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UNDERSTANDING ORBITAL TRANSFER TYPES WITH SECONDARY STUDENT CREATED PYTHON CODE

Abstract

Orbital transfers are critical components of a spacecraft's mission success. A transfer orbit must be used to execute a maneuver. The type of transfer orbit is variable depending on the type of transfer. The paper explores the variety of transfers for different mission needs with the aid of a Python program to easily change mission variables. The lead author, a secondary student, strongly believes multidisciplinary approach is especially useful in educating and inspiring younger students in real-world aerospace applications. The Hohmann Transfer is the simplest transfer to move between two coplanar orbits and requires a transfer ellipse burn. When raising an orbit, the spacecraft burns with sufficient additional velocity to intercept the target orbit at the apogee, or highest point of the transfer ellipse. At apogee, the spacecraft must burn a second time to emulate the planned target orbit. While not the fastest, the Hohmann transfer is the most fuel efficient. A faster transfer places the apogee beyond the target orbit. This faster orbit has a higher average velocity between the first burn (at the original orbit) and the second burn (at the intersection between the transfer ellipse and the target orbit). The transfer ellipse requires more fuel to raise its apogee beyond the target and to exit the transfer ellipse, emulating the planned target orbit. A third type of transfer, the bi-elliptic transfer, uses two different transfer orbits and three burns. The apogee of the first ellipse fails to reach the altitude of the target. Only the second transfer orbit has enough velocity to reach the target orbit. The bi-elliptic transfer is fuel efficient, but the spacecraft takes significantly more time to complete the transfer. As these transfers are essential for optimizing resources, this study analyzes different orbital transfers typical of mission planning. Understanding various types of orbital transfers is important as they are an essential part of mission planning. This study analyzes different orbital transfers to determine the best transfer for different mission requirements. This student wrote Python script to calculate characteristics of these various transfers. As inputs, the program uses the semi major axis of the initial orbit and the semi major axis of the target orbit. Outputs are the flight time and the required V. The advantage of using a Python program to calculate the transfers is the input variables can easily be changed to simulate different mission scenarios.