A SIMPLE ALGEBRAIC SOLUTION TO PROVE THE EFFICIENCY OF A TRI-ELLIPTIC TRANSFER ORBIT OVER THE HOHMANN TRANSFER ORBIT

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ABSTRACT

An algebraic solution is developed to find the range of values within which the tri-elliptic transfer orbit would be more efficient in terms of the incremental velocity required to operate as compared with the Hohmann orbital transfer. In the tri-elliptic transfer, the spacecraft is first given an impetus so that the initial circular orbit is converted into an elliptic transfer orbit. The spacecraft is given further impetus to convert to another suitable calculated elliptic transfer orbit. The final impetus is then given to convert the present orbit into a circular orbit of the desired final radius. This involves a total of four firings, as compared to three in bi-elliptic and two in Hohmann transfer orbits. Further, it has also been shown for the first time that the third transfer orbit in a tri-elliptic transfer orbit must always have an apoapsis radius less than the second transfer orbit apoapsis radius.

In this paper, a simple algebraic expression is obtained in three variables for the tri-elliptic transfer orbit as well as for the Hohmann transfer orbit and the two orbital transfers are compared for different values of these variables. A few practically possible values for the radii ratios are obtained to find the feasibility of the generated expressions.

The necessity for this problem is to employ the more efficient of the two methods, Hohmann and tri-elliptic in order to save the additional increment in velocity which would otherwise be required. This would in turn reflect upon a drop in the total propellant mass to be expelled, which in turn would cut the cost of the mission by appreciable limits. This save of propellant mass can indeed be added to the payload.

A limiting value has been obtained in this paper for the first time, which shows more efficiency for the tri-elliptic transfer over the Hohmann transfer for some values of the two parameters that are considered. This value is the least possible radius ratio at which a tri-elliptic transfer can be more advantageous than the Hohmann transfer orbit. This value was found to be 11.939.

REFERENCES

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