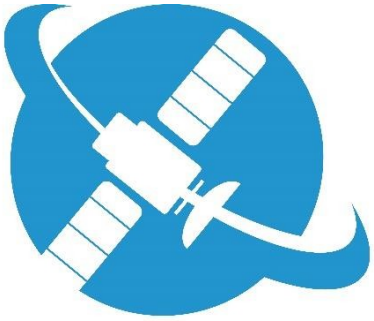


CUBESAT WIZARD

AD ASTRA PER ASPERA

Application Guide Manual

Installation + Tutorial

(Version 1.0)

www.cubesatwizard.com

Developed by: CubeSat Wizard Team

Intro to CubeSat Wizard APP

This is a MATLAB based App that can be used for Thermal Analysis and Power Generation Calculations for CubeSats in Low Earth Orbit (LEO). It is a freeware simulation software that is developed to facilitate CubeSat missions originating from different parts of the world. Provided the given inputs in terms of the structure surface properties, thermal properties and orbital parameters, the App simulates the results for Orbital propagation, Thermal Analysis and Power Generation for a specific period of time as well as for a specific Day of Interest. Under orbital propagation, RAAN angle, Beta angle, altitude evolution over the time frame is simulated. For Thermal Analysis, the App presents results for the Thermal loading at each face as well as the overall Thermal load determined for the whole CubeSat. Results for Temperature evolution over the orbits is also illustrated. The App also simulates Power Generation results of the CubeSat for one orbit as well as for the entire mission based on the No. of days selected. All simulation results are simulated on the basis of Theta angle from Orbit Noon. However, the CubeSat Wizard team is working on to enhance the App by providing alternative option of simulation based on True Anomaly as well as provide results for attitude propagation.

Installing CubeSat Wizard APP

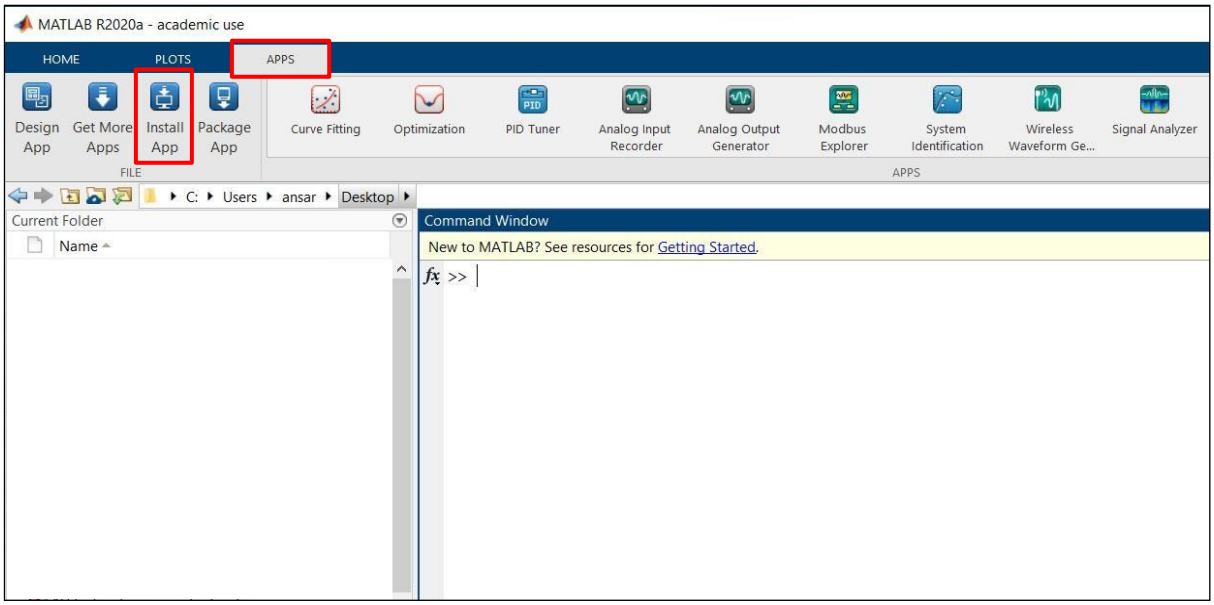
This App is a FREE simulation software that can be downloaded directly from the CubeSat Wizard official website. Below is the complete guideline on downloading and installing the CubeSat Wizard App software.

Note: To install and run this App, make sure to have MATLAB installed in your computer

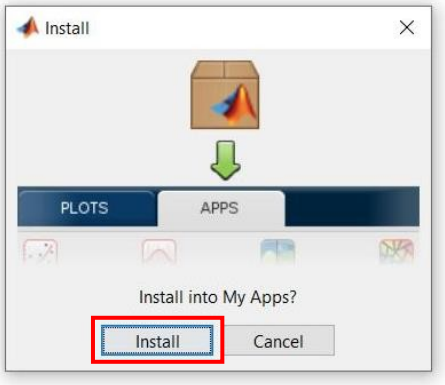
Installation Guidelines:

1. Go to our website: https://cubesatwizard.com/
2. At bottom of the page, click on "**CubeSat Wizard App v1.0**" to download the App.

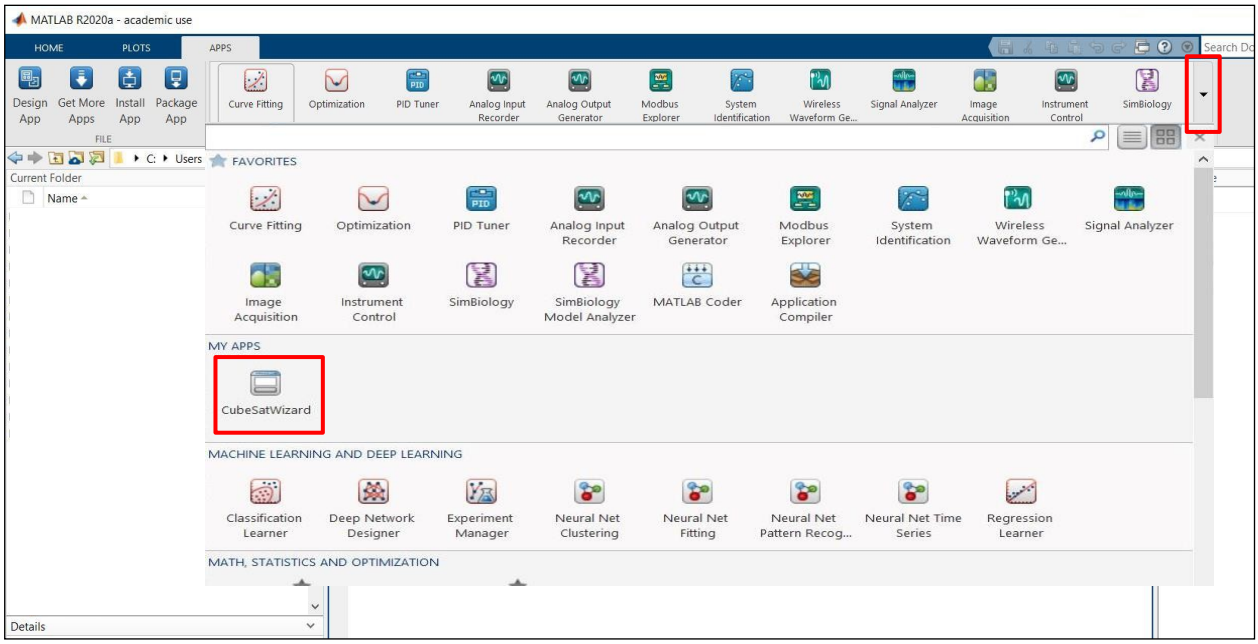
3. Once downloaded, extract the App from the compressed folder.
4. Open MATLAB software in your computer.
5. On the top menu bar, click on "APPS", then click on "Install App"



6. Browse the computer and open the downloaded app file. Click “Install”.



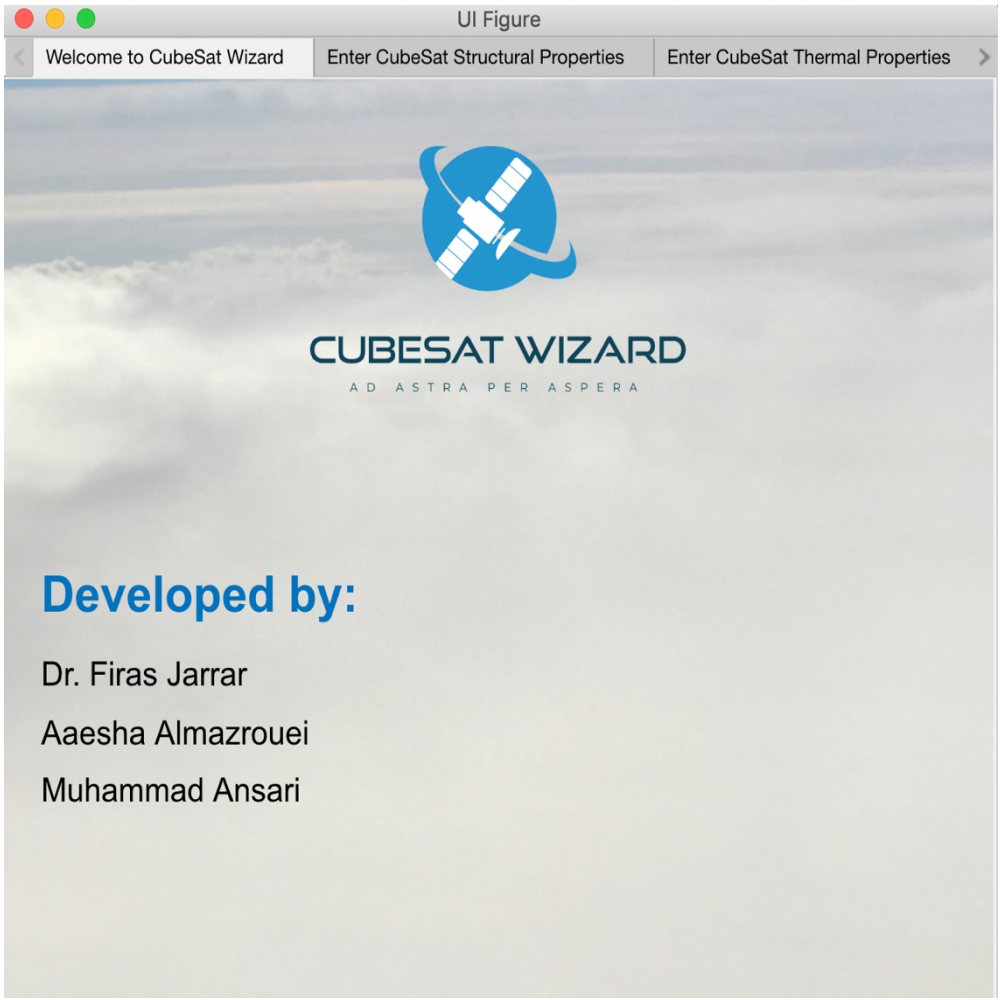
7. Once the App is successfully installed, to open the App, click on drop down menu at the Top and select CubeSat Wizard App.



Tutorial on CubeSat Wizard APP

In order to generate the simulation results using the App, the user is required to enter the surface properties of the Structure of the CubeSat, Thermal properties, Orbital parameters and Time of Interest. Finally, the user will be asked to select the desired result. In this tutorial, we will guide the user through each window of the App explaining all the inputs required.

Once the App is opened, the user is guided to the Main Page of the App. Then the user is required to move between different Tabs at the top of the window and enter all the input parameters required.

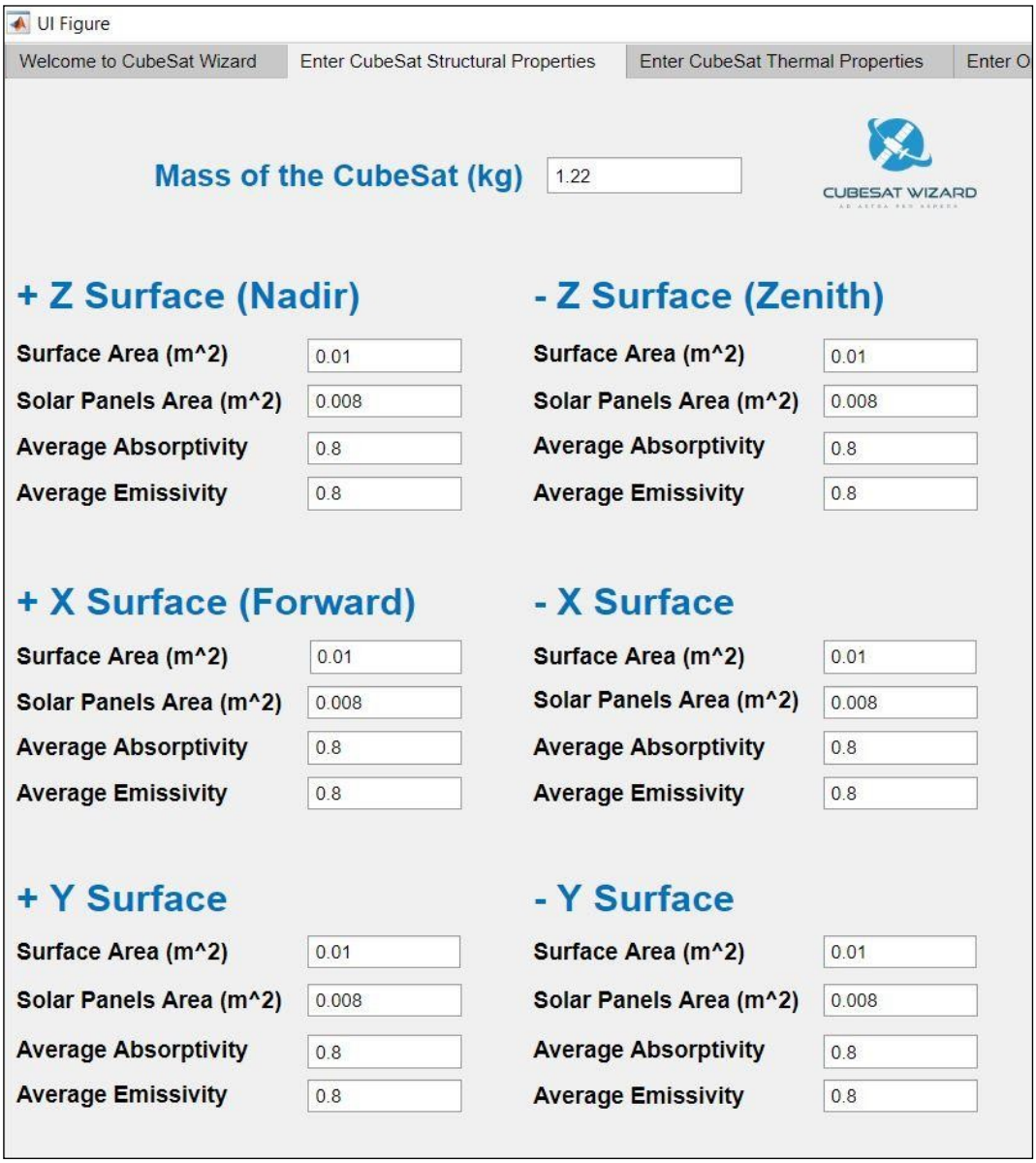


In this Tab, the user is required to enter all the structural properties of the CubeSat. The surface properties of the structure of the CubeSat depend on the design of the CubeSat and the material properties. The App requires the user to enter surface parameters for each face.

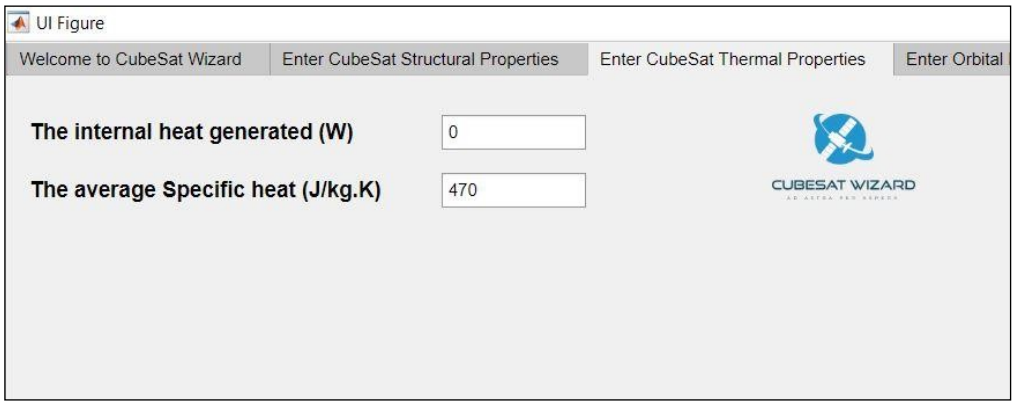
For example, a 1U CubeSat which is of 10 x 10 x 10 cm dimensions, the average mass is considered to be in the range of 1.0 Kg – 1.33 Kg. The surface area will be 0.01 m^2.

In this tutorial, we have considered a **1U CubeSat** with a mass of **1.22 Kg**, surface area for each face is **0.01 m^2**, solar panel area is considered to be **0.008 m^2**, average absorptivity and emissivity for each face is chosen to be **0.8**.

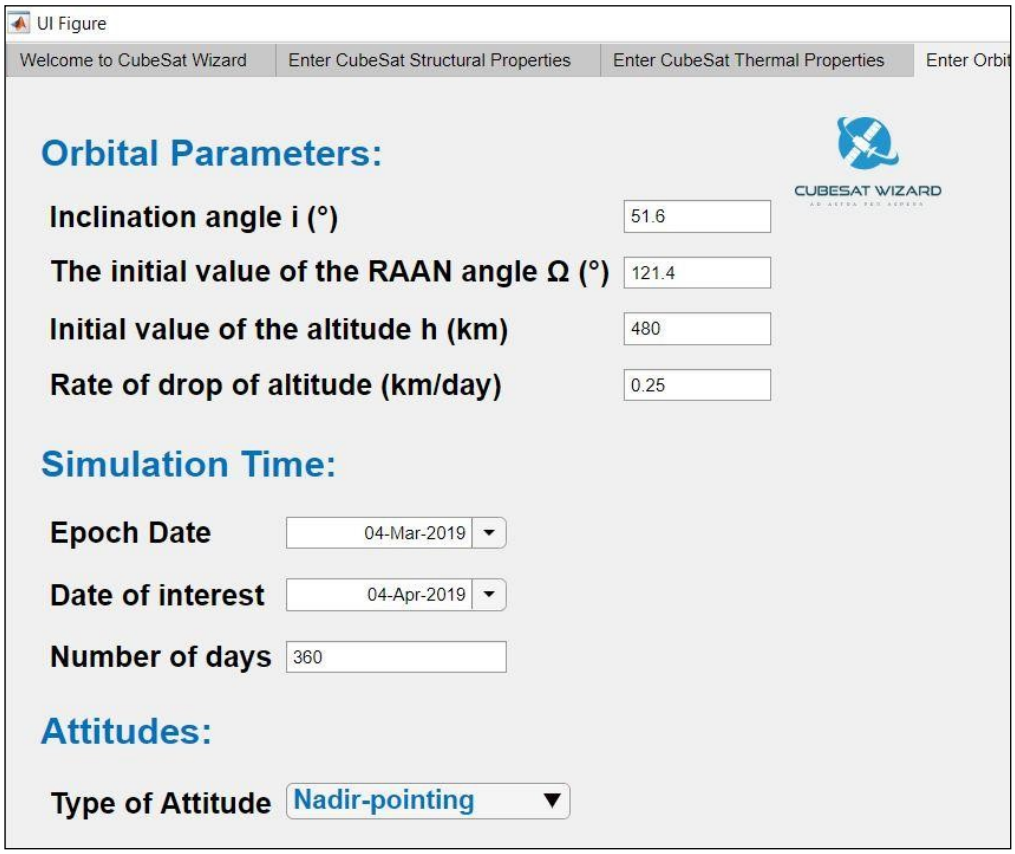
The App considers the Positive Z-Axis to be the face pointing towards Nadir (center of Earth).



This Tab allows the user to enter Thermal parameters for the CubeSat. For this tutorial, we have considered Internal Heat Generated within the CubeSat is equal to **0 W** and the Average Specific Heat is **470 J/kg.K.**

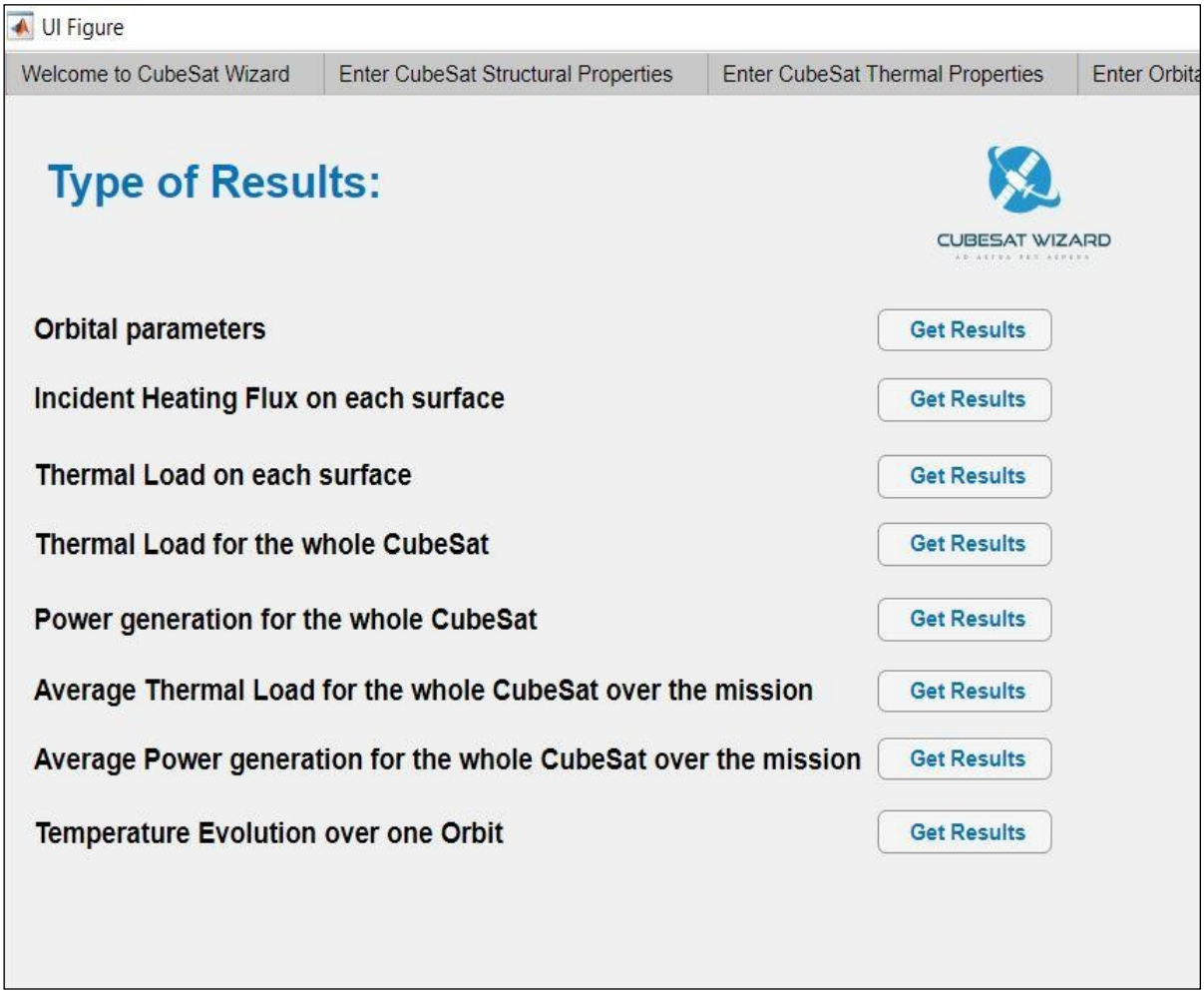


The next Tab requires the user to input orbital parameters, Epoch date for simulation and choose the type of attitude control desired for the CubeSat. Currently, we have one type of attitude control which is **Nadir pointing** but woki is undergoing for implementing alternative options. In this tutorial, we have taken inclination angle to be **51.6°**, RAAN angle to be **121.4°**, initial altitude to be **480 km** with a drop rate of **0.25 km/day**. The epoch date was set to **04-March-2019** with a simulation period of **360 Days**. The App also provides thermal and power generation results for a specific day of interest chosen by the user. In this case, **04-April-2019** has been set as Date of Interest.



Once all the parameters have been entered, the final Tab of the App displays the various types of results that can be generated. It is up to the user to select the type of result he or she is looking for and based on his or her preference, the simulation results will be generated in a new window tab. The type of results generated (but not limited to) by the CubeSat Wizard

are Orbital Propagation, Incident Heat Flux on each surface, Thermal Load for each surface, Power Generation and Thermal Load for the whole CubeSat in one orbit as well as Power Generation and Thermal Load for the whole CubeSat over the course of its mission. Finally, the App also provide results for temperature evolution for the day of interest.

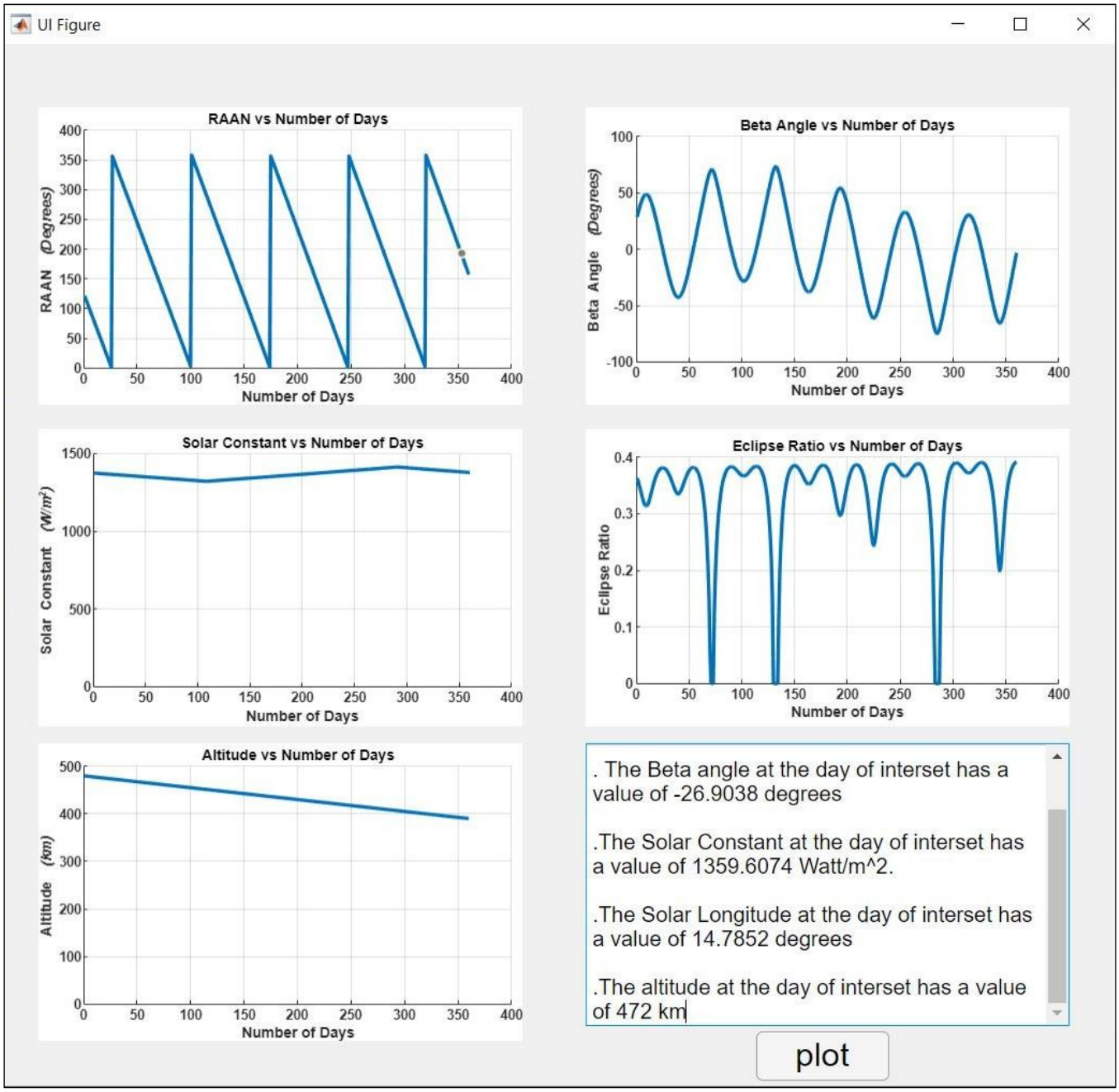


After clicking on any of the desired results, a new window will appear. However, the results will not be displayed yet. In order to generate and obtain the results, click on the **"Plot"** button that will illustrate the relevant results.

This tutorial will briefly overview each of the results and explain the significance of the obtained result and how a user can interpret them.

1. Orbital Propagation:

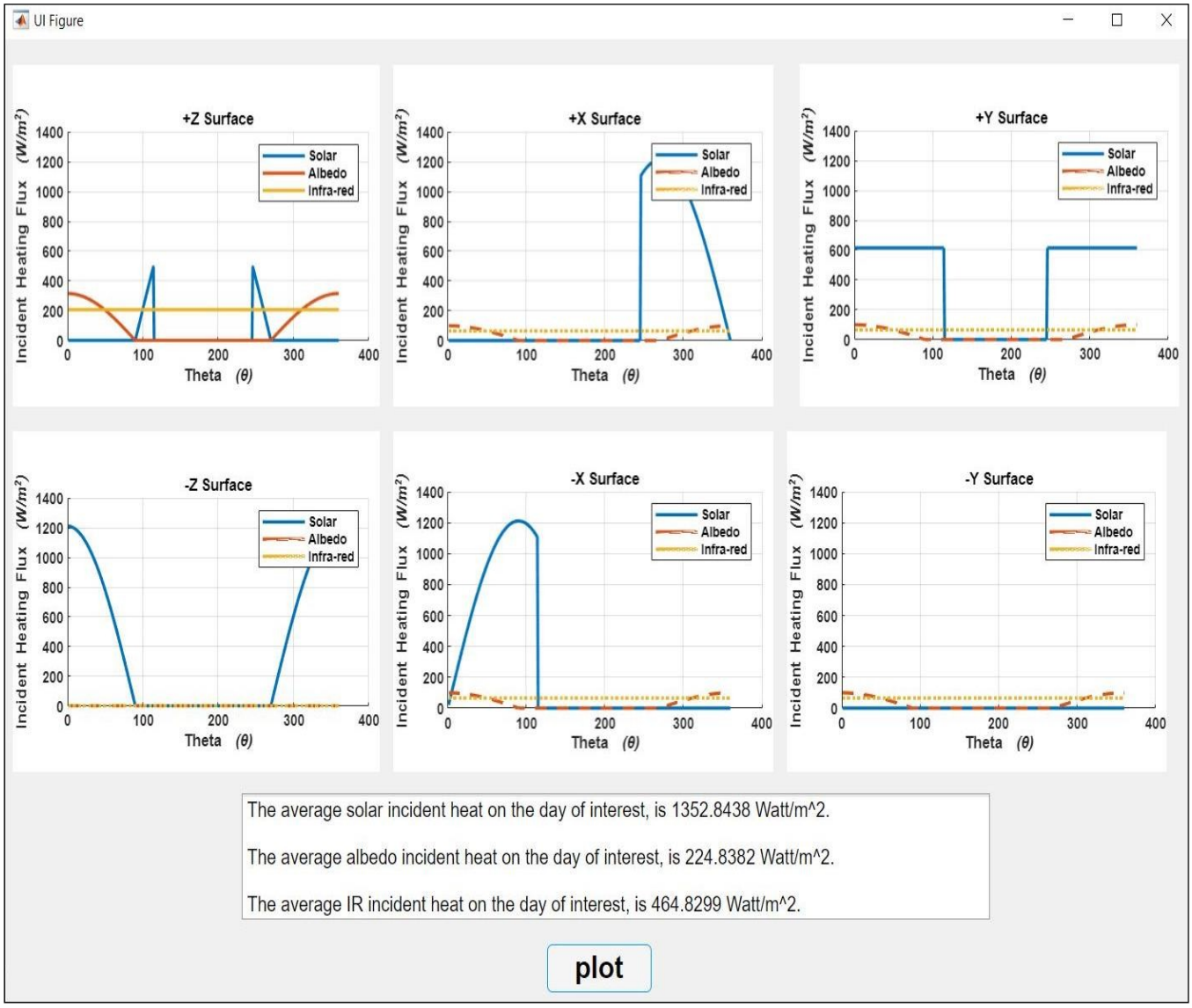
This tab displays the results for orbital propagation that includes evolution of RAAN angle, Beta angle, Solar constant, Eclipse ratio and Altitude over the number of days. The results tab also provides user with the option to obtain specific orbital variables on a chosen day of interest. For instance, at any specific chosen day and time of interest by the user, the value of the Beta angle or similarly any other orbital variable will be calculated and presented in a result window within the tab.



2. Incident Heating Flux on each surface

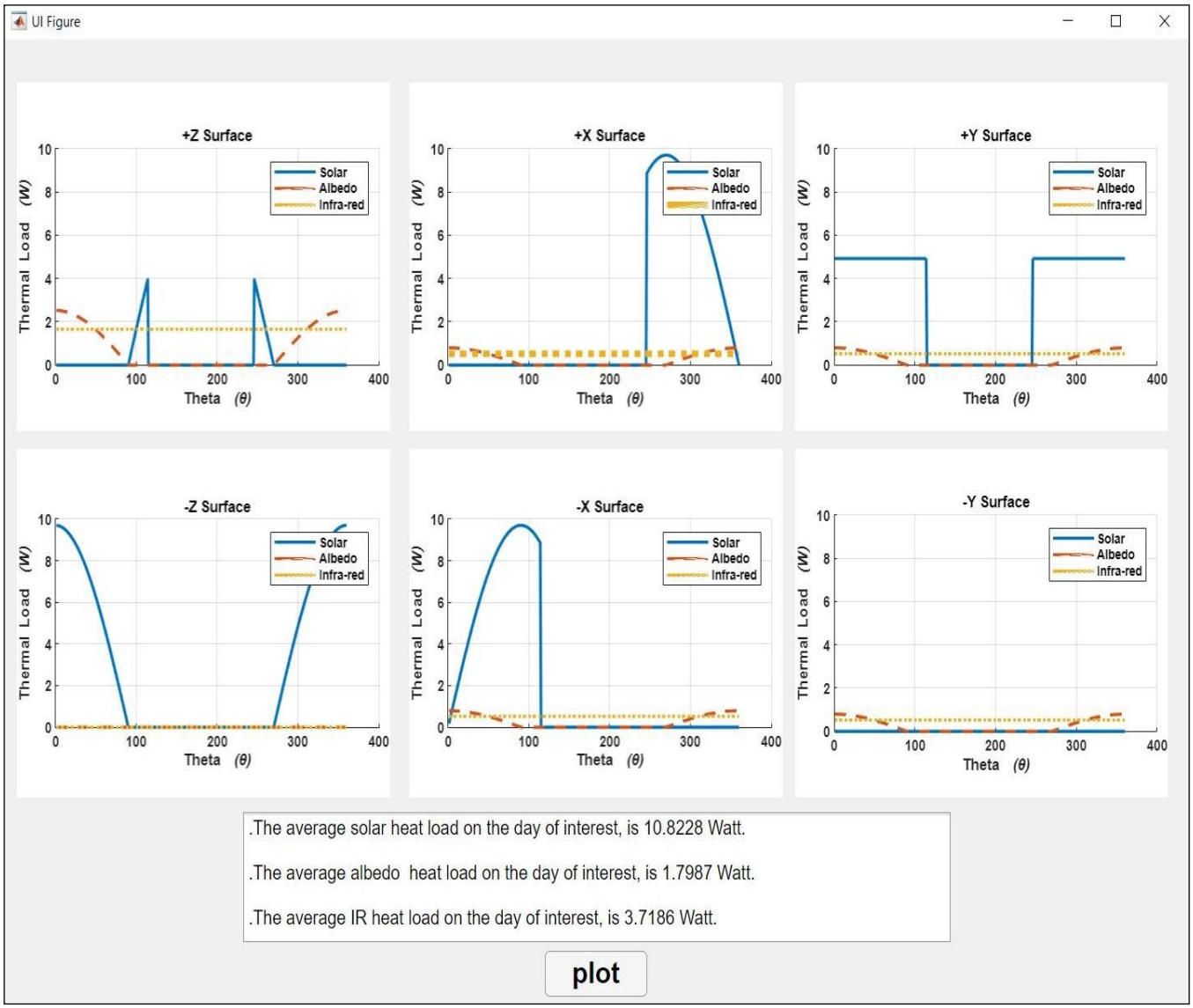
This tab provide results of Incident Heating Flux on each surface of the CubeSat for one complete orbit on the day of interest chosen by the user. The incident heating flux comprises of direct solar incident heat, albedo incident heat and the infra-red incident heat. Since the result illustrates the incident heating flux for each surface of the CubeSat, a total of six different plots have been generated showing the progression of solar, albedo and infra-red fluxes for the complete orbit.

In our simulation, we have associated the +Z Surface as the face pointing towards Nadir direction (Center of the Earth). Thus, the +Z Surface of the CubeSat will remain pointing in the Nadir direction always while orbiting.

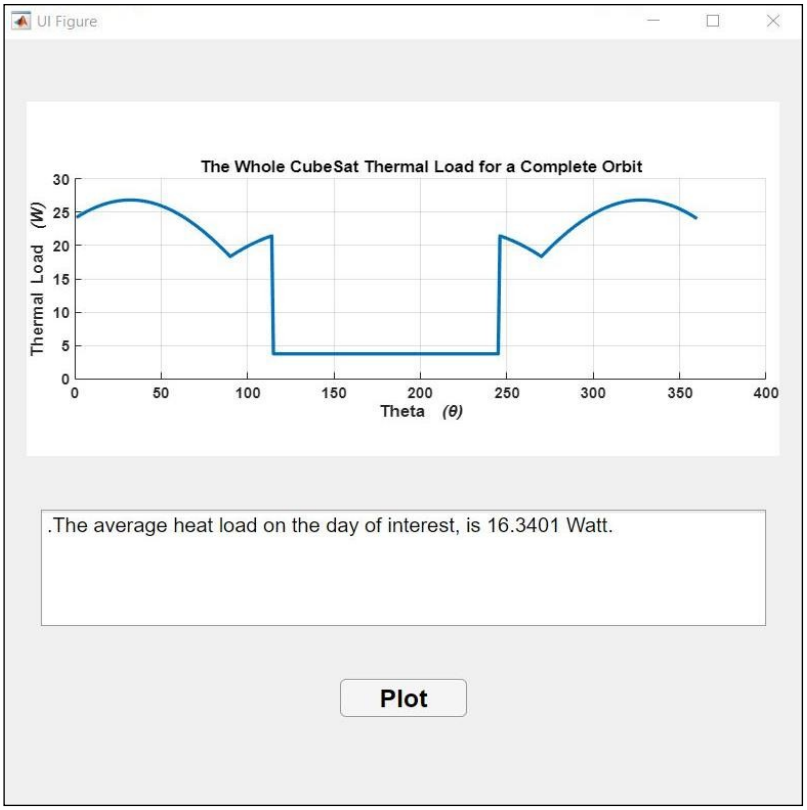


3. Thermal Load on each surface

This tab presents the results for thermal load of the CubeSat for one complete orbit on the day of interest chosen by the user. Similar to the incident heating flux, the thermal load also comprises of the direct solar thermal load, albedo thermal load and infra-red thermal load. The tab generates six different plots for each surface of the CubeSat illustrating the progression of solar, albedo and infra-red. Below the plots, a result window also illustrates the average values of solar load, albedo load and infra-red load on the day of interest selected by the user.



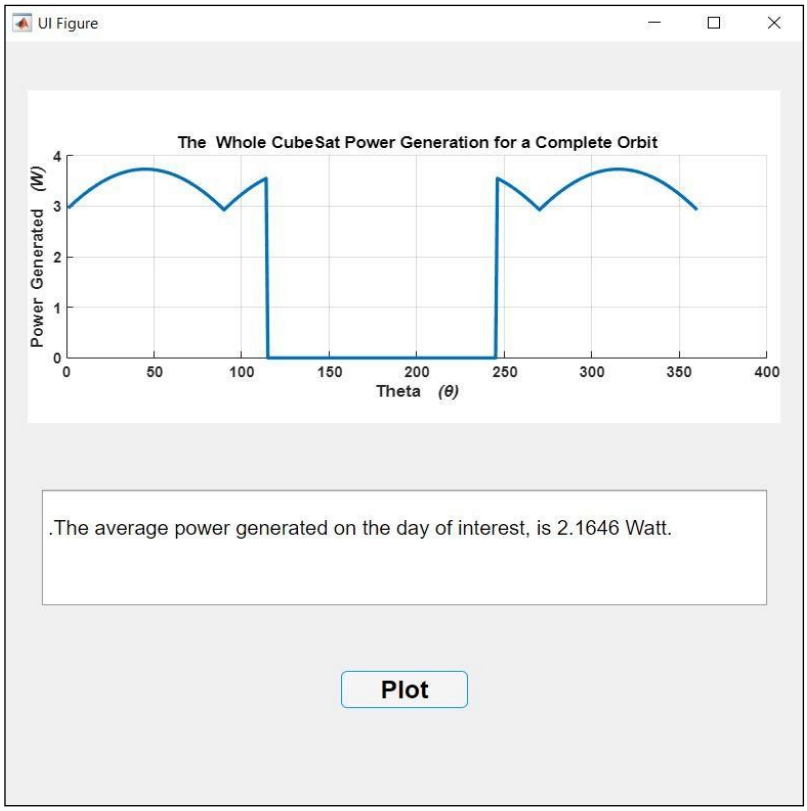
4. Thermal Load of CubeSat over 1 Orbit



This tab generates result for the full thermal load of the whole CubeSat for one complete orbit. The total thermal load result is inclusive of total direct solar load, total albedo load and total infra-red load that was measured on each surface.

The result window below the plot calculates the average total heat load on the day of interest that includes the thermal load of direct solar, albedo and infra-red.

5. Power Generation by CubeSat over 1 Orbit



This result tab illustrates the total power generated by the CubeSat in one complete orbit. The source of power generation on the CubeSat is solar panels. In our simulation, we have assumed to have a solar panel on each surface.

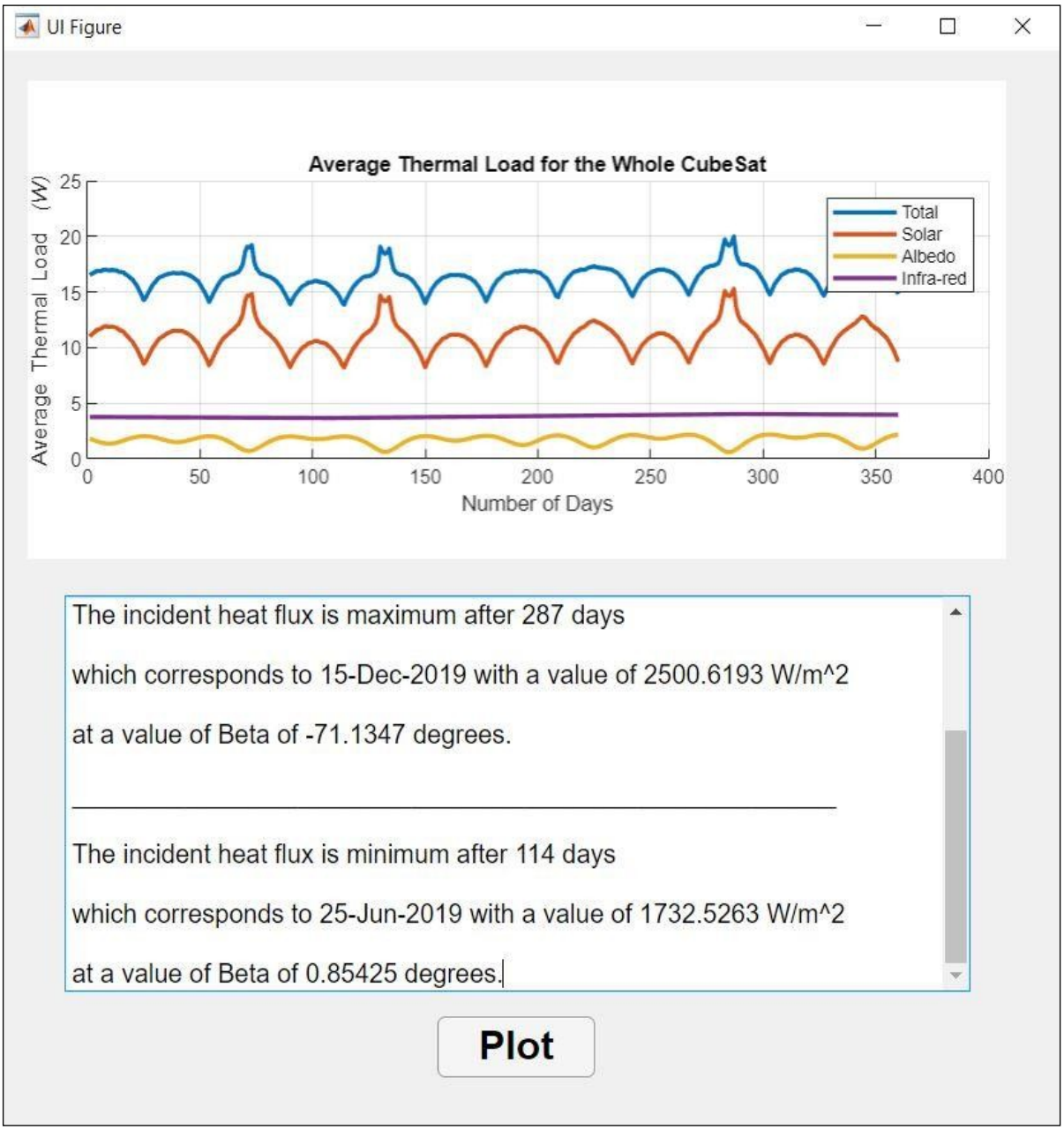
In our results, we have taken the effect of solar panel efficiencies while calculating the power generated by the CubeSat.

Below the plot, a result window also determines the average power generated by the CubeSat on the day of interest.

6. Average Thermal Load of CubeSat over mission

This tab present results for the Average Thermal Load of the whole CubeSat over the course of its entire mission. The duration of the mission is determined by the Number of Days chosen by the user. The graph shows four average thermal load plots out of which three are for the direct solar, albedo and infra-red. The fourth plot "Total" is a summation of the remaining three plots illustrating the total thermal load of the CubeSat.

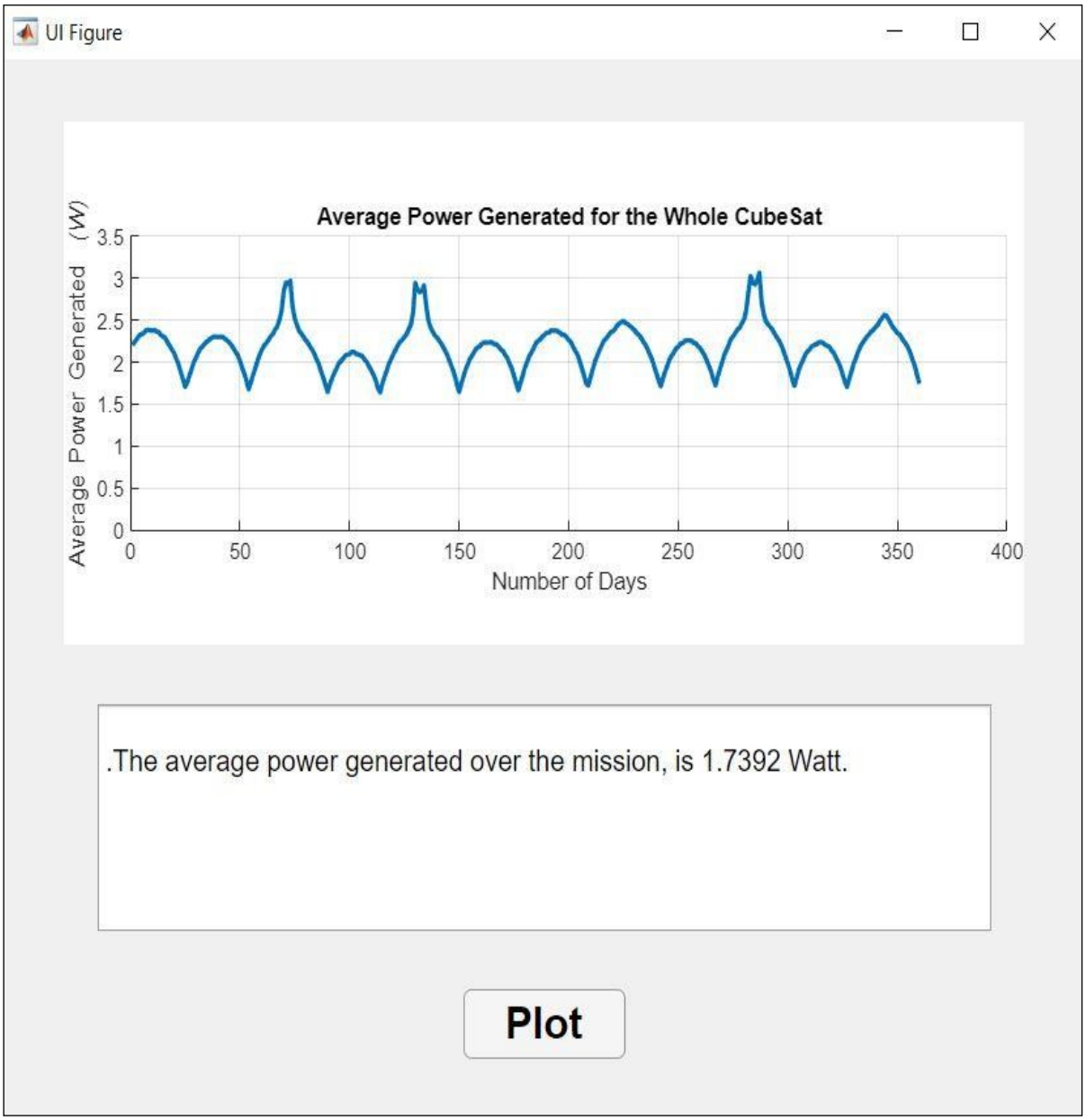
The result window underneath determines on which day Maximum or Minimum Incident Heat Flux was obtained identifying the value of Beta Angle.



7. Average Power Generation by CubeSat over mission

This result tab present results for the Average Power Generated by the CubeSat over its entire mission determined by the Number of Days. The plot illustrates how the power generated progresses each day of the mission. The result obtained is based on the average values of the power generation for each day over the course of its mission.

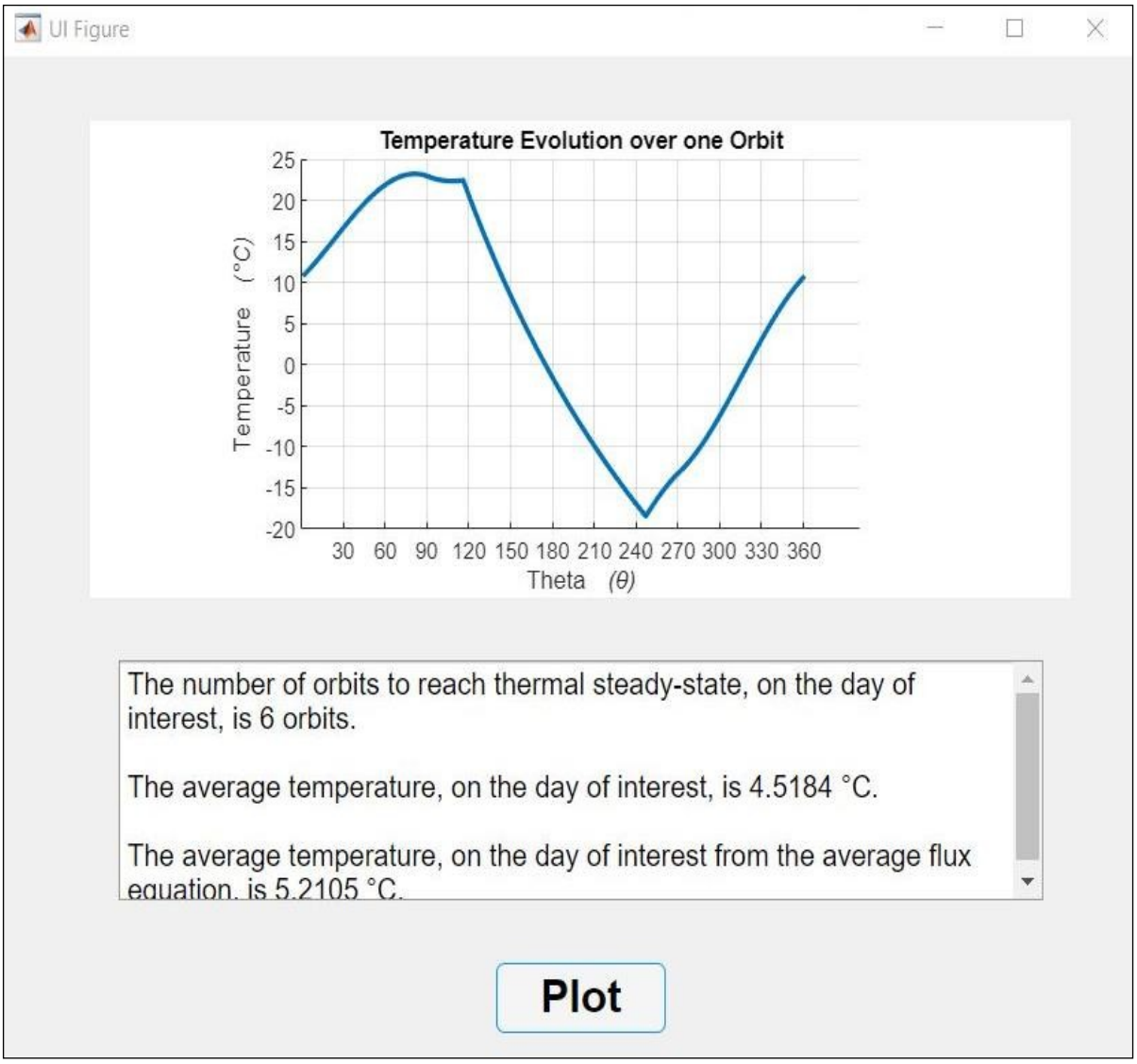
The result window calculates the Average power generated per day by the CubeSat during its entire mission.



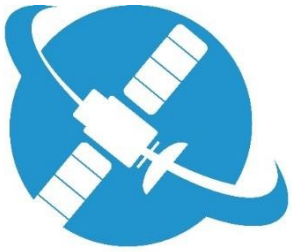
8. Temperature evolution of CubeSat over 1 Orbit

This is the final result tab of the CubeSat Wizard App. This tab presents the results for the evolution of temperature of the CubeSat over one complete orbit on the day of interest determined by the user.

The result window below provides further information about the number of orbits required to reach thermal steady-state. The App also calculates the average temperature of the CubeSat on the day of interest in two different ways. Firstly, it calculates the average temperature through the plot which is the same methodology as other previously calculated results. However, in this tab the average temperature is also calculated using the Average Flux Equation.



A video Tutorial of the CubeSat Wizard App can also be found on the link below.
https://www.youtube.com/watch?v=4fLaqFzPzEs&t=78s



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Thanking You

(Please feel Free to Contact us for any Inquiries)