# DEBRISK software user's manual
# LOS mode

| | NAME and ACRONYM | DATE and SIGNATURE |
|---|---|---|
| Written by | RTECH during the development phase<br><br>GMV during the maintenance phase | Next page |
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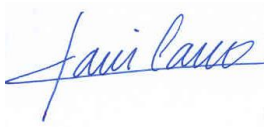
| Written during the maintenance by | Javier Carro (GMV) |  22/05/2023 |
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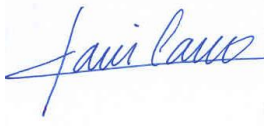
| Approved by | Project Manager<br>Javier Carro (GMV) |  22/05/2023 |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# Distribution list

| NAME | ACRONYM |
|---|---|
| ANNALORO Julien | DTN/TVO/PR |
| BELLUCCI Aurélie | DTN/DV/IFL |
| BERTRAND Régis | DTN/DV/IFL |
| CARPENTIER Benjamin | DTN/STS |
| CARRETIE Laura | DTN/QE/NEO |
| ELJED Olfa | DOA/SME/LOS |
| FARAGO François | DTN/STS/SPC |
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| PRALY Nicolas | DTN/STS/SPC |
| ROSSI Alberto | DTN/TVO/PR |

# SUMMARY OF CHANGES

| Issue | Revision | Date | Purpose of the modification |
|---|---|---|---|
| | | | Original reference: PR-DEBR-MU-110930-0463-RTECH<br>Initial version written by Fabien GUICHARD (RTECH). |
| 1 | 0 | 03/11/2011 | First revision |
| 1 | 1 | 08/11/2011 | Update following remarks from CNES |
| 1 | 2 | 09/11/2011 | Material properties added and conductivity deleted |
| 1 | 3 | 14/12/2011 | Review item discrepancies taken into account |
| 1 | 4 | 15/12/2011 | “Import from DAS” section added |
| 2 | 0 | 20/07/2012 | DEBRISK V2.0 |
| 2 | 1 | 25/07/2012 | Modification following DEBRISK.103 action |
| 2 | 2 | 16/08/2012 | Further information on SIRIUS ephemeris data files and extra expert settings added |
| 2 | 3 | 22/08/2012 | FA 493, 495 and v7 proofreading sheet taken into account |
| 2 | 4 | 10/09/2012 | Modifications for Debrisk v2.05.00 |
| 2 | 5 | 05/12/2012 | CNES remarks made during the meeting on documentation taken into account |
| 2 | 6 | 11/07/2013 | FA 534 and DM 611 and 617 taken into account |

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|---|---|---|---|
| | | | New reference: DBK-MU-LOG-0258-CNES |
| 1 | 0 | 13/01/2014 | DM 685 Default parameter values and document management by CNES taken into account |
| 2 | 0 | 28/02/2014 | Due to the change of contract, this version of the document follows reference document DBK-MU-LOG-0258-CNES version 01.00".<br>DM 686: nomenclature changed from "expert mode" to "scientific mode". |
| 2 | 1 | 25/04/2014 | CNES remarks taken into account (CNES_relecture_MUscientifique_GMV_24032014):<br>MM-3: §7.6.2.3, clarification regarding the box.<br>MM-4: §7.5.1.1, clarification regarding the DAS file.<br>DM-713: §7.6.1.1, §7.4.1 use of the "—userMaterials" option |
| 2 | 2 | 18/11/2014 | FA-727: Use of a UTF-8 compatible editor<br>Additional information on the way to custom the JVM memory. Section 7.10 (FEP-3 FEPS_DEBRISK_pk_man_fa_dd_mm_01_02.xls)<br>Additional terms added in section 3 (project action)<br>DM-752: Modification in the ergonomics of DEBRISK GUI |
| 2 | 3 | 09/12/2014 | Corrections due to FEPS raised by CNES during PKPV |
| 2 | 4 | 24/02/2015 | Added a warning to indicate that all the exported files (Electra, Google Eart, CSV) are done using the UTF-8 encoding.<br><br>Clarification of the use of the quantity attribute of a fragment for the computation of the thermal_mass and the casualty_area. |
| 2 | 5 | 13/04/2015 | Corrections taking into account CNES remarks raised after V02.07.01 delivery (DBK-MU-LOG-0258-GMV_02_04-RemPO)<br><br>FA-810: § 7.5.1.5, § 8.2.1.3, clarifications on the logic followed for defining the colours of "demise altitude" and "impact energy". |

| | | | |
|---|---|---|---|
| 2 | 6 | 07/05/2015 | FA-830: § 6.3, § 7.1, correction of minimum Java Virtual Machine version. |
| 2 | 7 | 12/12/2015 | DM-827 : Prise en compte de la STB du logiciel DEBRISK ed3 rév9 et autres évolutions du logiciel DEBRISK<br>Section 7.2 screenshot update to take into account the updates in the GUI.<br>Section 7.4.1: Addition of the –f flag to generate DML files in batch mode.<br>Section 7.5.1: Added the operation of the new “Import TLE” button (DEBRISK_675).<br>Section 7.5.1, section 8.2.1.3 : Added the new “Global Casualty Area” widget.<br>Section 7.5.1: Added the information about the display of automatically modified objects (DEBRISK_545 and DEBRISK_546). |
| 2 | 8 | 15/04/2016 | DM-833: Modification of section 7.6.2 to explain the computation of dimensions.<br>FA-872: Modification of section 8.2 to describe the modifications in the csv header.<br>DM-846 : Modification of section 5 to remove some resources that are not needed anymore.<br>Creation of section 7.5.1.5 Result Panel to detail the contents of the result panel after the execution. |

| | | | |
|---|---|---|---|
| 2 | 9 | 27/04/2017 | DM-891: Modification of section 7.4.1 to include the new expert parameters to define the satellite ablation, ballast parameters and objet file creation.<br>Modification of section 7.5.1.3 to include the satellite mass decomposition in the information area.<br>Modification of section 7.5.1.3 to include the aerodynamic mass field in the satellite definition dialog and its definition.<br>Modification of section 7.5.1.3 to include the new functionality of accepting the dimensions of an object even if they are incoherent.<br>DM-933: Modification of section 7.5.1.3 to describe the new algorithm of dimension input and to indicate the possible differences in two similar objects defined using different methods.<br>Modification of section 7.5.1.3 and 7.6.2 to indicate the rounding of dimensions with too many significant digits.<br>Modification of section 7.6.2.5 to include the new table with the significant digits per dimension. |
| 2 | 10 | 07/07/2017 | Implementation of CNES document corrections after review of version 2.9.<br>FA-991 update of error messages related to the definition of the fragments. Section 9.4.2 |
| 2 | 11 | 08/12/2017 | Modified the section 7.5.1.3 to include the information about the ballast mass and the aerodynamic mass of the satellite.<br>Added section 7.5.1.4 to describe the new simulation parameters tab.<br>Updated images to show the new simulation parameters section. |
| 2 | 12 | 05/12/2018 | Modification of section 7.5.1.3: addition of statement that the initial aerodynamic mass contains the mass of the solar panels. Change of screenshot to display the updated ones (with according correction of label for total mass with solar panels). Update of the screenshot of the right numerical values displayed in the edition of the spacecraft.<br>Name of the frame displayed in IHM: modification of section 7.5.1.2, modification of the overall screenshots.<br>Modification of section 8.2: addition of quantity, initial Ccond, final Ccond parameters in CSV file. Update list of parameters in TecPlot. |

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| 2 | 13 | 15/02/2019 | Modification of section 5 to include the complex shapes and the interpolator files (DM-1046).<br>Modification of section 6.2 to include the new versions of Windows.<br>Modification of section 7.5.1.3 to include de new complex shapes geometric parameters (DM-1048).<br>Modification of section 7.5.1.4 to include the information about the parameter's visibility depending of the other parameters value, and update of the parameters panels to include the new parameters (DM-1046).<br>Added section 7.6.2.5 and 7.6.2.6 to include the definition of the complex shapes and their constraints (DM-1046).<br>Modification of section 7.15 to include the errors related to the complex shapes (DM-1046).<br>Modification of section 8.2 to include the information about the modifications of the output files (DM-1046, DM-1056, DM-1069). |
| 2 | 14 | 29/11/2019 | DM-1082: Modified section 7.5.1.7 to update the graphic plots.<br>DM-1085: Modified the section 9.2 to modify the parameter ReferenceArea in ReferenceAeroAera and to add the new parameters ReferenceThermalArea and Qcond.<br>DM-1098: Modified the sections 6.3 and 7.1 to indicate that Java 1.8 is the minimum version to use for the virtual machine. |
| 2 | 15 | 20/01/2021 | DM 1101 : Added section 7.7 "Heat flow" to explain that the absorbed radiation flux is null.<br><br>Section 7.7 transformed into "Survivability parameter". The section "Normal shutdown" becomes section 7.8<br><br>DM-1427: Figures 19 (Adding a root object window), 49 (Box tumbling) and 50 (Flat plate tumbling) updated so only the accurate rotation arrows are displayed.<br><br>DM-1446 : Modified section 7.5.1.5 to add the fact that :<br>- there is one Materials tab per simulation (so the Materials tab are independent),<br>- there are some materials defined by default in the material tab, that are displayed in pur"le, named ""xx DEBRISK", and that cannot be modified,<br>- there are two buttons in"this tab ("sav" mate"ials" and "loa" materials").<br>Screenshot fig36 changed to show the list of purple materials.<br>Modified section 7.6.1.2 to add the default materials are displayed in pur"le, named ""xx DEBRISK" and cannot be modified. |

| | | | |
|---|---|---|---|
| | | | Modified section 7.6.1.3 to add the fact that the existing“materials ""xx DEBRISK" can be duplicated, but the copy cannot be reg“stered as ""xx DEBRISK", and the oxidation properties are not be duplicated.<br><br>DM-1462 : section 7.5.1.3 modified to add spheres as possible satellite shapes.<br><br>DM-1463 : section 9.2 modified to add the fact that the name, creation date, version and mode are written at the beginning of the csv and Tecplot files.<br><br>DM-1465 : section 7.4.1 modified to delete the ELECTRA file from the list of files that can be Generated.<br>section 7.5.1.1 modified to remove any mention of the ELEcTRA file.<br>section 8.5.4 modified to remove the ElectraFileException<br>section 9.1 modified to remove the reference to the creation of an ELEcTRA file.<br>section 9.2 modified to remove any reference to the ELEcTRA file.<br>section 9.3.1 modified to remove any reference to the ELECTRA file. This section no longer is centered on the creation of an ELECTRA file, but on the creation of a simulation, and on the exportation of the result files.<br><br>DM-1460 : section 7.6.2.5.2 modified to change the condition on h.<br><br>Added section 7.8 to include the oxidation flow equations. |
| 2 | 16 | 26/11/2021 | DM-1474: Updated object images in section 7.7 “Shape of objects”.<br><br>DM-1485: Addition of section 7.7.1.5 to describe the new hemispherical cylinder.<br><br>DM-1559: Removed section 7.7.1.7 containing the significant digits for object dimensions. |
| 2 | 17 | 11/02/2022 | Modified section 7.6.1.1 to remove the paragraph about the default location of the userMaterials file that is not applicable to the LOS mode.<br><br>Modified section 7.5.1.1 to update the description of the cross section area result and the associated screenshot.<br><br>Modified section 7.5.1.6 to improve the description of the save action.<br><br>Added section 9.5 with the 3D view configuration description. |

| | | | |
|---|---|---|---|
| 2 | 18 | 02/11/2022 | DM-1626: Added section 7.5.1.5.1 to explain the loading of a material list in the IHM.<br><br>DM-1627: Modified section 7.5.1.1 do add the new “Save As…” menu.<br><br>DM-1646: Modified section 10.2 to add the new “azimuth” column to the Tecplot file definition.<br><br>DM-1659: Modified section 10.2 to remove the “spacecraftMass” column from the Tecplot file definition. |
| 2 | 19 | 22/05/2023 | DM-1652:<br>Modification of the fragmentation validity range.<br>Update of screenshots to reflect the change of the IHM look & feel.<br>Modification of section 7.5.1.1 to include the Help menu description.<br>Modification of section 7.5.1.2 to remove the fragmentation altitude.<br>Modification of section 7.5.1.4 to include the update of simulation parameters section.<br><br>DM-1670:<br>Modification of sections 7.5.1.2, 7.5.1.3 and 7.6.1.3 to include the information<br>about the warning message for incoherences in the input values.<br><br>DM-1689:<br>Modification of section 7.4.1 to include the generation of the Cb/Mach file.<br><br>DM-1692:<br>Modification of section 7.5.1.6 to include the definition of the weighted casualty area.<br><br>DM-1693:<br>Addition of section 7.5.1.8 to describe the message area.<br><br>DM-1695:<br>Modification of section 9.5.3 to indicate how to deactivate the 3D view manually.<br><br>Global update of screenshots. |

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# 1 Introduction

This document is a manual whose purpose is to give an exhaustive introduction to the functions available to the DEBRISK user performing simulations of the ablation of debris from a spacecraft after it has been destroyed upon re-entry into the atmosphere.

DEBRISK has been created by RTECH under a development contract for CNES. It is now in maintenance phase by GMV, under contract for CNES.

# 2 Applicable and reference documents

## *2.1 Applicable documents*

| ID | Document | Reference | Issue | Date |
|---|---|---|---|---|
| AD1 | Technical Requirement Specifications | DBK-CT-SPEC-009-CNES | 5.4 | TBD |

## *2.2 Reference documents*

| ID | Document | Reference | Issue | Date |
|---|---|---|---|---|
| | | | | |

# 3 Terms, definitions and abbreviations

| Terms | Definition |
|---|---|
| Spacecraft | A spacecraft is the parent object of all other user-defined objects. It comprises a (cylindrical, spherical or parallelepiped) main body, and one or more solar panels if it is needed. When re-entering the atmosphere at the end of its life, the spacecraft first loses its solar panels, and then splits into one or more fragments at a given altitude. |
| Child | A child is a fragment within another object. By definition, a fragment is a child, either of another fragment, or of the spacecraft. An object may have several children. Children are released into the atmosphere where the parent ceases to exist. |
| Thermal mass | The thermal mass is the mass of an object, not including the mass of its children, if any. |
| Object | An object may be a spacecraft or a fragment. |
| Fragment | A fragment is a part of the spacecraft, as defined by its shape, its dimensions and its material. A fragment only exists after fragmentation of the spacecraft. |
| Aerodynamic mass | The aerodynamic mass is the mass of an object, including the mass of all generations of children, if any. |
| Downrange (IHM, .dat file) | Length of the projection of object's trajectory on the Earth's surface (from the re-entry point of the space craft) |
| Local downrange (dat file) | Downrange computed from the moment the child is born. |
| Downrange shortest | Minimum distance between the initial point of the SC trajectory's projection on the Earth's surface and the impact point. |

# 4 Conventions

## 4.1 Symbols

A red triangle indicates an important remark.

## 4.2 Stylistic conventions

Stylistic conventions are used to highlight elements in the DEBRISK program.

- *Button* « Button » “Button” references to software buttons are between quotation marks, French quotation marks or in italics.
- Important words are underlined.
- `Command lines` are written using the Courier font.

## 4.3 Initial conditions of simulation models

- An object is considered destroyed when its kinetic energy is below 14 J.
- The object temperature at birth, i.e. the initial simulation temperature, is 300 K for all objects.
- The atmosphere model used is the US 76 model.
- A central force model is used as the gravity model.

## 4.4 Purpose of the software

In 2008, the French Parliament voted the Space Operations Act (Loi sur les Opérations Spatiales, LOS), whose purpose is to set up a national system for authorisation and control of space operations under French jurisdiction. This law was followed by decrees and technical regulations which require that satellites should be subjected to a hazards study including an analysis of survivability on re-entry. This analysis can be carried out for uncontrolled or controlled re-entry at end of life, and also for special launch failure conditions.

CNES has been appointed by the State to certify the hazards studies. CNES must therefore acquire the means necessary for this certification. These means are put at the disposal of manufacturers and operators in the space sector bound by the LOS and are used for certification in all cases.

The DEBRISK software is part of these means and has been developed by CNES since 2009. The development of the DEBRISK tool is due to the necessity for CNES to have independent and justified calculation models, and to put at the disposal of the engineers in charge of the risk calculations or of their verification a qualified tool based on validated models, whose source code is fully mastered by CNES.
DEBRISK is intended to be the CNES tool used to conduct the analyses of the survivability of fragments originating in spacecraft on re-entry into the atmosphere.

The DEBRISK software is a tool for analysis of the ablation of debris from a spacecraft after its destruction on re-entry into the atmosphere. It is based on an object-oriented approach, in which the space object is represented by a set of interconnected basic and complex geometries. A structure of the parent-child type is used to define the relations between these different objects. Each object is defined by its shape, its dimensions, its mass and its material.

The user provides the initial kinematic conditions of the entry of the space object, and the software calculates the trajectory of the fragments and the possible ablation along this trajectory. The software gives a list of surviving objects and their characteristics on landing.

DEBRISK allows the creation of one spacecraft at a time, but of as many child fragments as required.

DEBRISK first calculates the trajectory and the kinematic conditions of the vehicle as a whole between the starting altitude specified by the user and the fragmentation altitude (between 100m and 200 km), considering a loss of solar power plant at 95 km. It then calculates the trajectory (between the fragmentation altitude and the ground) and the possible ablation of the fragments from the spacecraft. These fragments are defined by the user and can be matched as parent/child. Finally, DEBRISK calculates the casualty area of the surviving fragments.

To do this, the code solves the fundamental mechanics equation along the descent trajectory. Aerodynamic forces are estimated, for each flight domain, for each object. The heat fluxes encountered by the object for each flight domain are calculated, along with the increase in the temperature of the object. When the temperature of the object has reached the melt temperature, the object is ablated, and the changes in its dimensions and mass are taken into account when calculating the trajectory. The purpose of the DEBRISK tool is to calculate the surviving fragments of a spacecraft during its re-entry into the Earth's atmosphere. It makes it possible to provide this list of fragments to the ELECTRA tool and to calculate the associated casualty area.

The main functions of the DEBRISK software are:

- the calculation of the aerodynamic coefficients of the object,
- the calculation of the trajectory of an object in free fall towards the Earth,
- the calculation of the aerothermodynamic fluxes,
- the calculation of the temperature of the object,
- the calculation of the ablation of the object.

# 5 External view of the software

The following folders and files (between brackets) created by the DEBRISK installer are required for DEBRISK to operate:

- 3DModels: Containing the 3D models used for GoogleEarth.
- Database
- Images: Containing the images used by the software-
- Orekit-data: Containing the DE-406-ephemerides
- XSD files for the verification of the XML file structure.
- PDF files containing the user manuals.

# 6 Operational environment

## 6.1 General

The DEBRISK software requires the minimal software and hardware configuration described below.

## 6.2 Hardware configuration

It must be possible to execute the DEBRISK software on stations with:

- A monitor with minimum resolution of 1280x1024.
- A graphics card with minimum resolution of 1280x1024.
- An amount of RAM of 2 gigabytes minimum (see note below).
- 100 megabyte of disk space minimum.

Note: After a simulation including dozens of objects, it is recommended not to move on to a 2nd simulation without first closing the tab of the 1st simulation, so as not to take up too much memory, with consequences for the execution time.

## 6.3 Software configuration

The stations can be equipped with the following operating systems:

- Windows 7, 8, 10
- Linux REDHAT (Red Hat Enterprise Linux Desktop)
- Linux SUSE (OpenSUSE)

The operation of DEBRISK requires the installation of a JAVA virtual machine version 1.8 minimum.

The DEBRISK outputs are compatible with:

- Tecplot version 8 and later,
- Microsoft Excel 97 and later,
- Google Earth 5.0 and later,
- ELECTRA V4.3 and later.

In addition, Debrisk requires a recent PDF reader (e.g. Adobe Reader available on http://get.adobe.com/fr/reader/) in order to read this manual when using the DEBRISK "help" function (accessible by pressing "F1").

Please, note that the exported files by DEBRISK will be encoded following the UTF-8 format. See 10.3 for more information on this topic

# 7 Operating Manual

## 7.1 Configuration and initialisation

The DEBRISK installer comes in the form of a wizard proposing a limited and intuitive number of options.

The installer specifies whether the Java version installed is incompatible (1.8 minimum). However, if Java is not installed at all, the installer does not start. Moreover, if the version installed is too old, the following message is displayed (found on JAVA version 1.4):

In this case, install Java version 1.8 and restart the installer.

## 7.2 Installation of DEBRISK

The installation is carried out by opening the autoexec installation archive. An installation wizard is opened and proposes to modify the default installation directory. DEBRISK will then be created at the location specified by the user, with an executable ".jar" file inside and all the files necessary to launch DEBRISK.

All these files must remain in this installation directory, as they are used by the software to perform the simulations.

The default directory for the input/output files is the "<installation_directory>/DEBRISK/Database" directory.

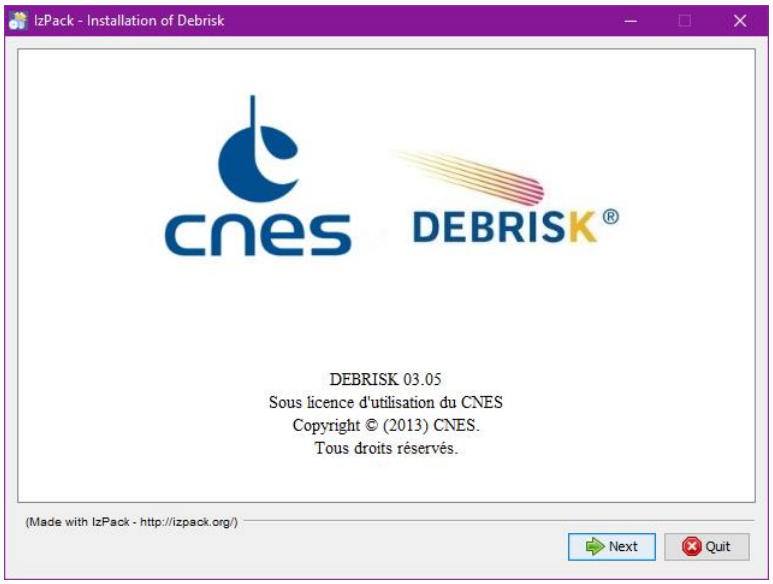



**Figure 1 Opening the wizard.**

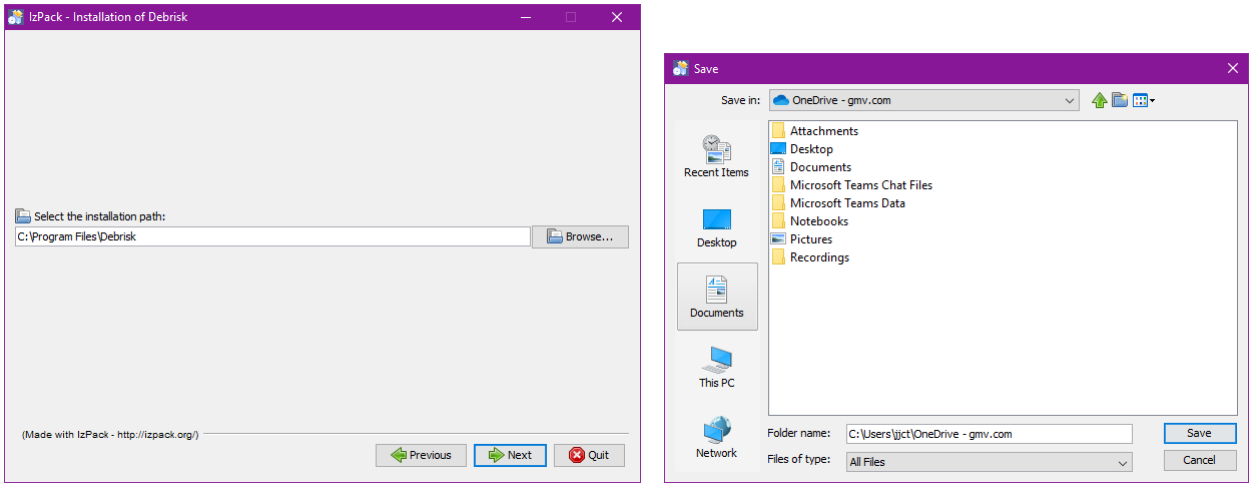



**Figure 2 Selecting the installation directory.**

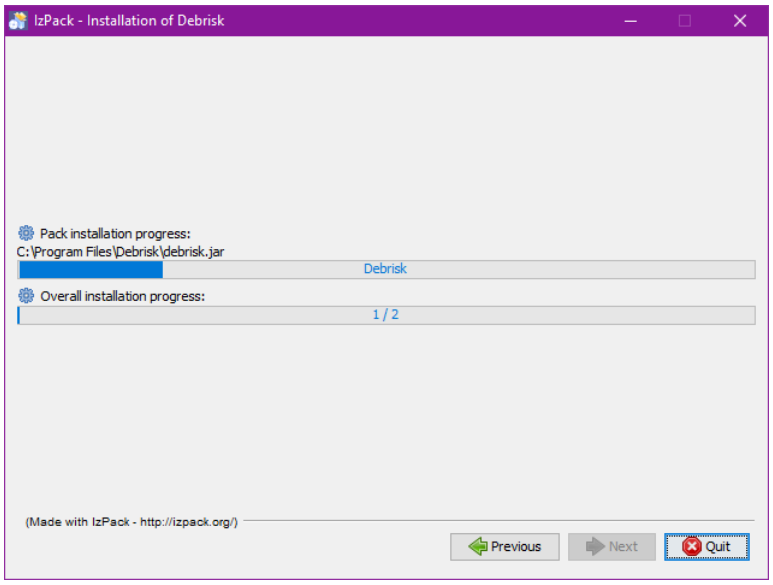



**Figure 3 Installation in progress**

You can choose to create a shortcut on the desktop:

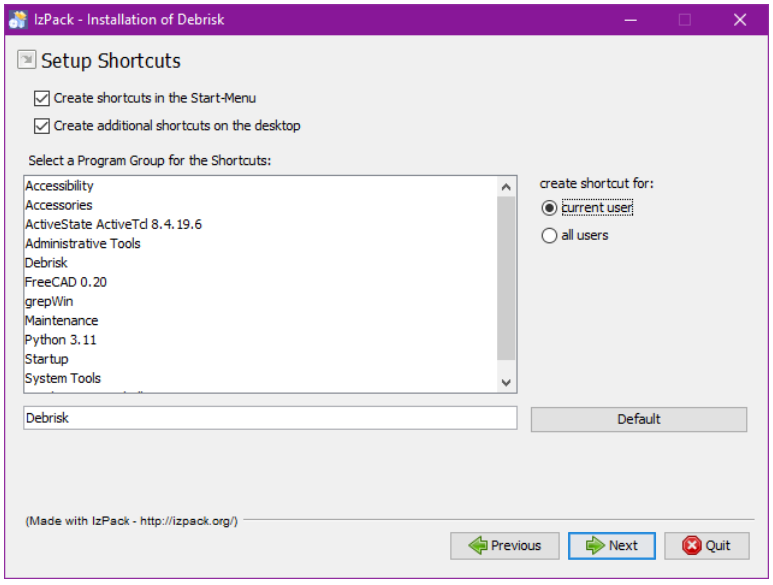



**Figure 4 Selecting a shortcut if required.**

The “Default” button is used to reset the default value of the group of shortcuts (i.e. “Debrisk”), if this had been modified by mistake.

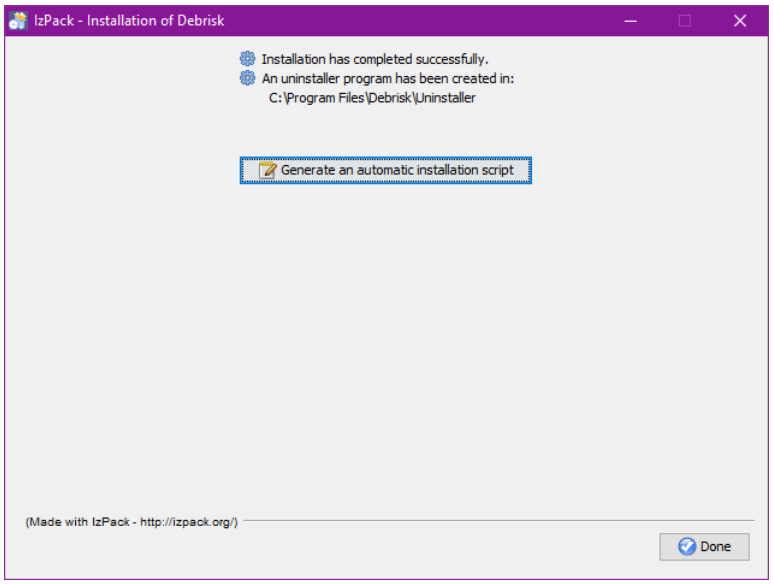



**Figure 5 End of the installation**

The “Generate an automatic installation script” button is used to generate a script to be used for an identical installation (useful in case of deployment in a “standard” environment).

When clicking on this button, the installer proposes to save a file which can then be copied from station to station to reproduce the same installation. The installation can then be launched as follows in command line:

« java -jar name_of_Debrisk_installer path_of_script ».

The installation then takes place in silent mode with the same user settings as for the installation which generated this script.

## *7.3 Uninstallation*

To uninstall DEBRISK, execute the “DEBRISK_INSTALL/Uninstaller/uninstaller.jar” file, where “DEBRISK_INSTALL” is the DEBRISK installation file.

The following window is displayed:

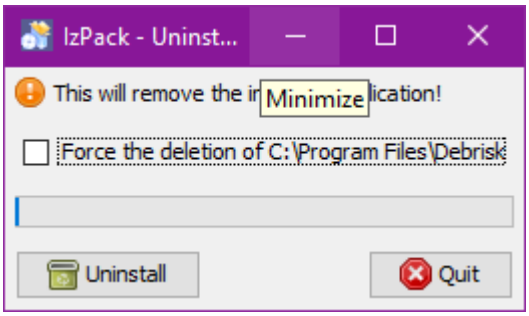



**Figure 6 Uninstallation window**

The “Force the deletion of …” option is used for the complete deletion of the Debrisk file (including the saved simulations and exports, the user material file or any other file which might be stored there).

Clicking on the “Uninstall” button launches the uninstallation. Click on “Quit” to close the window.

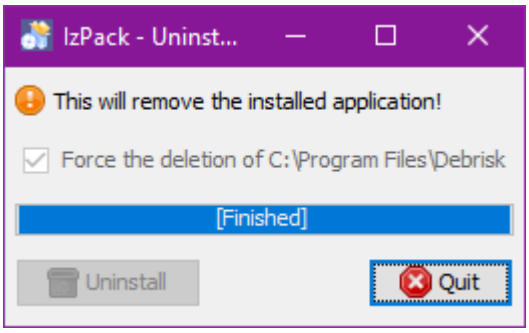



**Figure 7 Uninstallation completed**

## *7.4 Mode selection and control*

The DEBRISK software can be used in different modes:

- Standard mode: graphic interface (see chapter 7.5)
- Console mode

### 7.4.1 The console mode

The Debrisk software can be launched using a command line. Execution takes place in batch.

The syntax of the command line is as follows:

java -jar debrisk.jar --input xml_input_file_path --output no_extension_output_files_generic_path [-params] [--debug]

`params` is a combination of one or more value(s) among:

`-r` : creation of a CSV report

`-t` : creation of a TECPLOT file

`-k` : creation of a KML file

`-x` : creation of an XML file, if the *Create Cb vs Mach file* option is selected the "CbMach" CSV file will be generated with in the same location.

-f : creation of DML file (Flat XML)

For example, the line below:

"java -jar debrisk.jar --input /home/xxx/Debrisk/Database/case001.xml --output /home/xxx/Debrisk/Output/test1 -rtkx"

reads and loads the /home/xxx/Debrisk/Database/case001.xml file and creates the following files:

/home/xxx/Debrisk/Output/test1.csv

/home/xxx/Debrisk/Output/test1.dat

/home/xxx/Debrisk/Output/test1.kml

/home/xxx/Debrisk/Output/test1.xml

/home/xxx/Debrisk/Output/CbMach_test1.xml

"-rtkx" here is equivalent to "-r -t -k -x"

The extra "--debug" optional parameter is used to display more information in the logs (see §7.4.2).

The extra "--installDir <DIR>" optional parameter is used to specify the installation directory (<DIR> must here be replaced by the full path of the installation directory selected). By default, it is in the same location as the executable program.

The extra "--userMaterials <FILE>" optional parameter is used to specify the path of the material file (<FILE> must here be replaced by the path of the material file selected) to be used instead of the materials properties defined in the configuration file.

The "--help" command displays the notice of the command line syntaxes mentioned above.

### 7.4.2 The IHM mode

Apart from the desktop icon, the Debrisk software can be launched in IHM mode using a command line from the installation directory. The syntax of the command line is as follows:

java -jar debrisk.jar [--installDir <DIR>] [--userMaterials <FILE>] [--debug]

The "--installDir <DIR>" is an optional parameter used to specify the installation directory (<DIR> must here be replaced by the full path of the installation directory selected). By default, it is in the same location as the executable program.

The "--userMaterials <FILE>" is an optional parameter used to specify the path of the material file (<FILE> must here be replaced by the path of the material file selected) to be used instead of the materials properties defined in the configuration file.

The "--debug" is an optional parameter used to display more information in the logs (see §7.4.3).

### 7.4.3 Log management

All error messages sent by the application to the user (exception, confirmation, warning, information, etc.) are archived in the form of logs in a "Debrisk.log" file in text format located in the DEBRISK execution directory.

In addition to the normal "user" display, logs of the "DEBUG" type are recorded to save the information generated during the calculation (important variable values, location of the process in progress in the code, etc.). To display these extra logs, the "–debug" parameter must be specified when launching the application (see §7.4.1).

## *7.5 Normal operation*

### 7.5.1 Graphic interface

In this section, you will learn how to use DEBRISK. When opening the software, the home page should be similar to what you can see below.

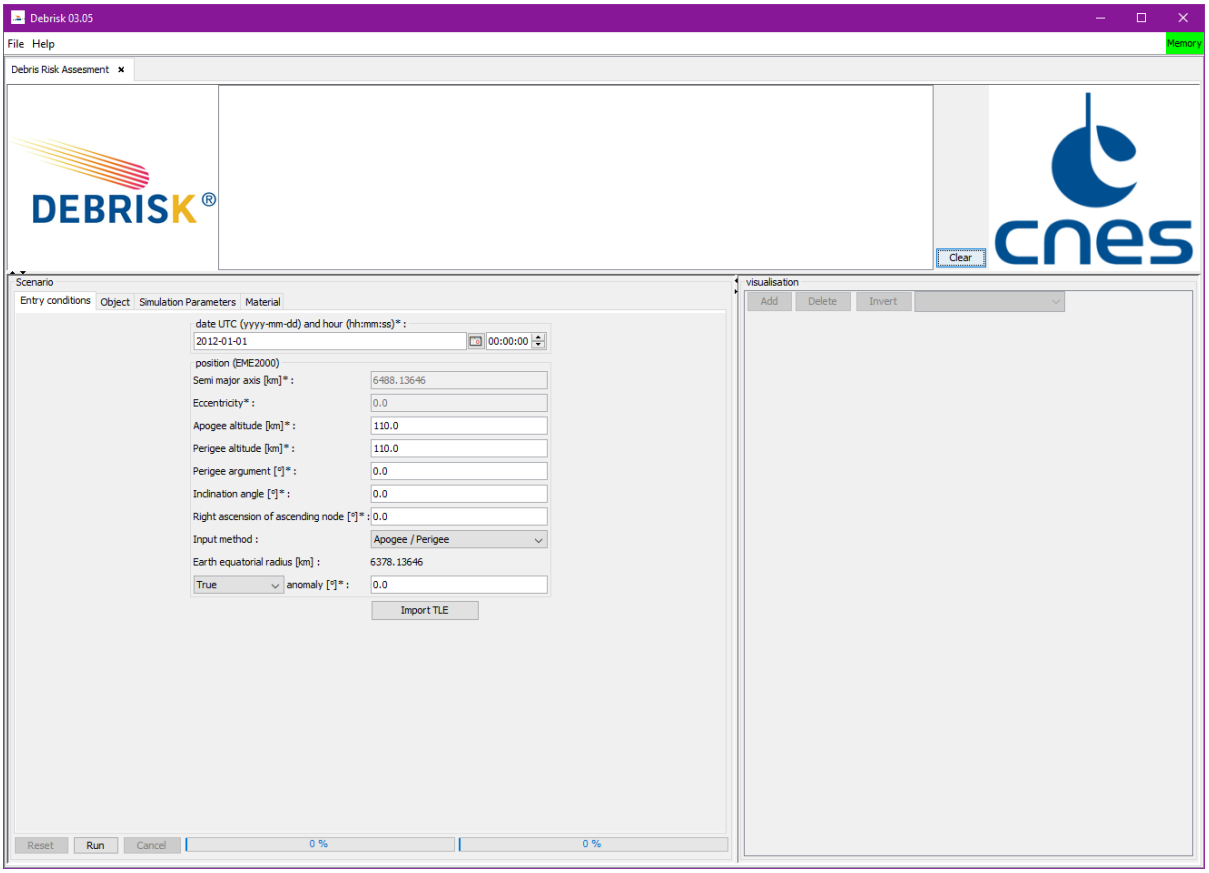



**Figure 8 Home page**

At this stage, it is possible to distinguish between the two main parts of the software, namely:

- the message area on the top,
- the scenario on the left,
- the view of the results on the right.

There is also a main menu accessible in the top left-hand corner.

#### 7.5.1.1 Menu

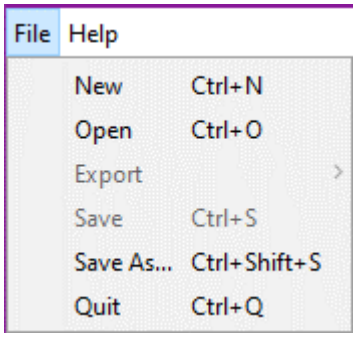



**Figure 9 Menu**

The following functions can be accessed from the *File* menu:

"New": creates a new tab in which you can create or open a new case to be studied.

"Open": is used to open a previously saved study case.

"Export": is used to export files to other software packages (Tecplot, Google Earth, CSV).

The *Tecplot*, *Google Earth* and *CSV* files will be encoded following the UTF-8 format. Hence, in order to be able to read it properly, you must use a text editor compatible with UTF-8 (such as notepad++, for instance).

If we want to import the file in Excel or any other program, you must indicate during this process that the file is encoded in UTF-8 format.

"Save": is used to save the case being studied by including the list of objects, the initial conditions, the simulation parameters, and the material properties. The case will be saved to the location from where it was loaded or saved last. In the case of new cases this menu is disabled until the case is saved for the first time.

"Save As…" equivalent to the menu "Save" but ask systematically for the file location to save.

"Quit": is used to close the software.

The following functions can be accessed from the *File* menu:

"Show Help: Opens the Debrisk user manual.

"Show Handbook/Methodology": Opens the Debrisk methodology guide.

"About": Shows the dialog containing the program information.

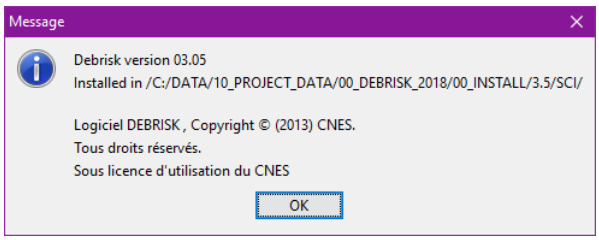



**Figure 10: About dialog.**

#### 7.5.1.2 Scenario area

Entry conditions:

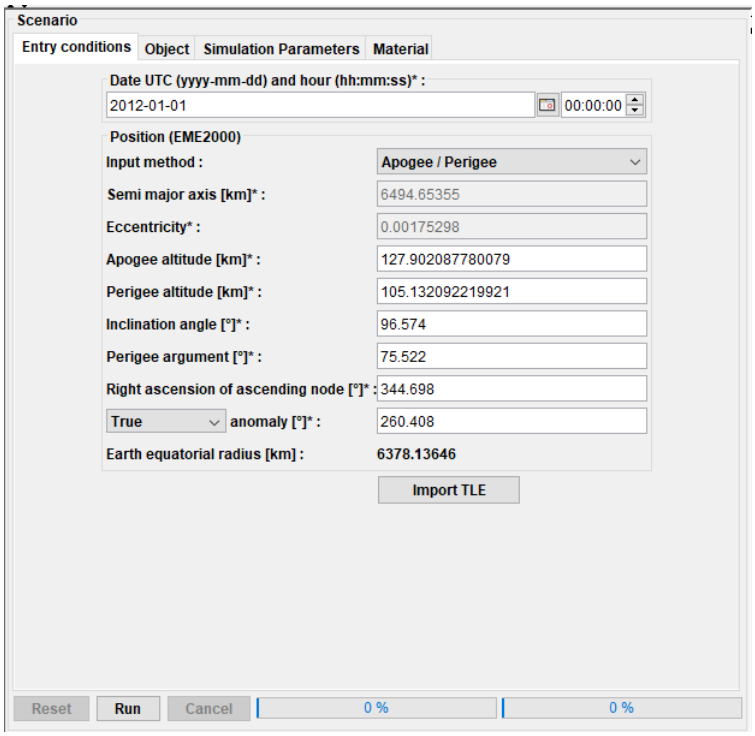



**Figure 11 Scenario area**

You will find various tabs in this area. The first one, named “Entry conditions”, must be filled in with the general parameters of the initial point corresponding to the kinematic conditions of the spacecraft to be studied. The parameters to be entered are the parameters of the Keplerian orbit of the object:

- The date and time in format YYYY-MM-DD and HH:MM:SS
- Selection of the entry parameters (Apogee/Perigee or semi-major axis/Eccentricity)
- Semi-major axis in km (according to the selection made above)
- Eccentricity (according to the selection made above)
- apogee altitude in km (according to the selection made above)
- perigee altitude in km (according to the selection made above)
- perigee argument in degrees

- inclination angle in degrees
- right ascension of ascending node in degrees
- anomaly (true, mean or eccentric) in degrees.

Remark: the frame in which the initial orbit is defined is displayed next to the label “position”.

It should be noted that when the semi-major axis and the eccentricity are entered, DEBRISK automatically calculates the apogee and perigee altitudes and vice-versa. It is therefore necessary to enter only one of these two sets. The Earth equatorial radius is given for information and is only used for this reverse calculation (apogee and perigee to semi-major axis and eccentricity).

The date entered is limited by the ephemeris data files available in the orekit-data/DE-406-ephemerides/ folder in the DEBRISK installation folder. Each file contains data for 300 years from the date mentioned in the file name (e.g. unxp1800.406 contains the data for the years 1800 to 2100). DEBRISK is therefore installed with the data for the years 1800 to 3000. If the date entered is outside this bracket, a message informs the user that simulation is not possible, and prompts him to download the data files containing the years for which he wants to conduct a simulation. These files are available on ftp://ssd.jpl.nasa.gov/pub/eph/planets/SunOS/de406/.

The values of the entry conditions will be verified for coherence, if the values are not coherent a message containing the incoherences is displayed at the bottom of the panel:

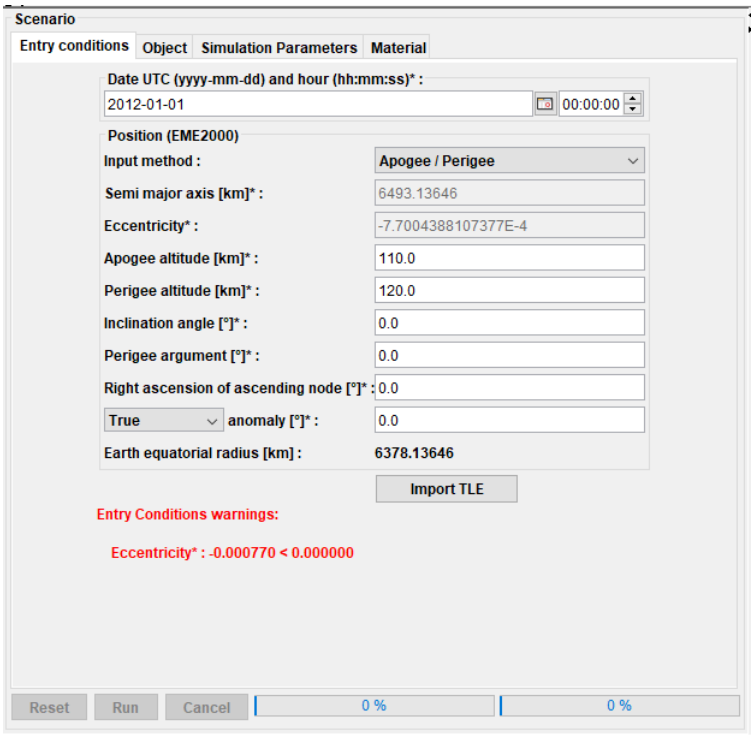



**Figure 12 message containing the incoherences.**

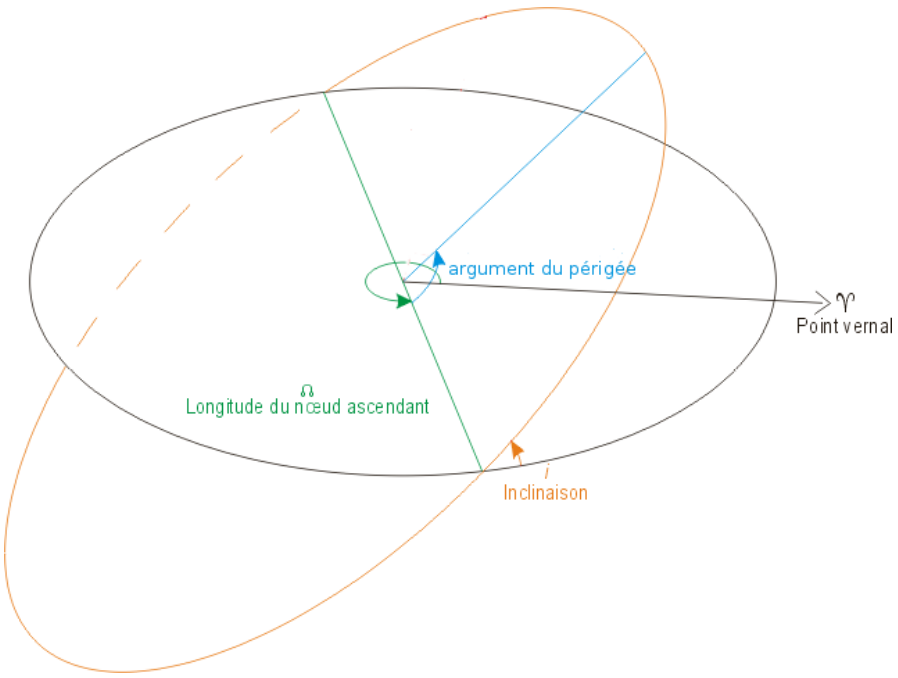


**Figure 13 Orbit definition**

| FR | EN |
|---|---|
| Argument du périgée | Argument of perigee |
| Point vernal | Vernal point |
| Longitude du nœud ascendant | Right Ascension of ascending node |
| Inclinaison | Inclination |

The *entry conditions* can be computed from a TLE, using *the Import TLE* button.

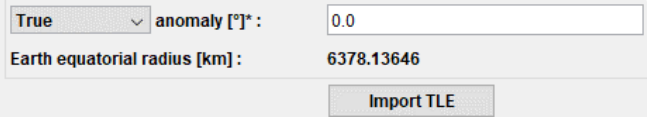



**Figure 14: TLE Import button**

When clicking in the Import TLE button a dialog will open to allow to insert the two lines elements of the corresponding orbit, the entry conditions will automatically be computed from this TLE.

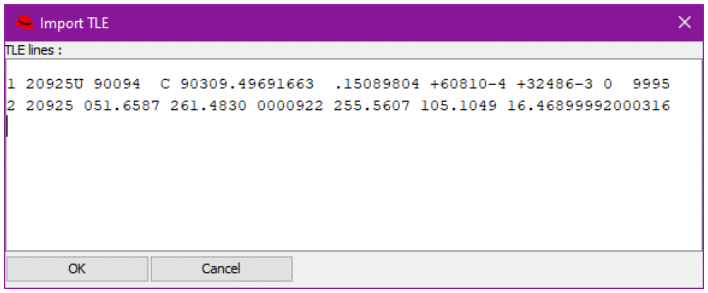



**Figure 15: Import TLE dialog**

The tle lines inserted in the Import TLE dialog shall respect the format of the two lines elements as described in https://celestrak.com/columns/v04n03/

In the lower part of the scenario area are three buttons: “Reset”, “Run” and “Cancel”. When all the objects have been created or imported, you can use the “Run” button to launch the simulation. You will then see the two progress bars move to 100%. The first progress bar shows the overall progress of the simulation, including all objects. The second progress bar shows the stage reached by the object currently being simulated.

The “Cancel” button can stop the simulation in progress.

Once the simulation has been completed, you must click on the "Reset" button before launching a new simulation or if input object data is to be modified. The "Reset" button resets the parameters to their initial value. The activation of these three buttons works according to the following logic:

- "Cancel" button is only active when the computation is running.
- "Reset" button is only active when results have been computed (and "Run" is not active).
- "Run" button is only active if we are:
  - Not computing
  - Results are not available (we have done "Reset" after having run)
  - The object table is not empty.
  - There are no errors in the object table.
  - We are not editing any object in the table (directly, if we are using a dialogue as it is modal, buttons state is not updated).

#### 7.5.1.3 Objects tab

The object tab allows you to add new objects using the *Add* button, to edit some objects already created using the *Edit* button, to duplicate objects using the *Duplicate* button, to delete them using the *Delete* button and to change from input to output display –and vice versa- after having run a configuration using the *Swap* button.

When clicking on "Duplicate", the whole group of children, grandchildren,… of the selected object will also be duplicated.

The activation of these buttons works according to the following logic:

- "Add" button follows the same logic than the "Run" button.
- "Delete" button is active whenever the "Run" button is enabled and at least one row is selected in the object table.
- "Duplicate"/"Edit" buttons are active when the "Run" button is enabled and if **one** row is selected in the object table.
- "Swap" button is only active when results of a computation are available i.e. whenever the "Reset" button is enabled

In the left part, you can see a tree representing the overall structure of the case you are about to simulate. The indentation of the elements in this tree shows the parent-child links existing between the different objects. This tree offers the user the possibility to drag and drop any object into another one: the latter will automatically become the parent of the selected object and the table will be properly updated with the new information. From a practical point of view, the user is not allowed to move an object downwards along the same branch since it does not add any physical meaning to the problem.

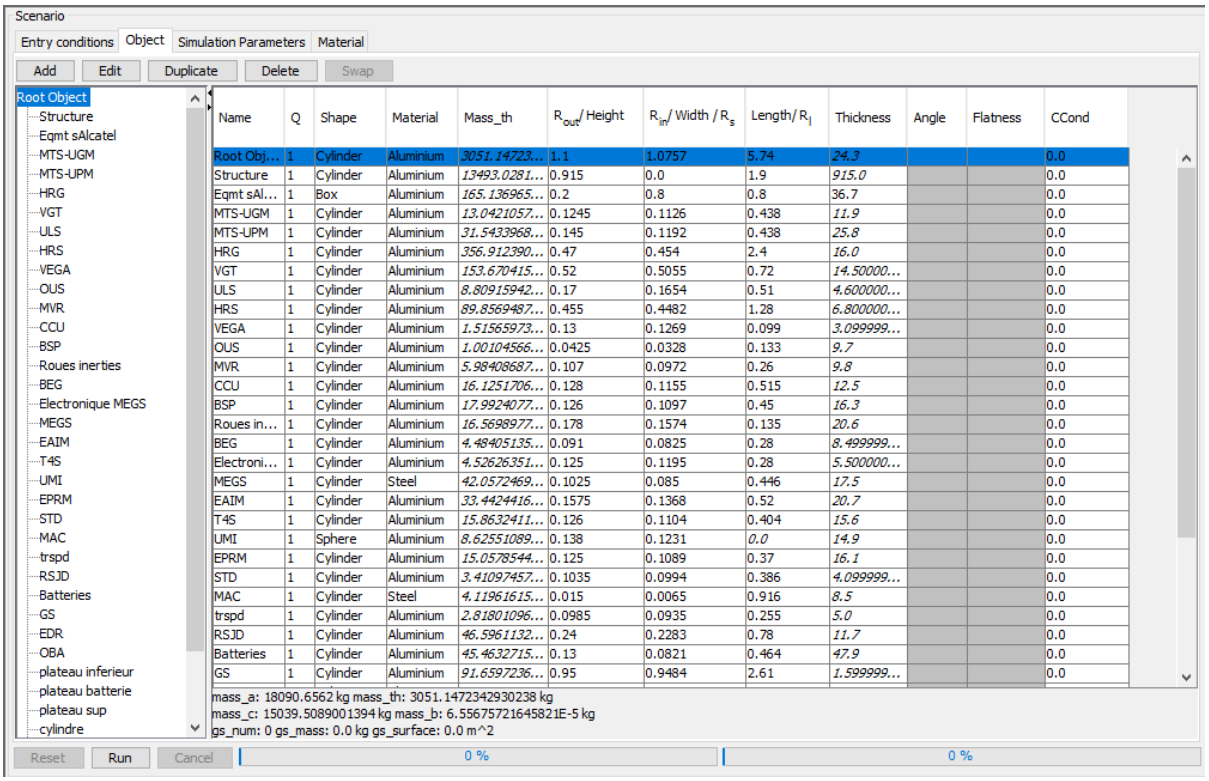



**Figure 16 Object tab**

Below the objects table, before the simulation, the satellite mass decomposition is displayed:

- mass_a: aerodynamic mass of the satellite (kg)
- mass_b: ballast mass (kg)
- mass_c: mass of the satellite children (kg)
- mass_th: thermal mass of the satellite (kg)
- gs_num: number of solar generators.
- gs_mass: total mass of the solar generators.
- gs_surface: total surface of the solar generators.

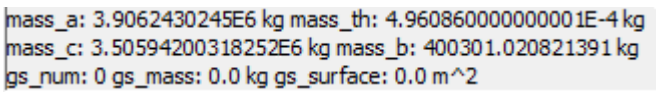



**Figure 17: Total casualty area after a simulation reset.**

If the ballast mass is negative, it will be displayed in red.

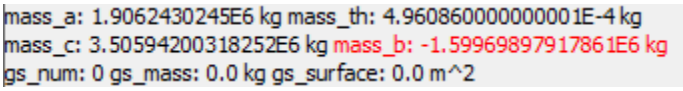



**Figure 18: Negative ballast mass.**

After the simulation, the total casualty area (corresponding to the addition of the casualty area of all the fragments) ) and the total weighted casualty area will be displayed below the objects table:

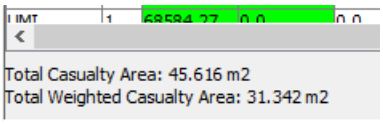



**Figure 19: Total casualty area value after an execution.**

If a configuration file without satellite aerodynamic mass (i.e. from a previous version) is opened, the satellite aerodynamic mass is computed by adding the satellite thermal mass and the mass of solar panels. This case will generally lead to a negative ballast mass.

## Creation of objects

Please note that the first object in the list is always a spacecraft, while the others are always fragments. The spacecraft can only be modelled by a box, a cylinder or a sphere, and solar panels can be added.

To add an object, select a parent object in the tree or the table and click on the *Add* button. A new window is displayed:

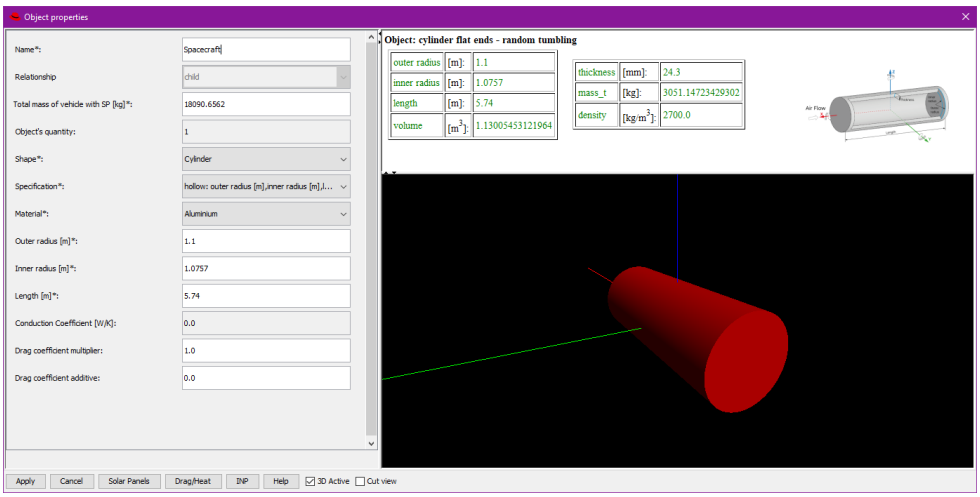



**Figure 20 Adding a root object window.**

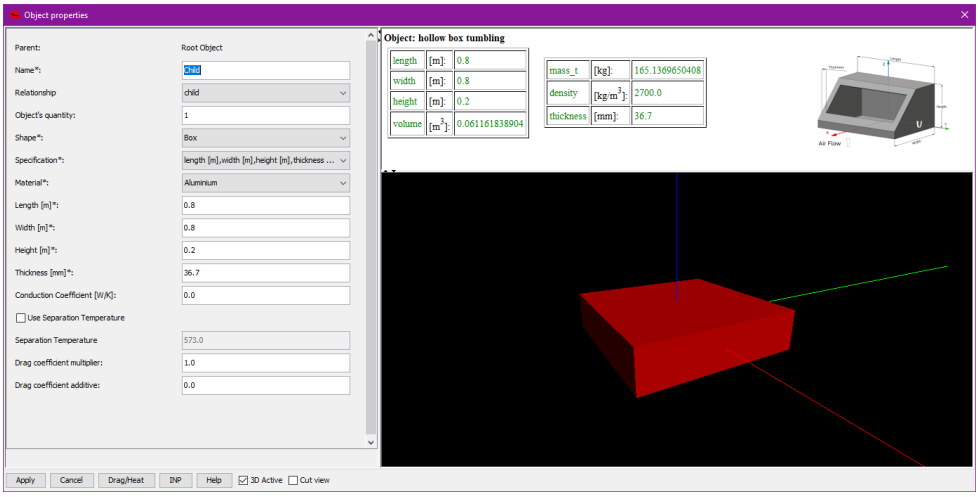



**Figure 21 Adding an object window.**

In this window, you are asked to enter the following elements:

- Parent: contains the name of the object parent of the one being created (for the spacecraft this field is not displayed).

- Name: allowing to insert the name of the object.

The name of the object cannot contain the character "#", using this character makes the object invalid.

- Relationship: menu to indicate if we are creating a "component" or a standard "child", for more details see "creation of components" paragraph below.

- Object's quantity: this parameter is used when the operator wants to define several fragments with the exact same characteristics. Even if Q>1, a single simulation will be run for the fragment.
  This value will only be used to compute the aerodynamic mass of an object having children with Q/=1 and for the casualty area (which will be computed as the casualty area of the simulated fragment multiplied by Q).

- Shape: selection of the shape of the object.

- Specification: selection of the mode to enter the dimensions of the object according to the data at your disposal. All the other data will be calculated by DEBRISK so that they correspond to the data provided by the user.

- Material: the material of the object to be selected in the list.

- Dimensions to be complemented according to the mode selected beforehand. If mass is one of the required dimensions, the thermal mass of the object is expected. The other dimensions are derived from the first ones and all the dimensions are displayed in the table on the right of the "Object properties" window.

- For the satellite only, the aerodynamic mass corresponding to:

$$aerodynamic_mass = thermal_mass + ballast_mass + children_mass + solar_generators_mass$$

The *ballast_mass* is then calculated automatically by DEBRISK as:

*ballast_mass = aerodynamic_mass – (therma_mass + children_mass + solar_generators_mass)*

*The ballast_mass is displayed below the object table.*

*For other objects, the aerodynamic mass is not displayed but is computed by Debrisk taking into account the quantity of unborn children of the fragment to be simulated. This value is computed recursively:*

*Aerodynamic_mass = thermal_mass_of fragment + ∑ (child_mass * child_quantity * (child_child_mass * child_child_quantity ...))*

- Conduction coefficient: This coefficient represents the thermal conductance between an object and its parent object. It only applies to objects which are in contact. It can be defined for any object except the root object (satellite). The definition of the conduction coefficient can be done following a Linear or a Polynomial model.

In the Linear case, the first number in each pair is the temperature, and the second corresponds to the value of the conductance coefficient. In this mode, a straight line is drawn between each pair of values.

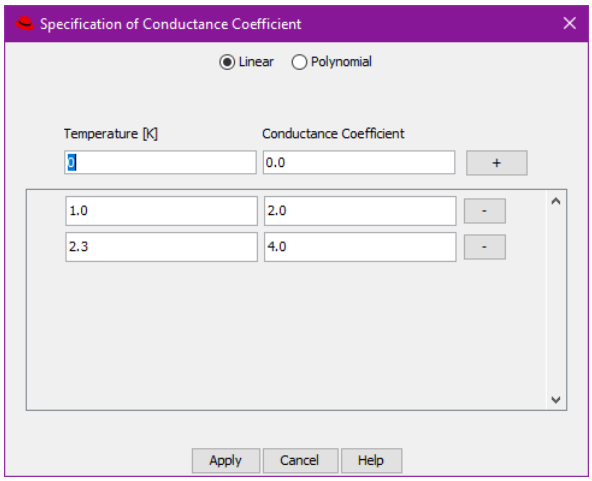



**Figure 22 : Linear model for conductance**

If you prefer to use the polynomial form, you must specify the degree of the polynomial and provide the coefficients. If you enter only one coefficient, this means that the parameter is constant over the whole temperature range.

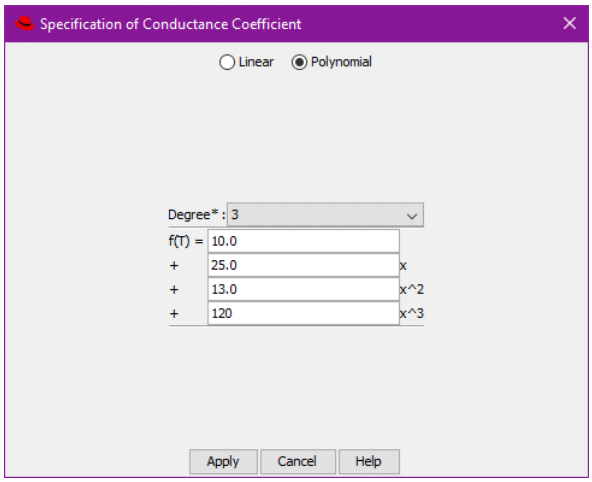



**Figure 23 : Polynomial model for conductance**

If no value is entered, the conductance coefficient value is the default value: 0.

Solar panels can be added on the root object (satellite) using the “solar panels” button, which is only displayed on the window for this object.

- Separation temperature

The user can choose to specify a temperature beyond which the object will automatically be considered fully ablated. To do so, the user can check the “use separation temperature” box and specify the separation temperature.

When an object has the "separation temperature" criterion activated, then all its children of type component who also have "separation temperature" criterion activated must have a higher separation temperature than their parent. Otherwise, they will be considered invalid and displayed in red.

You can then specify the number of solar panels, the mass and the unit surface of the panels.

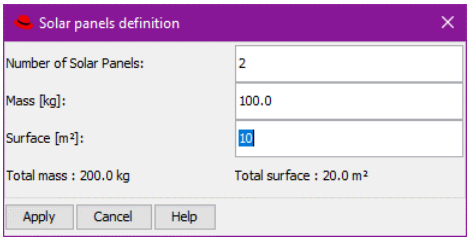



**Figure 24 Adding solar panels**

Finally, click on Apply to create the object or on Cancel to cancel the creation.

The values of the object will be verified for coherence, if the values are not coherent a message containing the incoherences is displayed at the bottom of the dialog and if the user applies a confirmation dialog will be displayed:

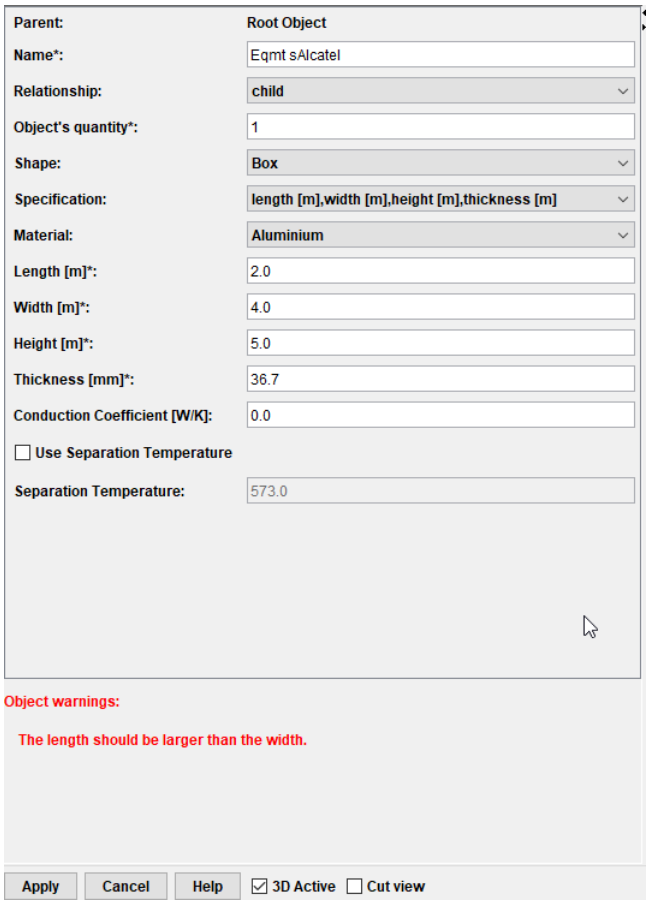



**Figure 25 Incoherence dimensions dialog**

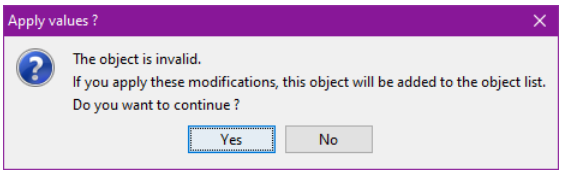



**Figure 26: confirmation dialog**

In this case the user has the option to continue the edition of the object or accept the incoherence, in the latter case the object line will be displayed in red in the object table.

| Name | Q | Shape | Material | Mass_t | Rout/ Height | Rin/ Width | Length | Thickness | CCond | xCd | +Cd |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spacecraft | 1 | Cylinder | Aluminium | -65904.0794 | 1.1 | 1.5 | 5.74 | -400.0 | 0.0 | 1.0 | 0.0 |
| Structure | 1 | Cylinder | Aluminium | 13493.0281 | 0.915 | 0.0 | 1.9 | 915.0 | 0.0 | 1.0 | 0.0 |

**Figure 27 Display of an incoherent object**

When you click on an object in the tree, the corresponding object in the table will be selected, and vice versa.

## Creation of components

A component is a type of object that has the following characteristics:

- A component cannot have children.
- The mass of a component is not taken into account in the aerodynamic mass of the parent.
- A component does not participate to the conduction heat fluxes.
- The spacecraft cannot be a component.
- When the parent disappears, the component will only be born if the parent's disappearance is due to the fact that it reached its separation temperature. Otherwise (in case of ablation, for instance), the component will not be born.
- When a component is born, its temperature equals its parent's separation temperature.

A component can be created by selecting "component" in the "Relationship" menu in the object properties window.

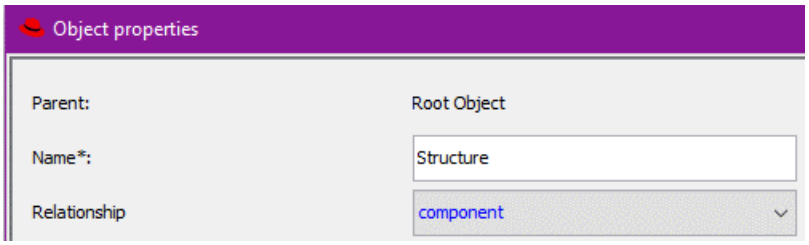



**Figure 28: Relationship menu**

When created, a component appears in blue in the objects tree on the left side of the objects table if a separation temperature has been defined for its parent. Otherwise, it is displayed in grey and will never be born.

If a component has descendants, they can only be of component type, otherwise the component will be displayed in red and considered invalid.

The spacecraft object cannot be of component type, otherwise it will be displayed in red and considered invalid.

**The objects table**

When you click on an object in the tree, the corresponding object in the table will be selected, and vice versa.

In the table you will find the following information:

- Name: object name, only used to track objects during data post-processing.
- Quantity of fragments: This parameter is used when the operator wants to define several fragments with the exact same characteristics. Even if Q>1, a single simulation will be run for the fragment. This value will only be used to compute the aerodynamic mass of an object having children with Q/=1 and for the casualty area (which will be computed as the casualty area of the simulated fragment multiplied by Q)
- Shape: shows the geometry selected to represent this object. This can be a sphere, a box, a cylinder, etc. All the geometries and associated parameters are presented later in this manual.
- Material: shows the material used for the object
- Mass_th: shows the mass of the object itself, without taking the mass of the children into account. This mass therefore corresponds to the thermal mass in the software, as it is the mass used in thermal equations.
- Rout/Height, Rin/Width/Rs Length/Rl and Thickness, Angle, Flatness: dimensions of the object. The dimension presented in the column depends on the type of object considered. If you run the mouse over the column header, you can view the dimension presented according to the shape. The Angle and Flatness columns apply only to complex shapes, for simple shapes they will be greyed out.
- CCond: Conduction coefficient that will be applied to the computation of the conduction flux.

In this table, double-clicking on one of the cells allows you to edit the corresponding data of the object, unless you double-click on the “name” column, in which case you can only edit the object name. Note that Shape cells cannot be edited in the objects tab.

Only the dimensions of the object corresponding to their definition method will be editable. The other dimensions are derived from the first ones are read only and displayed in italics.
The Angle and Flatness columns apply only to complex shapes, for simple shapes they will be greyed out.

For example, if a sphere is specified using inner and outer radius, the mass and thickness cells will be read only and displayed in italics.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| T4S | 1 | Cylinder | Aluminium | *15.8632411042505* | 0.126 | 0.1104 | 0.404 | *15.6* | | | 0.0 |
| UMI | 1 | Sphere | Aluminium | *8.6255108985673* | 0.138 | 0.1231 | *0.0* | *14.9* | | | 0.0 |
| EPRM | 1 | Cylinder | Aluminium | *15.0578544225061* | 0.125 | 0.1089 | 0.37 | *16.1* | | | 0.0 |

**Figure 29 Display of read only dimensions**

If you run your mouse above a line in the table, you will see information on the object as in Figure 30. This information includes in particular the physical parameters used to create the object. If one of the values is in red, this means that the value of this parameter is not consistent with the other chosen values.

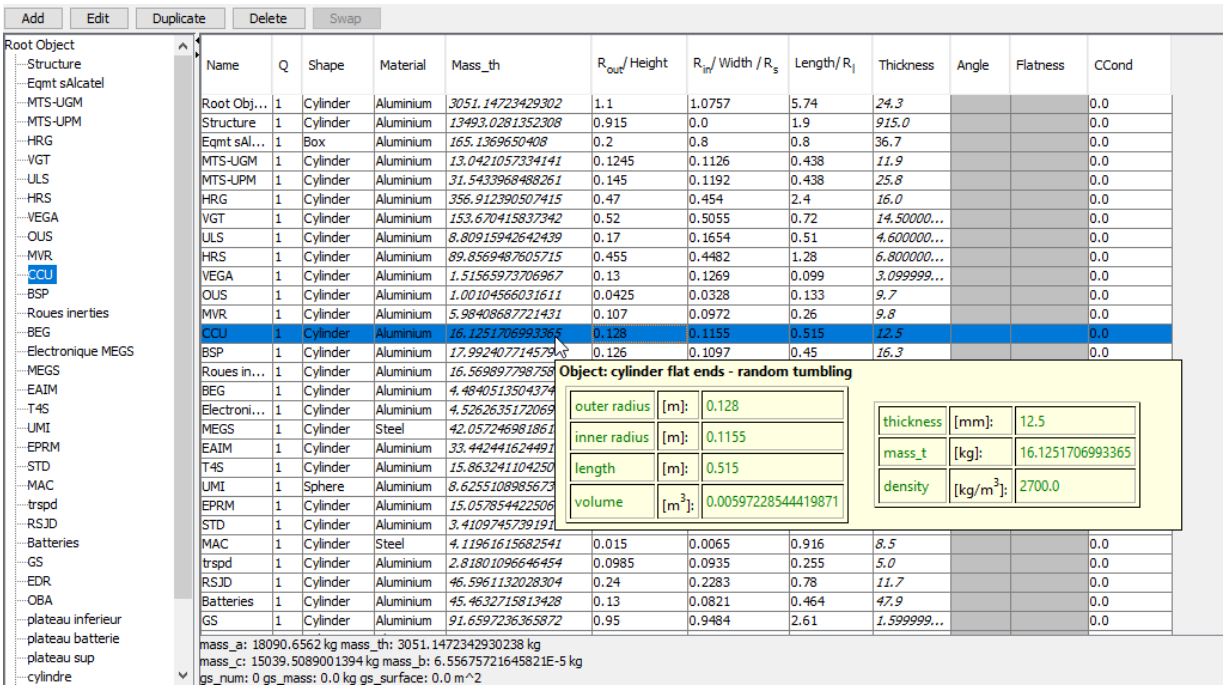



**Figure 30 Information table**

## Edition of objects

If you click on the “Edit” button, a new window will display as in Figure 31.

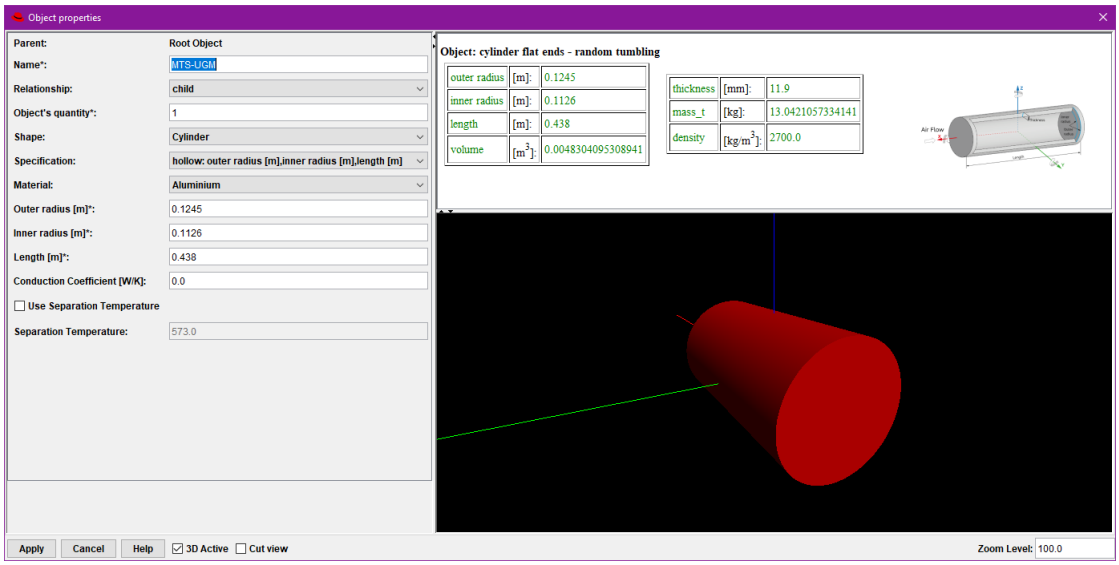



**Figure 31 Object edit interface.**

This window is identical to the one used to create an object. In this particular case, it is pre-filled with the data for the object selected. You will find in it the parameters visible in the previous table.

In the upper part of the window (Figure 31) you can see an image representing the shape of the object selected and its attitude. In the right part, you will find a table summarising the parameters used for the creation of the object. If one of the parameters is not consistent with the others, it will be in red.

You must click on the “Apply” button for the changes made to be taken into account.

The user can also change the values of the characteristics of each object directly by double-click on the cell of the object table to be modified. Once the operator clicks outside the selected cell, the validity checks are triggered and if the definition of the object is no longer coherent, it is displayed in red (and the “Run” button is disabled), as shown below:

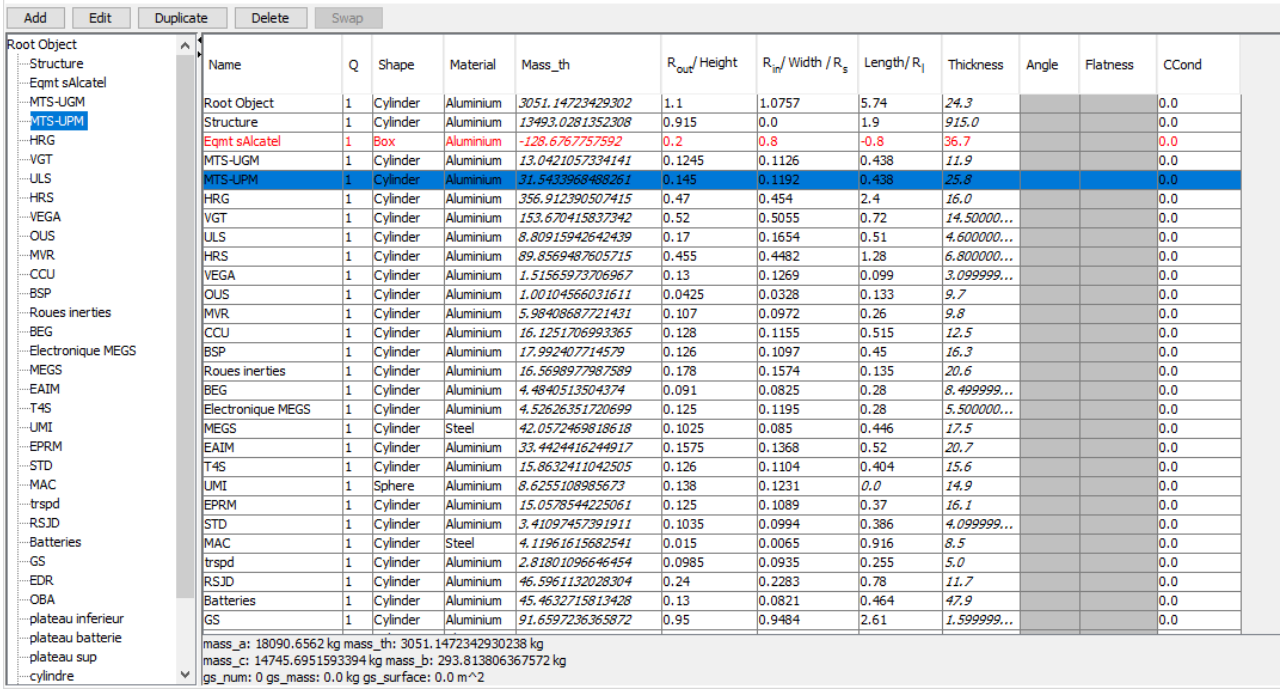



**Figure 32 Editing an object directly in the table**

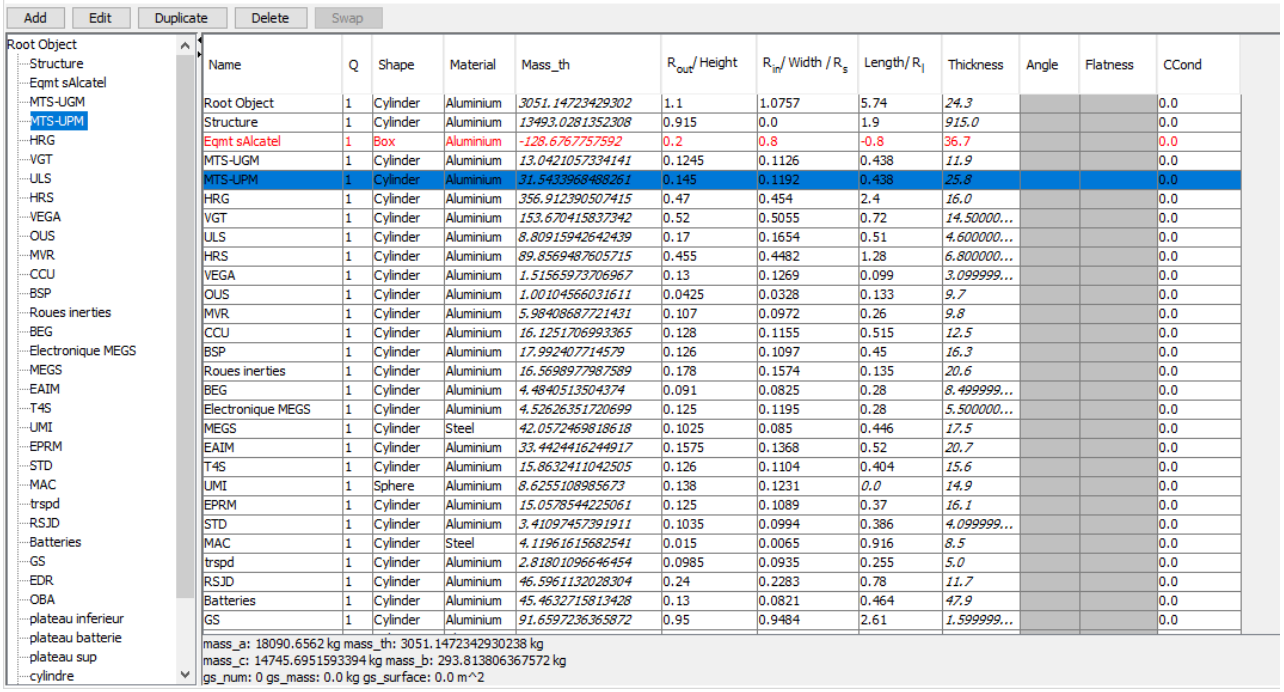



**Figure 33 Wrong value while editing an object directly in the table**

During the configuration loading, the program might modify automatically the characteristics of an object by rounding some values to remove some extra significant digits. A dialog window is opened to inform the user of the modification and the object line will be marked in blue.

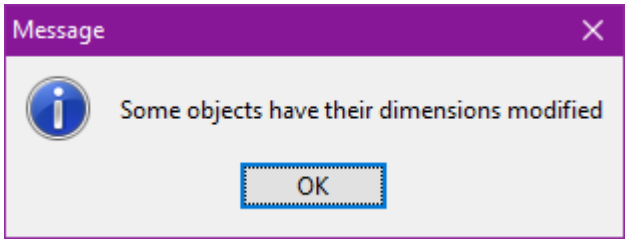



**Figure 34: Dialog to inform the user about the automatic modification of the object properties.**

The automatically modified object will be kept in blue, until the configuration is saved or until another property of the object is modified, in this case we consider that the automatically modified value has been assessed.

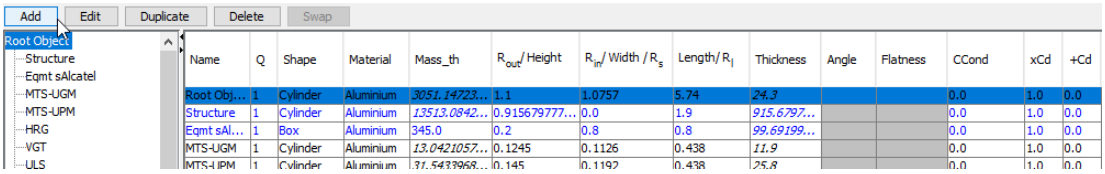



**Figure 35: Automatically modified object in input panel.**

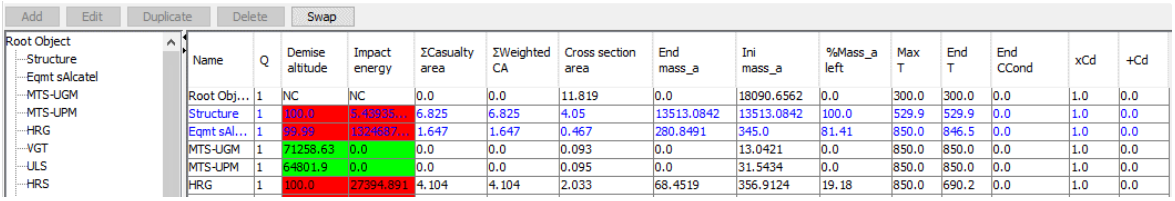



**Figure 36: Automatically modified object in result panel.**

#### 7.5.1.4 Simulation Parameters tab

In the Simulation Parameters tab, you will find the options to select:

- The fragmentation method for the satellite.
- The atmosphere model.
- The options for the creation of the Cb/Mach files.

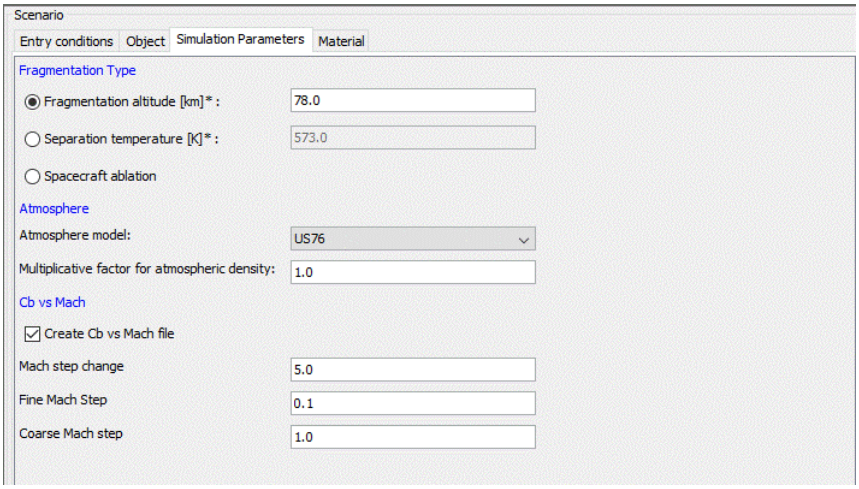



**Figure 37: Simulations Parameters tab**

The visibility of some of the input fields depend on the value of other fields:

- When “Atmosphere model” is “MSIS2000” the solar and magnetic activity fields are displayed.

#### 7.5.1.5 Materials tab

Each simulation has its own Materials tab, so the modification of the properties of a material of one simulation does not impact the corresponding material of another simulation.

In the Materials tab, you will find the properties of the various materials used in the simulation. This includes the following parameters for each material:

- density in $kg/m^3$
- heat of fusion in J/kg
- melting temperature in K
- oxidation heat in J/kg ($O_2$)

There is also a graph summarising the thermal properties of the material, in which you will find a line corresponding to the emissivity and Cp according to the temperature.

Some materials are defined by default. They are displayed in purple and named “xxx DEBRISK”. They cannot be modified. As for the other types of materials, the user can change the values of their characteristics of each material directly by double-click on the cell of the table to be modified.

I f one of the materials is not recognized by the software when opening of an XML file, DEBRISK ask the user if the materials shall be created with all their properties set to null or if the objects shall be associated with the “Unknown” material, whose properties are visible but cannot be changed in the material table.

The list of all the unknown materials is displayed in a single pop-up to warn the user:

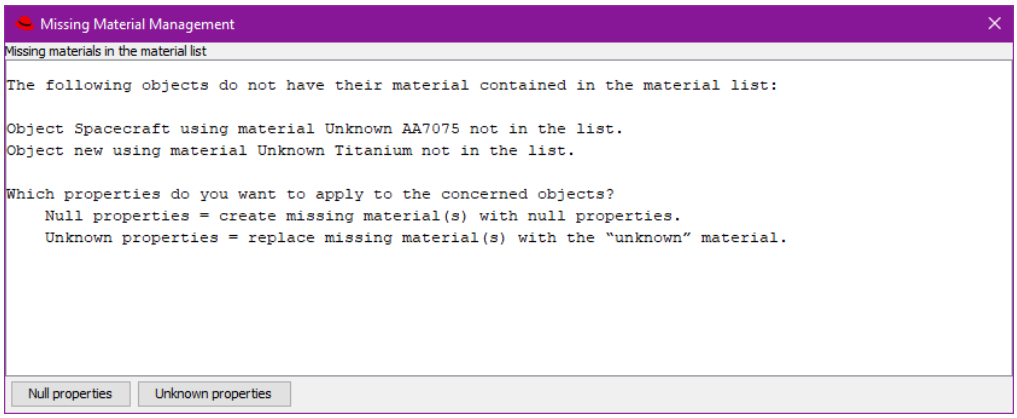



**Figure 38 Unknown materials warning pop-up**

The creation of these materials by the user is explained in section 7.6.1.3.

The panel contains 2 buttons:

- Load materials: To load a userMaterials file into the panels. The parameters not contained in the file will be loaded with their default values. If the values of the parameters of default materials are different from the default ones, an error message will appear.

- Save simulation parameters: To save the current materials panel contents into an xml file.

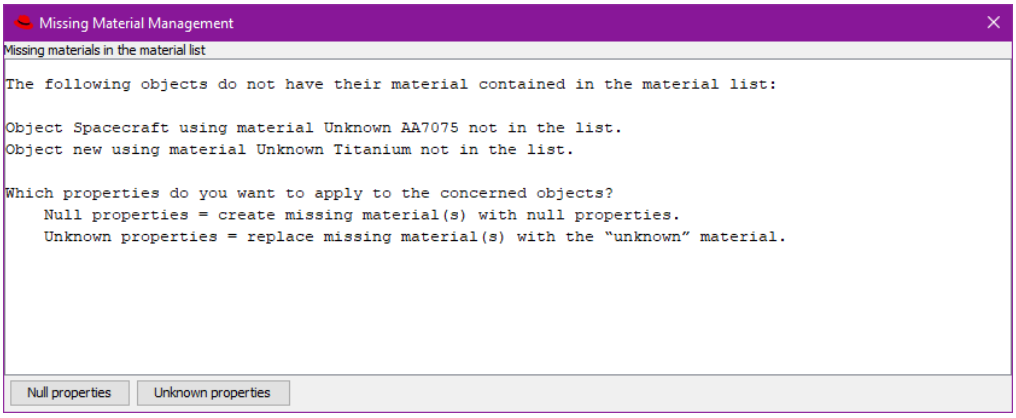



**Figure 39 Materials tab Panel**

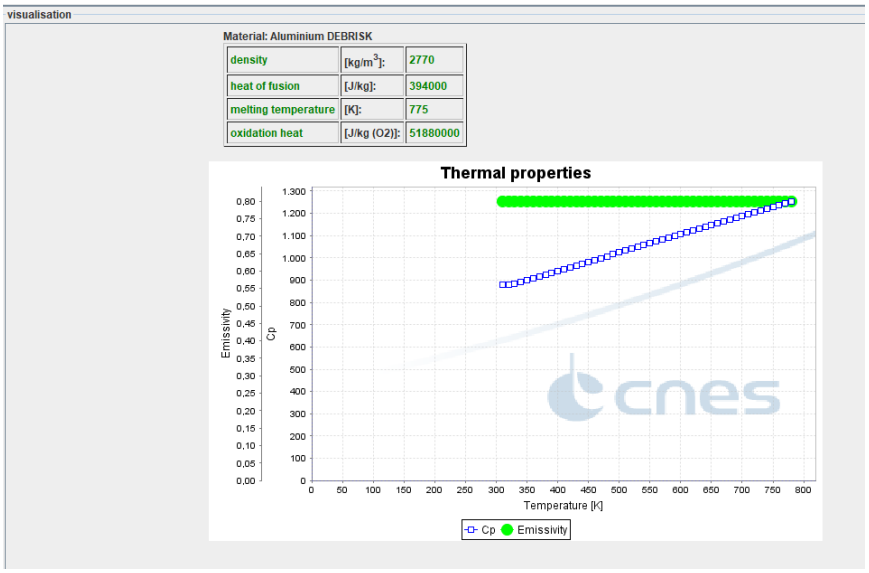



**Figure 40 Materials tab thermal properties graph**

#### 7.5.1.5.1 Loading of a material list

The user can load a material list using the "Load Materials" button and selecting a material list xml file. A confirmation window will be displayed:

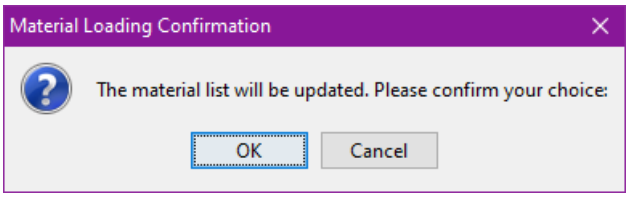



**Figure 41 Load materials confirmation dialog**

If the user cancels the current material list will remain unmodified, in other case the new material list will be loaded. The properties of objects related to material properties as the mass and volume will be modified accordingly.

If the new material list does not contain all the materials used by the objects in the simulation, the missing materials will be added to the list. A dialog will be displayed allowing the user to select to add these materials with all their properties set to null or not to add them and use the *Unknown* material instead:

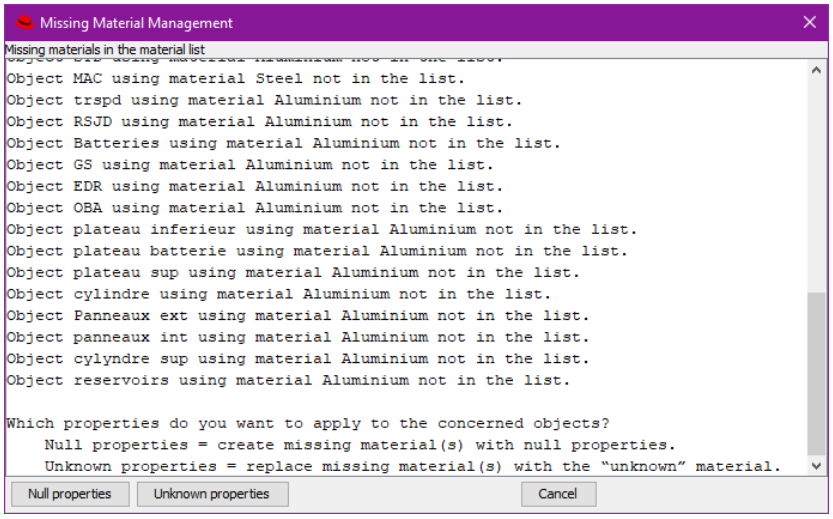
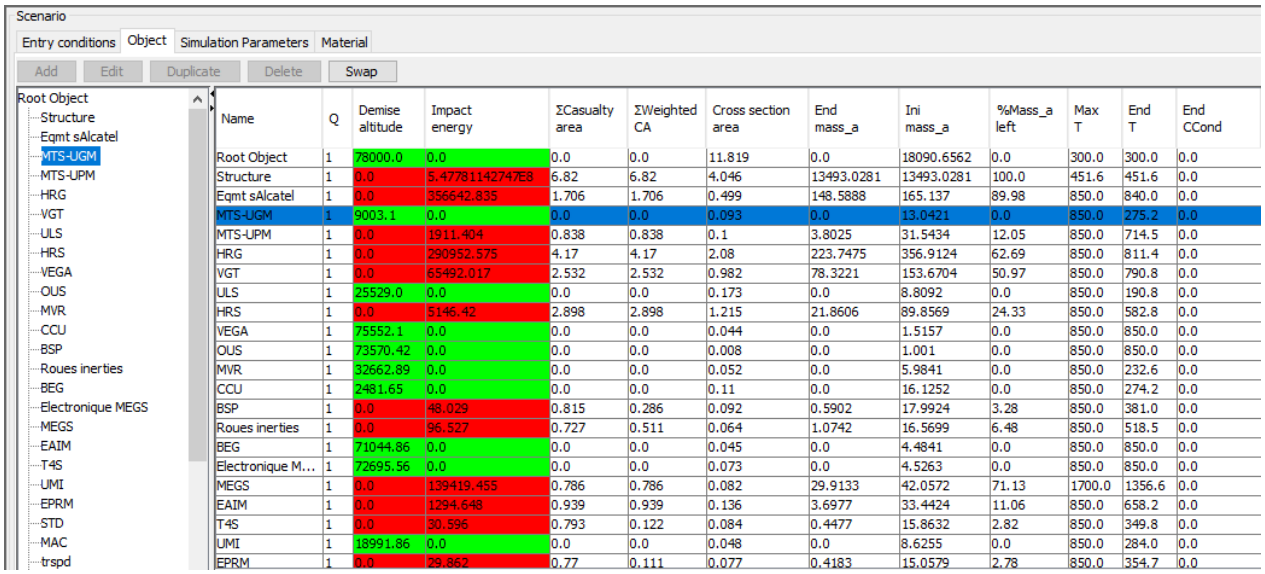



**Figure 42: Selection of missing material properties**

### 7.5.1.6 Result Panel

After a simulation, in the object tab, a table displays a summary of the state of each object at the end of the simulation.




| Name | Q | Demise altitude | Impact energy | ΣCasualty area | ΣWeighted CA | Cross section area | End mass_a | Ini mass_a | %Mass_a left | Max T | End T | End CCond |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Root Object | 1 | 78000.0 | 0.0 | 0.0 | 0.0 | 11.819 | 0.0 | 18090.6562 | 0.0 | 300.0 | 300.0 | 0.0 |
| Structure | 1 | 0.0 | 5.4778114274 7E8 | 6.82 | 6.82 | 4.046 | 13493.0281 | 13493.0281 | 100.0 | 451.6 | 451.6 | 0.0 |
| Eqmt sAlcatel | 1 | 0.0 | 356642.835 | 1.706 | 1.706 | 0.499 | 148.5888 | 165.137 | 89.98 | 850.0 | 840.0 | 0.0 |
| MTS-UGM | 1 | 9003.1 | 0.0 | 0.0 | 0.0 | 0.093 | 0.0 | 13.0421 | 0.0 | 850.0 | 275.2 | 0.0 |
| MTS-UPM | 1 | 0.0 | 1911.404 | 0.838 | 0.838 | 0.1 | 3.8025 | 31.5434 | 12.05 | 850.0 | 714.5 | 0.0 |
| HRG | 1 | 0.0 | 290952.575 | 4.17 | 4.17 | 2.08 | 223.7475 | 356.9124 | 62.69 | 850.0 | 811.4 | 0.0 |
| VGT | 1 | 0.0 | 65492.017 | 2.532 | 2.532 | 0.982 | 78.3221 | 153.6704 | 50.97 | 850.0 | 790.8 | 0.0 |
| ULS | 1 | 25529.0 | 0.0 | 0.0 | 0.0 | 0.173 | 0.0 | 8.8092 | 0.0 | 850.0 | 190.8 | 0.0 |
| HRS | 1 | 0.0 | 5146.42 | 2.898 | 2.898 | 1.215 | 21.8606 | 89.8569 | 24.33 | 850.0 | 582.8 | 0.0 |
| VEGA | 1 | 75552.1 | 0.0 | 0.0 | 0.0 | 0.044 | 0.0 | 1.5157 | 0.0 | 850.0 | 850.0 | 0.0 |
| OUS | 1 | 73570.42 | 0.0 | 0.0 | 0.0 | 0.008 | 0.0 | 1.001 | 0.0 | 850.0 | 850.0 | 0.0 |
| MVR | 1 | 32662.89 | 0.0 | 0.0 | 0.0 | 0.052 | 0.0 | 5.9841 | 0.0 | 850.0 | 232.6 | 0.0 |
| CCU | 1 | 2481.65 | 0.0 | 0.0 | 0.0 | 0.11 | 0.0 | 16.1252 | 0.0 | 850.0 | 274.2 | 0.0 |
| BSP | 1 | 0.0 | 48.029 | 0.815 | 0.286 | 0.092 | 0.5902 | 17.9924 | 3.28 | 850.0 | 381.0 | 0.0 |
| Roues inerties | 1 | 0.0 | 96.527 | 0.727 | 0.511 | 0.064 | 1.0742 | 16.5699 | 6.48 | 850.0 | 518.5 | 0.0 |
| BEG | 1 | 71044.86 | 0.0 | 0.0 | 0.0 | 0.045 | 0.0 | 4.4841 | 0.0 | 850.0 | 850.0 | 0.0 |
| Electronique M... | 1 | 72695.56 | 0.0 | 0.0 | 0.0 | 0.073 | 0.0 | 4.5263 | 0.0 | 850.0 | 850.0 | 0.0 |
| MEGS | 1 | 0.0 | 139419.455 | 0.786 | 0.786 | 0.082 | 29.9133 | 42.0572 | 71.13 | 1700.0 | 1356.6 | 0.0 |
| EAIM | 1 | 0.0 | 1294.648 | 0.939 | 0.939 | 0.136 | 3.6977 | 33.4424 | 11.06 | 850.0 | 658.2 | 0.0 |
| T4S | 1 | 0.0 | 30.596 | 0.793 | 0.122 | 0.084 | 0.4477 | 15.8632 | 2.82 | 850.0 | 349.8 | 0.0 |
| UMI | 1 | 18991.86 | 0.0 | 0.0 | 0.0 | 0.048 | 0.0 | 8.6255 | 0.0 | 850.0 | 284.0 | 0.0 |
| EPRM | 1 | 0.0 | 29.862 | 0.77 | 0.111 | 0.077 | 0.4183 | 15.0579 | 2.78 | 850.0 | 354.7 | 0.0 |

**Figure 43 Results table**

We then find:

- Name: Containing the object name.
- Q: Containing the quantity of fragments. This parameter is used when the operator wants to define several fragments with the exact same characteristics. Even if Q>1, a single simulation will be run for the fragment. This value will only be used to compute the aerodynamic mass of an object having children with Q/=1 and for the casualty area (which will be computed as the casualty area of the simulated fragment multiplied by Q).
- Demise altitude: The object destruction altitude, the cell is coloured in red if the object is not destroyed and in green if it does not reach the ground.
- Impact Energy: The energy of the fragment on impact, the cell is coloured in red if the energy on impact is higher than 14J (or value of maximum energy on impact specified in the expert settings file), in yellow if it is lower or equal, or in green if the object does not reach the ground.
- ∑ Casualty Area: The casualty area in the case of an object which reaches the ground.
- ∑ Weighted CA: The weighted casualty area in the case of an object which reaches the ground.
- Cross section area: Average surface.

- End mass_a: Final aerodynamic mass of the fragment, in case the fragment is destroyed before reaching the ground, otherwise it will be 0.0.
- Ini mass_a: Initial aerodynamic mass of the fragment.
- %Mass_a left: Percentage ratio between End mass_a and Ini mass_a.
- Max_T: Maximum temperature reached by the fragment.
- End_T: Final temperature of the fragment when it is destroyed or reaches the ground.
- End_CCond: Final value of the conductance coefficient when the object is destroyed or reaches the ground.

Below the table, the total casualty area is displayed:

Total Casualty Area = casualty_area_fragment * quantity * parent_quantity * parent_parent_quantity….

Total Weighted Casualty Area = weight_factor * total_casualty_area

With weight_factor computed as:

$$0 \quad if \qquad \text{Energy} < \min WCA$$

$$0.5 - 0.5\cos\left(\frac{\ln(Energy) - \ln(\min WCA)}{\ln(\max WCA) - \ln(\min WCA)}\right) \quad if \qquad \min WCA \leq Energy \leq \max WCA$$

$$1 \quad if \qquad \text{Energ} > \max WCA$$

With “min WCA” and “max WCA” the values of the fields “Minimum/Maximum impact energy for weighted casualty area” defined in the “Models section” of the “Simulation Parameters” tab.

### 7.5.1.7 Viewing area

The viewing area is in the right part of the interface. It is used to analyse the evolutions of the various parameters during the simulation. The results are presented in five types of predefined graphs that can be selected via a combo-box:

- altitude vs. time
- thermal mass vs. time
- thermal mass vs. altitude
- altitude vs. downrange
- temperature vs. time

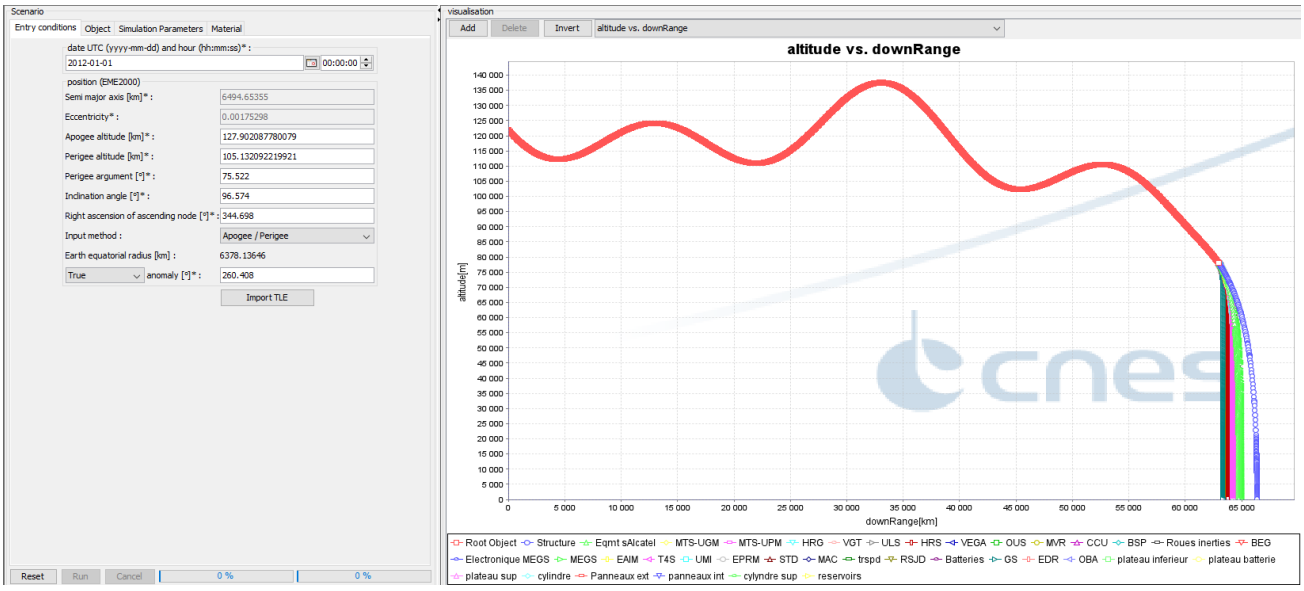



**Figure 44 Viewing area on the right**

The user is also able to add/delete any other custom graphics to plot one of the available parameters against any other one. To add a new plot, once the button “add” is clicked, a new window appears where the user can choose the parameters to be plotted.

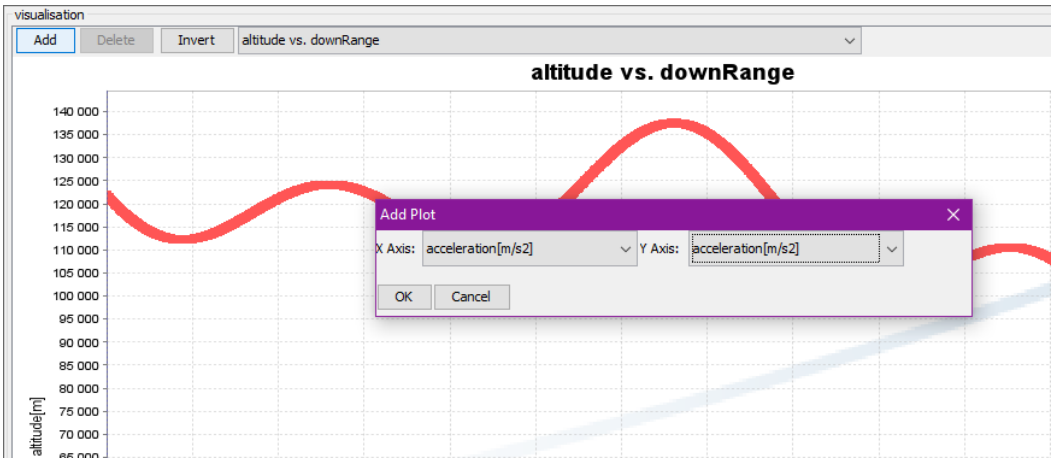



**Figure 45 Creation of custom plot**

To delete any custom graphic, one must only click on the "Delete" button after having selected the plot to be removed (please note that the five plots defined by default cannot be removed).

The user can additionally change the order of the axis of the selected plot by clicking on the "Invert" button:

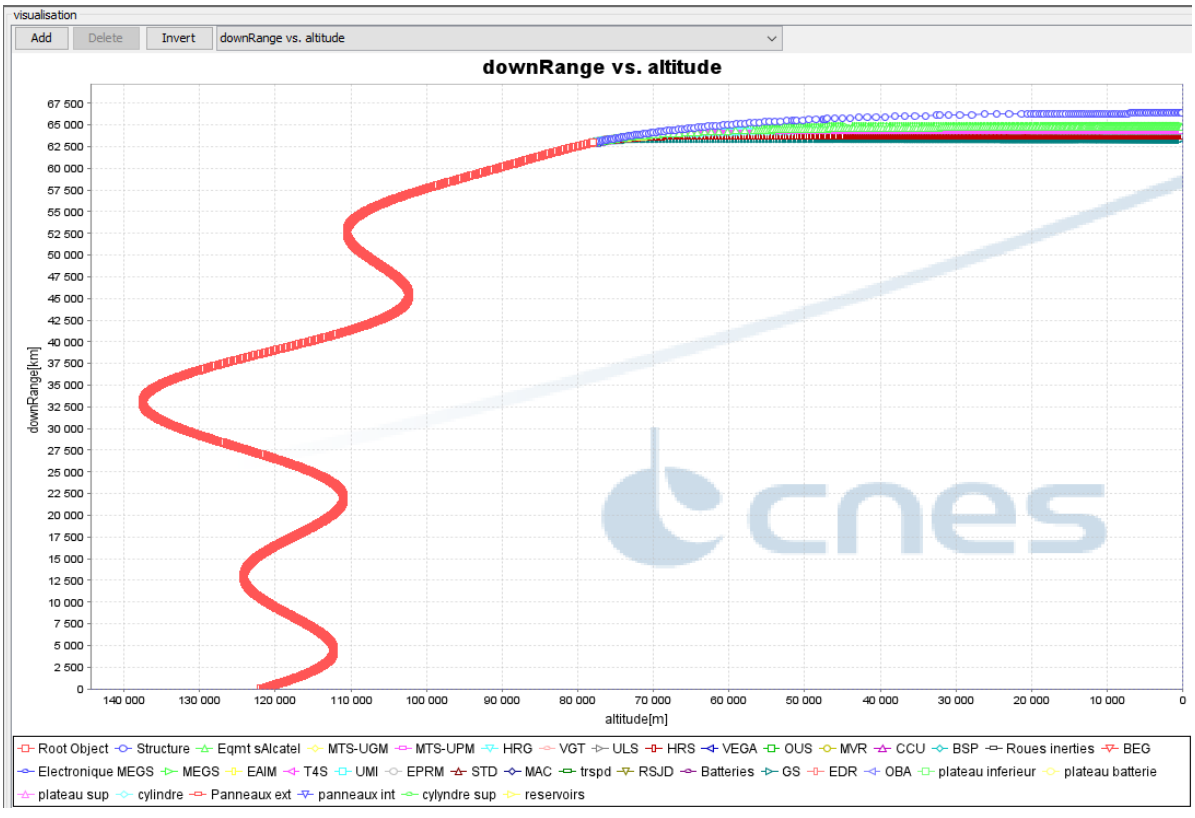



**Figure 46 Invert plot**

When there are too many objects in the simulation, it can be interesting to only view some of them in order to make the analysis easier. To do this, you must select these objects in the table on the left, right-click on one of the objects and click on “Plot selected objects”. Only the objects that have been selected in the table are displayed in the graphic.

To make multiple selections, you can use the “CTRL” and “SHIFT” buttons on your keyboard. The selected lines will be coloured in blue.

## Google-Earth view

Here-below is an example of simulation viewed in Google Earth.

To be able to view the results in Google Earth, you must save the simulation by clicking on the "Export" button, and then "KML", select the backup directory, the file name, and click on "save".

Finally, open Google Earth and open the file you just saved. In the top left-hand part, you can click on the second button to see the trajectory move.

You will then see that when an object is destroyed or reaches the ground, the 3D model of the object turns into a small yellow thumbtack. You can click on it to obtain more information on the end-of-flight of this object, as you can see on Figure 47.

The simulation made can also be saved by clicking on *File* and then on *Save,* and by selecting a backup name. This will save the list of objects, as well as the parameters of the scenario, making it possible to re-launch an identical simulation at a later stage.

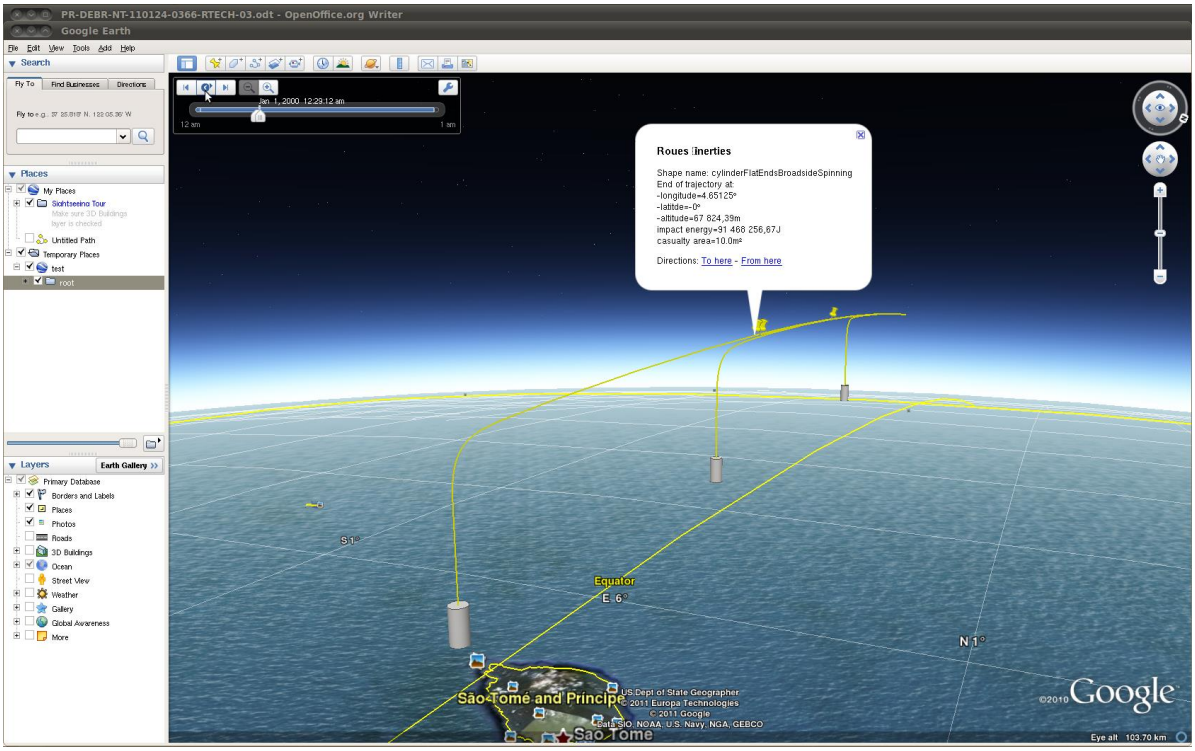



**Figure 47 Simulation viewed in Google Earth**

#### 7.5.1.8 Message zone

The top area of the IHM contains a message zone where all the messages produced during the execution are displayed.

The contents of the message zone can be cleared using the “Clear” button.

The message zone will not be cleared when resetting the simulation or executing it again.

Each simulation has an independent message zone.

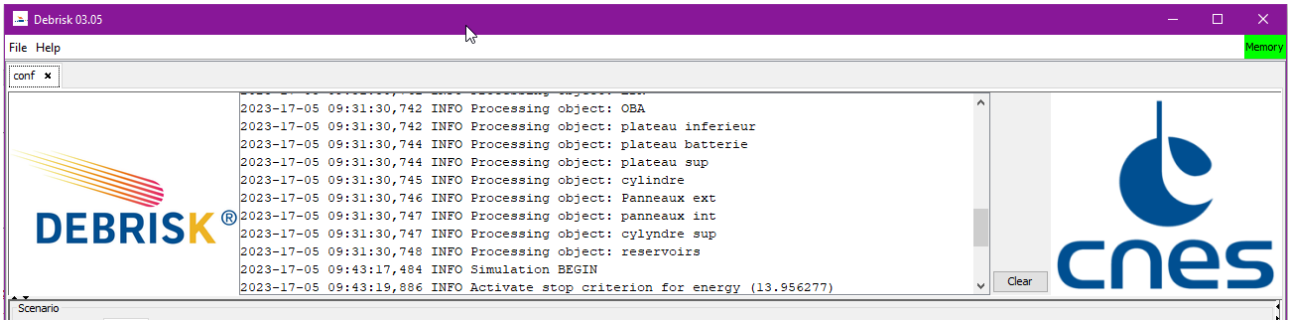



**Figure 48: Message area**

## *7.6 Materials*

### 7.6.1.1 Materials file

An alternative location of the materials file can be specified by the user using the command line option:

--userMaterials <materials file path>

The option works both in batch mode and in MMI mode.

### 7.6.1.2 Integrated materials

A certain number of materials are created during the installation of Debrisk. You can choose among these materials every time you want to create or edit an object. A drop-down list containing all the materials is available.

Some materials are defined by default. They are displayed in purple, are named "xxx DEBRISK" and cannot be modified or removed.

### 7.6.1.3 Materials created by the user

If you wish to use a specific material not available as yet in DEBRISK, you can create it. To do so, you must click in the "Material" tab in the "Scenario" part, and then on the *Add* button.

When you wish to create a new material, you have two possibilities. Either you create it from scratch (by clicking directly on *Add*), or you derive it from an existing material by selecting a material and clicking on *Duplicate*. Either way, it is not possible to name the new material with a character string containing "Debrisk". When duplicating a "xxx DEBRISK" material, the oxidation properties are not duplicated, they are set to their default values.

The userMaterials file will not be automatically saved each time the property of a material is changed. The user can save the materials by using the "save materials" button. To create a totally new material, you must enter the following parameters:

- Name: material name
- Density: density of the material (in $kg/m^3$)
- Melting Temperature: melting temperature (K)
- Heat Of Fusion: heat of fusion (J/kg)
- Oxide Heat Of Formation: oxidation flux (J/kg ($O_2$))
- Emissivity: emissivity

- Heat Capacity: heat capacity (J/kg/°K),

For the first five parameters, you must enter a single value, which will be a character string for the name of the material, and numeric values for the density, the melting temperature, the heat of fusion and the oxide heat of formation. The name of the material created cannot contain the character string "debrisk".

If the material definition is invalid because some parameters are out of range an warning method will be displayed at the bottom of the window and if the user wants to apply the values a confirmation will be requested.

For the emissivity and the heat capacity, you can enter either a table of values according to the temperature or a polynomial (or a constant) representing this relationship.

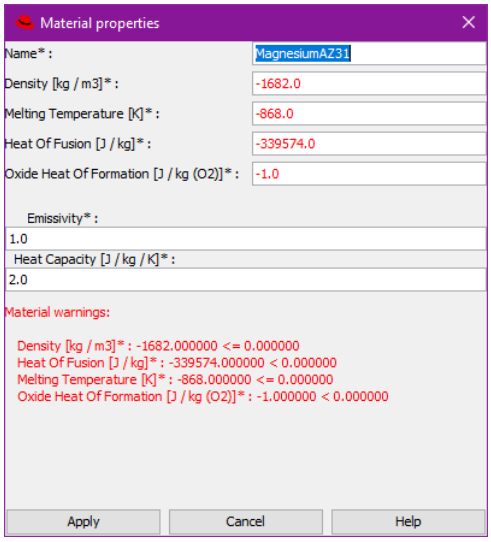



**Figure 49 Adding a customised material.**

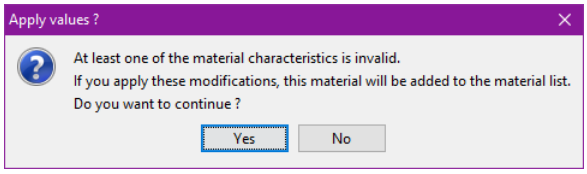



**Figure 50: Confirmation dialog for invalid materials.**

If you wish to enter a table of values, select the "linear Interpolation" type in the window which opens (see Figure 51). The first number in each pair is the temperature, and the second corresponds to the value of the parameter you wish to define, i.e. in our example, the emissivity. In this mode, a straight line is drawn between each pair of value.

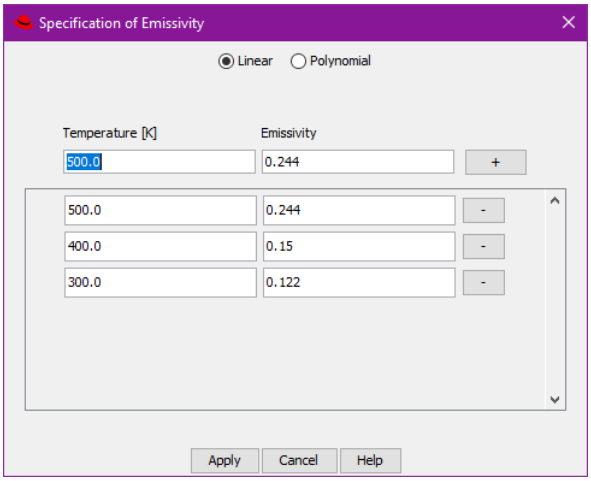



**Figure 51 Entry of a linear evaluation**

If you prefer to use the polynomial form, you must specify the degree of the polynomial and provide the coefficients. If you enter only one coefficient, this means that the parameter is constant over the whole temperature range. In the example given above (see Figure 52), k is considered as constant and equal to 110, regardless of the temperature.

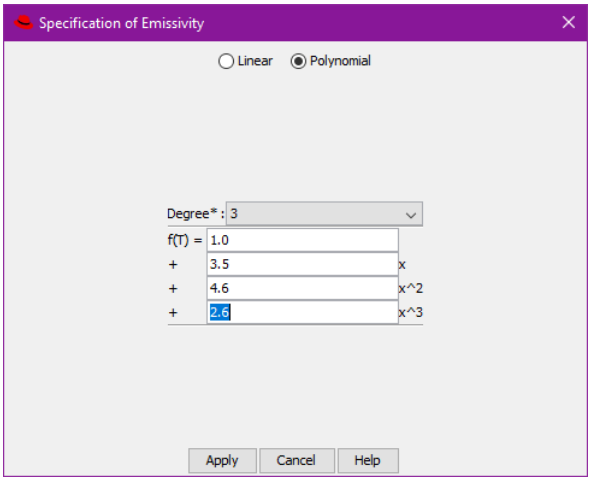



**Figure 52 Entry of a polynomial**

In both cases the emissivity and Cp will be evaluated in the temperature range (300K to melting temperature) in steps of 10 degrees to verify that both properties are positive (>= 0.0) in all the range.

If this is not the case, an error message will be displayed and it will not be possible to apply the changes to the material until the problem is corrected.

## 7.7 *Shape of objects*

The objects available in DEBRISK are described in this section. The objects are defined by their geometrical shape. The attitude of the object depends on its aerodynamic behaviour, on the forces applied on separation, on the position of the centre of gravity of the object, factors which are difficult to predict accurately. The use of external tools could be envisaged to guide the user in the choice to be made for each object. In the current version, all the objects are considered to be in tumbling attitude mode during their re-entry. The tumbling attitude of each object is defined by its shape and defined below in the corresponding section.

To choose the shape of the object, you must click and fill in the *shape* field in the "object properties" window.

Depending on the shape, you can select the set of dimensions to fill out. With these values the software will compute the rest of the dimensions.

The precision for the dimensions used to define a shape is 14 significant digits, the rest of the dimensions will be computed with the machine precision.

The same object defined using different sets of dimensions will produce two similar objects but not identical, so the results of the simulation may differ.

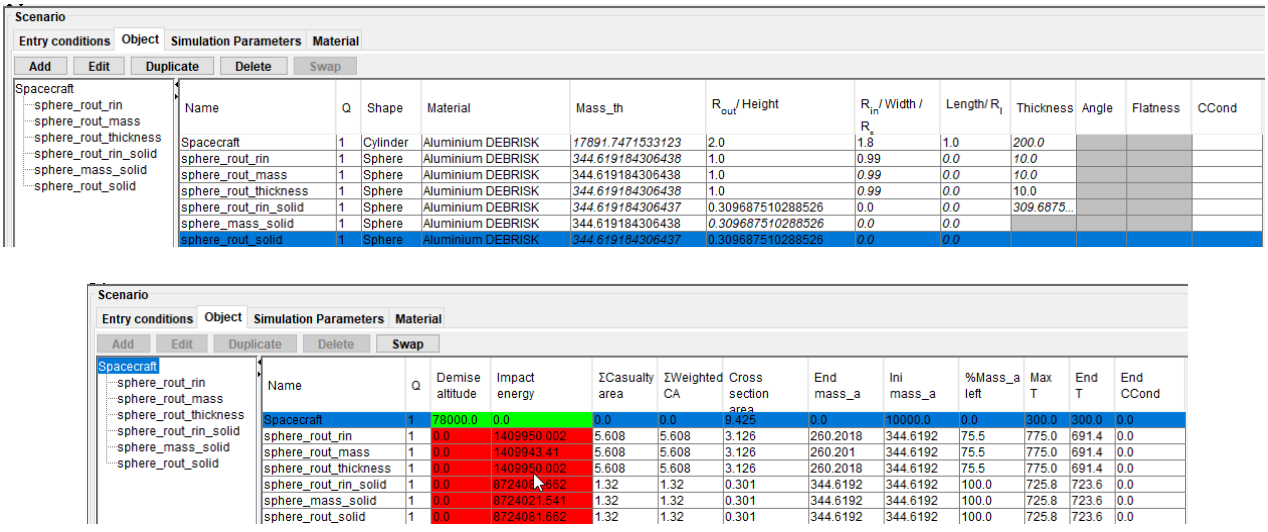



**Figure 53 Spheres defined using different methods, obtaining different results**

#### 7.7.1.1 Sphere

There is only one type of sphere, which is assumed to be in random tumbling mode around the three axes presented in the figure below.

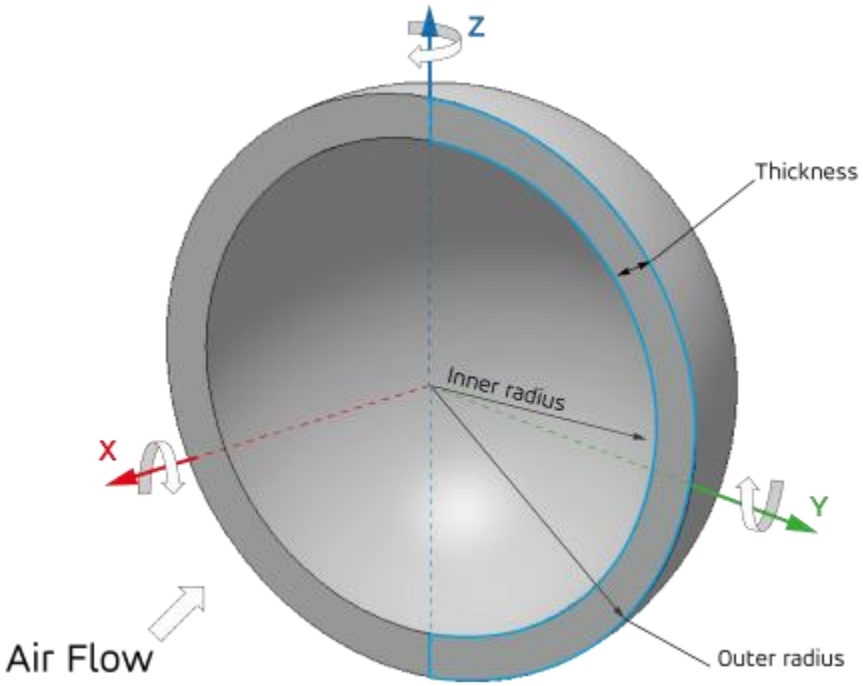



**Figure 54 Hollow sphere random tumbling.**

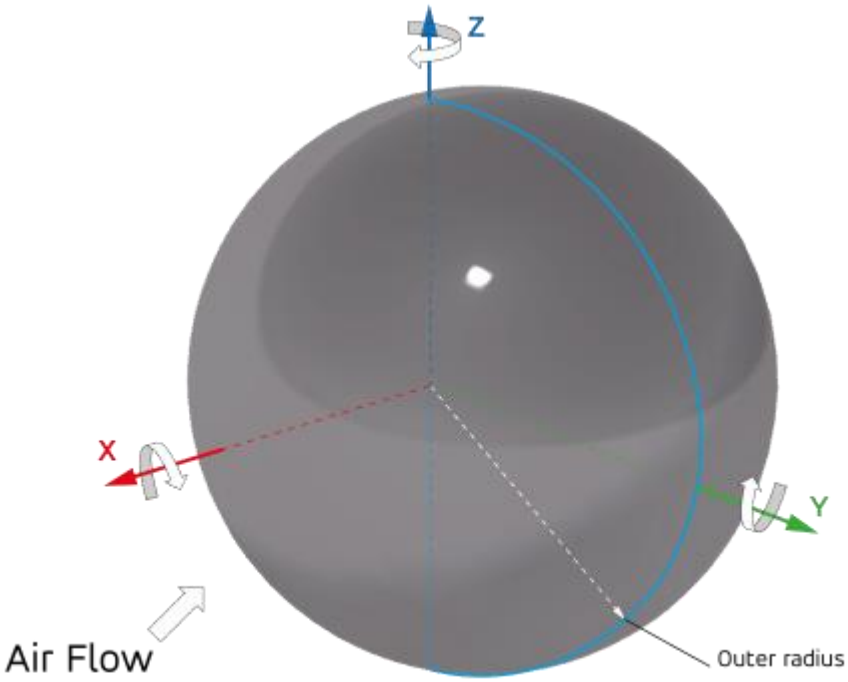



**Figure 55 Solid sphere random tumbling.**

To create a spherical object, you can enter one of the following sets of parameters according to the selection made in the “specifications” field.

- For the hollow sphere:
  - outer radius and inner radius
  - outer radius and mass
  - outer radius and thickness

- For the solid sphere:
  - mass
  - outer radius

The other parameters required for the calculation and not given by the user will be computed by the software. For example, if you choose to enter the outer and inner radii, the software will calculate the corresponding thickness and the mass according to the material selected.

#### 7.7.1.2 Cylinder

The cylinder is considered to be in random tumbling mode as defined in Figure 56.

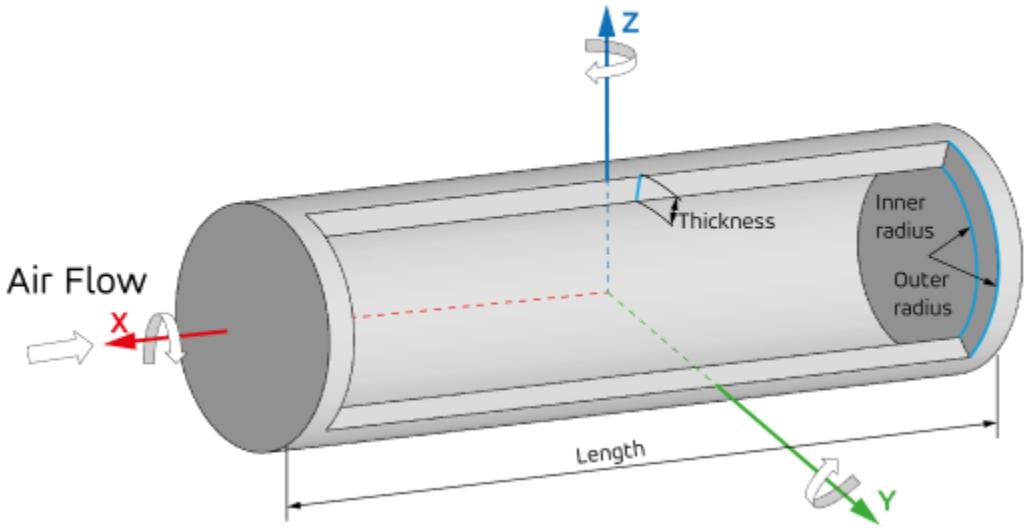



**Figure 56 Hollow cylinder random tumbling**

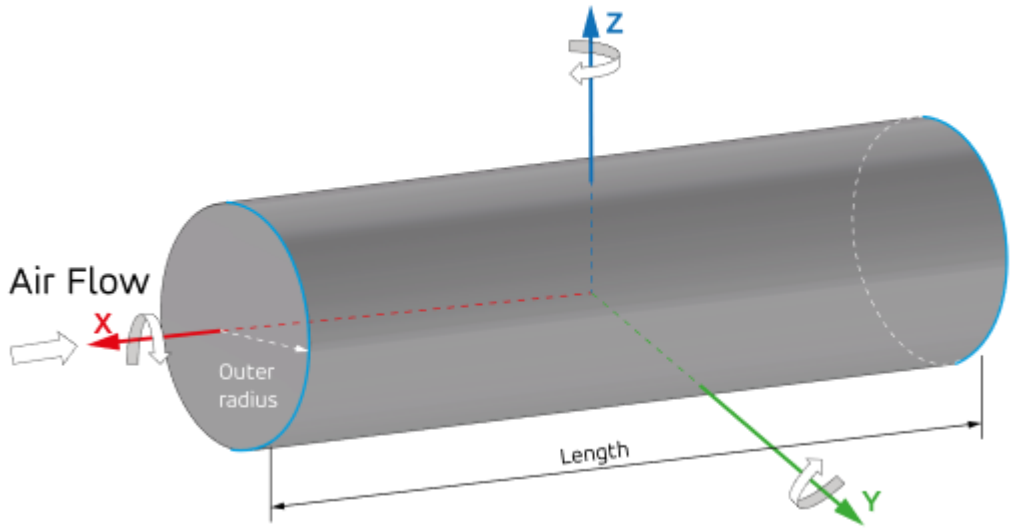



**Figure 57 Solid cylinder random tumbling**

To create a cylinder, it is necessary to provide one of the sets of information bellow:

- Hollow cylinder:
  - outer radius, inner radius and length
  - outer radius, thickness and length
  - outer radius, length and mass

- Solid cylinder:
  - outer radius and mass

The other parameters required for the calculation are deduced by the software.

The length and inner and outer radii must be between 0 and 100m.

#### 7.7.1.3 Box

The box is defined by the user by entering one of two following series of parameters:

- length, width, height, thickness
- length, width, height, mass

For a hollow box, both series can be used. For a solid box, use the < length, width, height, mass > series, having first calculated the mass by the volume x density.

Note: the length must be greater than the width and the width must be greater than the height.

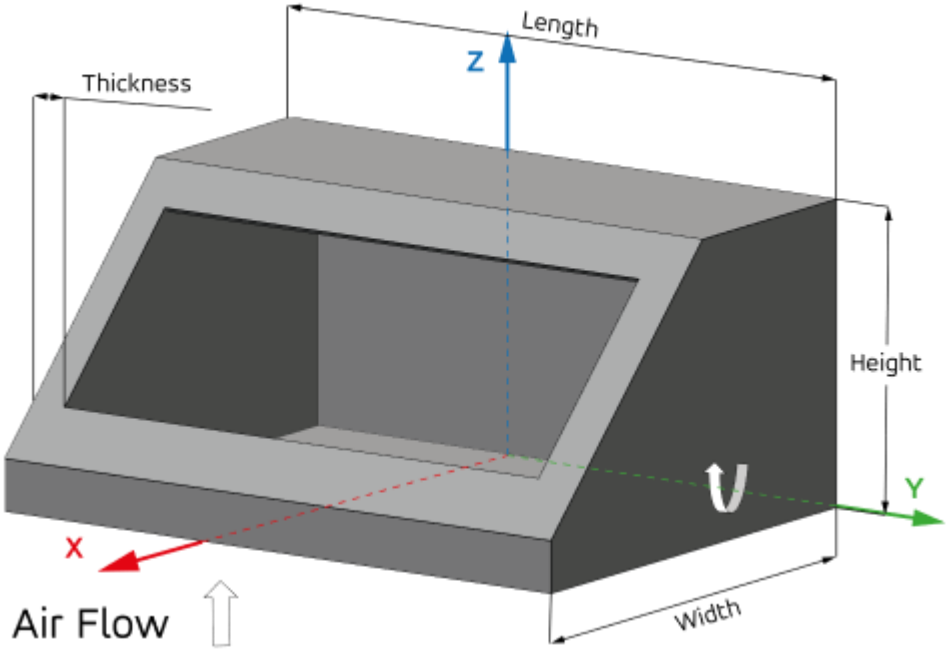



**Figure 58 Box tumbling**

The box is considered to be in random tumbling mode around its longest axis.

#### 7.7.1.4 Flat plate

The flat plate can be defined by the following parameters:

- length, width, thickness
- length, width, mass

Note: as the box, the length must be greater than the width and the width must be greater than the thickness.

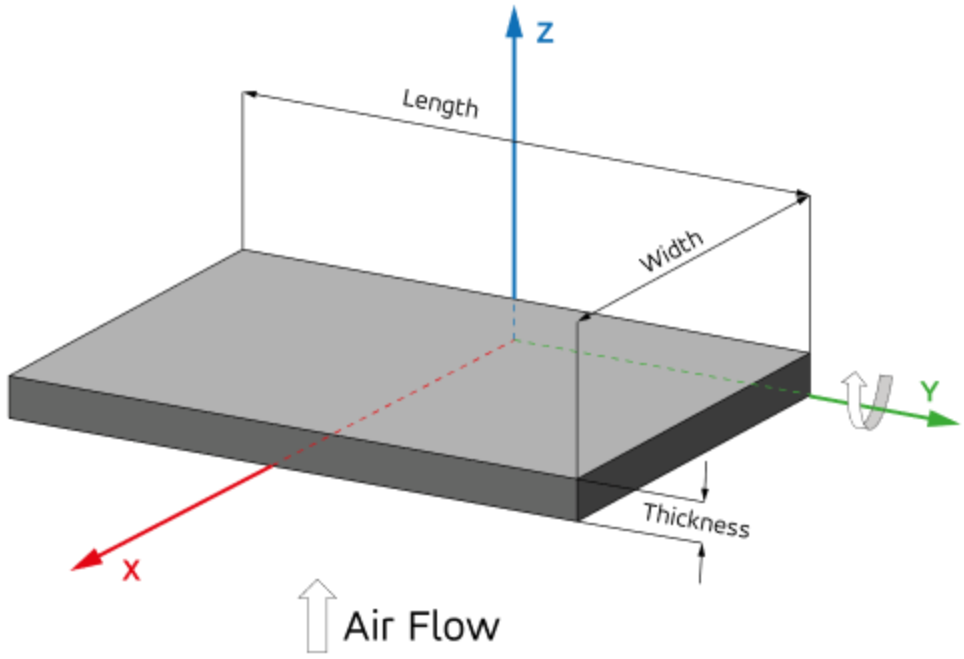



**Figure 59 Flat plate tumbling.**

As the box, the flat plate is considered to be in random tumbling mode around its longest axis.

The thickness of the plate must be below 10% of the width. Otherwise, a box object must be used.

#### 7.7.1.5 Hemispherical cylinder

The hemispherical cylinder is considered to be in random tumbling mode as defined in Figure 60.

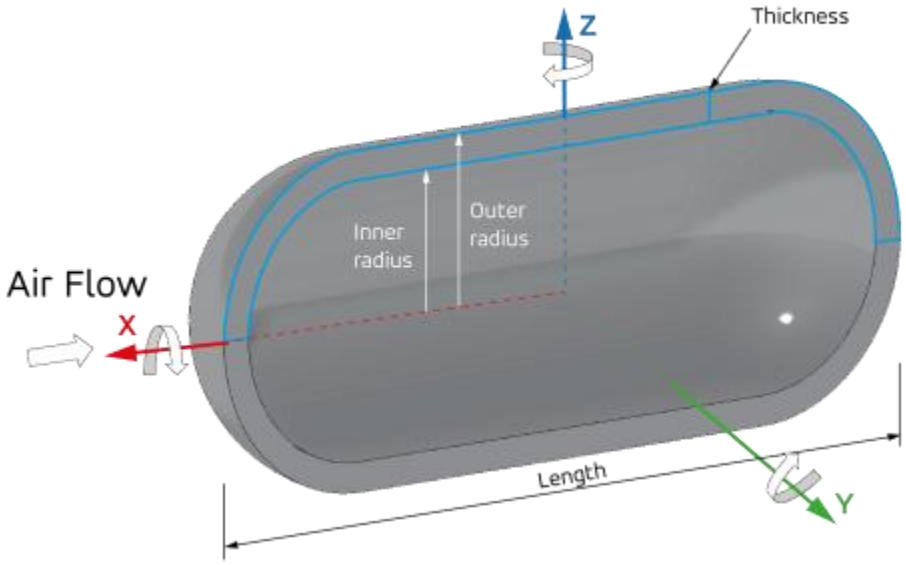



**Figure 60 Hollow hemispherical cylinder random tumbling**

To create a hemispherical cylinder, it is necessary to provide one of the sets of information bellow:

- Hollow hemispherical cylinder:
  - outer radius, inner radius and length
  - outer radius, thickness and length
  - outer radius, length and mass

The other parameters required for the calculation are computed by the software.

The length and inner and outer diameter must be between 0 and 100m.

#### 7.7.1.6 Complex shape

The complex shapes are divided in to categories depending on the value of the flatness parameter:

- Conical
- Spherical

Complex shapes are defined by the following parameters:

- large radius, small radius, height, thickness, angle
- large radius, small radius, height, mass, angle

The angle of aperture of complex shapes can be between 0 and 360 degrees, for the range of angle values between 359 and 360, the shape is considered closed and the value of 360 is used.

When defining a complex conical shape, tube equations will be used if all the following conditions are satisfied:

$$\boldsymbol{R_l = R_s}$$

$$\boldsymbol{angle = 360.0^{\circ}}$$

$$\boldsymbol{0.1 < \frac{e}{R_l} < 1.0}$$

#### 7.7.1.6.1 Complex conical shape

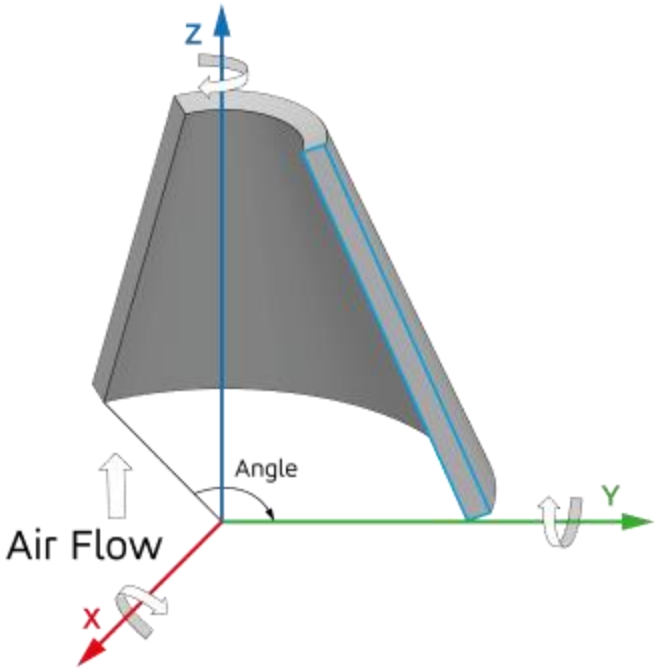



**Figure 61 Complex conical shape tumbling.**

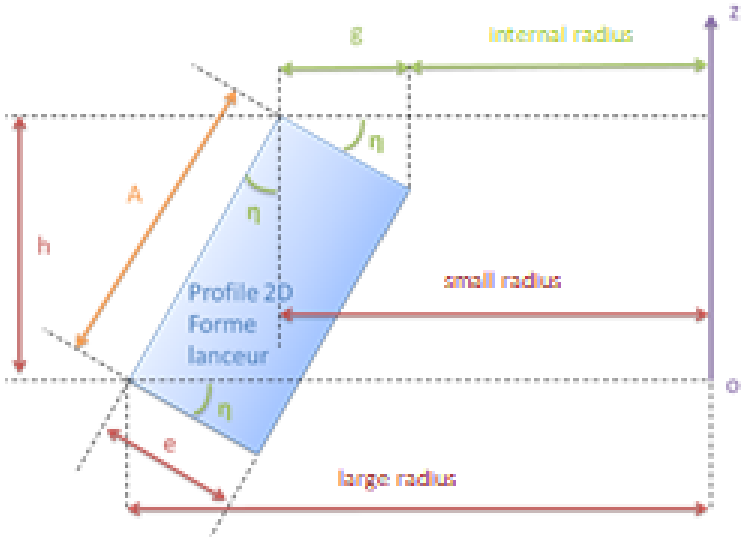



**Figure 62 Complex conical shape profile.**

The apothem of the conical shape is computed as follows:

$$A = \sqrt{h^2 + \left(\frac{D_G - D_P}{2}\right)^2}$$

The angle η is defined as follows:

$$\cos\eta = \frac{h}{A}$$

The following constraints shall be respected by the shape to be considered valid:

$$\boldsymbol{R_l \geq R_s}$$

$$\boldsymbol{R_l > e\ cos\,\eta}$$

$$\boldsymbol{h > 0}$$

$$\boldsymbol{0 < e\ \leq \frac{A}{10}}$$

When the following conditions are fulfilled:

$$\boldsymbol{R_l == R_s}$$

$$\boldsymbol{1.0 > \frac{e}{A} > 0.1}$$

the conical shape is modelled as a tube.

When

$$\boldsymbol{\frac{e}{A} \geq 1.0}$$

an error is raised indicating the user that a cylinder shall be used to model the shape.

#### 7.7.1.6.2 Complex spherical shape

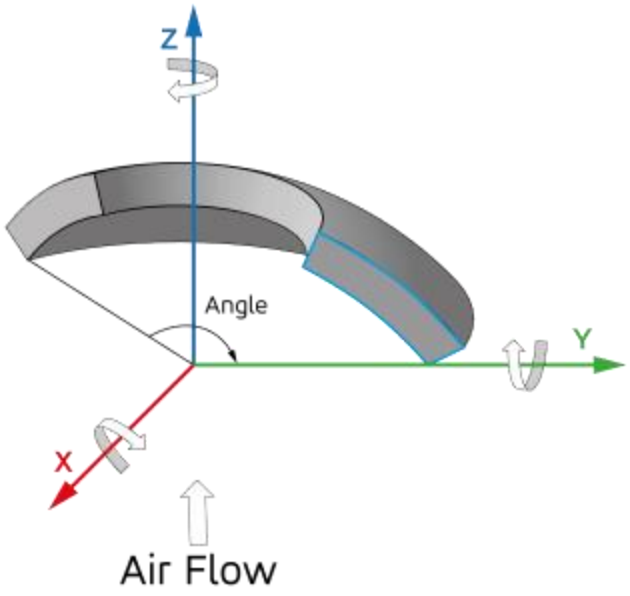



**Figure 63 Complex spherical shape tumbling.**

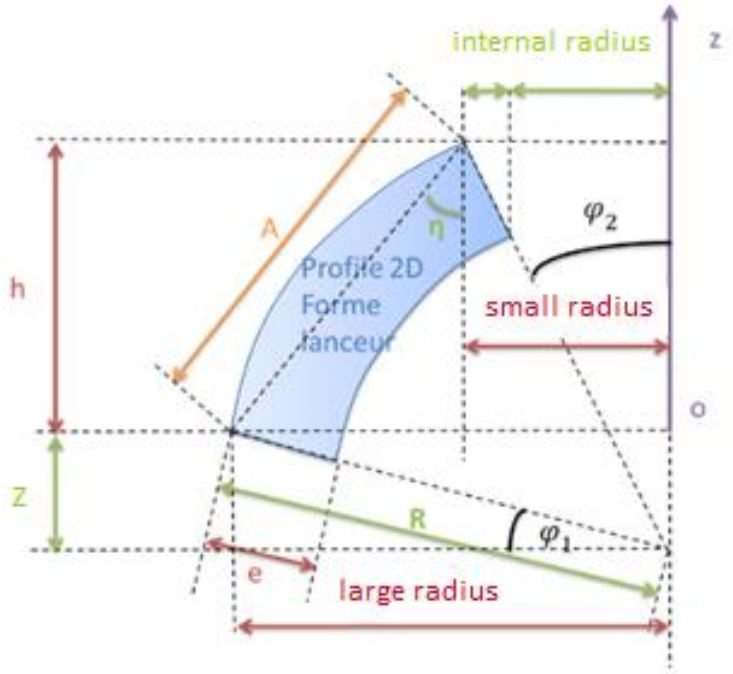


**Figure 64 Complex spherical shape profile.**

The apothem of the conical shape is computed as follows:

$$A = \sqrt{h^2 + \left(\frac{D_G - D_P}{2}\right)^2}$$

The following constraints shall be respected by the shape to be considered valid:

$$\boldsymbol{R_s \geq 0}$$

$$\boldsymbol{R_l \geq R_s}$$

$$\boldsymbol{h > 0}$$

$$\boldsymbol{h \leq \frac{1}{2}\sqrt{(D_g)^2 - (D_P)^2}}$$

$$\boldsymbol{0 < e \leq \frac{A}{10}}$$

## 7.8 Heat flow

The absorbed radiation heat flow is assumed null at any altitude.

## 7.9 Oxidation flows

The heat and mass flow produced by the oxidation depends on the model used:

OxyV3

- $\vartheta_O$ : stoichiometric coefficient of the oxygen in the formed oxide
- $\vartheta_M$ : stoichiometric coefficient of the metal alloy in the formed
- $M_O$ : molar mass of the oxygen [kg mol$^{-1}$]
- $M_M$ : molar mass of the metal alloy formed in the oxide [kg mol$^{-1}$]
- $x_M$ : mass fraction of metal formed in the oxide
- $\Delta_f H^0$ : molar standard formation enthalpy (<0) [J mol$^{-1}$]
- $M_{MO_x}$ : molar mass of the oxide [kg mol$^{-1}$]
- $\rho_0$ : mass density of the alloy oxide [kg m$^{-3}$]
- $x_0$ : thickness of the oxide layer [m]

$$\dot{q}_{ox} = -\frac{1+\frac{\vartheta_O}{\vartheta_M}\frac{M_O}{M_M}}{1+x_M\frac{\vartheta_O}{\vartheta_M}\frac{M_O}{M_M}}\ \frac{\Delta_f H^0}{M_{MOx}} x_M\ \rho_0\ \frac{dx_0}{dt} = k_{ox}\frac{dx_0}{dt}$$

With

$$\frac{dx_0}{dt} = \frac{k'(T)}{x_0} \text{ For adherent materials}$$

$$\frac{dx_0}{dt} = k'(T) \qquad \text{For non-adherent materials}$$

And

$$k'(T) = A_w e^{-\frac{E_a}{k_B T}}$$

With $A_w(T)\ et \frac{E_a}{k_B}(T)$ defined by the parameters *Aw* and *Ea_kB* of the material in the configuration file.

The mass flow or ablation produced for non-adherent materials only is:

$$\dot{m}_{ob} = -\frac{1}{1+\frac{\eta_O}{\eta_M} x_M \frac{M_O}{M_M}} \rho_0 \frac{dx_0}{dt} S_{exposed} = k_{oxMassFlowRate} \frac{dx_0}{dt} S_{exposed}$$

## 7.10 Survivability parameter

The survivability parameter is computed as follows:

$$< survivabilityParameter > = \frac{< demiseAltitude >}{< creationAltitude >} - \frac{< finalThermalMass >}{< initialThermalMass >}$$

## 7.11 Normal shutdown

To shut down the DEBRISK software, use the "Quit" function in the main menu, accessible in the top left-hand corner.

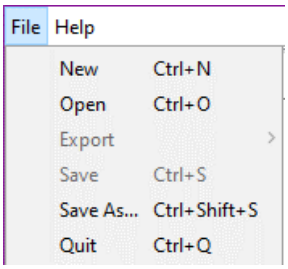



**Figure 65 Closing the software.**

If the results of any of the simulations defined have not been saved, a warning pop-up is displayed to the operator.

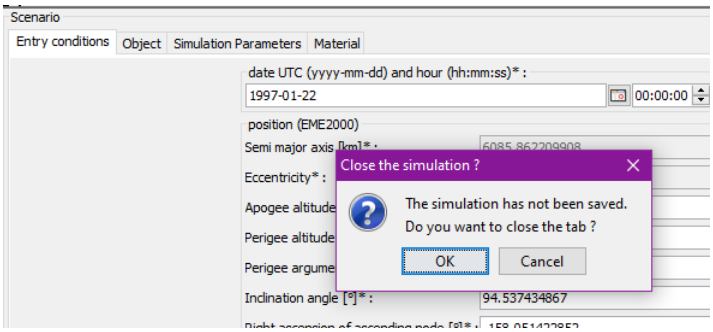



**Figure 66 Simulation not saved warning pop-up**

# 8 Error situation

Section 9.3 describes the possible error messages in DEBRISK according to their location or reason for being displayed, as well as the procedure to be applied in these cases.

## *8.1 Recovery procedures*

Similarly, section 9.3 describes the possible error messages in DEBRISK according to their location or reason for being displayed, as well as the procedure to be applied in these cases.

## *8.2 Java Virtual Machine (JVM) memory management*

The maximum memory size that the JVM allows DEBRISK will depend on several issues, mostly on the operating system (OS).

In particular, on Windows 32 bits, the JVM limits the maximum memory size for DEBRIK to about 300 Megabytes. When this limit is reached, the garbage collector is triggered in order to try to free some memory, and the DEBRISK application is slowed down.

It's somehow possible to handle the JVM in terms of memory allocation, via the following parameters:

-Xmx<size>: It allows defining the maximum memory size of the JVM.

-Xms<size>: It allows defining the memory size that will be allocated on JVM start.

The size is defined with a value and the units. For instance, to launch DEBRISK on a Windows 32 bits machine with a memory size of one Gygabyte, the command line would be:

java –Xmx1024m –Xms1024m –jar debrisk.jar

It's recommended to use the same value for the initially allocated memory (-Xms) and the maximum memory size (-Xmx). A minimum value of 1024m for both parameters is recommended when running on a Windows 32 bits architecture.

For further information on the management of memory by the JVM, please refer to the following link: http://docs.oracle.com/cd/E19563-01/819-4438/gavou/index.html

In order to monitor the current memory consumption, a dedicated area (called "Memory") has been included in the top for the main DEBRIK window. It is displayed in green when the consumed memory is below 75% of the available memory, in red if it is above 90% and orange otherwise.

When passing the mouse over this area, dedicated information is shown:

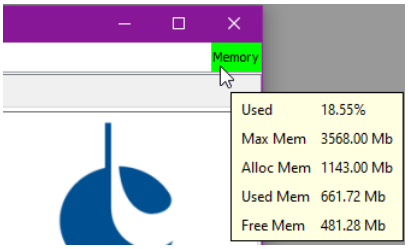



**Figure 67 Memory monitor**

Information included in this area includes:

- Used Memory (%): percentage defining the used memory with respect to the maximum available one
- Maximum Memory: it is the maximum quantity of memory to be dedicated to the current process
- Allocated Memory: it is the memory that has been allocated by the program in current run
- Used Memory: it is the real memory currently being used
- Free Memory: it is the current free memory (difference between the allocated and the used memory)

# 9 Reference manual

## 9.1 Introduction

Keyboard shortcuts in the main window can be used to access the different DEBRISK menus/options:

- ALT + F: pulls down the “File” menu
- CTRL + N: execution of the “New” menu
- CTRL + O: execution of the “Open” menu
- CTRL + S: execution of the “Save” menu
- CTRL + Q: execution of the “Quit” menu
- ALT + H: pulls down the “Help” menu
- F1: execution of the “Help-> Show help” menu
- CTRL + A: execution of the “Help->About” menu
- CTRL + W: closing of the active simulation tab

The following commands can be used in the window panes or forms:

- TAB: used to move from one field to the next
- Enter: is used to validate the form
- Esc: is used to close the current window pane
- F1: is used to display Help.

## 9.2 Definitions and operation of the monitor

The station must be equipped with a monitor with minimum resolution of 1280x1024.

## 9.3 Plate ablation

The ablation of the plate will be realised modifying the length and width of the plate but maintaining its thickness.

## *9.4 Error messages*

If the input parameters are not conforming to the use of the software, an error message is displayed. Input parameters are expected in the following cases:

- Entry of initial conditions
- Creation of objects
- Creation of a new material
- Reading of an input file

In addition, messages of the "operation" type can also be displayed.

### 9.4.1 Error messages when entering the initial conditions

When a field is not correct, the following message is displayed:

Error in one of the input fields: <errorMessage>

<errorMessage> can be:

- The initial date is not correct
- Fragmentation altitude should be between 70 km and 100km
- The eccentricity cannot be negative
- Inclination angle should be between 0° and 180°
- Impossible to create Orbit with these values

### 9.4.2 Error messages when creating an object

The creation of objects must be done according to certain rules (see chapter 7.5.1.3).

Failure to comply with these rules causes an error message in the input window as shown below:

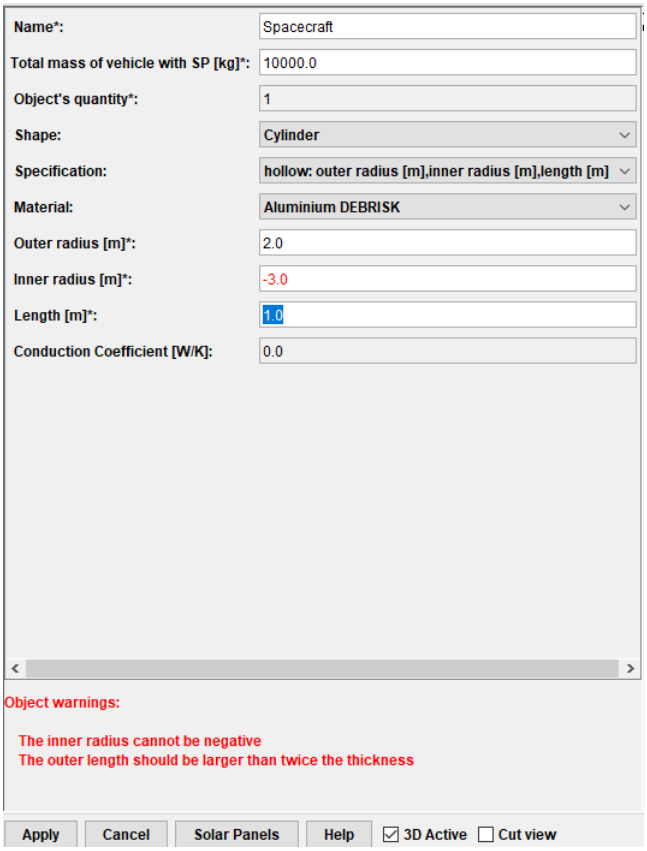



**Figure 68 Error message**

These messages are either generic (independent of the shape of the object):

- "Object name shall not contain '#'"
- "The volume cannot be negative"
- "The mass should be > 1e-10."
- "Invalid values found! <VALUES>."

This message means that the properties of the object are not physical. Here <VALUES> indicates the properties of the object so that the user can make the correction.

Depending on the shape of the object:

- Sphere:
  - “The inner radius cannot be negative.”
  - "The outer radius cannot be negative."
  - "The inner radius cannot be larger than 100m."
  - "The outer radius cannot be larger than 100m."
  - "The outer radius cannot be smaller than inner radius"
  - "The mass cannot be negative"
  - "The thickness cannot be negative"
  - "Resulting inner radius *(<VALUE>)* cannot be negative"
  - "Resulting outer radius (%s) cannot be larger than 100m"
  - "The mass cannot be greater that the equivalent solid sphere *(<VALUE> > <VALUE>)*.”

- Cylinder:
  - "The inner radius cannot be negative."
  - "The outer radius cannot be negative."
  - "The outer length cannot be negative."
  - "The inner radius cannot be larger than 100m."
  - "The outer radius cannot be larger than 100m."
  - "The outer length cannot be larger than 100m."
  - "The outer radius cannot be smaller than inner radius"
  - "The thickness cannot be negative"
  - "The mass cannot be negative"
  - "Resulting inner radius *(<VALUE>)* cannot be negative"
  - "Resulting thickness *(<VALUE>)* cannot be negative"
  - "The mass cannot be greater that the equivalent solid cylinder *(<VALUE> > <VALUE>)*."
  - "The outer length should be larger than twice the thickness"

- Box:
  - "The length should be larger than the width."
  - "The width should be larger than the height."
  - "The height should be larger than twice the thickness."
  - "The width cannot be negative."
  - "The mass cannot be negative"
  - "The thickness cannot be negative"
  - "The length cannot be negative."
  - "The height cannot be negative."
  - "The length cannot be larger than 100m."
  - "The width cannot be larger than 100m."
  - "The height cannot be larger than 100m."
  - "The mass cannot be greater that the equivalent solid box (<*VALUE*> > <*VALUE*>)."
- Plate
  - "The width cannot be negative."
  - "The length cannot be negative."
  - "The thickness cannot be negative"
  - "The mass cannot be negative"
  - "The width cannot be larger than 100m."
  - "The length cannot be larger than 100m."
  - "The length should be larger than the width."
  - "The thickness cannot be larger than 10% of the width. Please use a box instead."

- Complex
    - "The minor diameter cannot be negative"
    - "The major diameter cannot be negative"
    - "The height cannot be negative"
    - "The thickness (<VALUE> m) shall be less than 10.0% of the apothem (<VALUE> m)"
    - "The thickness cannot be larger than 100.0 mm"
    - "The mass (<VALUE> kg) cannot be negative";
    - "The height (<VALUE> m) cannot be larger than 100.0 m"
    - "The minor diameter cannot be larger than 100.0 m"
    - "The major diameter cannot be larger than 100.0 m"
    - "The volume (<VALUE> m3) shall be larger than 0 for complex shape”
    - "The angle (<VALUE> deg) shall be larger than 0"
    - "The angle (<VALUE> deg) cannot exceed 360.0 deg"
    - "The flatness (<VALUE>) shall be either 1 or 2 "
    - " The major diameter (<VALUE> m) cannot be smaller than the minor diameter (<VALUE> m)”
- Complex spherical
    - "The combination of the small diameter and thickness is such that the internal minor diameter is negative"
    - "h > sqrt(large_radius^2 - small_radius^2) (<VALUE> > <VALUE>) [m] "
- Complex conical
    - "The combination of the small diameter and thickness is such that the internal minor diameter is negative (<VALUE> m)"

- Tube
  - "The outer radius cannot be negative"
  - "The inner radius cannot be negative"
  - "The outer length cannot be negative"
  - "The outer radius cannot be larger than 1000000.0 m"
  - "The inner radius cannot be larger than 1000000.0 m"
  - "The outer length cannot be larger than 1000000.0 m"
  - "The outer radius cannot be smaller than inner radius"

### 9.4.3 Error messages when creating a new material

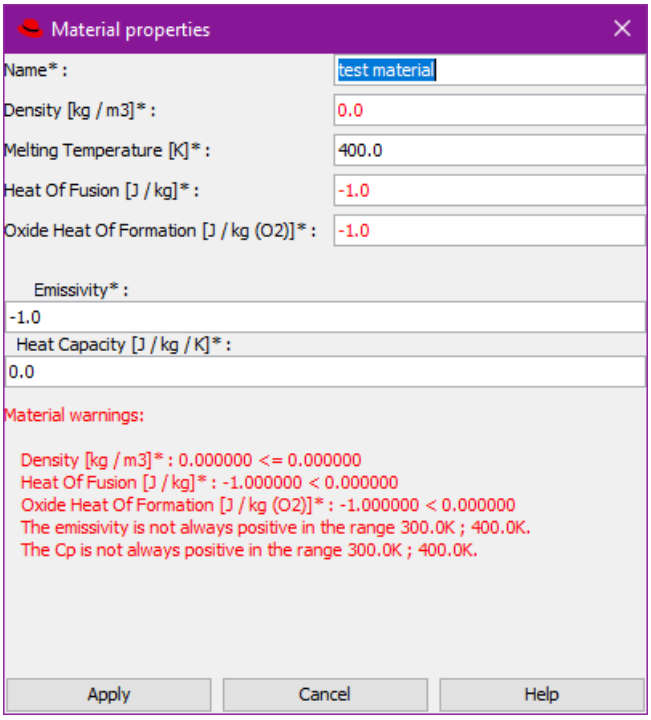



**Figure 69 Entry of a user-defined material**

If a mandatory field is not filled in, an error message is displayed:

“The following errors occurred:

<MSG>

You’ll have to correct the errors before you can continue.”

<MSG> can be:

- “A name should be specified”
- “This name already exists”
- “The density is not valid”
- “The melting temperature is not valid”
- “The heat of fusion is not valid”

- "The oxide heat of formation is not valid"
- "The emissivity is not valid"
- "The heat capacity is not valid"

If a negative emissivity or heat capacity is introduced by the user, the following error occurs:

"<MSG> Material Emissivity is not positive in all the temperature range."

If a negative heat capacity is introduced by the user, the following error is obtained:

"<MSG> Material Heat Capacity is not positive in all temperature range."

### 9.4.4 Error messages when reading an input file

If the format of the input file is not the expected format, an error message is displayed.

"<MSG> Check the log file for more details".

<MSG> depends on the exception type. The possible exceptions and the corresponding message are listed below:

- CVSFileException: "Error reading/writing CSV file: <ERROR> (<file_path>)"
- InvalidDasFileException: "This is not a valid DAS file (<file_path>). Operation aborted."
- InvalidDebriskDirectoryException: "The installation directory does not contain the necessary files. Please check the installation files and restart. Debrisk will quit now."
- InvalidUserMaterialFileException: "The user defined materials file is not valid (<file_path>). Operation aborted."
- InvalidXMLFileException: "This is not a valid Debrisk XML file (<file_path>). Operation aborted."
- KMLFileException: "Error reading/writing KML file: <ERROR> (<file_path>)"
- OrekitConversionException: "Cartesian conversion error. Operation aborted."
- OrekitNotInitializedException: "Orekit not initialised. Operation aborted."
- TecplotFileException: "Error reading/writing Tecplot file: <ERROR> (<file_path>)"
- XMLFileException: "Error reading/writing xml file: <ERROR> (<file_path>)"
- ZipFileException: "Error reading/writing zip file: <ERROR> (<file_path>)"

### 9.4.5 Operation error messages

- If the simulation exceeds 1000000 seconds, the following message is displayed:

  "Simulation took more than the max duration (xxx s)."

- During an export, if the output file already exists but is not accessible (rights), the user is warned by the following message:

  "The file to write to already exists but it cannot be deleted. Please check the permissions on this file and try again."

- When an attempt is made to import a simulation when the current tab already contains data, the following message is displayed, and the simulation is loaded in a new tab:

  "Current tab already contains data; data will be stored in new tab."

- If the user tries to add an object at the root of the tree when a spacecraft already exists (there can only be one spacecraft), the following message is displayed:

  "You can't add a spacecraft: please first select the spacecraft item in object list if you want to add children or edit the current spacecraft."

- If a simulation loaded from a file contains unknown materials, the following message is displayed:

  "Cannot create material of type <MATERIAL_TYPE>.

  Properties will be taken from titanium."

- When loading a DAS file, the following message may be displayed if certain materials are not recognised:

  "DAS file contains n entries.

  <NB> unknown materials found.

  Please check your table for unknown materials,

  They currently have the same thermal properties as Titanium."

- When a problem is detected during the propagation of an object, this object is shaded in the interface and the user is warned by the following message at the end of the simulation:

  "The computation has ended but n object(s) could not be computed correctly.

  These objects are indicated in grey."

  Here, "n" indicates the number of objects in error.

  To find out the details of the errors, the user must do an XML export ("save" option) and look up the file generated. This contains, for each calculated object ("<object>" tag), a "results" tag containing the calculation results for this object. Inside, a "<stopReason>" tag gives a description of the error which caused the simulation of this object to stop.

Errors of the "abnormal" type may also occur:

- If the user presses F1 to display Help and the user's manual has not been found in the DEBRISK installation directory, the following message is displayed:

  "The document DBK-MU-LOG-0268-GMV.pdf could not be found. (Help unavailable)"

- If the files required for the operation of DEBRISK, and usually located in the directory containing the DEBRISK executable file, are not found, the following message is displayed:

  "The installation files have not been found.

  Those files should be in the directory where the debrisk.jar is installed.

  In your case this is <installationDirectory>

  For the current execution only, you'll be asked to select the directory where the installation files are located."

Messages of the "internal" type may also be displayed: They start with "Internal error" and indicate a malfunction of the application (case not managed by the application).

Confirmation messages can also be displayed if the program has to delete or replace an existing file.

## 9.5 3D View configuration

The 3D view configuration colours can be configured by the user through the *dirPath.properties* file that is located in the installation directory after loading or saving a configuration.

The 3D view is activated by default, if the program does not work correctly using the 3D view (graphic card problem, etc) the 3D view can be deactivated manually by editing the *dirPath.properties* manually and setting the value of the property *isUse3DActivated* to *false*.

The following values can be modified to configure the 3D view:

| Key | Value | Range |
|---|---|---|
| isUse3DActivated | Selects if the 3D View is active | [true, false] |
| view3D.backgroundRed | Background red channel value | [0.0, 1.0] |
| view3D.backgroundGreen | Background green channel value | [0.0, 1.0] |
| view3D.backgroundBlue | Background blue channel value | [0.0, 1.0] |
| view3D.outerSurfaceRed | Shape's outer surface red channel | [0.0, 1.0] |
| view3D.outerSurfaceGreen | Shape's outer surface green channel | [0.0, 1.0] |
| view3D.outerSurfaceBlue | Shape's outer surface blue channel | [0.0, 1.0] |
| view3D.outerSurfaceAlpha | Shape's outer surface alpha channel | [0.0, 1.0] |
| view3D.innerSurfaceRed | Shape's inner surface red channel | [0.0, 1.0] |
| view3D.innerSurfaceGreen | Shape's inner surface green channel | [0.0, 1.0] |
| view3D.innerSurfaceBlue | Shape's inner surface blue channel | [0.0, 1.0] |
| view3D.innerSurfaceAlpha | Shape's inner surface alpha channel | [0.0, 1.0] |
| view3D.borderSurfaceRed | Shape's border surface red channel | [0.0, 1.0] |
| view3D.borderSurfaceGreen | Shape's border surface green channel | [0.0, 1.0] |
| view3D.borderSurfaceBlue | Shape's border surface blue channel | [0.0, 1.0] |
| view3D.borderSurfaceAlpha | Shape's border surface alpha channel | [0.0, 1.0] |
| view3D.complexBorderSurfaceRed | Complex shape's border surface red channel | [0.0, 1.0] |
| view3D.complexBorderSurfaceGreen | Complex shape's border surface green channel | [0.0, 1.0] |
| view3D.complexBorderSurfaceBlue | Complex shape's border surface blue channel | [0.0, 1.0] |
| view3D.complexBorderSurfaceAlpha | Complex shape's border surface alpha channel | [0.0, 1.0] |

The other values in the *dirPath.properties file* are managed internally by *DEBRISK* and shall not be modified.

# 10 Tutorial

## *10.1 Introduction*

The purpose of this part is describing briefly the general operation of DEBRISK; it proposes a typical case of object creation and the creation of result files.

## *10.2 Starting up*

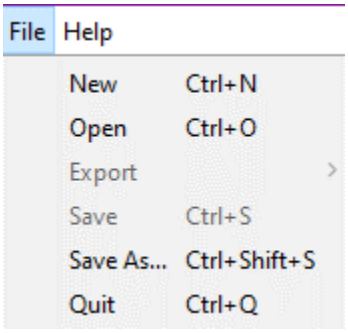



**Figure 70 Menu**

The following functions can be accessed from the *File* menu, in the top left-hand corner of the screen:

"New": this creates a new tab in which you can create or open a new case to be studied.

"Open": is used to open a previously saved study case.

"Export": is used to export files to other software packages (Tecplot, Google Earth, CSV).

The *Tecplot*, *Google Earth* and *CSV* files will be encoded following the UTF-8 format. Hence, in order to be able to read it properly, you must use a text editor compatible with UTF-8 (such as notepad++, for instance).

If we want to import the file in Excel or any other program, you must indicate during this process that the file is encoded in UTF-8 format. The parameters contained in these files are detailed below:

- CSV file

The CSV file contains a header with the name, date of creation, version of DEBRISK and mode (SCI or LOS). This header is then followed by the data:

| Parameter | Units |
|---|---|
| Parent id | -- |
| Id | -- |
| Name | -- |
| Quantity | -- |
| Shape | -- |
| Material | -- |
| Initial altitude(m) | m |
| Initial mass(kg) | kg |
| Rout/Height(m) | m |
| Rin/Width/Rsmall(m) | m |
| Length/Rlarge(m) | m |
| Thickness(m) | m |
| Angle(deg) | deg |
| Cb_intial(kg/m2) | kg/m2 |
| Stop reason | -- |
| Demise altitude(m) | m |
| Impact mass(kg) | kg |
| Final Rout/Height(m) | m |
| Final Rin/Width/Rsmall(m) | m |
| Final Length/Rlarge(m) | m |
| Final Thickness(m) | m |
| Final angle(deg) | deg |
| Cb_onGround(kg/m2) | kg/m2 |
| Impact energy(J) | J |
| Cross section area(m2) | m2 |
| Total casualty area(m2) | m2 |

| Parameter | Units |
|---|---|
| Weighted casualty area(m2) | m2 |
| Initial CCond(W/K) | W/K |
| Final CCond(W/K) | W/K |
| End temperature(K) | K |
| Max temperature(K) | K |

- Tecplot file

The first lines of the Tecplot contain the name, date of creation, version of DEBRISK and mode (SCI or LOS). Then, the Tecplot files contains the following data:

| Parameter | Units |
|---|---|
| time(s) | s |
| altitude(m) | m |
| longitude(deg) | deg |
| latitude(deg) | deg |
| azimuth(deg) | deg |
| velocity(m/s) | m/s |
| velocityInertial(m/s) | m/s |
| acceleration(m/s2) | m/s2 |
| flowRate(kg/s) | kg/s |
| downRange(km) | km |
| localDownRange(km) | km |
| downRangeShortest(km) | km |
| FPA(deg) | deg |
| extTemperature(K) | K |
| extDensity(kg/m3) | kg/m3 |
| extPressure(Pa) | Pa |
| Mach | -- |

| Parameter | Units |
|---|---|
| Knudsen | -- |
| aerodynamicMass(kg) | kg |
| thermalMass(kg) | kg |
| kineticEnergy(J) | J |
| referenceAeroArea(m2) | m2 |
| referenceThermalArea(m2) | m2 |
| radiationArea(m2) | m2 |
| outerArea(m2) | m2 |
| wallTemperature(K) | K |
| Cd | -- |
| dragForce(N) | M |
| ballisticCoefficient(kg/m2) | kg/m2 |
| QconvColdWall(W/m2) | W/m2 |
| Qconv(W/m2) | W/m2 |
| Qoxidation(W/m2) | W/m2 |
| QradGain(W/m2) | W/m2 |
| QradLoss(W/m2) | W/m2 |
| Qcond(W) | W |
| Qnet(W/m2) | W/m2 |

“Save": is used to save the case being studied by including the list of objects and the initial conditions.

“Save As”: is unsed to save the case being studied under another name.

“Quit”: is used to close the software.

Entry conditions:

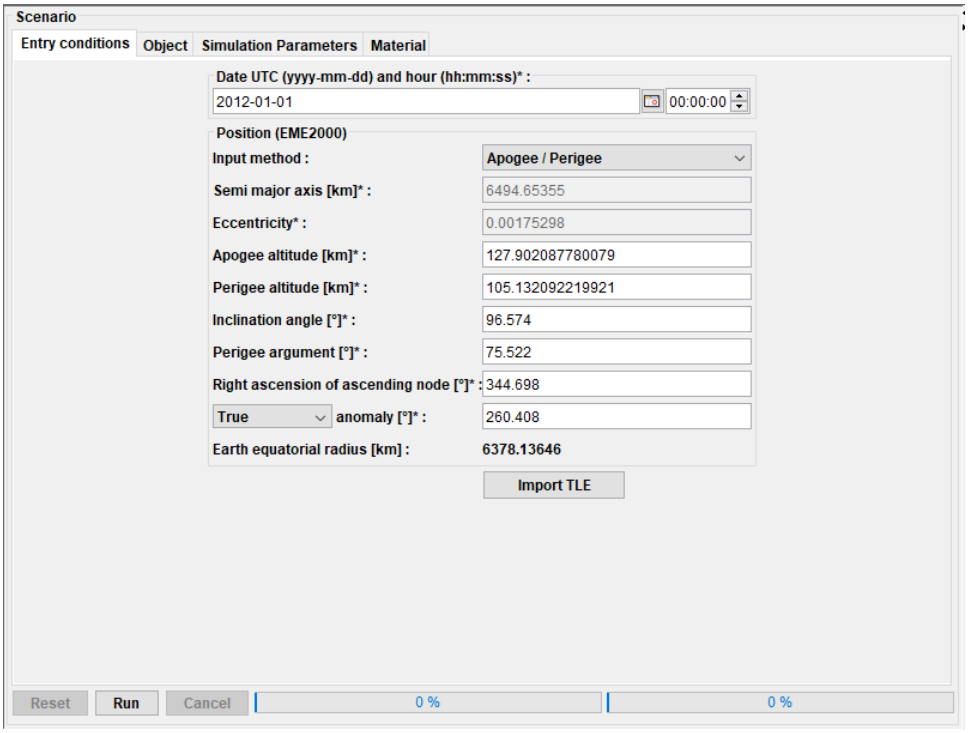



**Figure 71 Entry conditions**

### 10.2.1 Scenario area

You will find various tabs in this area. The first one, named “Entry conditions”, must be filled in with the general parameters of the entry point corresponding to the kinematic conditions of the spacecraft to be studied. The parameters to be entered are the parameters of the Keplerian orbit of the spacecraft object.

#### 10.2.1.1 Object tab

The object tab allows you to add new objects using the *Add* button, to edit some objects already created using the *Edit* button, to duplicate objects using the *Duplicate* button or to delete others using the *Delete* button.

When clicking on “Duplicate”, the whole group of children, grandchildren… of the selected object will also be duplicated.

In the left part, you can see a tree representing the overall structure of the case you are about to simulate. The indentation of the elements in this tree shows the parent-child links existing between the different objects.

To add an object, select a parent object in the tree or the table and click on the *Add* button. A new window is displayed.

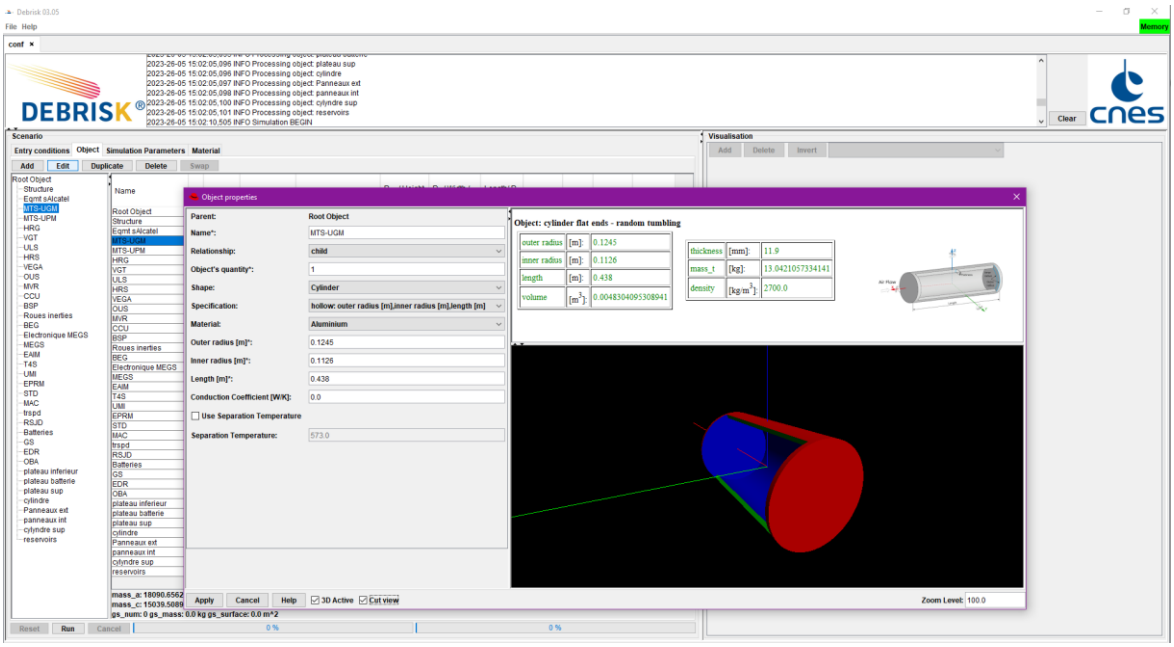



**Figure 72 Creating an object.**

In this window, you are asked to enter the following elements:

- object name
- Relationship. This parameter allows to define if the new object is a standard “child” or a “component” of the parent object.
- Quantity of fragments. This parameter is used when the operator wants to define several fragments with the exact same characteristics. Even if Q>1, a single simulation will be run for the fragment. This value will only be used to compute the aerodynamic mass of an object having children with Q/=1 and for the casualty area (which will be computed as the casualty area of the simulated fragment multiplied by Q).
- selection of the object shape
- selection of the mode for entry of the dimensions of the object according to the data at your disposal. All the other data will be calculated by DEBRISK so that they correspond to the data provided by the user.
- The material of the object to be selected in the list.
- Dimensions to be complemented according to the mode selected beforehand.
- Conduction coefficient.

Please note that the first object in the list is always a spacecraft, while the others are always fragments.

Solar panels can be added on the space object, modelled only by a box, a cylinder or a sphere, using the “solar panels” button, which is only displayed on the window for this object.

#### 10.2.1.2 Materials tab

In the materials tab, you will find the properties of the various materials used in the simulation. This includes the following parameters for each material:

- density in $kg/m^3$
- heat of fusion in J/kg
- melting temperature in K
- oxidation heat in J/kg ($O_2$)

#### 10.2.1.3 Viewing area

The viewing area is in the right part of the interface. It is used to analyse the evolutions of the various parameters during the simulation. The results are presented in five types of predefined graphs:

- altitude vs. time
- thermal mass vs. time
- thermal mass vs. altitude
- altitude vs. downrange
- temperature vs. time

In the table on the left, the columns have been modified to present a summary of the state at the end of the simulation for each object. We then find:

- the quantity of fragments
- the object destruction altitude: the cell is coloured in red if the object is not destroyed, and in green if it does not reach the ground. In case of error during the calculation, this cell is shaded (see §9.3).
- the energy on impact: the cell is coloured in red if the energy on impact is higher than 14J, in yellow if it is lower or equal, or in green if the object does not reach the ground. In case of error during the calculation, this cell is shaded (see §9.3).

- the casualty area in the case of an object which reaches the ground (sum of all the fragments if the quantity is > 1).
- The initial aerodynamic mass
- the final aerodynamic mass
- the percentage of aerodynamic mass left
- maximum surface used for the calculation of the casualty area
- the maximum temperature
- the final temperature

The user can switch between the views of the object panel (before/after execution) by clicking on the "Swap" button.

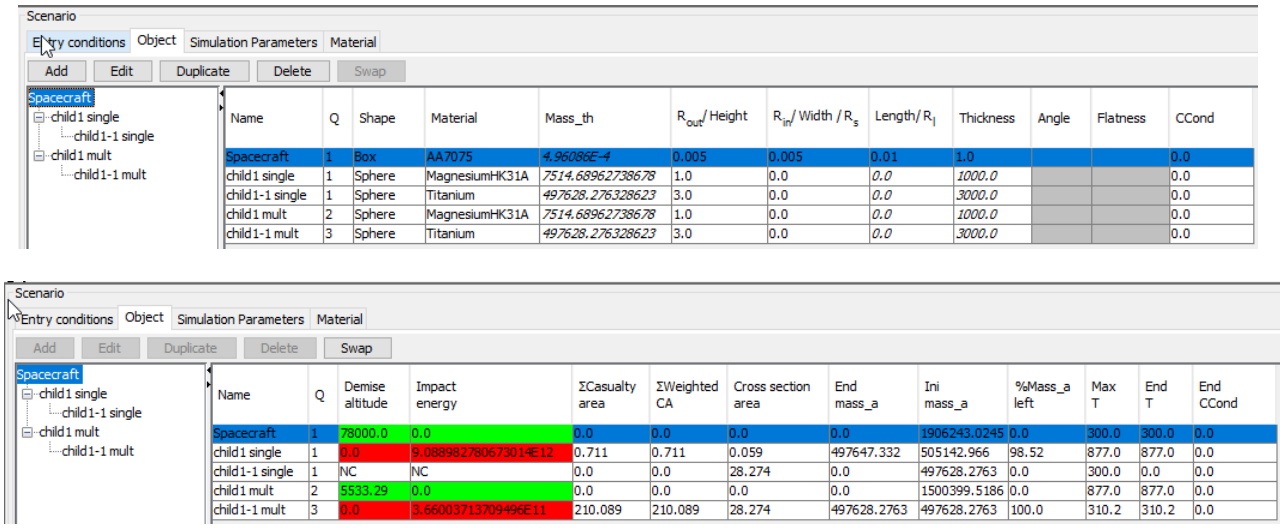



**Figure 73 Swap objects table view**

Below the objects table we will find an entry where the total casualty area (corresponding to the addition of the casualty area of all the fragments) will be displayed, the value will only be displayed when an execution has been done and removed when the simulation is reset:

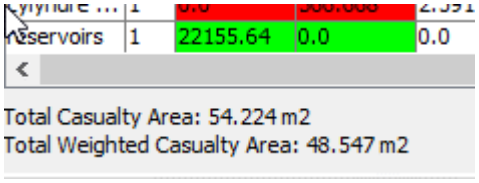



**Figure 74: Total casualty area value after an execution.**

## *10.3 Using the software for a typical task*

### 10.3.1 Creation of a simulation and result files

From the *File* menu, in the top left-hand corner of the screen, click on the "New" tab: this creates a new tab in which you can create or open a new case to be studied.

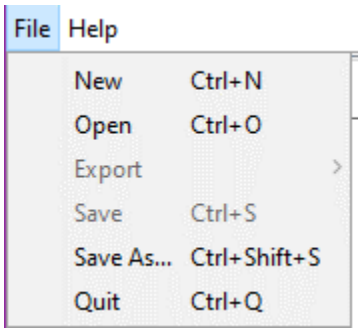



**Figure 75 Menu**

You will find various tabs in this area. The first one, named "Entry conditions", must be filled in with the general parameters of the entry point corresponding to the kinematic conditions of the spacecraft to be studied. The parameters to be entered are the parameters of the Keplerian orbit of the spacecraft object.

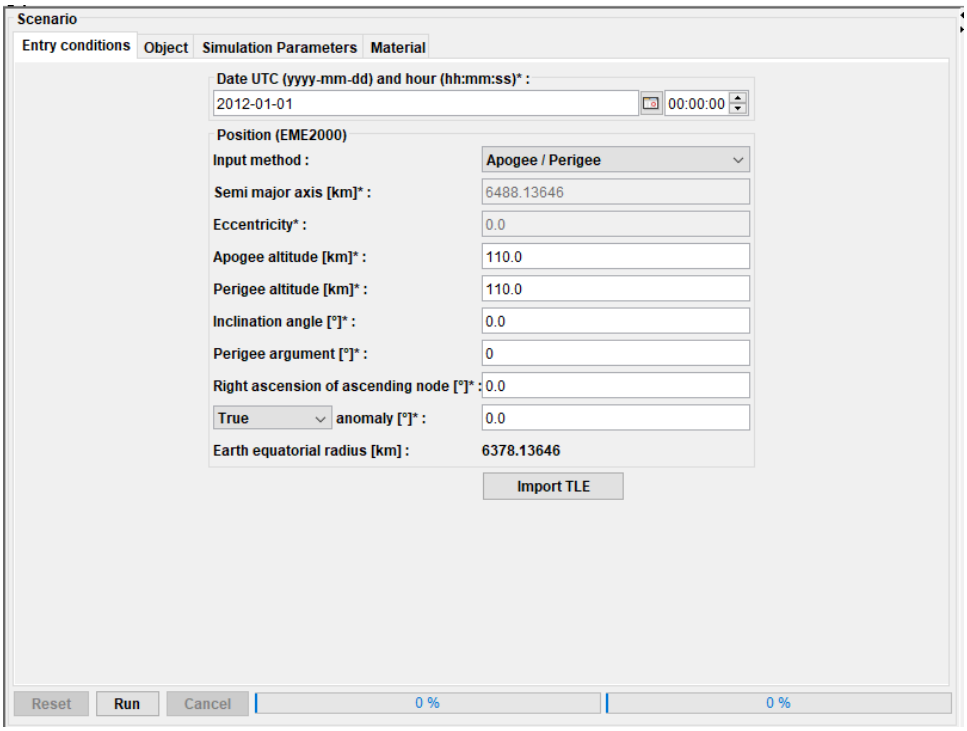



**Figure 76 Entry conditions**

Click on the *object* tab, and then on the *Add* button; a new window is displayed:

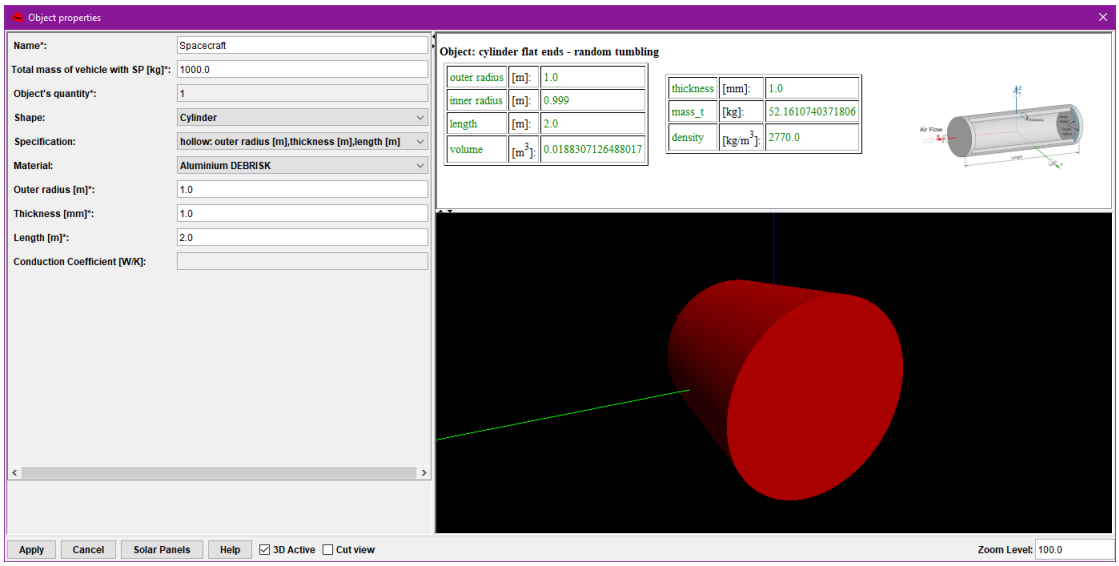



**Figure 77 Creating a spacecraft.**

- Enter the outer radius, for example 1m.
- Enter the thickness of the cylinder, for example 1mm
- Enter the length, for example 2m
- Enter the aerodynamic mass, for example 1000kg

Press “apply”, and then again on the *object* tab, and on the *Add* button to create a child object.

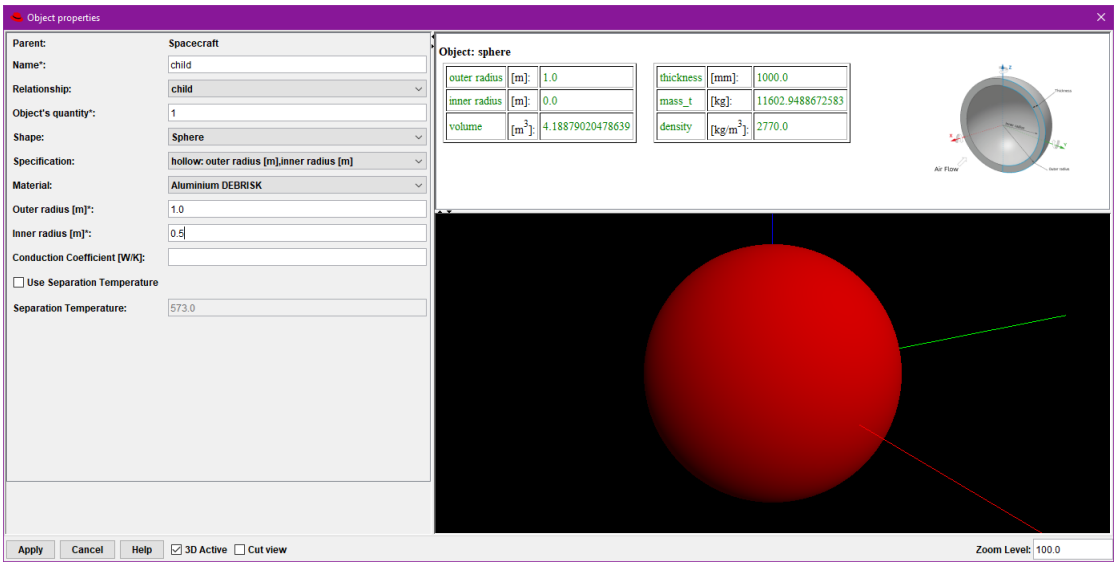



**Figure 78 Creating a child object.**

- Enter the outer radius, for example 1m.
- Enter the inner radius, for example 0.5m.

Then press “apply”

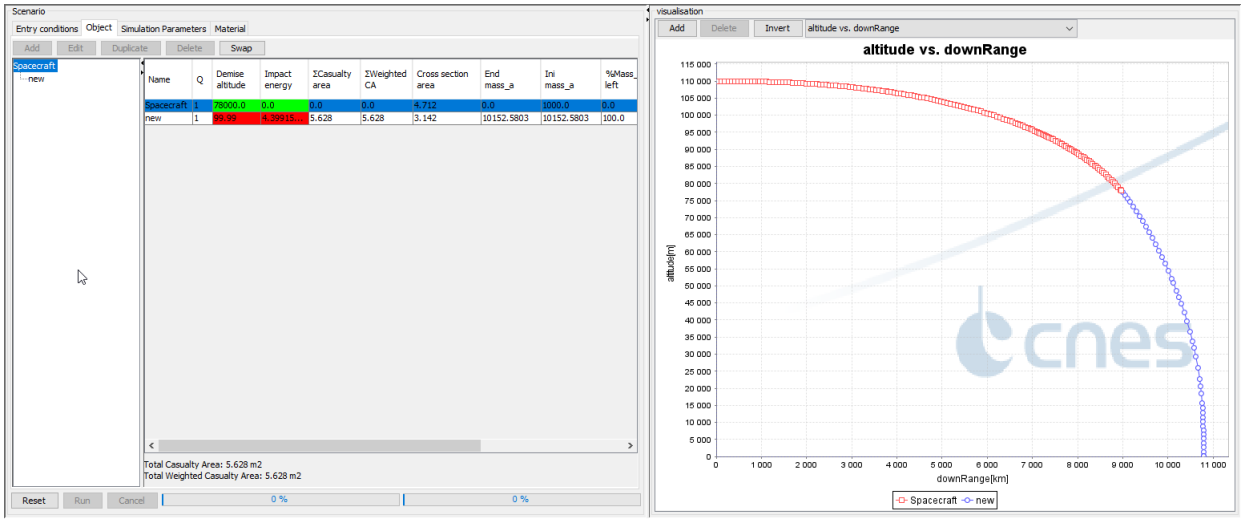



**Figure 79 Results and viewing area.**

Press “Run” to launch the simulation; you will see a graph displayed in the right part of the screen.

To save the simulation, different formats are available (Flat XML, Tecplot, Kml, CSV). To create one of these files, click on the File menu in the top left hand corner of the screen, click on the “Export” tab and select the desired format. It is possible to save all files at once by clicking on the “Zip” tab.

Name the file, then using the drop-down menu, choose the folder where you want to save the file. Note that the folder proposed by default is the last one used in DEBRISK.

Press “Save” to save the file in the folder you have chosen.

During the export of the file, the following pop-up will be displayed (a similar pop-up window is shown whatever the exported file is):

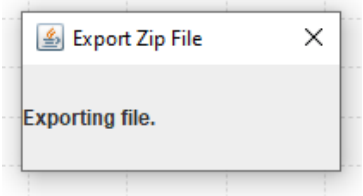



**Figure 80 Export file pop-up**

The flatXML, KML and XML file will be encoded following the UTF-8 format. Hence, in order to be able to read it properly, you must use a text editor compatible with UTF-8 (such as notepad++, for instance).

If we want to import the file in Excel, you must indicate during this process that the file is encoded in UTF-8 format.

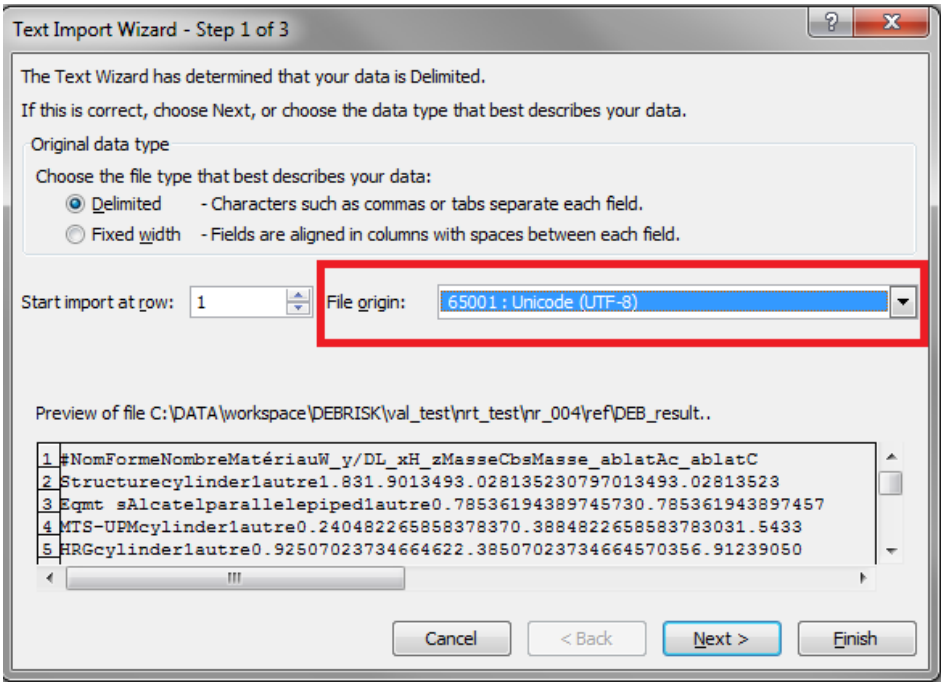



**Figure 81 Importing a file encoded following the UTF-8 format in Excel**