Trajectory Design using Satellite Tool Kit for a Venusian Atmospheric Probe

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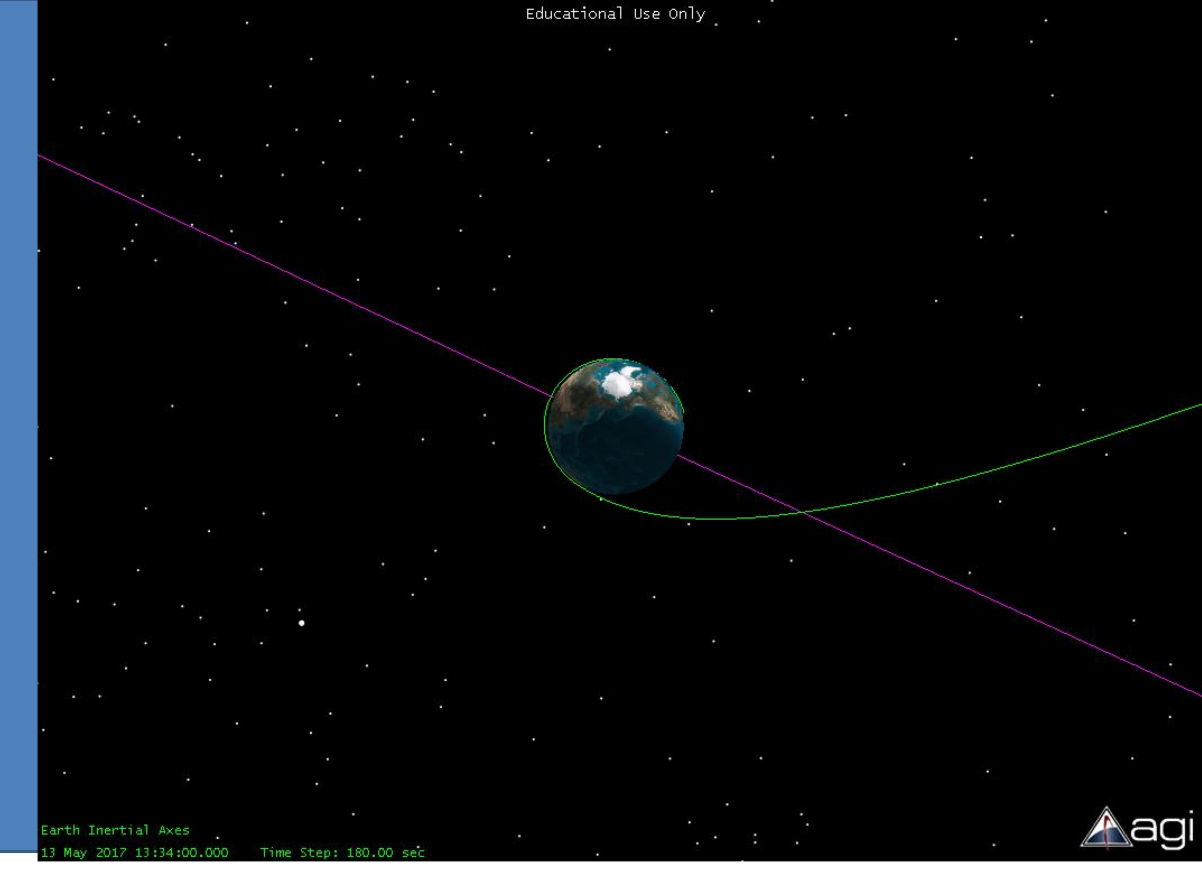


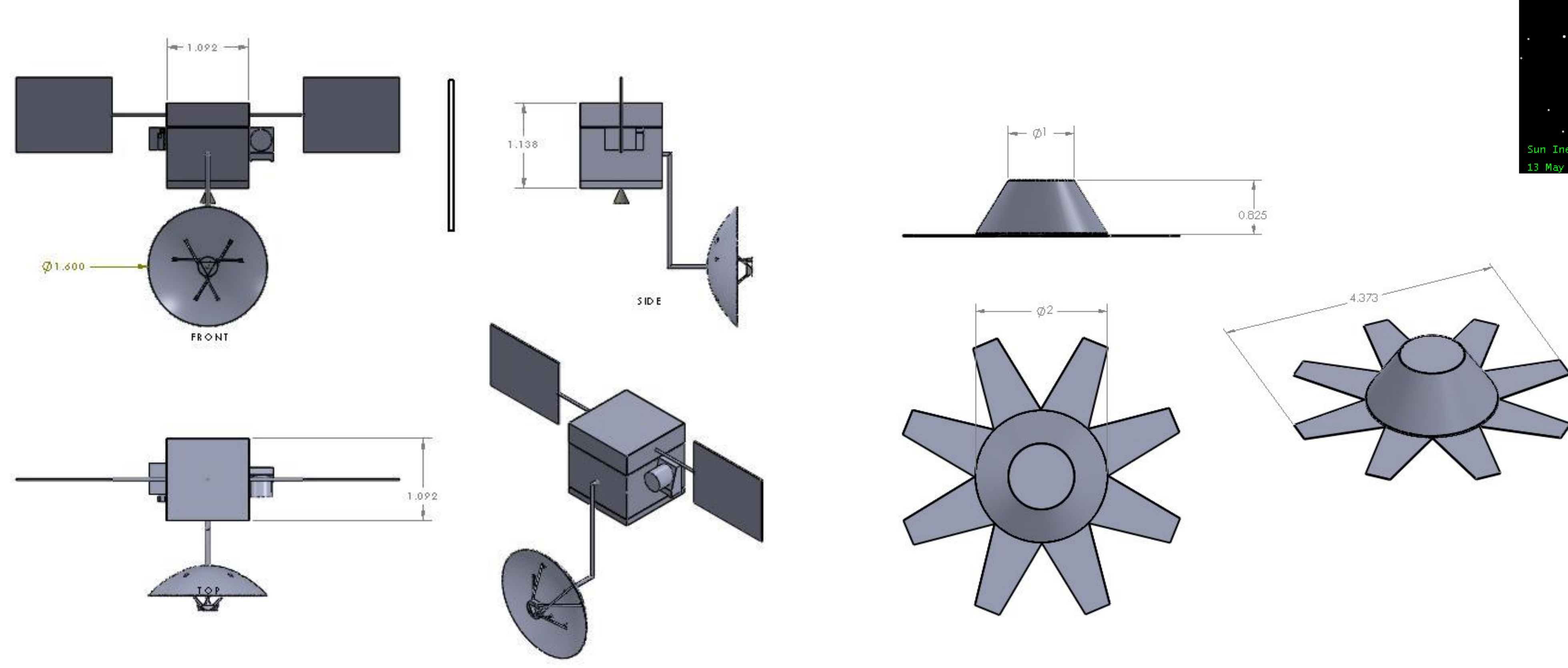
Venusian Atmospheric Probe Mission

Objective

Design an unmanned vehicle capable of sampling the atmosphere of Venus for biological life over a range of altitudes. Return the samples to Earth or test the samples at Venus and transmit this data back to Earth. While sampling, measure and record ambient conditions. Design this mission to be completed by December 21, 2020.

Background

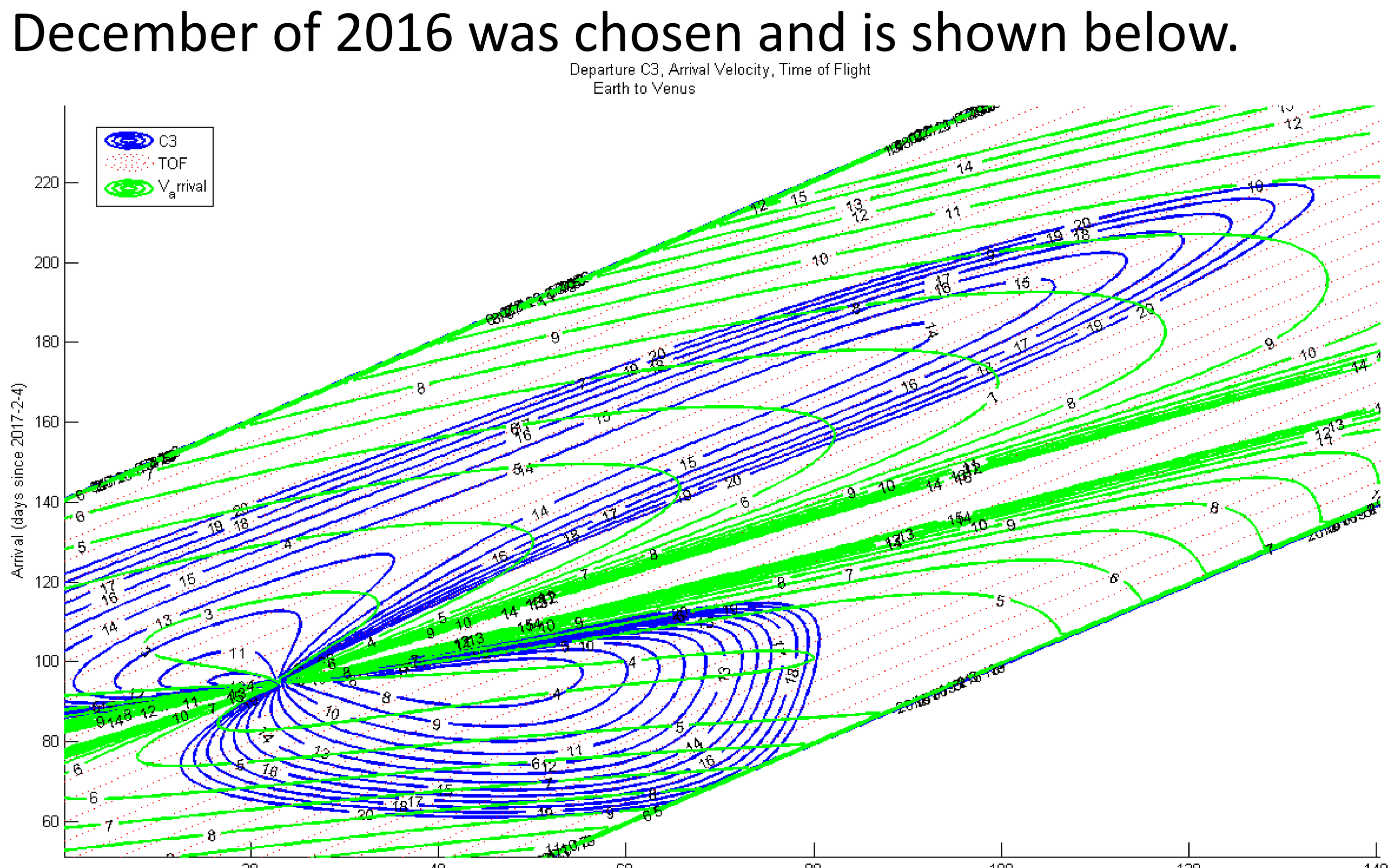
Atmospheric testing on Venus has revealed that the clouds contain two chemical compounds, hydrogen sulfide (H_2S) and sulfur dioxide (SO_2) , that react with each other, and therefore cannot exist independently in close proximity. This, coupled with much lower levels of carbon monoxide (CO) than expected, implies that something may be consuming carbon monoxide and releasing hydrogen sulfide and sulfur dioxide. It has been postulated that microorganisms similar to some types of terrestrial bacteria may be able to survive in the Venusian upper atmosphere while conducting such a metabolic process.



Group Work

We have completed a conceptual design that accomplishes all of the mission requirements and have presented that conceptual design to a panel of judges. We are currently using the comments of those judges to refine and advance our design. Our preliminary design review is due the ninth week of this quarter.

One of the primary design drivers was the overall weight of the spacecraft. This weight is directly related to the propellant requirement of the orbiter. To determine the propellant required for the orbiter, an optimal trajectory had to be designed. A two body trajectory estimation was done in MATLAB to create C3 contour plots of the launch windows. The launch window in December of 2016 was chosen and is shown below.

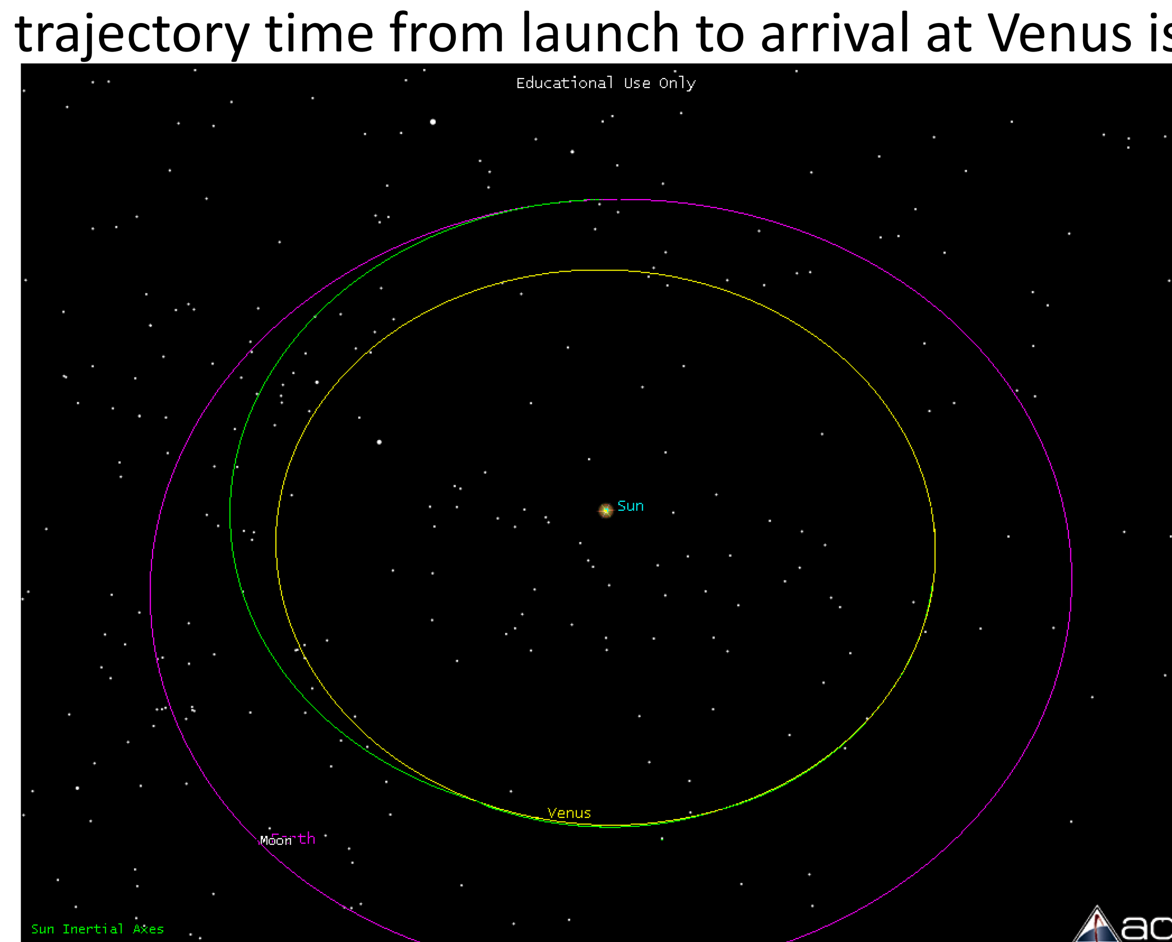


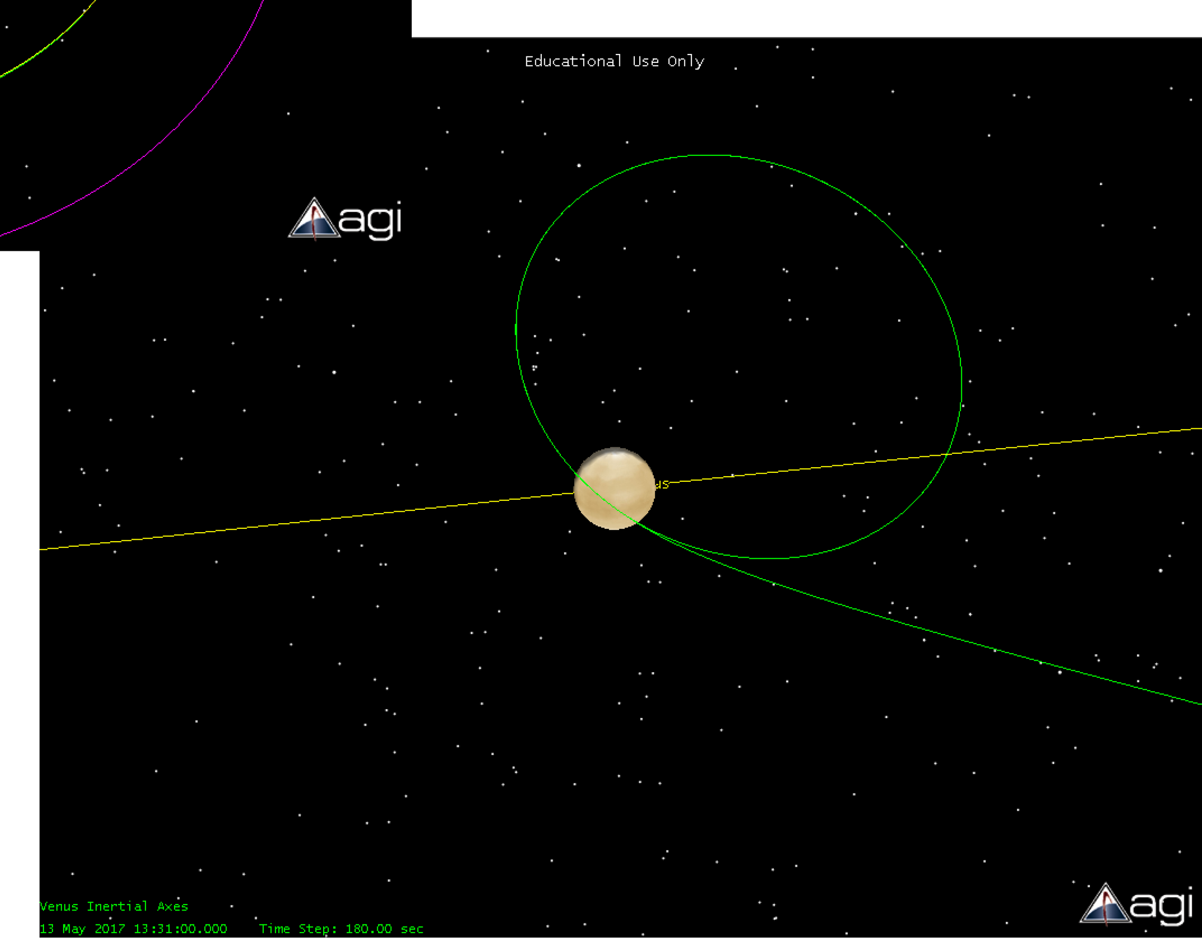
Satellite Tool Kit

Trajectory Calculations

To determine exact values for multi-body problems, some type of iteration program must be used. My goal in using STK was to create a complex trajectory that would determine exact ΔV requirements as well as provide details on the optimal launch and arrival dates.

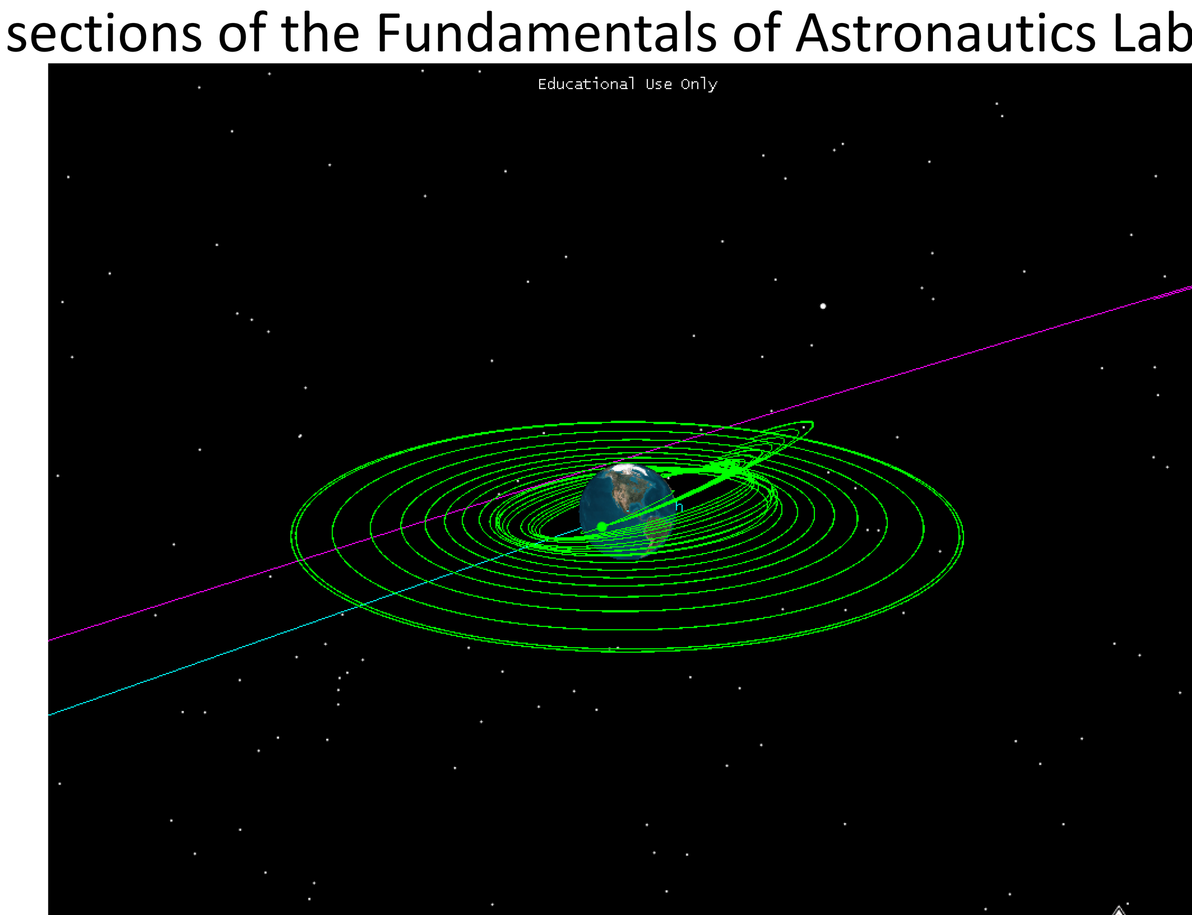
After more than sixty hours spent learning the software, I was finally able to accomplish my goal. Launching on Dec 26, 2016 and arriving on May 7, 2017,my mission required a total change in velocity of 1.254 km/s at Venus. The total trajectory time from launch to arrival at Venus is 134 days.





Tutorial and Presentation

In addition to using STK for the Venusian Atmospheric Probe mission, I prepared a tutorial to introduce new users to many of the available options in STK. This tutorial was primarily for first time users and provides a step-by-step design for a simple plane change and Hohmann transfer using the Astrogator tool in STK. The concepts introduced in this tutorial are usable for any trajectory design. Prior to the tutorial, I presented an overview of the astrodynamic theory behind plane changes and Hohmann transfers. Understanding the theory behind maneuvers is required to successfully design trajectories in STK/Astrogator. I presented this PowerPoint and tutorial combination to four sections of the Fundamentals of Astronautics Laboratory.



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