Appendix R

pyTCDT (TCDT 2.0)
A flexible and scriptable toolbox for thermal analyses.

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Abstract

The tool provide users an integrated environment with analytical functions, ARTIFS and TOPIC integration, array function execution, editors, plotting and scripts management. As the name suggest it is implemented in Python so it will be available for different platforms and its distribution will be simplified wrt version 1.X.

Thermal Concept Design Tool (pyTCDT)

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Sheet 1

Overview

- **Why a New Tool**
- **Version 2.0: pyTCDT**
- **Simple example**
- **Future Developments**
- **Video Examples**

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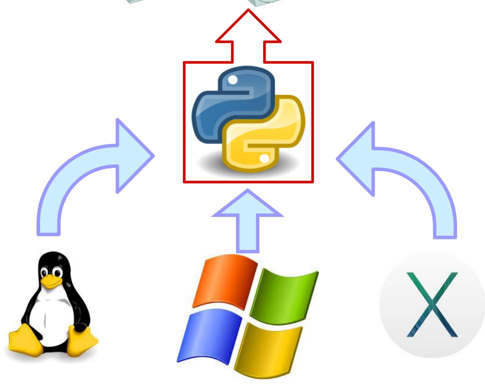
Version 2.0: Why a New Tool

Keywords:

Stand Alone	Multiplatform	Maintainable
Parametric	Scriptable	Pythonic

- **Useful features from old version**
  - THECAL functions.
  - User extendibility.
  - ARTIFIS/TOPIC integration.
- **Upgraded features**
  - Simplified distribution & installation.
  - Simplified maintenance.
- **New features**
  - Unit of measure management.
  - Automatic function iterations.
  - Fluids Properties library.



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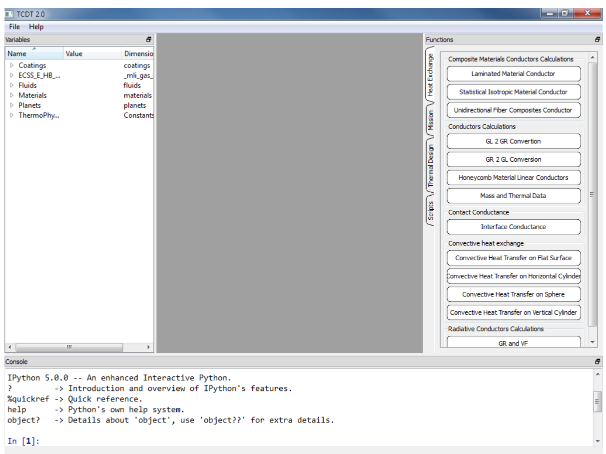
Version 2.0: pyTCDT (1)

- Useful thermal design and analysis functions are included into a stand alone computing environment.
- Operated by using GUI or by command line in the embedded console.
- Complex problems can be solved combining THECAL functions in user scripts.



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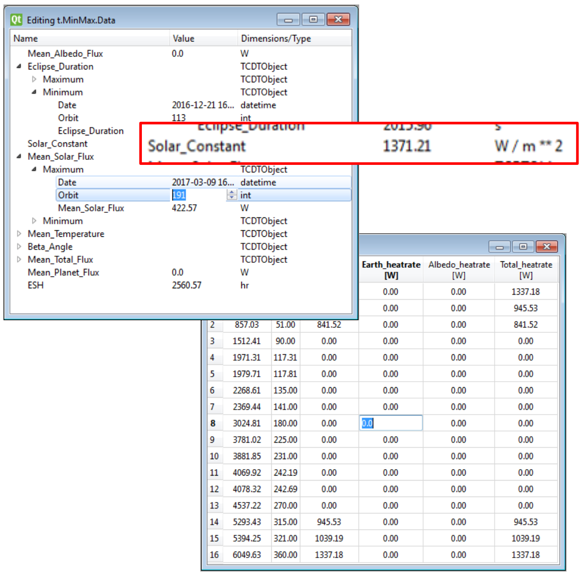
Version 2.0: pyTCDT (2)

- TCDT Parameters are quantities, they may contains unit of measure information (dimension).
- Parameters values can be converted in any compatible unit of measure included in the toolbox.
- Parameters can contains single or multiple values, of the same unit.
- Operators can be applied to parameter in the usual way, the unit of measure of the result will be generated according the operation (*e.g. 1 joule / 2 seconds = 0.5 watt*).



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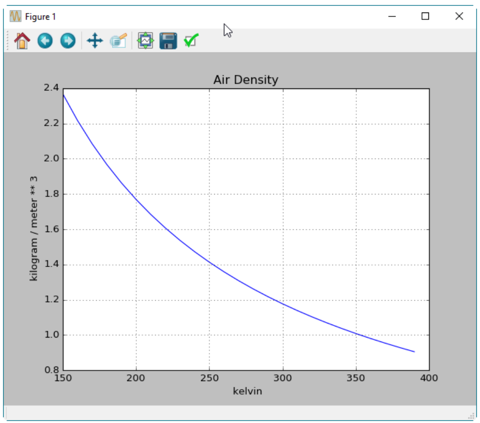
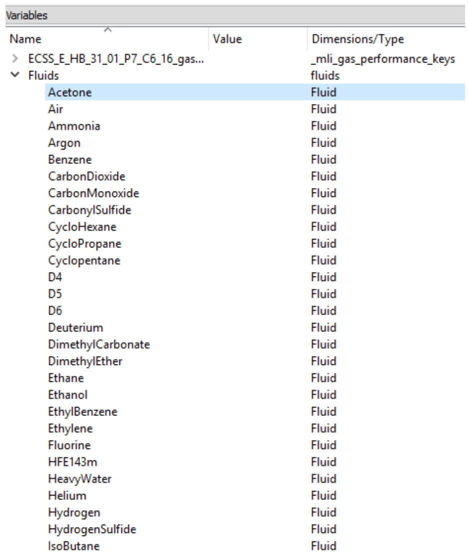
Version 2.0: pyTCDT (3)

- Pure Fluids objects derives their properties directly using Coolprop library, included in the distribution





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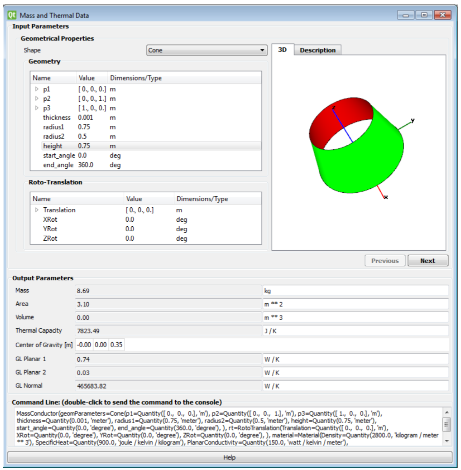
Version 2.0: pyTCDT (4)

- Functions user interface can accept single values or arrays.
- Unit of measure conversions can be performed within the GUI.
- Function widgets contains graphical aids to help user to input correct data.
- Each input parameter can be evaluated by a formula typed directly in the input textbox.
- Widgets shown the function call command line, completed with all required input parameters.



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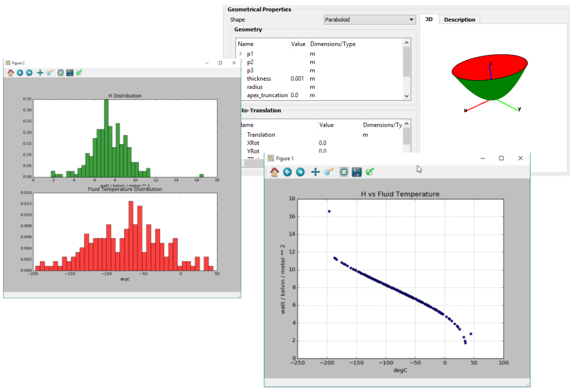
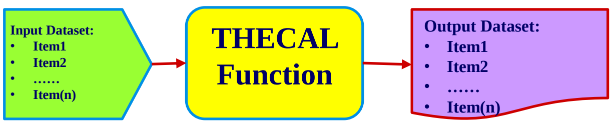
Version 2.0: pyTCDT (5)

- Data can be shown in 2D/3D plots or 3D views.



- Functions can be used in stochastic and sensitivity analyses.



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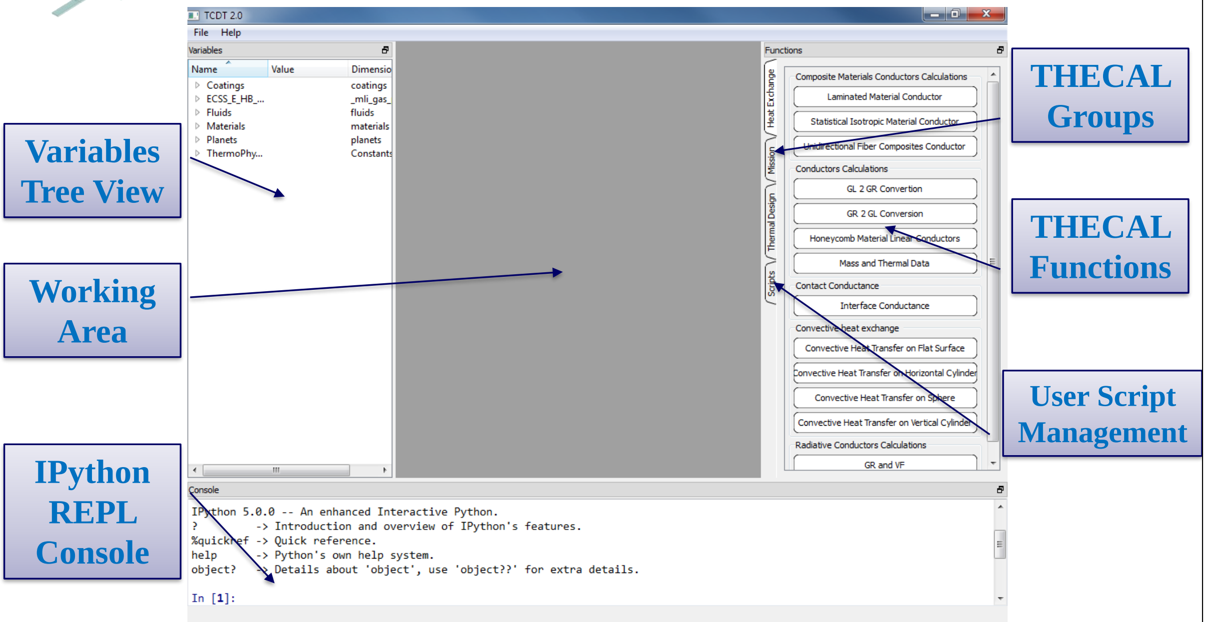
New User Interface



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Thermal Analysis Calculator Functions List

- Mission related calculations:
  - Eclipse Calculator
  - ARTIFS manager
  - TOPIC manager
- Linear Conductor calculations:
  - Laminated Material GL
  - Isotropic Material
  - Unidirectional Fiber Composites
  - Honeycomb Material **(with thermal network generation)**
  - Bulk Material
- Radiative Conductance
  - GR and VF
- Contact Conductance
  - Bolt
  - Interface
- **Convective Heat Exchange**
  - **General Inclined Flat Surface**
  - **Horizontal Cylinder**
  - **Vertical Cylinder**
  - **Sphere**
- Thermal Design
  - Define Battery
  - Solar Array Power
  - Solar Array Size
  - MLI Performance
  - **MLI ECSS Gas Performance**

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Example (1) Problem definition

Find the best honeycomb thickness (*tk*) of a panel of 0.2X0.2 m^2:

- painted with a external coating (ε = 0.9).
- exposed to Space (T_{space} = 3 K).
- internal temperature of T_{req} = 20 °C.

Requiring:

- A maximum heater power of 13.7 W on internal plate.
- A maximum panel weight of 0.35 Kg.
- Honeycomb thickness shall be between 15 and 150 mm.

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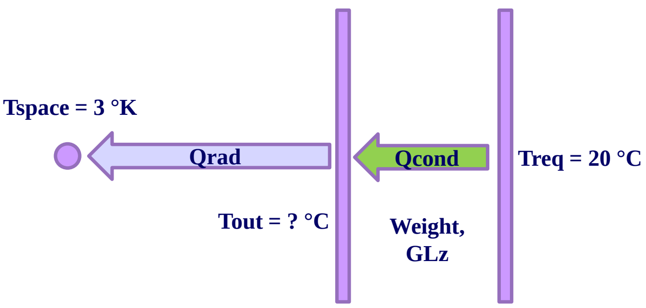
Example (2) Mathematical Model



Heat Balance:

$$Qrad = Qcond$$

So:

$$\sigma \varepsilon A(Tout^4 - Tspace^4) = GLz(Treq - Tout)$$

Where *GLz* is evaluated by THECAL HoneyComb function according *tk*

Choose *tk* → Evaluate *GLz* and Weigth → Compute *Tout* → Evaluate *Qcond*

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Example (3)
Solution with pyTCDT

Create a script with 2 functions:

- *HCData(Epsilon, Tspace, Treq, Tk, L, W)*: Solve the mathematical problem and return HC weight and flux
- *OptimHC(testThicknessArray, maxweight, maxheat)*: find the optimal value, thickness range where the requirements match and generate reporting plots.

Launch Script in pyTCDT Console

Console

```
In [3]: Optimization.OptimHC([x/10 for x in range(150,1500,1)],0.35, 13.7)
Out[3]:
BestT = Quantity(73.2, 'millimeter')
MaxTk = Quantity(85.7, 'millimeter')
MinTk = Quantity(60.7, 'millimeter')

In [4]:
```

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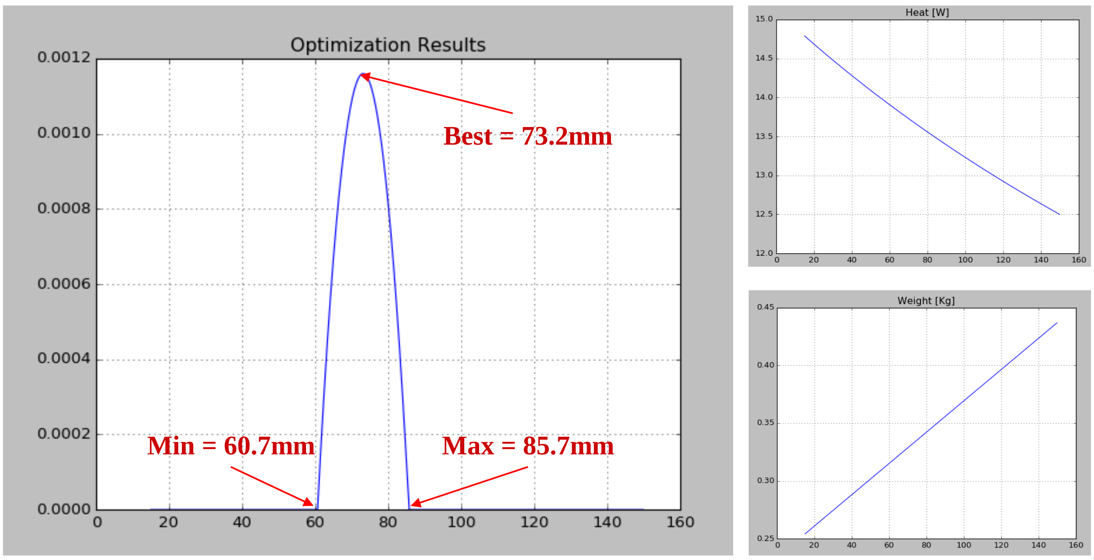
Example (4)
Results



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Road Map

- pyTCDT will be released to ESA before the end of October 2016.
- TCDT web site will be updated with new user agreement and new download link.
- pyTCDT will be release to the community after ESA approval, TCDT users that have an account will be notified with an email.

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Possible Future Developments

- New THECAL Functions
  - Forced convection heat exchange.
  - Heat fluxes computation for complex shapes.
  - GUI Auto generation for user defined functions.
- Management of a thermal model
  - Build and edit a model.
  - Import/export in ESATAN TMS format (including GMM).
  - Simplified solver for thermal network.
- Optimization features
  - Latin hypercube matrix generation.
  - Stochastic optimization engine.
  - Allow numpy tensors

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Video example

- Using TCDT Function GUIs
- Using the TreeView and the Console
- Settings and Scripting
- Vectorial Functions
- TCDT Data Structures

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Save the attachment to disk or (double) click on the picture to run the movie.

TCDT Team

DISTRIBUTION & MAINTENANCE

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WEB: www.blue-group.it/TCDT

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