MAE 146 Astronautics Project: Mission to Didymos
Problem 4 Report

(a) Earth State at Departure

At the departure time of $t = t_{ref} + 12$ days, the propagated Cartesian state vector for Earth is:

- Position (km): $\vec{r} = [-137632102.0700, \ -60910122.1032, \ -75.5878]$
- Velocity (km/s): $\vec{v} = [11.5578, \ -27.2548, \ 0.0000]$

(b) Didymos State at Arrival

At the arrival time of $t = t_{ref} + 412$ days, the propagated Cartesian state vector for Didymos is:

- Position (km): $\vec{r} = [-93352849.7628, \ 179932113.2926, \ 8419364.9434]$
- Velocity (km/s): $\vec{v} = [-27.4660, \ -3.4753, \ 1.5059]$

(c) Nominal Transfer

Assuming a zero-sphere of influence at both bodies, the nominal transfer between the dates specified in parts (a) and (b) requires a total transfer magnitude of: $\Delta V = 20.028 \, km/s$

This ΔV is exceptionally high because forcing a strict 400-day transfer window between these two arbitrary dates requires a highly inefficient trajectory. The trajectory is plotted in Figure 1.

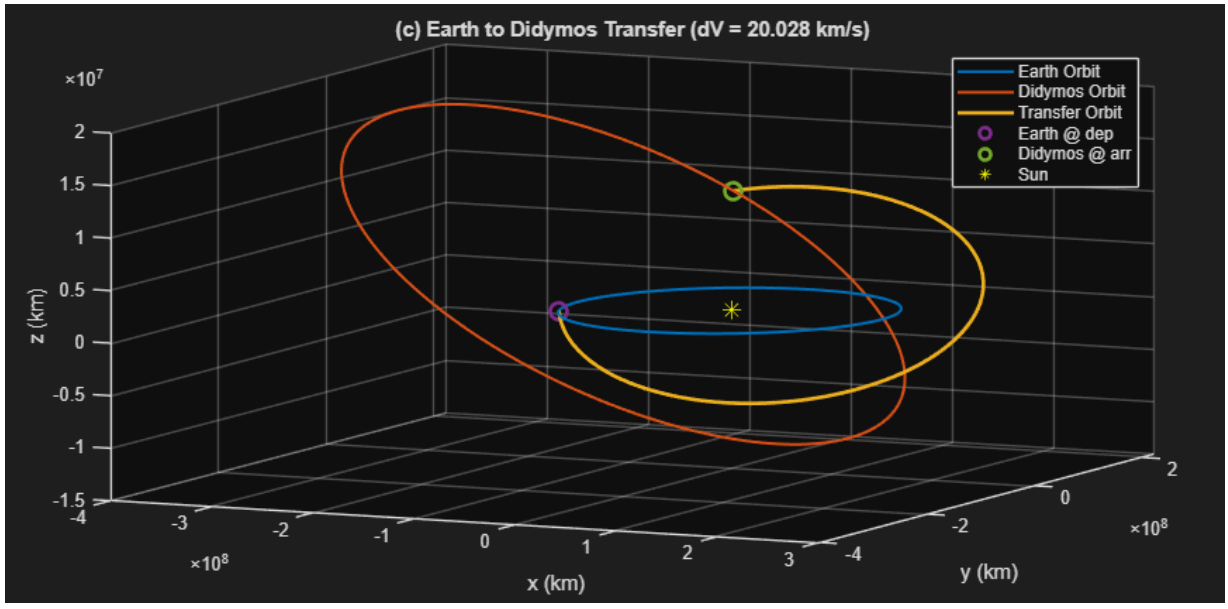

Figure 1: (c) Earth to Didymos Transfer (dV = 20.028 km/s)

(d) Porkchop Plot Analysis

To find a more efficient launch window, a porkchop plot was generated for outbound prograde trajectories (cw = false) over a 1000-day window from t_ref, evaluated at 5-day intervals. Transfers with a time of flight <= 100 days were excluded. The plot is shown in Figure 2.

The grid search identified a local minimum that is significantly more efficient than the nominal transfer:

- Minimum $\Delta V = 7.873\ km/s$
- Optimal Departure Time (t_0): $t_{ref} + 595$ days
- Optimal Arrival Time (t_f): $t_{ref} + 1000$ days

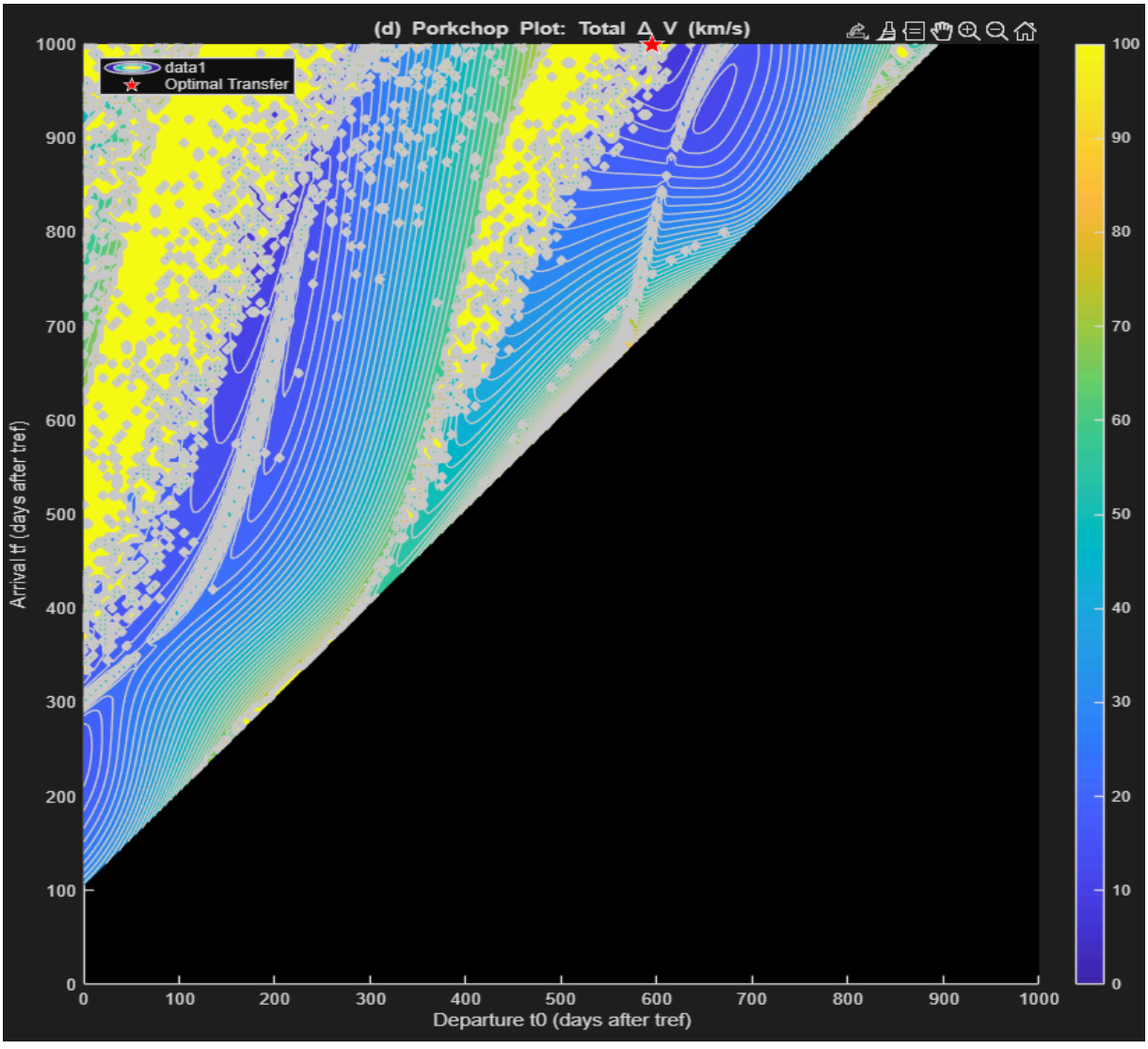

Figure 2: (d) Porkchop Plot: Total Delta V (km/s)

(e) Optimal Transfer Trajectory

Using the local minimum identified from the porkchop plot, the optimal transfer trajectory was computed. By waiting for the proper planetary alignment (launching at 595 days and arriving at 1000 days), the spacecraft achieves a much more natural transfer orbit, drastically reducing the required delta-v from about 20 km/s to 7.87 km/s. The transfer orbit is plotted in Figure 3.

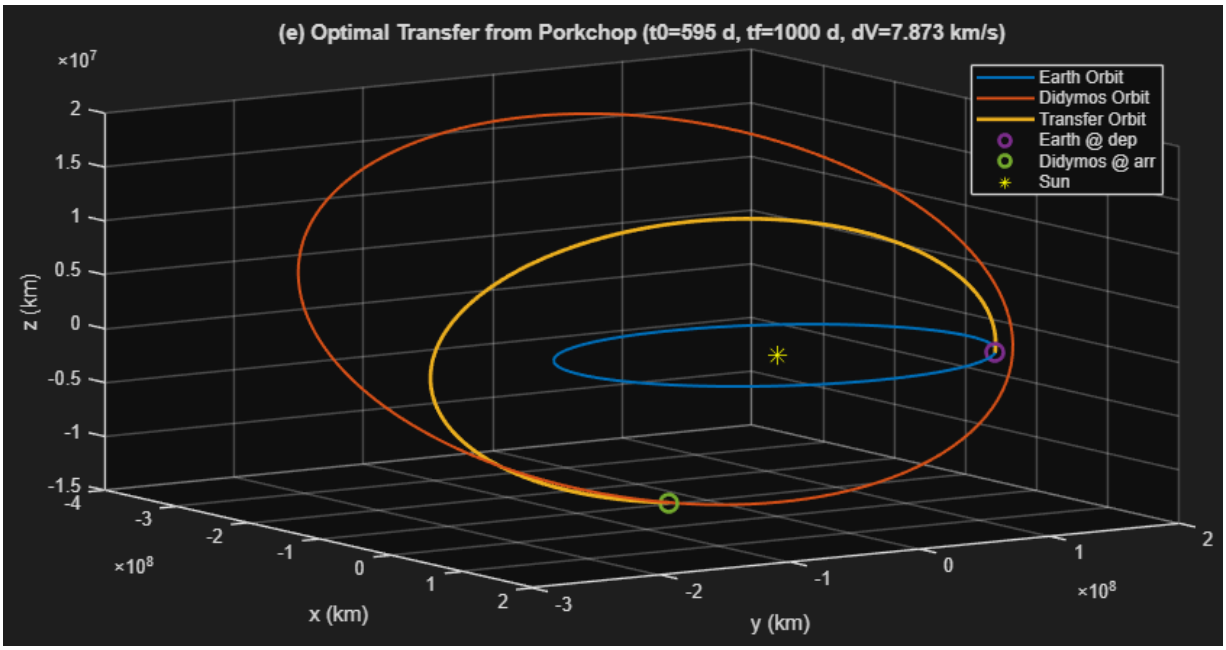

Figure 3: (e) Optimal Transfer from Porkchop (t0=595 d, tf=1000 d, dV=7.873 km/s)