ASEN 6060
ADVANCED ASTRODYNAMICS
Transfer Design Example

Objectives:

- Demonstrate a relevant trajectory design example from following paper:
  - Bosanac, N; Webster, C.M.; Howell, K.C.; Folta, D.C., 'Trajectory Design for the Wide Field Infrared Survey Telescope Mission,' September 2019, Vol. 42, No. 9, pp. 1899-1911, Journal of Guidance, Control and Dynamics

Nancy Grace Roman Space Telescope

Space telescope destined for a Sun-Earth L_2 halo orbit

1. Pre-specified initial state from launch vehicle provider
2. $\Delta\bar{V}_{LEO}$ must occur 10-60 minutes after initial epoch
3. $\Delta\bar{V}_{LEO}$ must be predominantly within orbital plane
4. Mission orbit remain within 36° of SE-L_2 line
5. Transfer remain within 33° of SE-L_2 line
6. Earth, lunar shadow avoidance for 10 years
7. $\left|\Delta\bar{V}_{L_2OI}\right| < 15$ m/s

These constraints are applied early in the design process to facilitate efficient search for feasible trajectory

Credit: Bosanac, N; Webster, C.M.; Howell, K.C.; Folta, D.C., 'Trajectory Design for the Wide Field Infrared Survey Telescope Mission,' September 2019, Vol. 42, No. 9, pp. 1899-1911, Journal of Guidance, Control and Dynamics

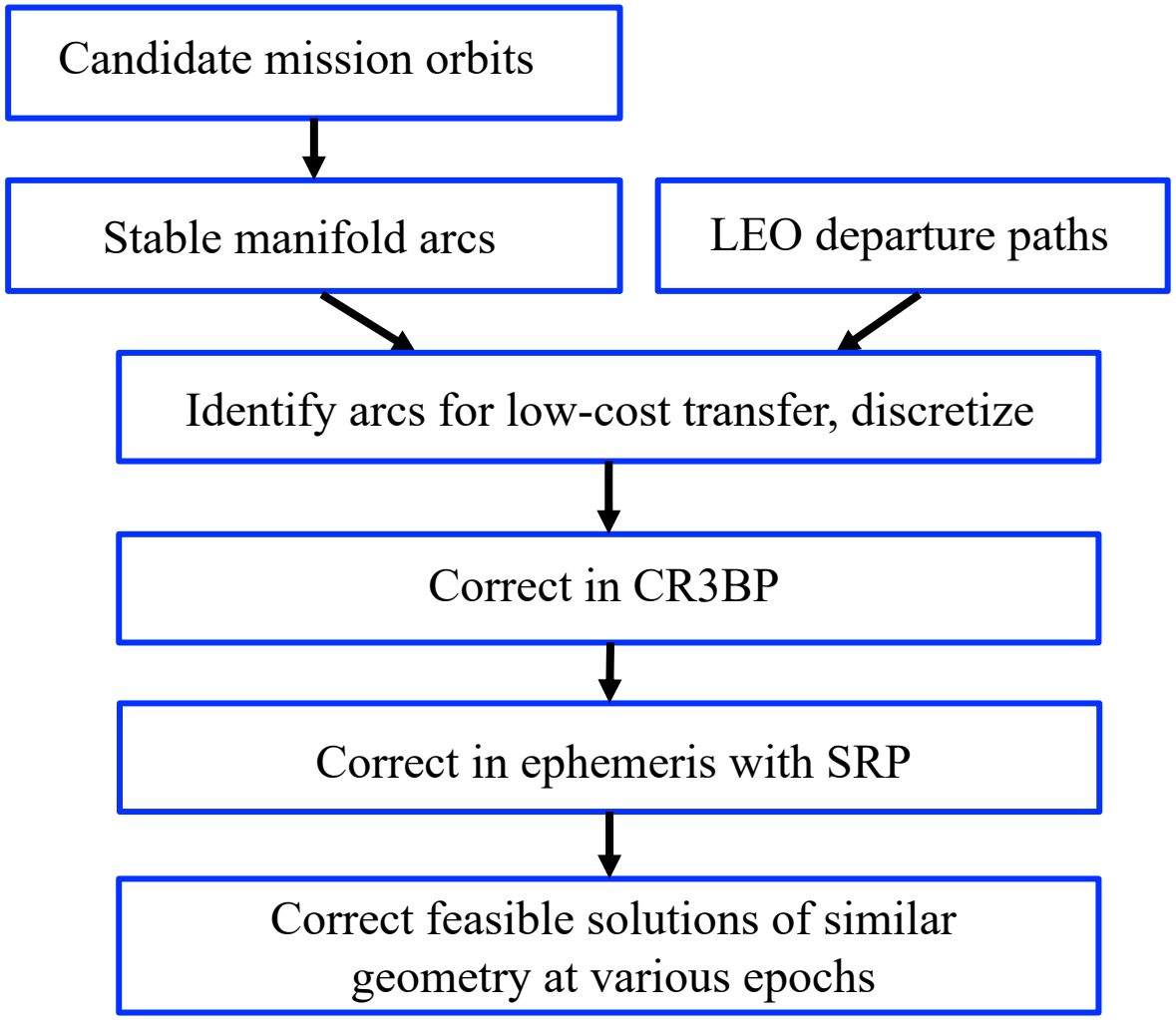
Overview of Trajectory Design Process

Data generation

Construct initial guess

Correct to recover feasible trajectory

Explore various launch dates



Credit: Bosanac, N; Webster, C.M.; Howell, K.C.; Folta, D.C., 'Trajectory Design for the Wide Field Infrared Survey Telescope Mission,' September 2019, Vol. 42, No. 9, pp. 1899-1911, Journal of Guidance, Control and Dynamics

Step 1: Identify Candidate Periodic Orbits

Relevant mission orbit constraints:

- Mission orbit remains within 36° of SE-L_2 line
- Earth, lunar shadow avoidance for 10 years

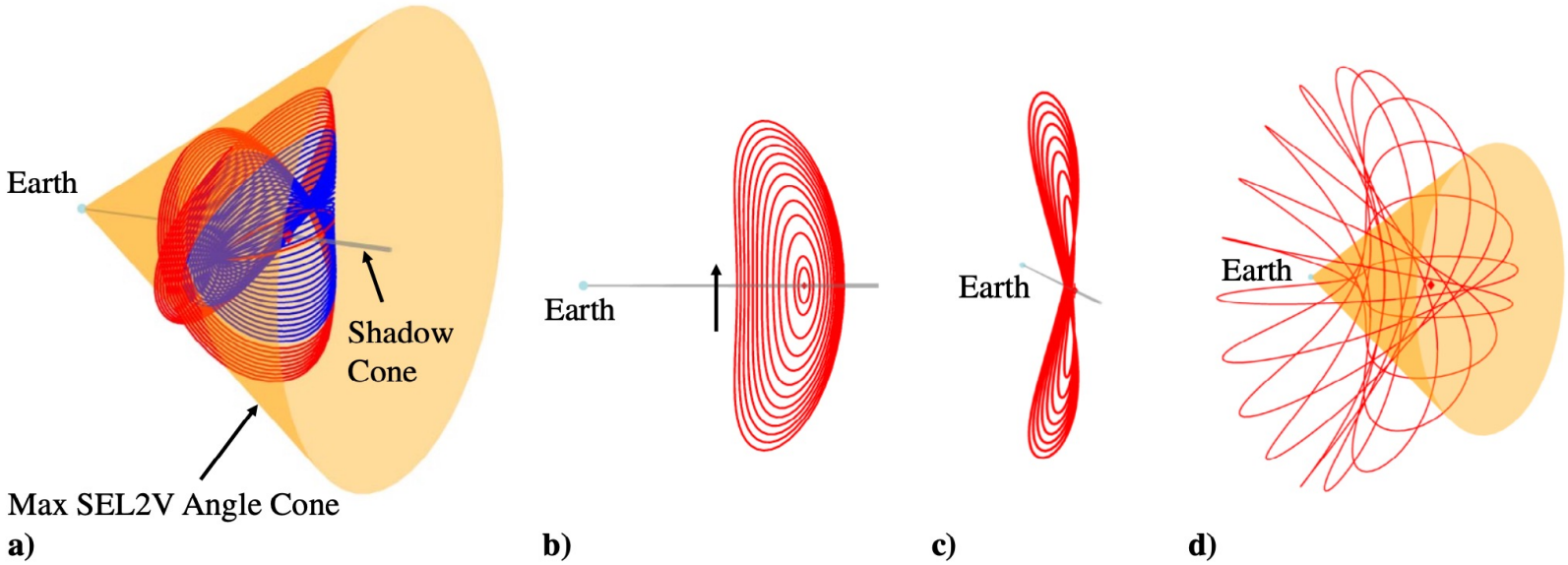


Fig. 1 Feasible (blue) and infeasible (red) periodic orbits in the a) L_2 halo, b) L_2 Lyapunov, c) L_2 vertical, and d) L_2 axial families.

Credit: Bosanac, N; Webster, C.M.; Howell, K.C.; Folta, D.C., 'Trajectory Design for the Wide Field Infrared Survey Telescope Mission,' September 2019, Vol. 42, No. 9, pp. 1899-1911, Journal of Guidance, Control and Dynamics

Step 2: Generate Stable Manifolds for Candidates

Record crossings with surface of section: $x_H = 0.7(1 - \mu) + 0.3L_{2,x}$

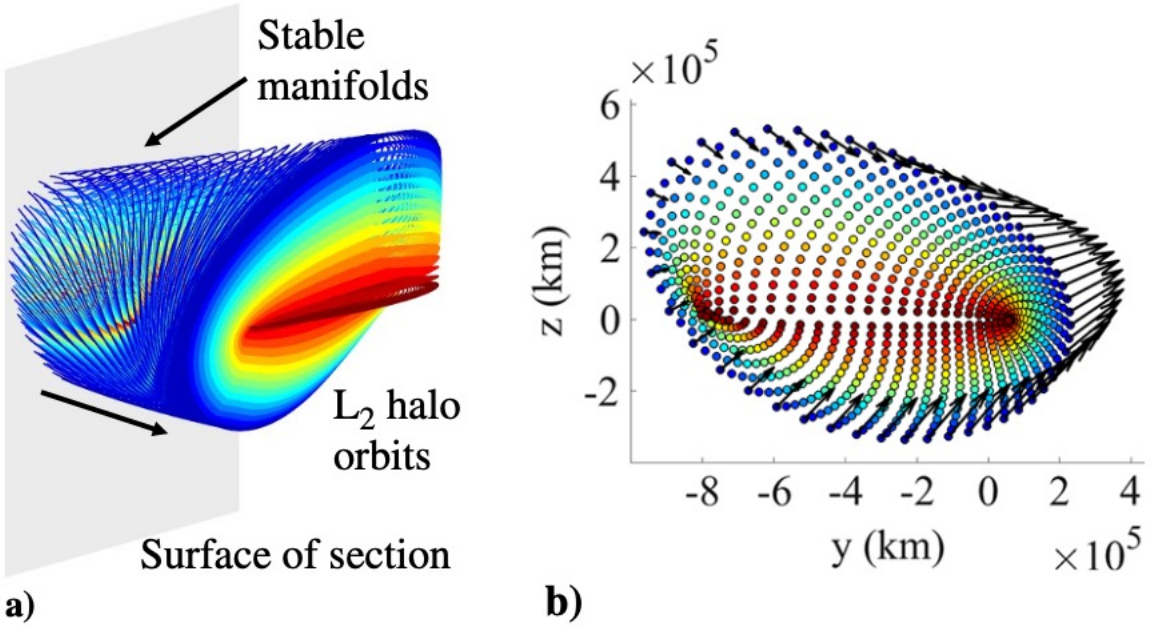


Fig. 2 Stable manifolds for members of the SE L_2 northern halo family in a) configuration space and b) on a (y, z) map.

Credit: Bosanac, N; Webster, C.M.; Howell, K.C.; Folta, D.C., 'Trajectory Design for the Wide Field Infrared Survey Telescope Mission,' September 2019, Vol. 42, No. 9, pp. 1899-1911, Journal of Guidance, Control and Dynamics

Step 3: Generate LEO Departure Arcs

Constraints:

- Pre-specified initial state from launch vehicle provider
- $\Delta\bar{V}_{LEO}$ must occur 10-60 minutes after initial epoch
- $\Delta\bar{V}_{LEO}$ must be predominantly within orbital plane

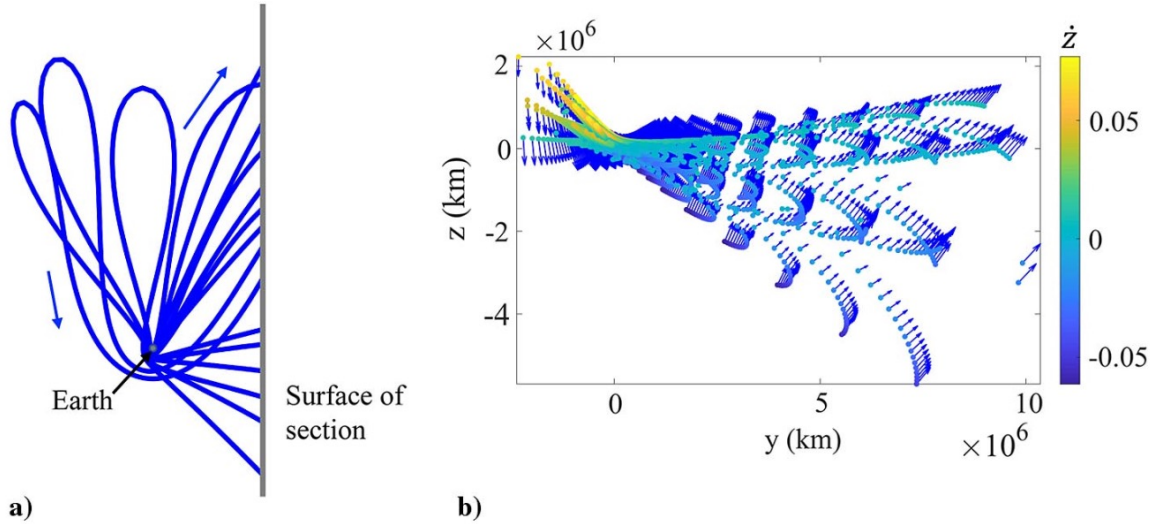
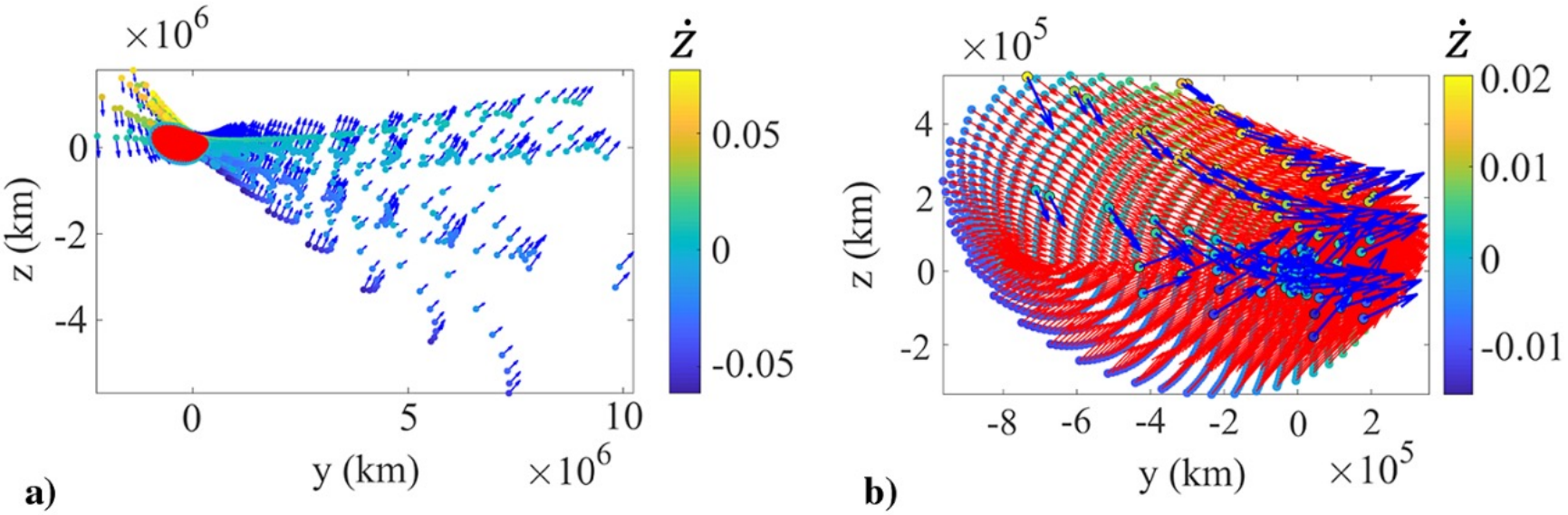


Fig. 3 Paths departing the LEO and intersecting the hyperplane: a) selected solutions projected onto the xy plane, and b) larger data set represented on a (y, z) map.

Credit: Bosanac, N; Webster, C.M.; Howell, K.C.; Folta, D.C., 'Trajectory Design for the Wide Field Infrared Survey Telescope Mission,' September 2019, Vol. 42, No. 9, pp. 1899-1911, Journal of Guidance, Control and Dynamics

Step 4: Construct Initial Guess



Credit: Bosanac, N; Webster, C.M.; Howell, K.C.; Folta, D.C., 'Trajectory Design for the Wide Field Infrared Survey Telescope Mission,' September 2019, Vol. 42, No. 9, pp. 1899-1911, Journal of Guidance, Control and Dynamics

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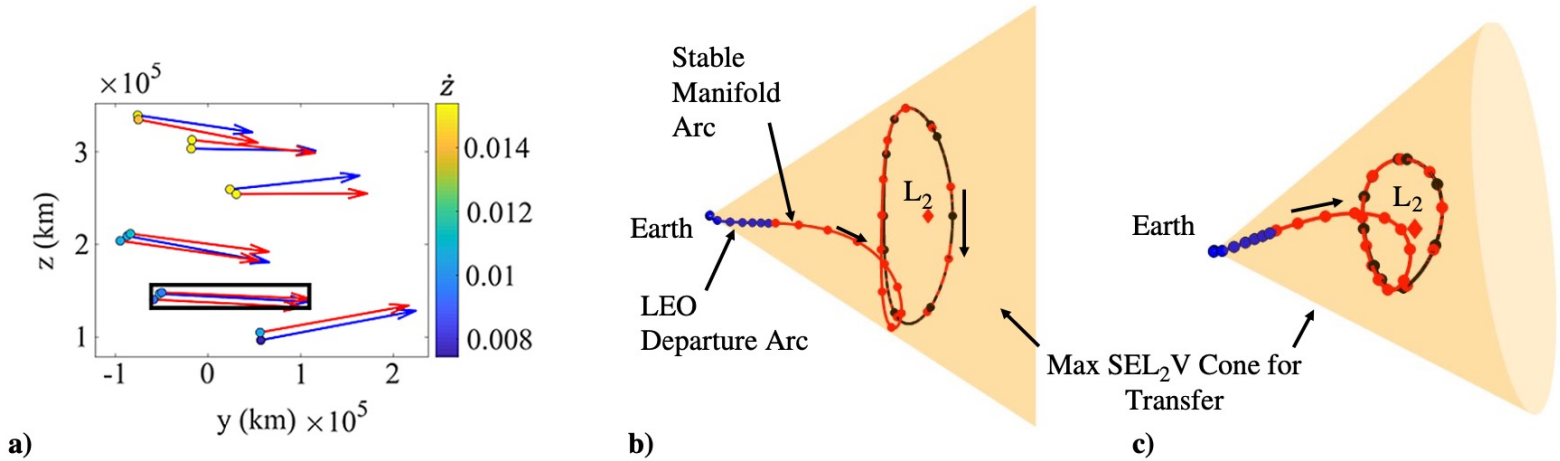


Fig. 5 An initial guess a) constructed by selecting individual arcs on a map, b) viewed from above the SE plane, and c) viewed in three dimensions.

Credit: Bosanac, N; Webster, C.M.; Howell, K.C.; Folta, D.C., 'Trajectory Design for the Wide Field Infrared Survey Telescope Mission,' September 2019, Vol. 42, No. 9, pp. 1899-1911, Journal of Guidance, Control and Dynamics

Step 5: Correct Trajectory in CR3BP

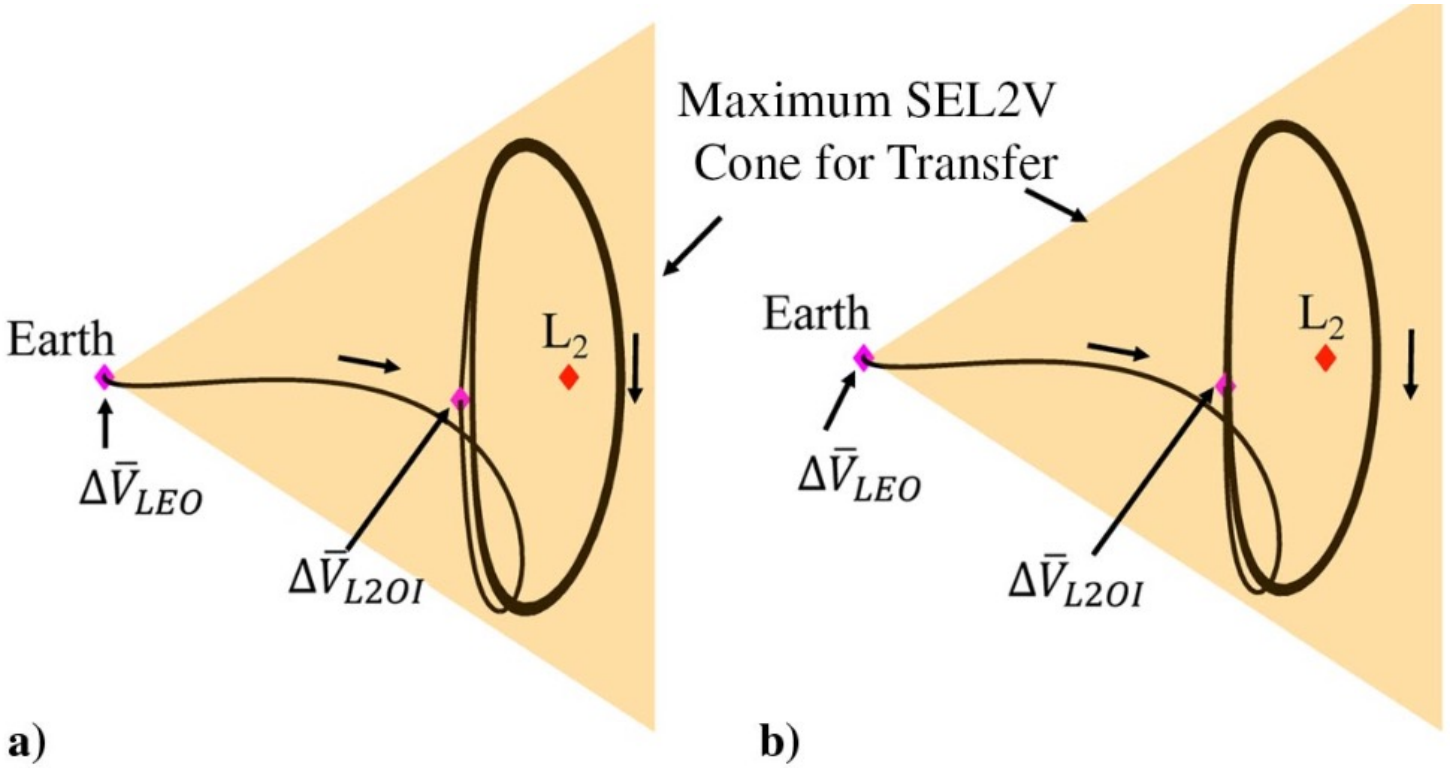
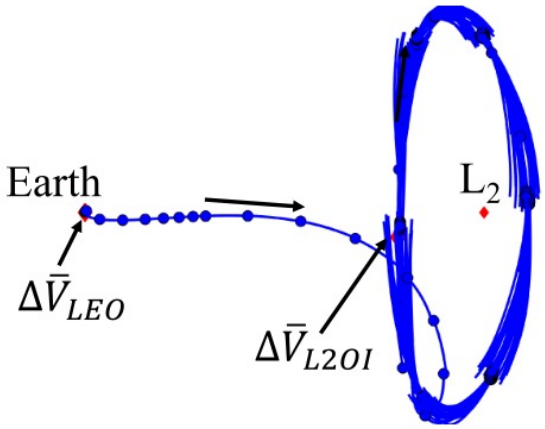


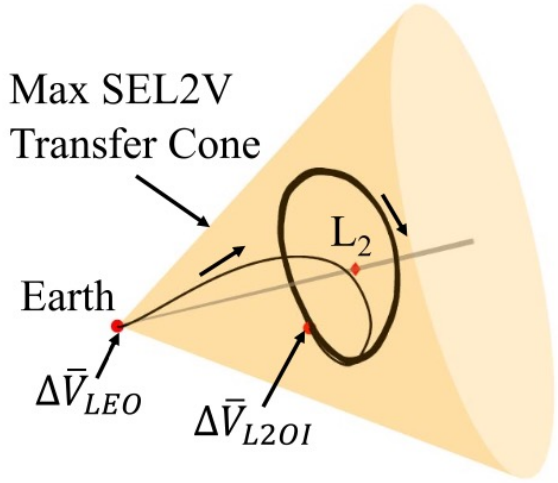
Fig. 6 A two-impulse continuous trajectory in the CR3BP: a) after initial corrections with $|\Delta V_{L_2OI}| = 37.4$ m/s and b) final solution with $|\Delta V_{L_2OI}| = 8.40$ m/s.

Credit: Bosanac, N; Webster, C.M.; Howell, K.C.; Folta, D.C., 'Trajectory Design for the Wide Field Infrared Survey Telescope Mission,' September 2019, Vol. 42, No. 9, pp. 1899-1911, Journal of Guidance, Control and Dynamics

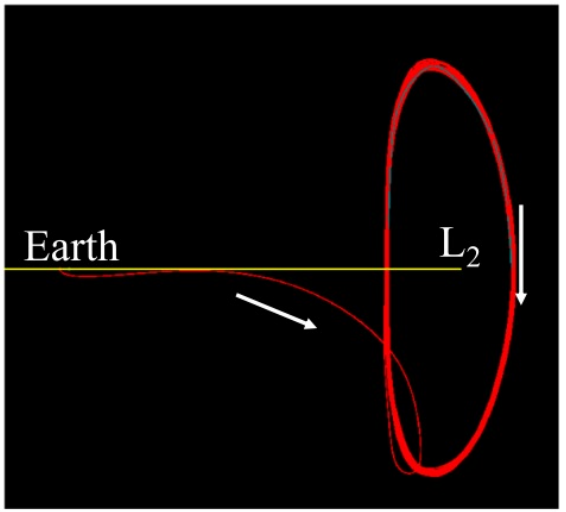
Step 6: Correct in Ephemeris Model w/ SRP



a)



b)



c)

Credit: Bosanac, N; Webster, C.M.; Howell, K.C.; Folta, D.C., 'Trajectory Design for the Wide Field Infrared Survey Telescope Mission,' September 2019, Vol. 42, No. 9, pp. 1899-1911, Journal of Guidance, Control and Dynamics