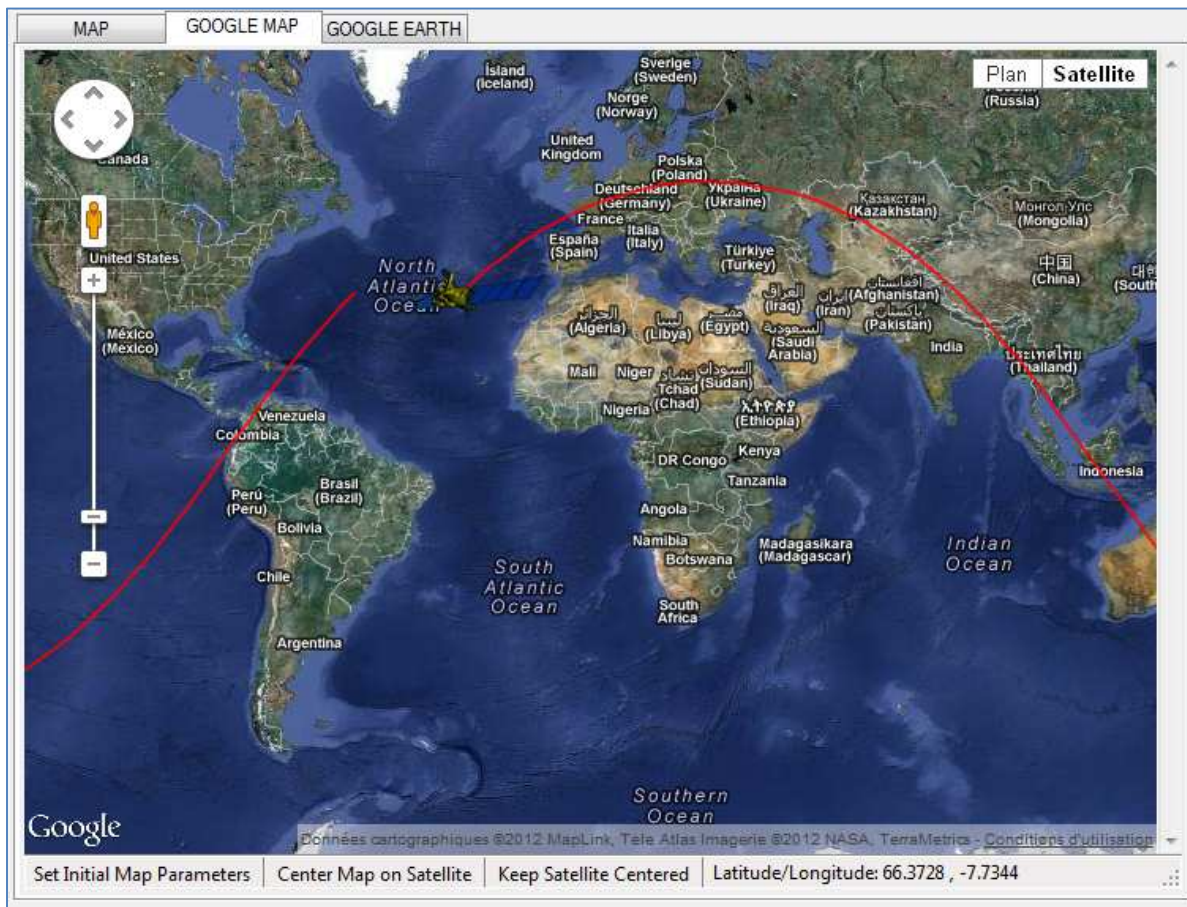
In those cases, the Phasing parameters allow to determine the mean orbit (Altitude, Inclination...) needed to carry out the mission.

As TLE provide osculating parameters, the Phasing provided by TLE Analyser is correct as long as the Satellite is frequently maintained on his mean orbit.

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- **Google Map (based on a Mercator projection)**
 - This view mode provides a full options map from **Google Maps API**
 - As the map is based on a Mercator projection, it's not relevant for orbit with $85^\circ < \text{INC} < 95^\circ$.
 - Tracking mode is available.

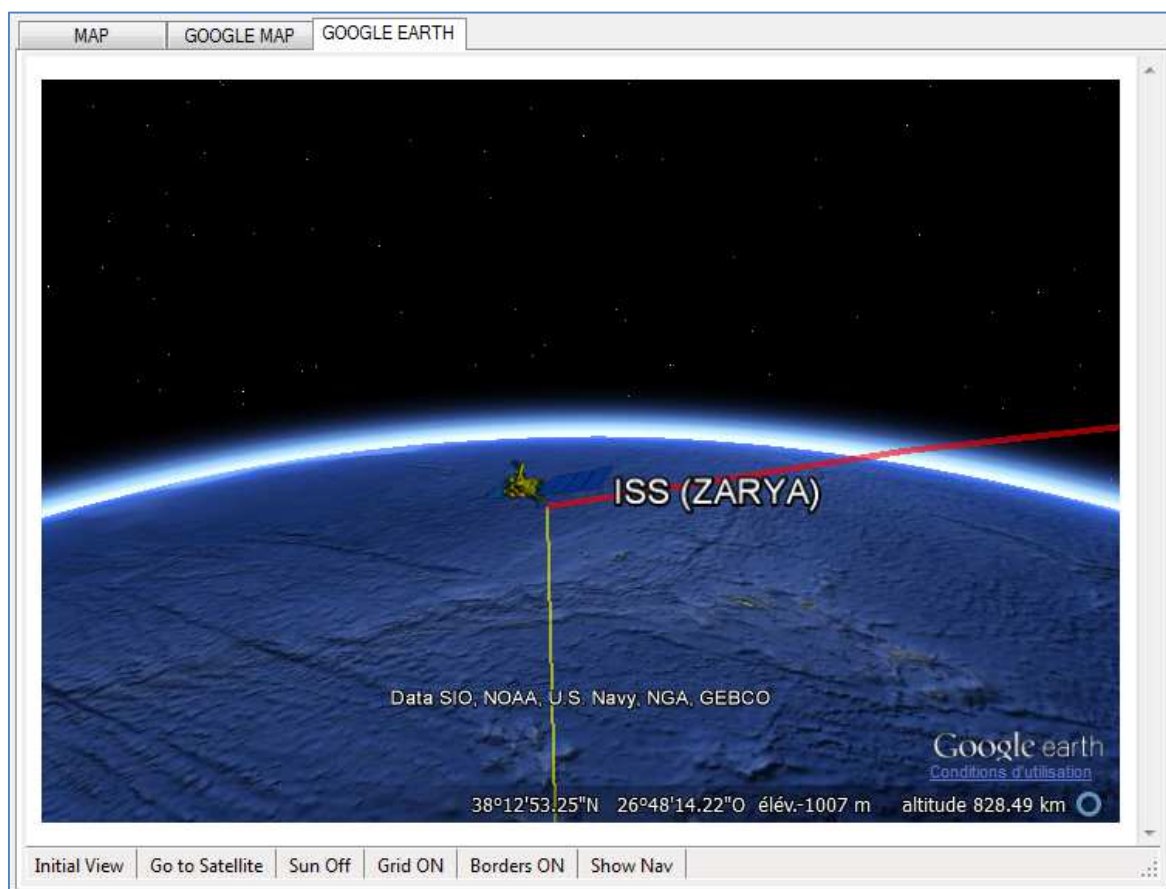


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- **Google Earth**

- This view mode provides a 3D view from **Google Earth API**
- **Google Earth plugin must be installed in your web browser.**
- Tracking mode is available.



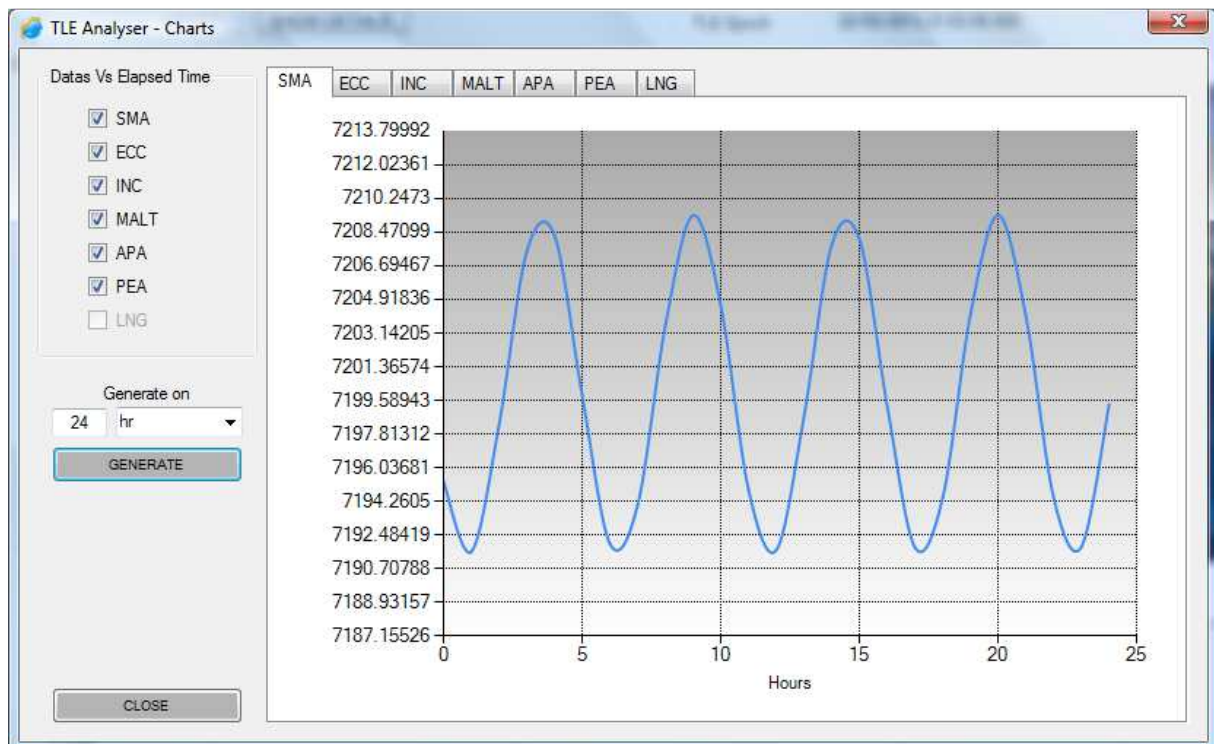
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5. Chart Generator

TLE Analyser allows you to generate XY Plot for some orbit parameters.

- First of all, a satellite must be loaded
- Select Chart Generator option
- 3 time options are available (hours, minutes, period)
- You can generate only on 10 days max. (due to SGP4 accuracy)



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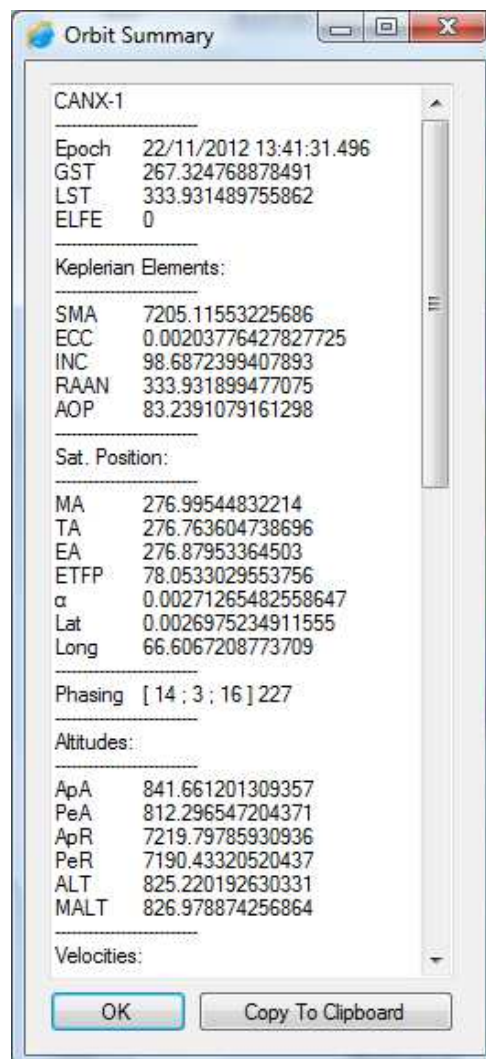
6. Menu



TLE MENU

- **TLE Menu**

- **Open Favorites:** Load *Favorites.txt* file into TLE list
- **Save to Favorites:** Save current TLE into C:\TLEAnalyser\FAV\Favorites.txt
- **Delete from Favorites:** Delete current TLE from Favorites
- **Reload:** Allow to reload the TLE at initial TLE epoch
- **Summary:** Display a complete summary of all orbit parameters.



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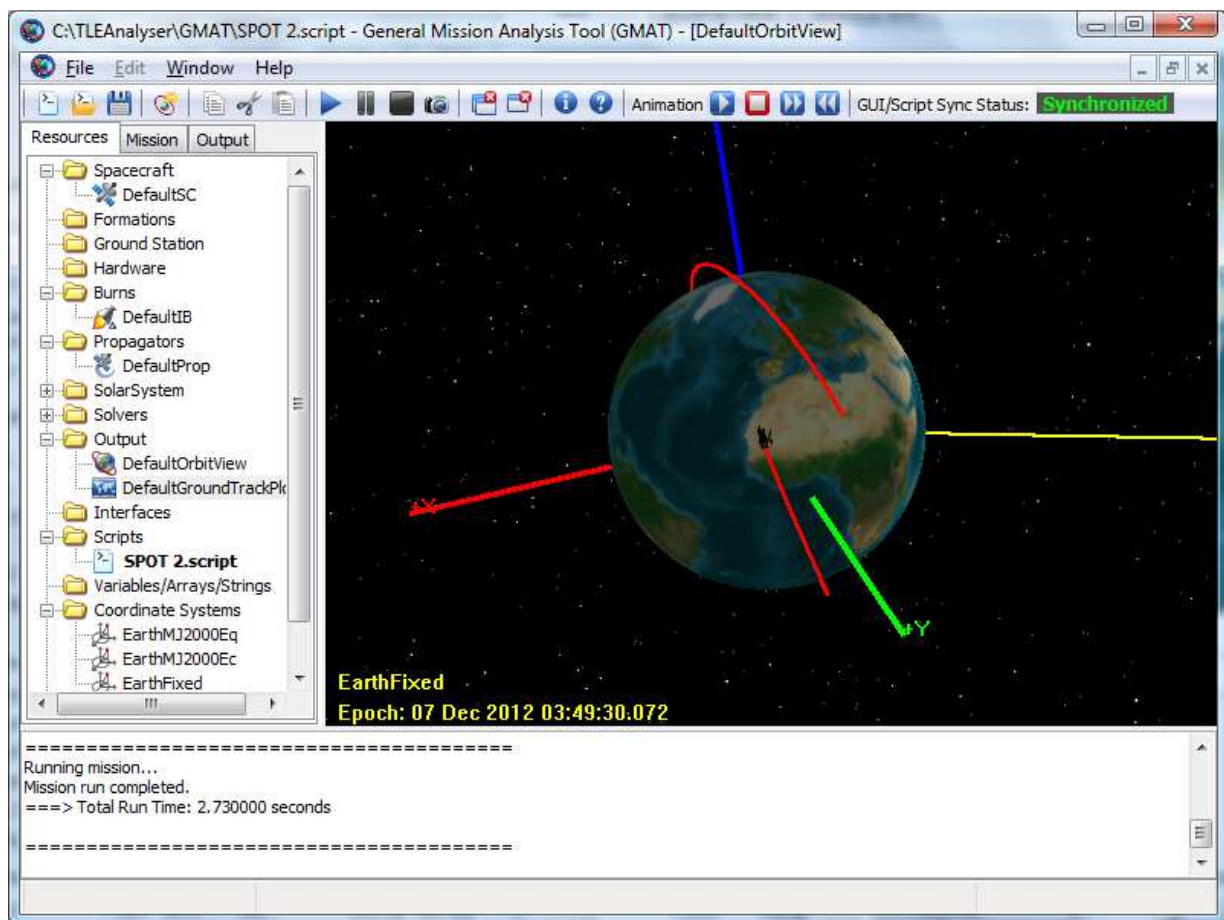


EXPORT MENU

- **Export Menu**

- **Export To GMAT:**

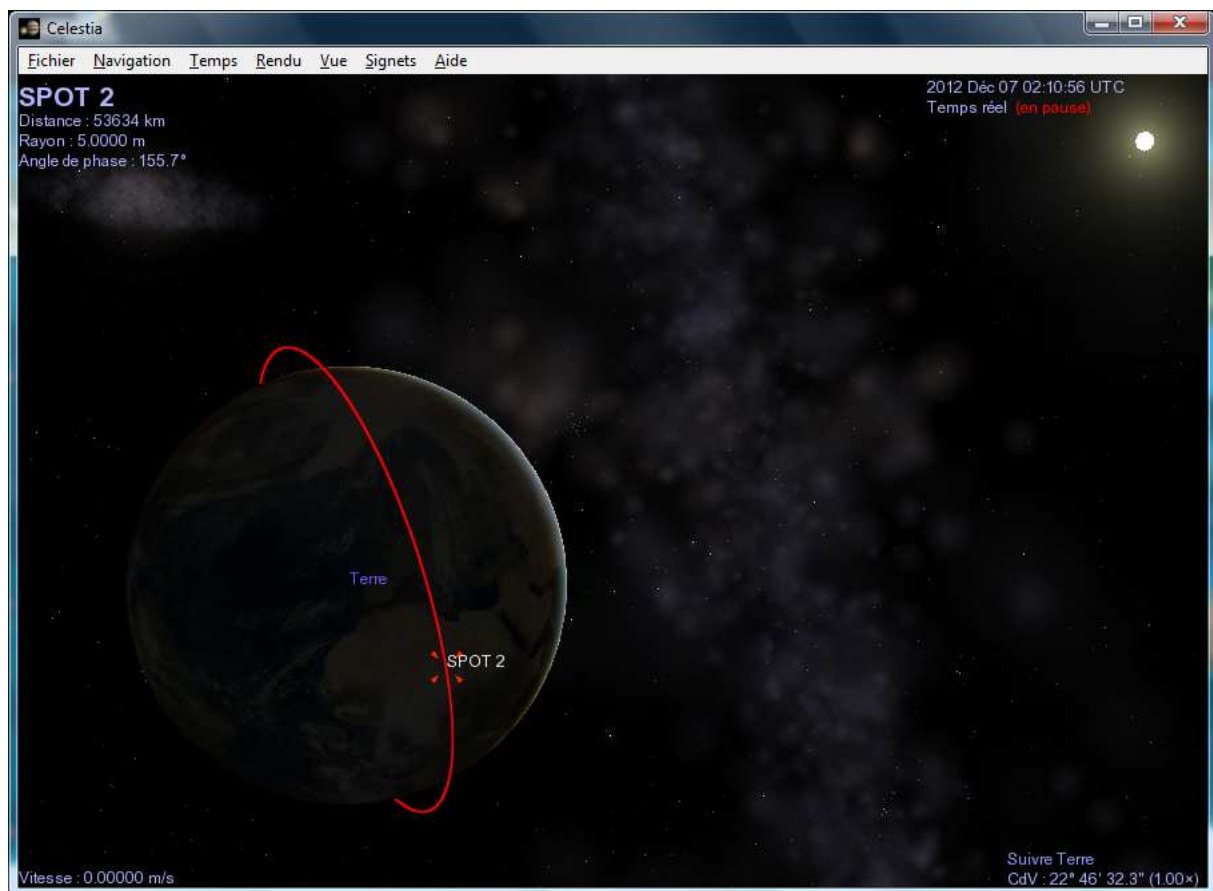
- Allow to generate a **GMAT** *.script* file to be directly used by the NASA software.
 - GMAT *.script* files are located in C:\TLEAnalyser\GMAT\
 - GMAT *.script* files are optimised for GMAT R2012a version



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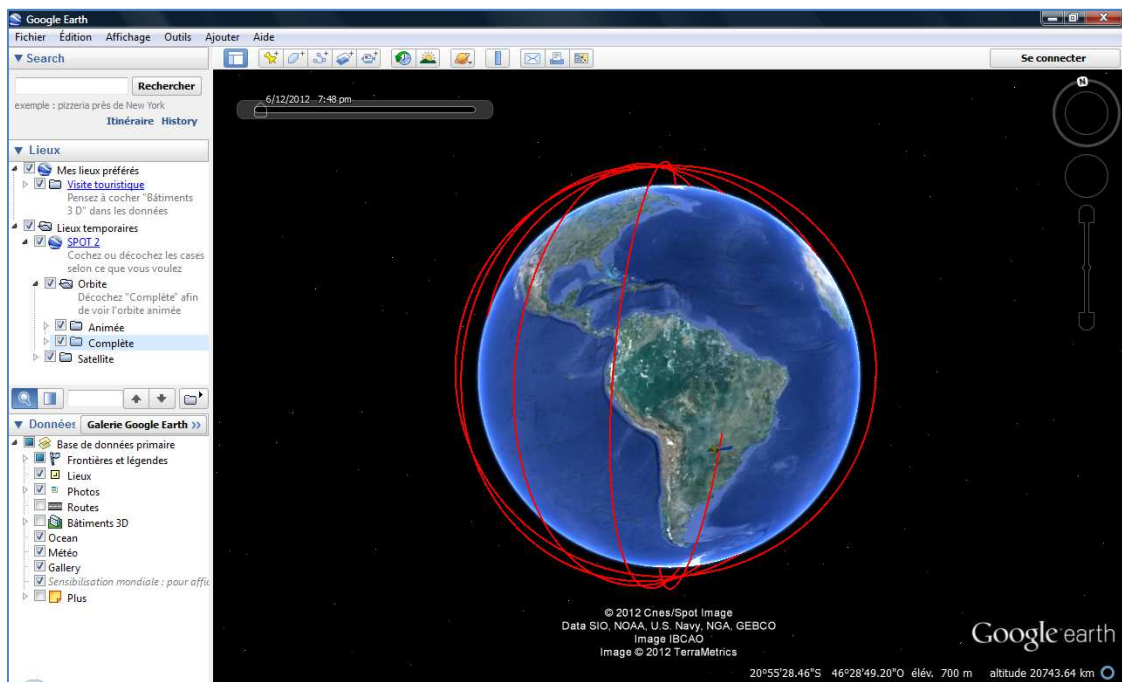
- **Export To CELESTIA:**
 - Allow to generate a **Celestia** Folder to be directly used by the famous software.
 - **Satellite** folder is located in C:\TLEAnalyser\CELESTIA\
 - The folder can be directly paste into **Extras Celestia's** folder
 - Don't forget to enable "Orbit" option in **Celestia**.
 - **Be careful, it seems that Celestia doesn't use SGP model. It would be better to choose the effective epoch before export to Celestia.**



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- **Export To Google Earth:**
 - Allow to generate a Google Earth Folder with .kml file and satellite.png file
 - Satellite folder is located in C:\TLEAnalyser\GOOGLEEARTH\
 - Satellite.kml file can be directly executed from this folder
 - Export is not enabled for **Full Track Mode**
 - **Export might be longer for more than 1 periods tracks**



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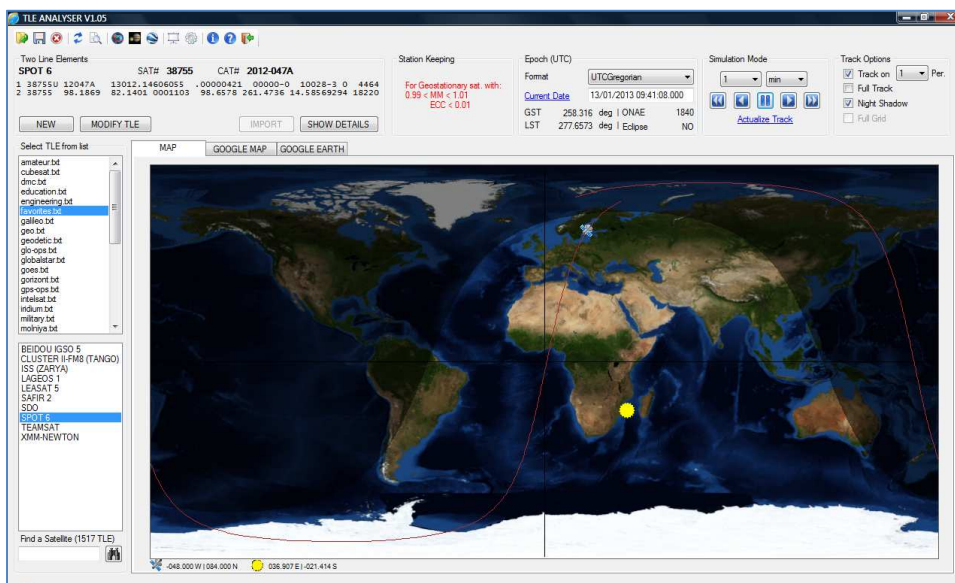
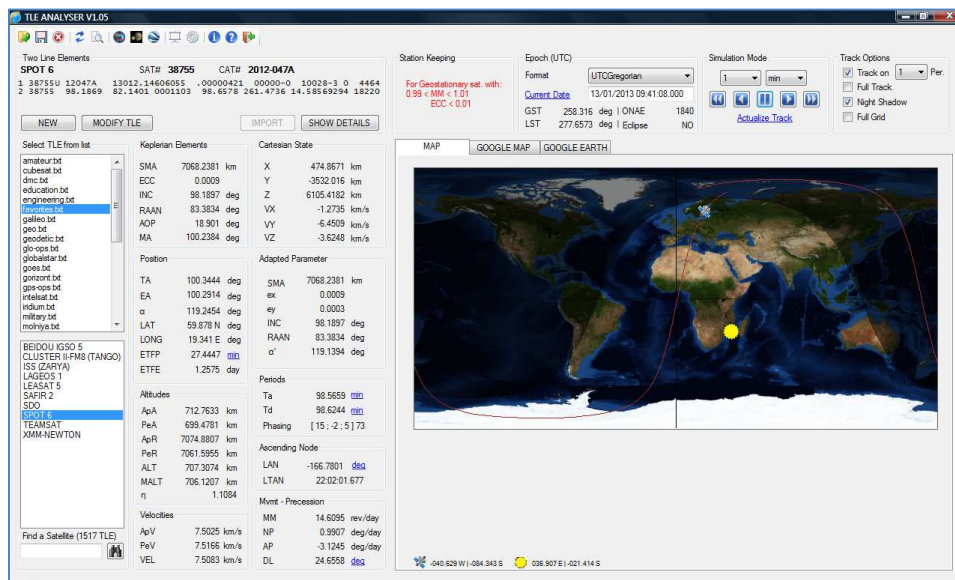
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OPTIONS MENU

- **Options Menu**

- **Chart Generator:** Allow to generate XY Plots
- **Change Mode:** Allow to choose between lower or larger maps
- **TLE Analyser Options:** Display program's options (see §2)
- **About TLE Analyser:** Display the README file with information about version and updates.
- **Help:** Display the User Manual (pdf)
- **Exit:** Allow to Exit TLE Analyser



7. Shortcuts

(Focus must be out of the Maps)

- Open Favorites: Ctrl + O
- Save to Favorites: Ctrl + S
- Reload a TLE: Ctrl + R
- Export to GMAT: Ctrl + G
- Export to Google Earth: Ctrl + L
- Export to Celestia: Ctrl + T
- Summary: Ctrl + M
- About: F2
- Help: F1

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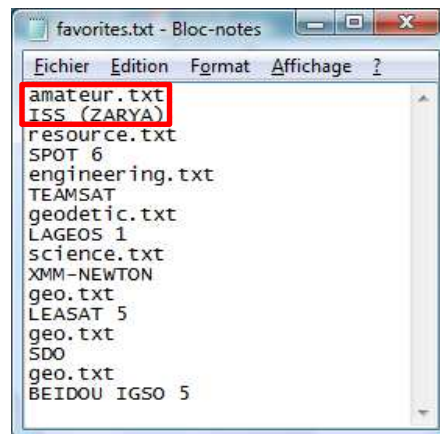
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8. Error Handling

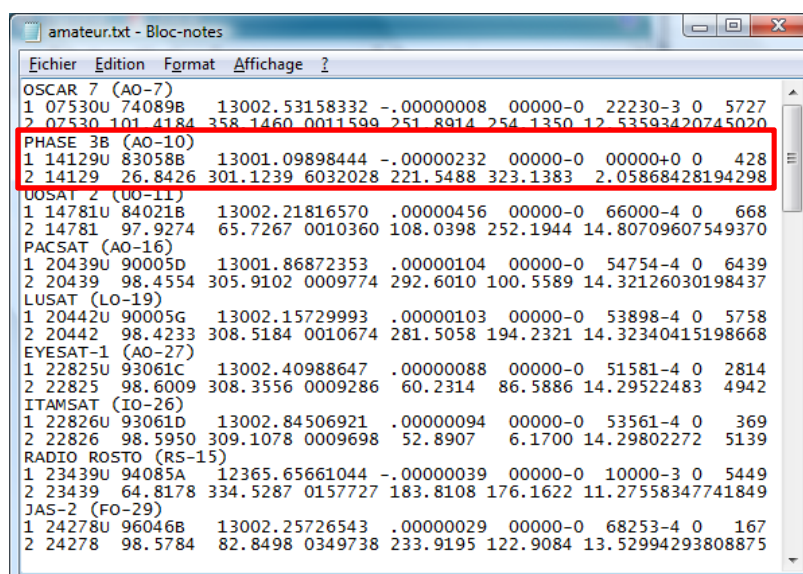
- **Files format**

Corrupted files should provide errors during TLE ANALYSER using.

- **Favorites file** (C:\TLEAnalyser\FAV\favorites.txt) must keep following format:
 - 2 lines for 1 satellite:
 - 1st line for the TLE file name
 - 2nd line for the satellite name



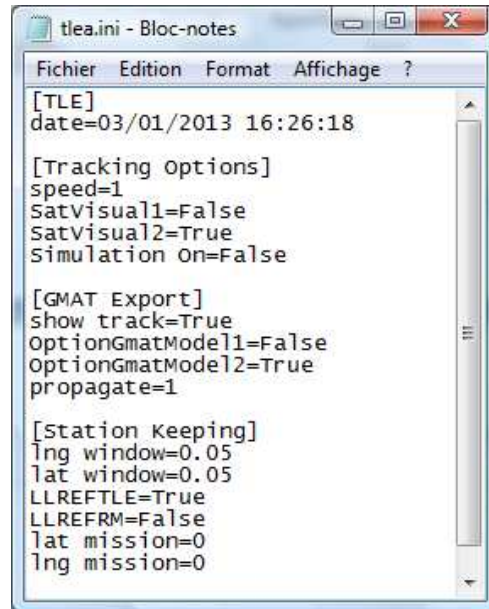
- **TLE files** (C:\TLEAnalyser\TLE\) must keep following format:
 - 3 lines for 1 satellite:
 - 1st line for the satellite name
 - 2nd line is the Line 1 of the TLE
 - 3rd line is the Line 2 of the TLE



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- **INI file** (C:\TLEAnalyser\tlea.ini) must keep following format:



- **Date** parameter corresponds to the last update of all TLE files.
For a 1st installation and without TLE update with TLE ANALYSER, this date corresponds to the TLE provided by TLE ANALYSER.

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End of the document.