Trajectory Design for Mars 2020

Aston McDonald

Position and Velocity of Earth at Launch and Mars at Arrival

Planet	Rx (km)	Ry (km)	Rz (km)	Vx (km/s)	Vy (km/s)	Vz (km/s)
Earth (Launch)	9.1900e+7	-1.2094e+8	5.3201e+3	23.2280	17.9096	-8.7892e-4
Mars (Arrival)	-1.4192e+6	2.3490e+8	4.9571e+6	-23.3106	1.9125	0.6120

Orbital Elements

| Planet	a (km)	e	i (rad)	ω(rad)	Ω (rad)	ν (rad)	E (deg)
Earth (Launch)	1.4690e+8	0.0168	4.5956e-5	-1.2898	3.0872	-2.7184	-2.7114
Mars (Arrival)	2.2794e+8	0.0934	0.0323	-1.2801	0.8640	1.9932	1.9062

Finding Velocity of s/c at Burnout

- Utilized Zero Radius SOI and patched conics assumption
- Brute force trial and error through iteration with error in velocity x,y, and z directions
  - Initial Guess with Hohmann Transfer
  - Once tolerance was met it was adjusted in adjunct with step size
  - Propagated orbits with the Two Body function seen in HW3
  - Through experimentation max iterations to receive decent miss distance was found to be i=10000=1e4
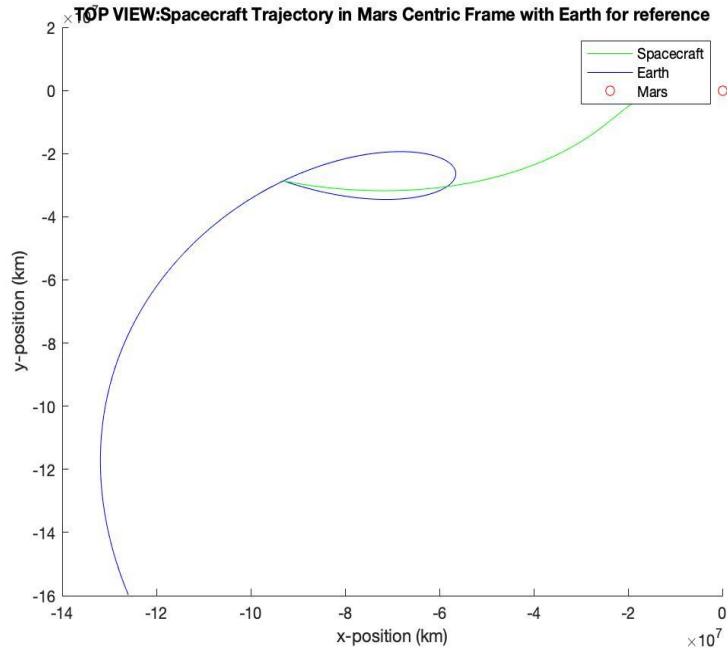
Results:

- Spacecraft Velocity vector: [26.43665, 19.51899, 1.15681]
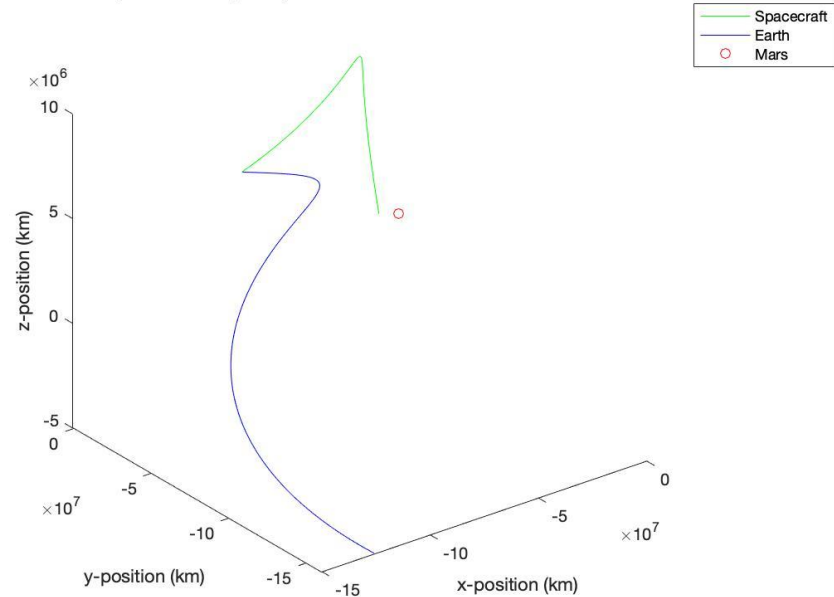- Hit or Miss magnitude of error was 1.59747 km

Combined Resulting Trajectories in Heliocentric Frame
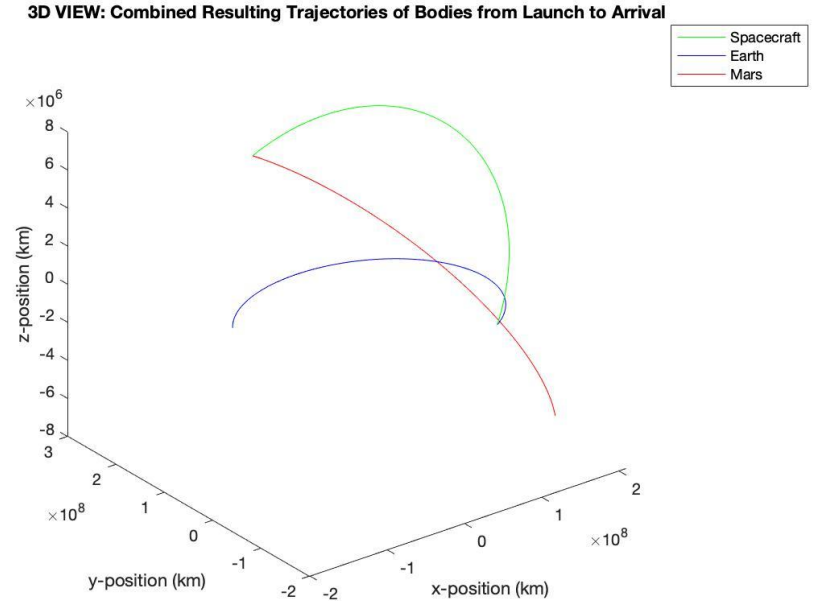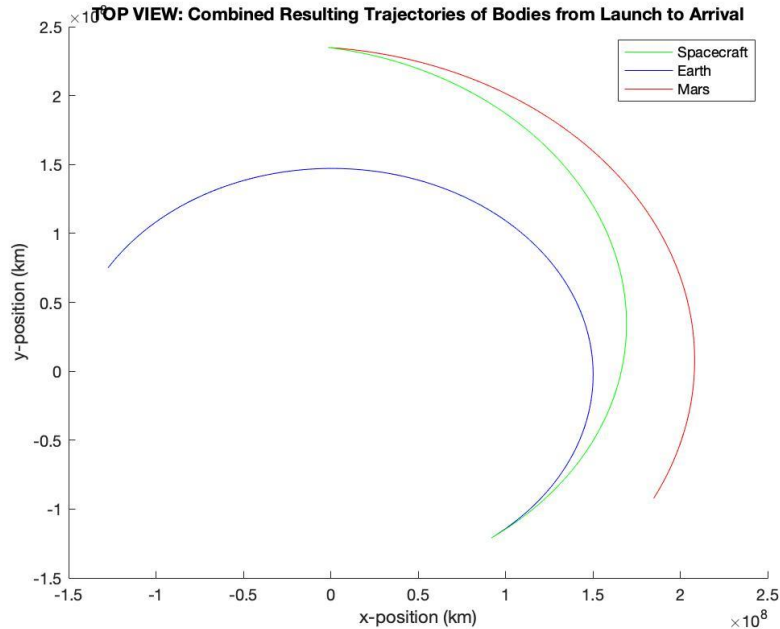
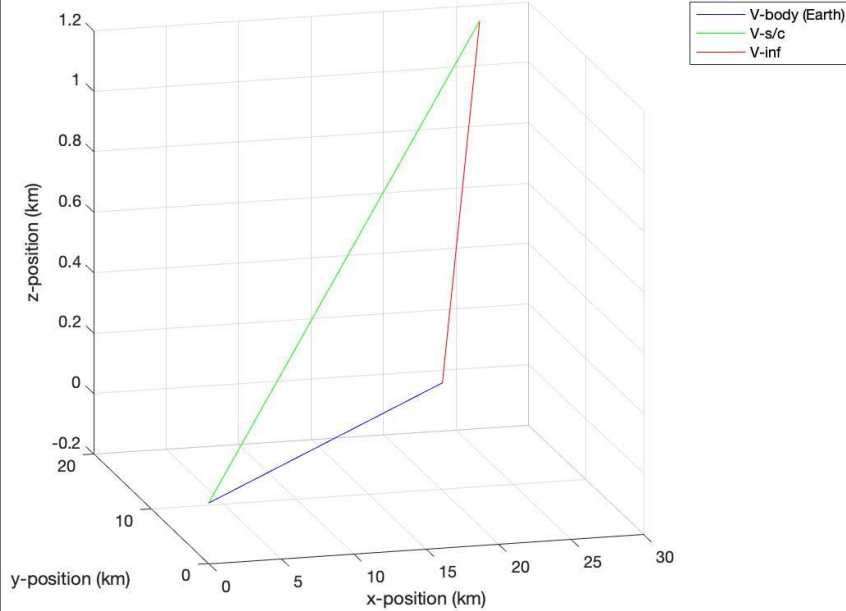# Spacecraft Trajectory in Mars Centric Frame with Earth Trajectory for Launch time reference

Vinf **Velocity Diagrams for Launch and Arrival**

Magnitude of **V**-inf (Launch) = 3.7717 km/s
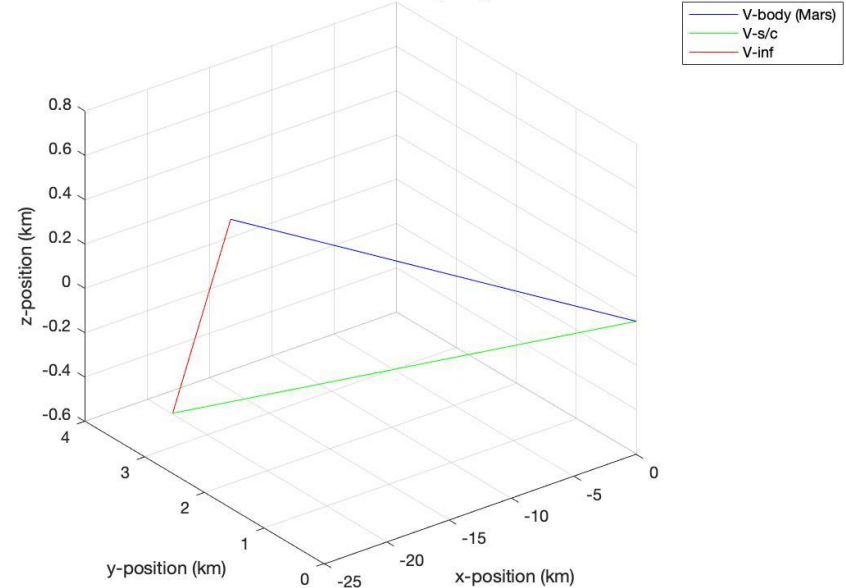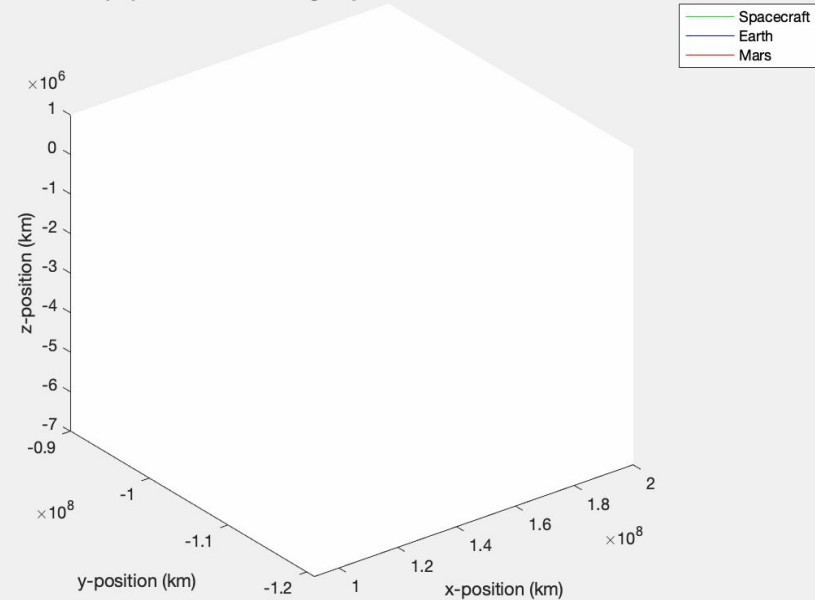
Magnitude of **V**-inf (Arrival) = 2.7233 km/s

Animated Trajectories

ANIMATION (Top): Combined Resulting Trajectories of Bodies from Launch to Arrival
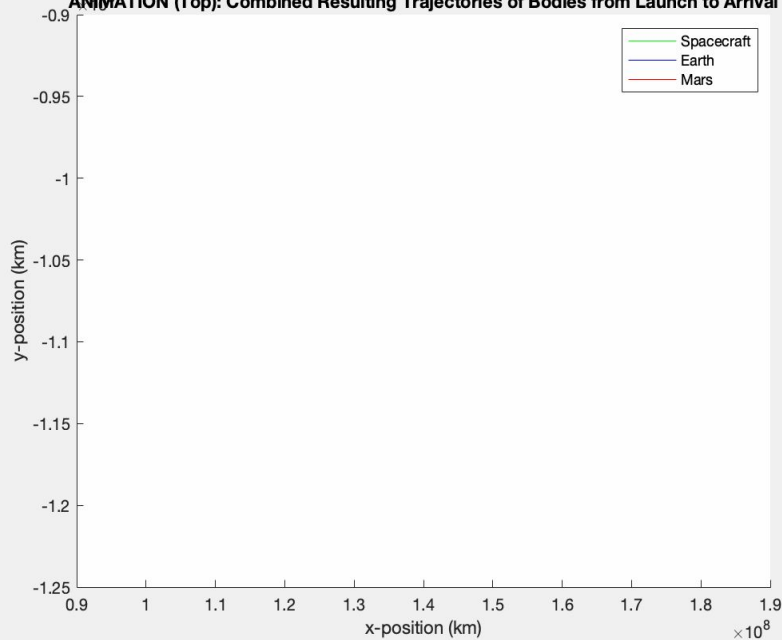
ANIMATION (3D): Combined Resulting Trajectories of Bodies from Launch to Arrival

Inclination of Final Orbit

- Based on the north pole of Mars the inclination of the spacecraft orbit as it approaches mars was found to be 28.194268 degrees

```
khat=[4.461321045940511e-01  -5.583636558975008e-02 8.932236257109472e-01];
  % h = r x v
h=cross(rvscA(1:3),rvscA(4:6));
  %inclination
isc=acosd(dot(h,khat)/(norm(h)*norm(khat)));
```

NASA Launch Vehicle Performance

- Using the VinfL magnitude C3 was found to be 14.2259
- When cross referenced with the Atlas V (541), mass was ~4250 kg
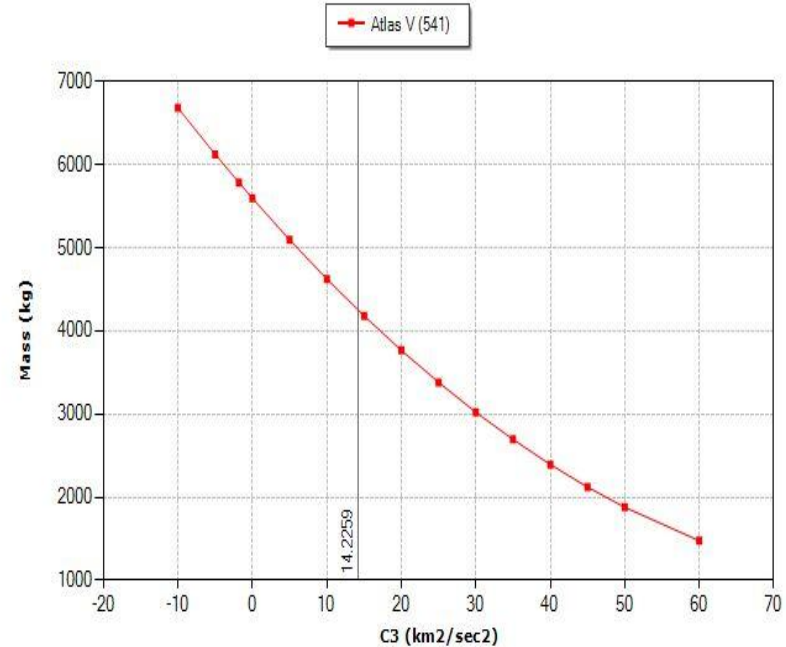
Results

- Using the collinear maneuver at Mars capture the deltaV was found to be 2.0653 km/s
- The mass left over was found to be ~2106 kg
- Mass of Propellant as a remainder was ~2144 kg
- The Published mass of the Mars 2020 rover is 1025 kg
  - The difference between published mass and found value is likely from the actual spacecraft. As well as Launch/Deploy equipment.

Citations

<u>Given:</u>

NASA launch vehicle performance website

<u>Source Code:</u>

Bemis, R. (n.d.). Animated GIF. Retrieved December 13, 2020, from https://www.mathworks.com/matlabcentral/fileexchange/21944-animated-gif