TriaXExcelPro
3D Dynamic Tool
"4D"
USER's Manual
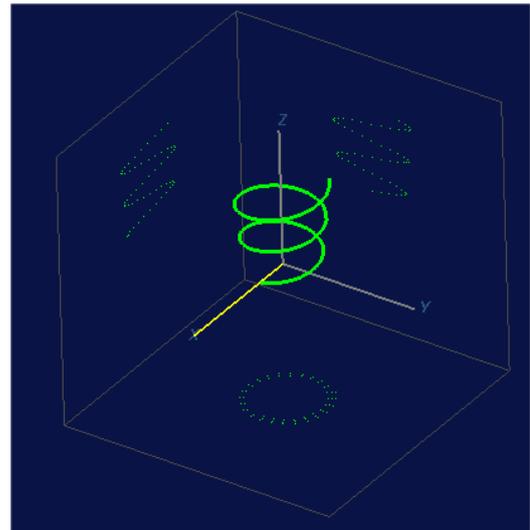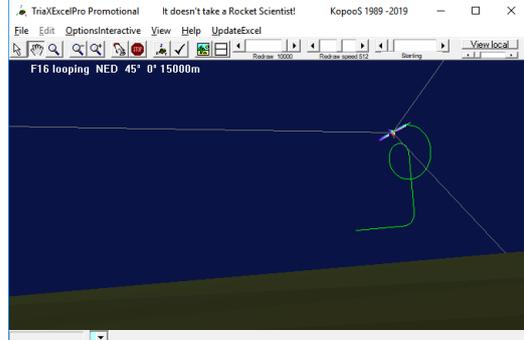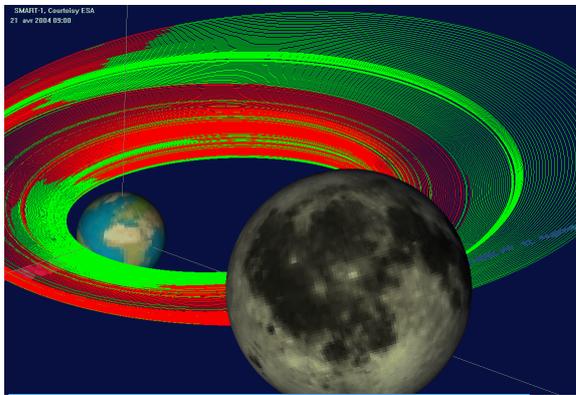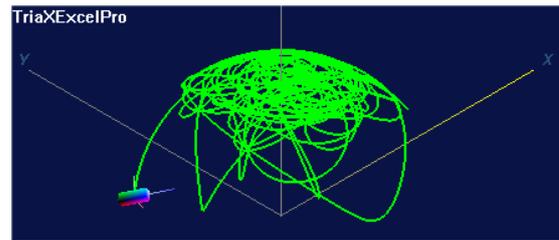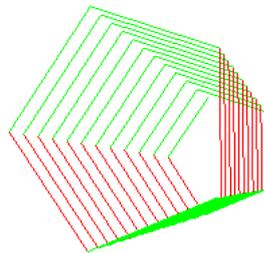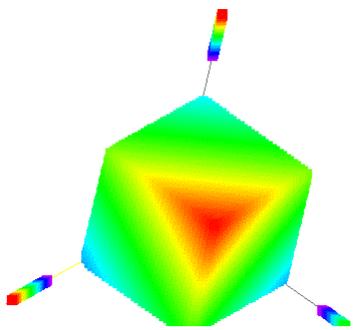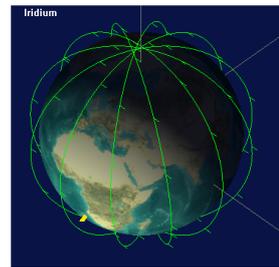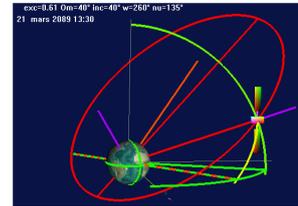
www.KopooS.com   **Jan. 2022**

USER's Manual TriaXExcelPro

Congratulations and Welcome!!!

You are now the proud owner of an evaluation copy of TriaXExcelPro, the fast, fun, and eas*y-to*-use <u>Three Dimensional Dynamic</u> viewer program (abbreviated as 3DD or "4D").

The use of the program is as simple as possible for engineers, students and autodidacts. The approach, when developing the program, has always been to make it accessible to any person who is not a specialist of the 3D techniques.

The view can involve a huge number of points, up to a million (1 048 575 max) contrary to the graphics in Excel (limited to 32 000 max).

TriaXExcelPro is distributed as demonstration program to reach the widest possible audience, but it is still copyrighted material. You are granted permission to try out the program for 30 days, to see if you want to keep it and use it, and if you decide the program is worth a reasonable fee, there are many easy ways to get in touch with us and many attractive incentives when you register.

Also, you are encouraged to copy the entire shareware package and pass it around to anyone who may be interested, as long as you don't change any of the files and at the very most charge a small media and handling fee.

The program has been designed for viewing dynamically in three dimensions any line, dots or solids via a finite elements description.

The recommended use of the program is to run the program without any excel sheet open in order to see the Demo. After, the user can use the excel sheets provided with the program and make its own changes update…

The ascent compatibility in the program update and releases is one of its main features. Older cases are compatible with the current program release. That allows also maintaining the accuracy and the bug free principle in a very efficiently manner.

Pictures and views using the program have been published in scientific papers.

User's manual TriaXExcelPro

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2. Getting Started

The use of the software is as simple as possible, with no deviation with respect to the genuine Excel use. Please read the file "Readme.txt" for the software installation and last minute improvements.

2.1. To Plot a real three dimensional 3DD object

- o Open Excel (version 2003, 2007 and over)

- o Put the values X, Y, Z of the object in three contiguous columns

- o Select an other cell in the Excel sheet and write a formula like: **= MAX(A2:C60)** for the range of cells containing X,Y,Z or in short **= MAX(A2)**
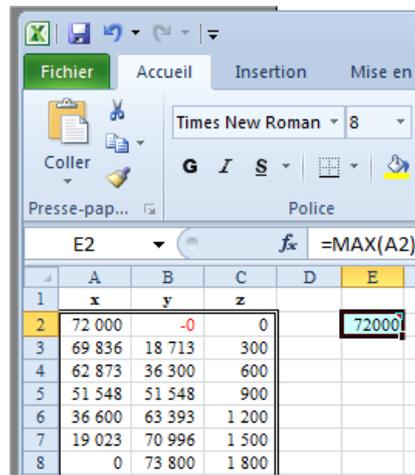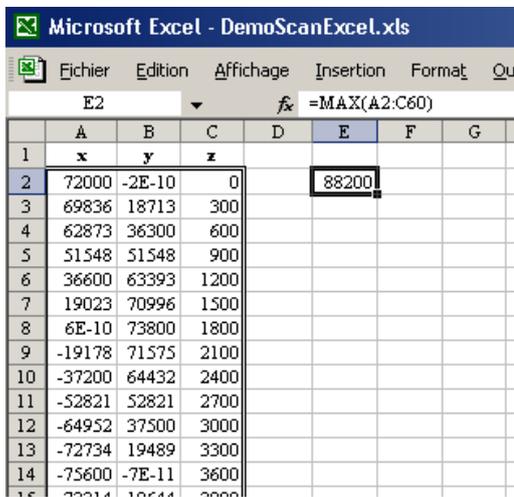
- o And run TriaXExcelPro program. **It's all.**

- o After a while for the data loading, the Triaxial **3DD** object is shown in a window. Using the mouse (right click) the object rotate automatically…
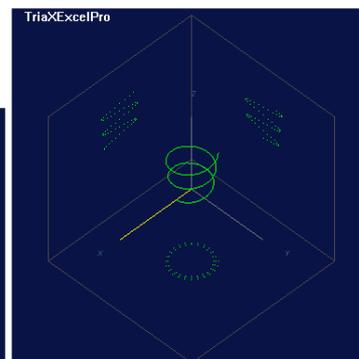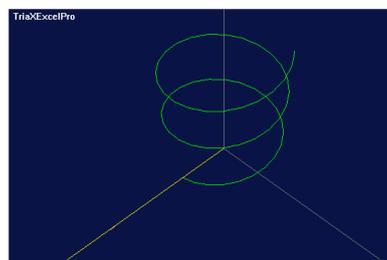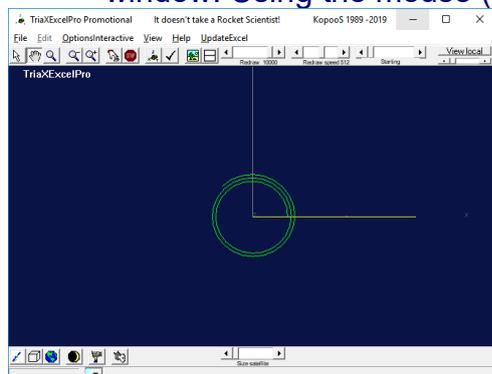
- o In the toolbox

,

One can also use the Triax icon 🔺 to see immediately the Iso-view. One can also use the scrollbar "Redraw" to redraw dynamically the 3D plot, and adjust the

redraw speed using the scrollbar "Redraw speed". Other features implemented: the scrollbar labelled "Starting" that allows showing only a part of the full 3D trajectory, the command "View local" that is a smart features for viewing the trajectory from a local frame that can follow the current point or any other….

Note: the tool is compatible with any release of Excel (Excel 2003, Excel 2007, …) but not with the very limited edition called "Excel Starter".

3. Special features

Special features:

o   Enjoy the mouse functions left or right button down in the plot window

o   Try the toolbar icons (zoom in, zoom out x 3 at each click)

o   Try also the full size for the window.

o   Automatic rotation: Double Click in the plot window to disable or enable the automatic rotation given while moving the mouse with the right button down. Use also the icons .

o   Dynamic plot: Move the cursors labelled "Redraw Start" and "Redraw Speed" in order to watch dynamically the plot increasing and get the full **3DD** function. This is also very useful for the scan process…

o   If the time is given (see full syntax here after), the time will appear moving on the plot!

o   Enjoy also the so called "Cubic View" that is not very common, except for KopooS tools. That give not only the 3DD view but also the projection on the 3 faces of a cube. To disable that Cubic View, just check the corresponding box in the options . Note that the textbox let the user to adjust the length ratio of the cube sides
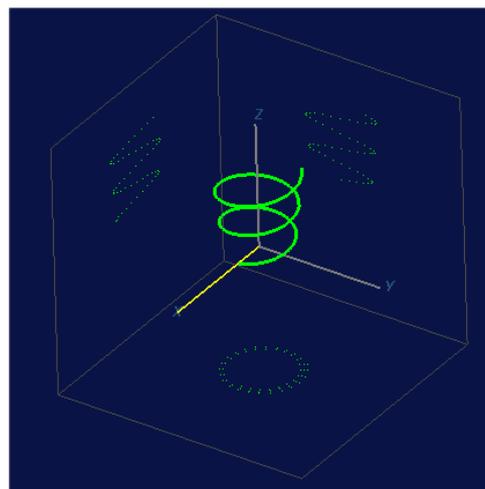
Note : if Excel is not already open, the program sent a message to open it, and if still not open, then a Demo plot is run   or   the previous file plot is run.

The maximum number of lines is more than 1 048 575 (instead of 32 000 for the genuine 2003 2007 Excel plots) (note still need a max of 65 536 lines exactly for TriaXExcelPro with the 2003 Excel; but more up to a million with further releases).

o   Enjoy the bottom toolbar for enabling some fast actions:

Satellite show, Cubic View, Earth/Moon show, Local frame, Option access, Satellite size scrollbar.

*and **Dots** feature showing the dots with Pen Up between dots.*

4. Full syntax of the specification formula

The full syntax of the specification formula for TriaXExcelPro is to put in one single cell:

= 0.01 + LEN("MyTitle **opt** ") + MAX(A2:C200) + MAX(D2:D200)+MAX(E2:F30)

+ MAX(G2:K200) + MAX(L2:M200) + MAX(N2:O200) + MAX(P2:Q200)..

In this example

0.01 is a scaling factor for the values X, Y, Z. .Its major effect is to set the ISO scale mode.

MyTitle is the message comment which will appears on the upper left corner.

*(Note : In this comment string "MyTitle", some optional **directives** can be added for being interpreted by the software, see **chapter 6** below)*

A2:C200 is the range for the cells containing **X, Y, Z**. *units* m *by default*

D2:D200 is the range for the cells containing the **time T** (in days) of the data X, Y, Z. *units* s *by default, starting date 30 December 1899 at 0h0m0s.*

E2:F30 is the range for the cells containing **Time and Events/Colours** with event=1 (or other colours up to 32, see at right) for starting the plot with a Event major colour, event=0 (or other colours up to 32) for continuing the plot with a Nominal minor colour. *It is also accepted a string ending with S for starting the plot with an Event major colour, ending with E for continuing the plot with a Nominal minor colour. Also it is accepted a thrust value or 0 when not thrusting. Also accepted a string with the numbers of each thrusters fired or nothing when all thrusters are off.*
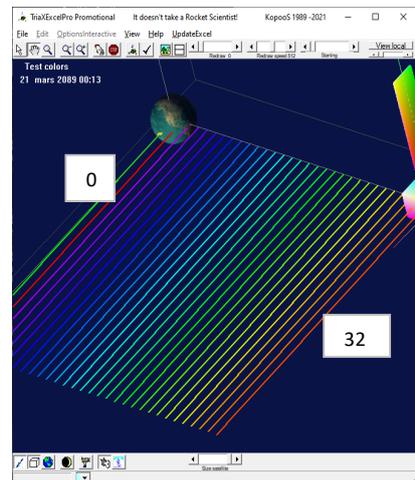
G2:K200 is the range for the cells containing **Time and Quaternions** w,x,y,z. *(Note Quaternions are referenced to some main frame. With a rotation of **theta** around the unit vector **u** having the Cartesian coordinates ux,uy,uz, we have w= cos(theta/2), x=sin(theta/2) ux, y=sin(theta/2) uy, z=sin(theta/2) uz. For some attitude analysis it is useful to use the quaternion of the Satellite body frame wrt the local orbital frame)*

L2:M200 is the range for the cells containing **Time and rotation** in deg of one solar panel.

N2:O200 is the range for the cells containing **Time and rotation** in deg of last solar panel *(or a parameter to be plotted along the Z axis when using the optional directives " **valz** " in the title without additional column).*

P2:Q200 is the optional range with the optional directive " **valz** " in the title for the cells containing the time in P column and a parameter in Q column to be plotted along the z axis with the scale in color and numeric values on Z axis (or on X axis with **valx** etc.)

Note the use of the genuine Excel function names (MAX, LEN or NBCAR) for the keywords allows the full update of the specification formula when the Excel sheet is modified, lines added, columns added, etc. The user can select even its own functions.

The full syntax of the specification formula for TriaXExcelPro with *optional directives* = " penuplabel " is to put in one single cell:

= 0.01 + LEN("MyTitle **penuplabel** ") + MAX(A2:C200) + MAX(D2:D200) + MAX(E2:E200)

A2:C200 is the range for the cells containing **X, Y, Z**. *units* m *by default*

D2:D200 is the range containing a value to be used for the colour (from min to max)

E2:E200 is the range for the cells containing the text **labels for each points**.

4.1. Notes regarding the specification syntax

The **order** of the terms in the formula **must be preserved** even with blank columns between columns.

The specification of the range for the cells containing X, Y, Z can be **simplified** by MAX(A2:C2), or even by MAX(A2): the tool will **automatically** count the number of cells not empty in the first column and will change accordingly the last column number and the row number from C2 to Cnumber.

The specification for the Time column can be **simplified** as MAX(D2), etc.

If the time column is common to some parameters, it can be omitted in the specification of those parameters.

Moreover the 6 or 7 MAX() specification can be simplified by a single one MAX(A2:O200) or MAX(A2:Q200) if the Excelsheet is designed accordingly.

If the cell containing the formula is not selected, **the program will take into account automatically the first cell it found containing a key word MAX**. At least if the check performed is not conclusive, the Demo will be run.

When the title contains the directive "**kmday**", the timescale for the planets rotation and trajectory will be understood as km and days.

Very short simplified specification

When all the data depends on the same time, then the tool allow the following short specification where the time column appears only once, example **"= MAX(A2)+MAX(T2)+MAX(V2)+MAX(E2)"**

This is interpreted as the data X,Y,Z in 3 columns A,B,C, the time in day in column T, the events given by the thrust value in a single column V (with the time being the same as in column T) and the quaternion in 4 columns E,F,G,H (with the time being the same as in column T) .

In such case, the tool will expertise the specification and counts the number non-empty or non blank rows under the "z" cell C2 –for example if the last non-empty cell is in the row 200--, the tool will work with

"= MAX(A2)+MAX(T2)+MAX(V2)+MAX(E2)" according to the equivalent induced specification:

"=   MAX(A2:C200)+   MAX(T2:T200)+   MAX(T2:T200,V2:V200)+   MAX(T2:T200,E2:H200)"

      X, Y, Z (m)   **Time** (s)   Time (s), thrust   Time (s), w,x,y,z

                                        Events   **quaternions**

4.2. Keyboard

When the frame is selected, the user can type on "i" or "I" for using a real ISO view (camera eye placed along the vector (1,1,1) , i.e. an angle of 35° from the axes or a similar view at 45° from each axes

Also the user can type on "t" or "T" for showing the dots or the labels when in "penuplabel " mode.

Also, the user can use the arrows up, down left, right for adjusting by small increments the frame orientation.

Typing on Z allow to fix the Z axis of the plot on the vertical of the screen. Same for X and Y

4.3. Notes regarding the program features

DYNAMICALLY CHANGE THE WORKSHEET DATA TO IMMEDIATELY CHANGE THE TriaXExcelPro PLOT.

The menu bar includes the command "UpdateExcel" that can be clicked in order to see the changes in the worksheet   File   Edit   OptionsInteractive   View   Help   UpdateExcel .
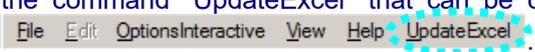
But this can be done also continuously by setting Interactive in the OptionInteractive. Great !

<u>Important</u>: the User shall save all the Excel sheets before using that genius feature. The watchdog used to check the Excel data changes may not work properly on some machine. One can enable or disable this feature using the menu "OptionInteractive". It is recommended to disable the interactivity when we have to perform many modifications in the Excel sheet. Enable the interactivity after the sheet update, or simply "UpdateExcel".

<u>SCALING FACTOR</u> :The plot is performed with an automatic scale on each axis, except if a scaling factor is given.

If the scaling factor is given different from 1 in the formula:

o   An ISO view (ortho-normal frame) is used for the 3DD plot.

o   The earth sphere (ray = 6 378 137*scaling factor) and the moon on its orbit will be shown. The moon ephemerid is coming from S. Bouiges formulae. To show the moon (ray = 1 738 000*scaling factor) instead of the earth, use the directive "moon" in the title.

<u>MANY INDEPENDENT OBJECTS CAN BE DRAWN</u>. The " penup " function is available: when into the X column, a **X data is empty** (i.e. its **cell equal nothing**), the **plot line is interrupted**, like a pen up. The plot starts again with the next cell X not empty

<u>SATELLITE ICON</u>

o   The satellite drawing size and features can be changed in the Options: A checkbox "satellite" allows displaying a satellite in ISO scale mode. The size of the spacecraft can be adjusted with a scroll bar.

o   All the **faces of the boxes have different colours** which is useful when looking at attitude control or when looking at which face of the solar array is pointing to the Sun.

With Thrust (events=1)

Without Thrust (events =0)
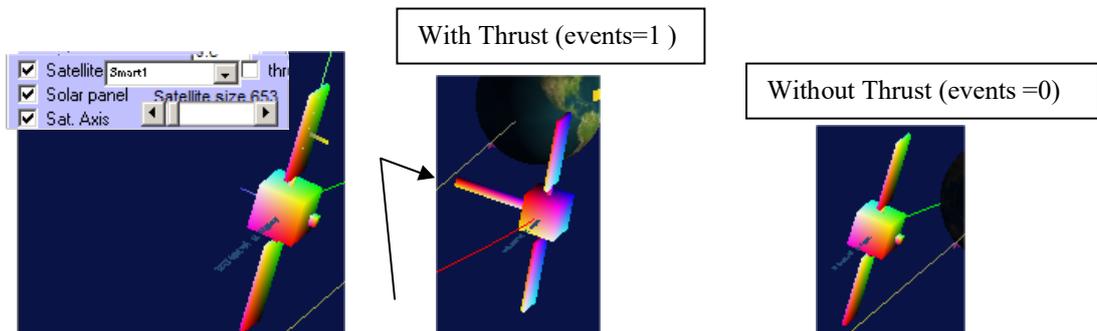
o   If the Quaternion cells specification are given, the tool will orient the spacecraft own axis (generally X along the velocity, Y toward the south and Z toward the Earth) with respect to the fixed Galilean reference axis.

o   Moreover, the solar panel rotation (around the spacecraft Y axis) can be set automatically at best for a maximum Sun illumination.

<u>ICON PALETTE</u>

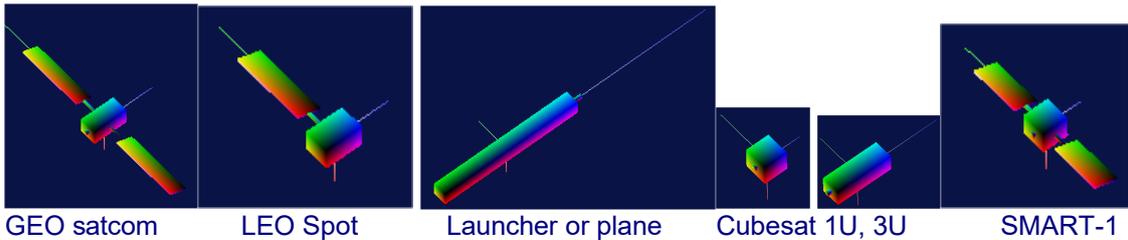Currently, the following sets of 3D images are available

GEO satcom   LEO Spot   Launcher or plane   Cubesat 1U, 3U   SMART-1

Each 3D image includes a dynamic thrust jet for one (or several TBC) thrusters. The jet is for now a simple coloured extended long cylinder.

OTHER OPTIONS
See the Menu File/Options to change many settings as labelled.
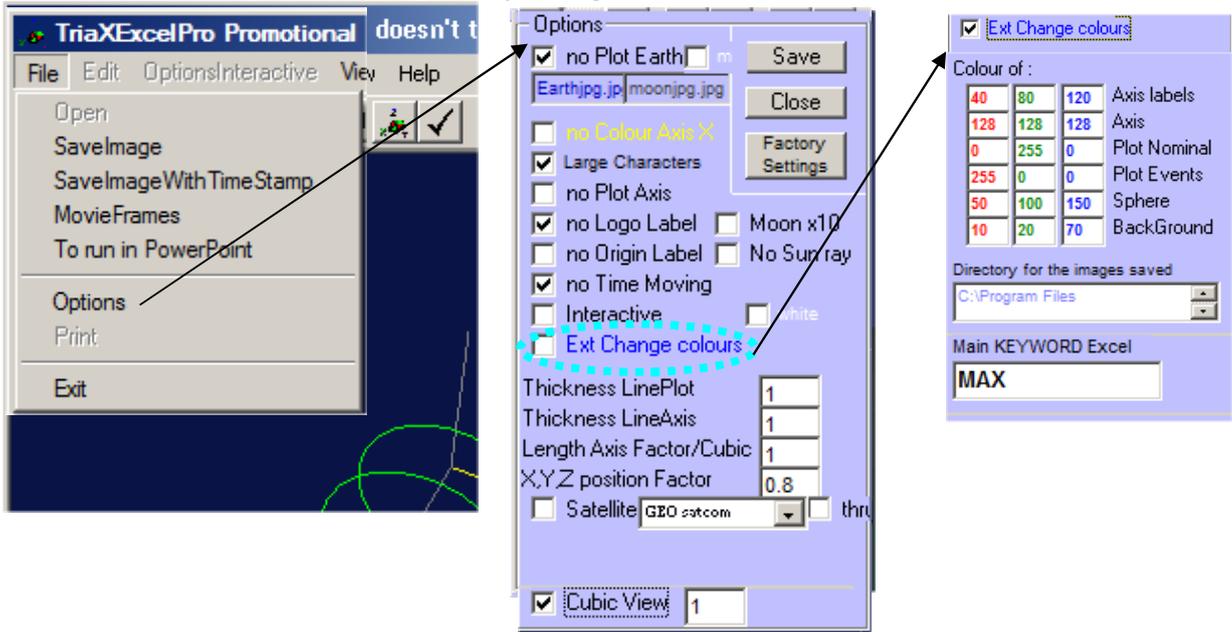
POWERPOINT PRESENTATION: one can use the software in a Powerpoint presentation: See the Menu **File** / **To run in PowerPoint** for creating a specific file and facilitating the needed specification to paste into one of the Powerpoint object.

Note: Each time the programme run, it create (and reset/clear if exist) a file in the programme directory with the name « _TriaXExcelPro.txv ». One can rename that file for traceability or future use in a Powerpoint presentation.

Important Note: the association of all the files having an extension ".txv" is automatically managed by the tool. **Hence the user can simply click on such files ".txv" for running the 3DD tool without Excel, which is much more than a video because it is dynamic.**

To run the Demo : Go to the Help menu, and click on OK of the last menu window.

5. Alternate formulae with the optional directive "penup"

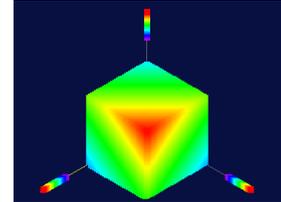**Note: Alternate formulae with the directive " penup " in the title for performing volumic scan processes, etc. The full syntax of the specification formula for TriaXExcelPro penup is to put in one single Excel cell:**

= 0.01 + LEN("MyTitle **penup**") + MAX(A2:C200) + MAX(D2:D200)+MAX(E2:F30) + MAX(G2:K200).

In this example

> 0.01 is a scaling factor for the values X, Y, Z.

> MyTitle   is the comment which will appears on the upper left corner (the directive **penup** will not been shown).

> A2:C200   is the 3 columns range for the cells containing X, Y, Z of the finite elements location. The size of each dot can be specified in the options "Thickness LinePlot", *unit* m *by default*

> D2:D200   is the single column range for the cells containing a value used for the color specification (from min to max).

> E2:F30   is ignored.

> G2:K200   represent the cells containing the data of independent objects to be plotted – actually only the first three columns (G E F) are taken into account-.

One can also use a simplified specification = 0.01 + LEN("MyTitle **penup**") + MAX(A2:C200) where the color specification follows the "z" value

The scan process of the volume uses the redraw scroll bar dynamically.
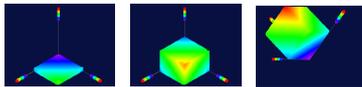
Of course the feature of Cubic View is also available for the **penup** mode:
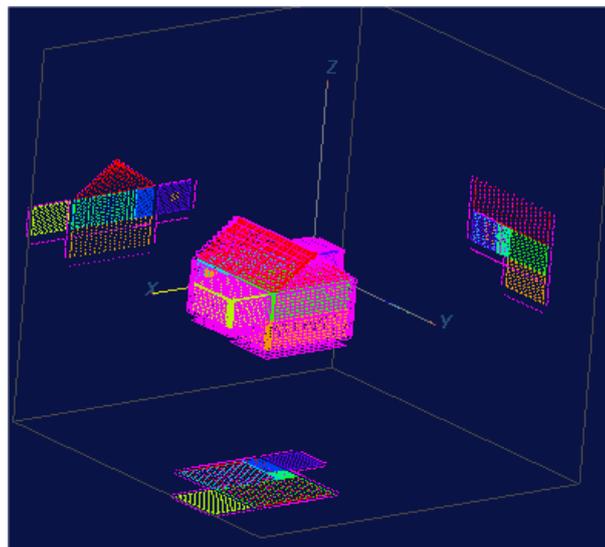
6. List of optional directives for the comment string

In this comment string "MyTitle", some optional **directives** can be added for being interpreted by the software. The list of **directives (always written in lower case)** is:

1. **moon** or **lune**: for drawing an orbit around the Focus moon instead of the earth (also available **earth**, **terre**, **sun**, **soleil**, **mercury**, **venus**, **jupiter**: for all those cases, the 3D image of the focus is provided).

2. **xyzw** : for using the quaternion in the order x,y,z,w instead of w,x,y,z.

3. **valz** : for drawing on the z axis the values of a parameter (also **valx**, **valy**).

4. **penup** : for drawing coloured dots suited for showing a solid volume according to a colour scale and performing a scan process as described in the **chapter 5**.

5. **penuplabel**: for drawing coloured labels instead of dots according to a colour scale.

6. "**kmday**" distance for X,Y,Z in units km instead of the default value (m); time in days instead of the default value (s). Note "**kmdays" or "km days" or "km day"** are accepted.

7. **xyz**   : for using the 3 first columns with the data order X, Y, Z (that is by default).

8. **yzx** : for circular permutation or exchange.

9. **yxz** : for circular permutation or exchange.

10. **xzy** : for circular permutation or exchange.

11. **zyx** : for circular permutation or exchange.

12. **ned   la   lo   h** : for specifying the starting location in the North/East/Down frame with la=refLatdeg lo=refLongdeg h=refH_m and for using the input data N, E, D in place of the Cartesian X,Y,Z.

13. **seconds** (or " **s** " with spaces) : for specifying the time in seconds, default unit.

14. **metres** (or " **m** " with spaces) : for specifying the distance in metre, default unit.

15. **" ms "** (or " **sm** ") with spaces : for specifying the distance in metre and time in seconds, default units.

16. **etc**.

17.

7. Movie feature

In the tool bar , the icon ⊟ allows to record a sequence of pictures: A new window with title "Movie sequence" is then shown: It allows setting eventually the period of time between the frames and the maximum number of ftrames. The Command Buttons "Start Video" shall be clicked in order to start the recording. The Command Buttons "End Video " can be clicked at any time to interrupt the recording and to close that window.

The maximum number of frame is by default 900. The period of time is by default 0.6 sec.

The checkbox "simulation model time" allows to take pictures synchronised with the trajectory. The range of timing is increased.

WARNING: the frame are saved with the format "BMP" which is an uncompressed format, thus each frame may require about 1 Mo. The number of frames saved shall be low enough for reducing the space needed on the hard disk.
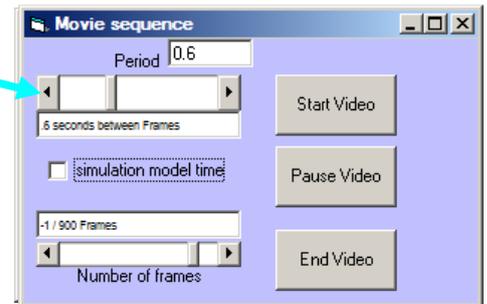
The final movie shall be performed using for example 🖳 Anim.exe from "Jasc Software Inc" that can transform a serie of pictures into an animated GIF or AVI files. The size of such movie can be very well compressed (there are no sounds).

Annex 1: Quaternion format

In this tool, the quaternion are used to set the orientation of the satellite with respect to the reference frame.

The quaternion are usually given by a set of 4 number w,x,y,z defining an axis of rotation with a unit vector "**u**" and an angle around this axis "θ":

w=cos($\theta/2$),

x=**u**$_x$.sin($\theta/2$),

y=**u**$_y$.sin($\theta/2$),

z=**u**$_z$.sin($\theta/2$).

WARNING 1: The quaternion are sometimes called q1, q2, q3, q4 where sometimes q1 play the role of the real component "w" or sometimes q4 plays the role of "w".

Most of the time the quaternion real component's **"w"** is chosen positive. But the tool accepts every unit quaternion (from TriaX release 47).

Unfortunately, there are no means to clear the ambiguity. The only additional relation $\sum_1^4 q_i^2 = 1$ does not provides means to distinguish the right component which contain "cos($\theta/2$)".

WARNING 2: even written as logically w,x,y,z, some quaternion are given with the last one "z" in the role of "cos($\theta/2$)".

Annex 2: How does this tool work?

The 3DD tool TriaXExcelPro doesn't use any *a priori or apparent* links with Excel: it is a totally independent tool**.**
But the design of TriaXExcelPro allows it to use the data from Excel for performing a 3DD plot.

The key of the design of TriaXExcelPro is the use of the internal layers of Windows for:
    Checking the application that are running, in particular Excel
    Selecting the most recent Excel application and searching for the main directive (by default the word MAX)
    For eventually copying the specified data into its own working file.

The interactive process between TriaXExcelPro and Excel is based on the watchdog technique: regularly, **TriaXExcelPro** is checking if the Excelsheet **changes** (the user may change a formula that may change the 3DD plot,….) and in that last case, it can perform a new updated 3DD plot.

Annex 3: Update from previous releases

Release 2.8 0 6m: optional directive **penuplabel** added for plotting coloured labels instead of dots in penup mode. In penup mode, the scale is shown on the three axis. Function with directive "valz" improved by adding a numeric scale on the Z axis (on X axis with valX …). Added keyboard function typing "i" or "I" for ISO orientation or not, and "t" or "T" for switching from dots to labels in **penuplabel** mode. Excel sheet "DemoLogoExcel.xlsx" updated with many examples Copyright updated up to 2022.

Release 2.8 0 6j: Many upgrades with ascending compatibility. Full compatibility with TriaXOrbitaL that launch automatically this visualisation tool at the end of its run, without need of Excel. Color scale enlarged from 0 and 1 up to 32 accepted as values for events (2=purple up to 32=red). Scrollbar added for CubicView range and length of the axes. Moon icon can be used for hiding the Moon. Slight adjustment of the Earth meridian Greenwich using now the Chobotov formulae for the longitude from Gamma vernal point to the Greenwich at midnight (was previously in advance by1h30 for noon now). Other focus than earth are available with their 3D image. Etc.

Release 2.8.0.06h: Several enhancements (add toolbar button for showing only dots, ValZ scale, etc.).

Release 2.8.0.06. Several update including a toolbar for fast actions, Earth texture enhanced, added flexibility (non full compliant specification can be accepted without bugs), User manual updated, file "DemoLogoExcel.xls" updated.

Release 2.8.0.05. Compatibility release for Windows 10. One minor bug solved (regarding zyx permutations)

Release 2.8.0.03. Second important compatibility release for Windows 8. Huge 3DD view can be performed (up t a million of points). By default, the very useful Cubic view is set (see in the option for unclick to disable that feature). Some other very minor features added.

Release 2.8.0.01. enhanced for windows 8 compatibility (including some pauses of few milliseconds for fast computers asynchrone compatibility).

Release 2.5.0.53H. Sun ray enhanced

Release 2.5.0.53D. Important feature added: the Cubic View, showing the 3D dynamic plot and also the 3 projections on the 3 faces of a cube. Many other minor features added (automatic expertise for the planet size show), the demo excel sheet has been updated.

Release 2.5.0.52A. Added automatic association of the files generated by TriaXExcelPro "*.txv" with the tool TriaXExcelPro. Now, just one double-click on that file in explorer and the 3DD live is available.

Release 2.5.0.51D. A very begnin bug has been cleared (only for non-common cases when using short specification). Improvement for the use into powerpoint: option feature added when clicking in the bottom left corner of the plot window (click on the status bar, the mouse over "close" options automatically close the options).

Release 2.5.0.51b : User's Manual updated and features added.
    1) Command "View local" added with smart features for viewing the trajectory from a local frame that can follow the current point or any other. Try it!
    2) Movie tool improved with the capability of taking frames synchronously with the trajectory time (a check box added in the pop-up window appearing when clicking on the movie icon). Try it!
    3) Slight improvement of the 3D images of Launcher and Cubesats

Release 2.5.0.50C to improve the visulisation in PenUp mode : several plots can be performed successively without need to play on the zoom or to restart the tool.

Release 2.5.0.50a that include the possibility for the user to visualize a GEO Satcom, or a LEO Spot or a Launcher or a Cubesat. See File/options in the menu. The setting are as always saved once the user click on Save.

Release 2.5.0.49e including several minor updates : the comments with a simple formula are accepted LEN("message xx" & C3), when pressing x or y or z that axe is kept for further views with the triax icon. As far as possible, only direct frame x,y,z are shown.

Release 2.5.0.49b including several minor updates performed for the satellite visualisation, for the units and for other basic features for scan (size of dots). Added with the directive "column" the feature to plot in PenUp mode with the data organized in one column (as succesively row for x then row for y then row for z etc)

Release 2.5.0.47: User's Manual updated. Update of the default values in seconds and metre for time and distance: this made the tool more compatible with EcosimPro® reports for examples. Previous settings should use the directive "kmday" in the comment string. The tool has been improved for all quaternion including the one with negative real component.

Release 2.5.0.46: User's Manual updated. Update of the movie feature implementation.

Release 2.5.0.43: User's Manual updated. Feature added: Automatic count of non empty cells, simplified specification expertise, keywords added "seconds", " s ", "NED" for North, East, Down frames.

Release 2.5.0.42: User's Manual updated.

Release 2.5.0.32: Feature added: the starting point of the 3D dynamic plot trace can be changed using a new scroll-bar.

Release 2.5.0.28: Issue checked.

Release 2.5.0.20: Minor update :Powerpoint specification bug corrected.

Release 2.5.0.16: Minor update in the interactive feature.

Release 2.5.0.13: A feature allows to write directly the specification like "=MAX(A2:C60) " in a textbox of the TriaXExcelPro window when an excelsheet without any specification has been found. This new feature is usefull when many similar excelsheet shall be viewed in the "three dimensions dynamic -3DD" mode

Release 2.5.0.9: A useful button of the toolbar has been added for taking picture easier than with the menu. Also note that one can Double Click on the toolbar for its customisation.
Features added: the colorization of the plot with respect to an other parameter is now enabled with the optional directive valz...
Satellite when shown can display its own frame axis: the red one for Xsat, the green for Ysat and the blue for Zsat
Automatic rotation of the solar arrays of the satellite when shown is now enabled.

Rel 2.5.7: User manual upgraded after implementation of some features.
Implementation of the automatic rotation of the solar arrays of the satellite for maximizing their illumination by the sun.
Implementation of a variable size satellite feature.

Rel 2.5.6: Implementation of a possibility for an user defined main KEYWORD instead of the default "MAX". Even if it is recommended to use the keyword MAX, the user can specify any other function of Excel or any other key word. The option window (extended when clicking on colour change) allow those changes.
Without consequence bug corrected: for very small Excel sheet (lower than 30 lines of data), the without consequence alarm of divide by zero has been mastered into its progression bar management.

Rel 2.5.1: User manual upgraded.

Rel 2.4.0.8: No bug correction. User feature added for volumes scanning, toolbar upgraded with buttons for changing the ISO view and many others views, some icons changed. Menu item "OptionInteractive" added.

Rel 2.3.0.63: Minor bugs correction: user title and   very simplified specification again fully managed

Rel. 2.3.0.62: Major revision: add the quaternions functions for the attitude plots with respect to the main frame

Rel. <2.3.0.62 Releases Beta.