Problem 3

Part a)

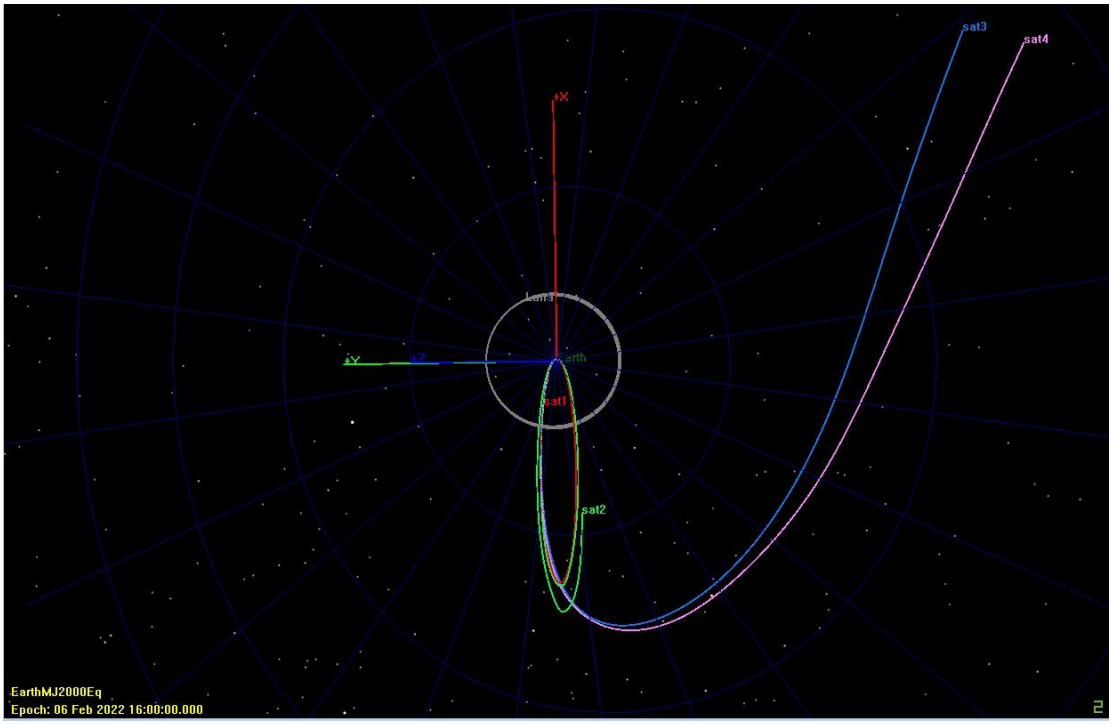

Figure 1 – October 9th, 2021, i = 0 degrees

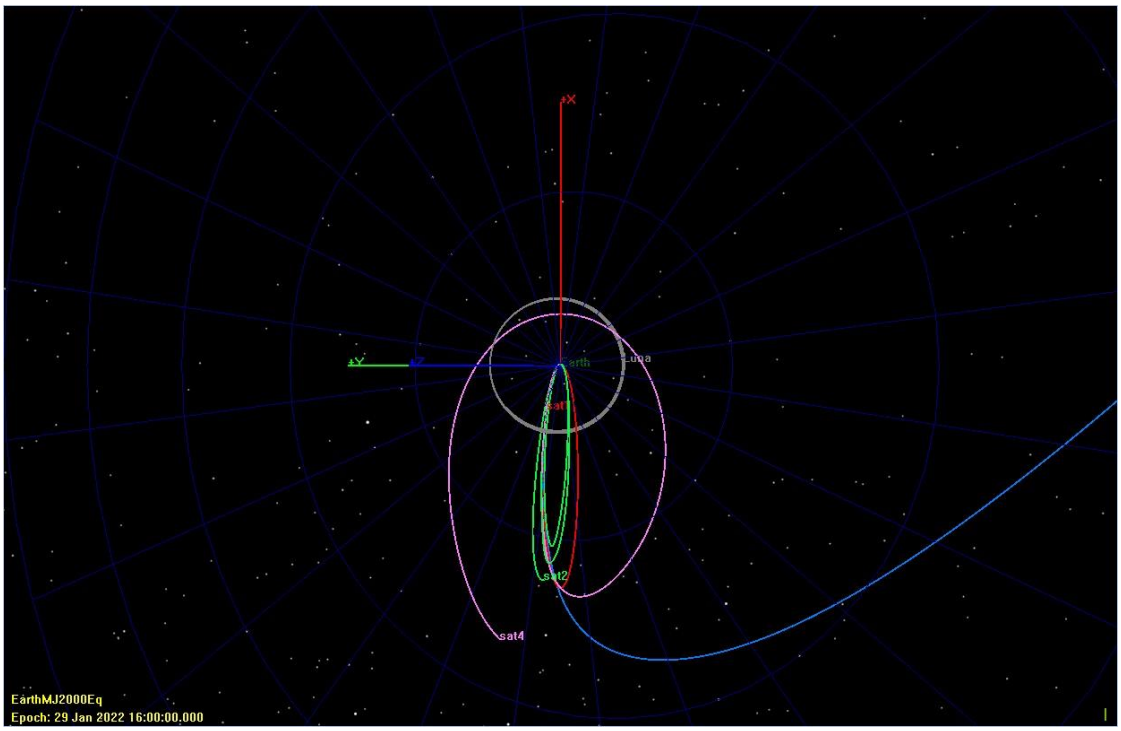

Figure 2 – October 1st, 2021, i = 0 degrees

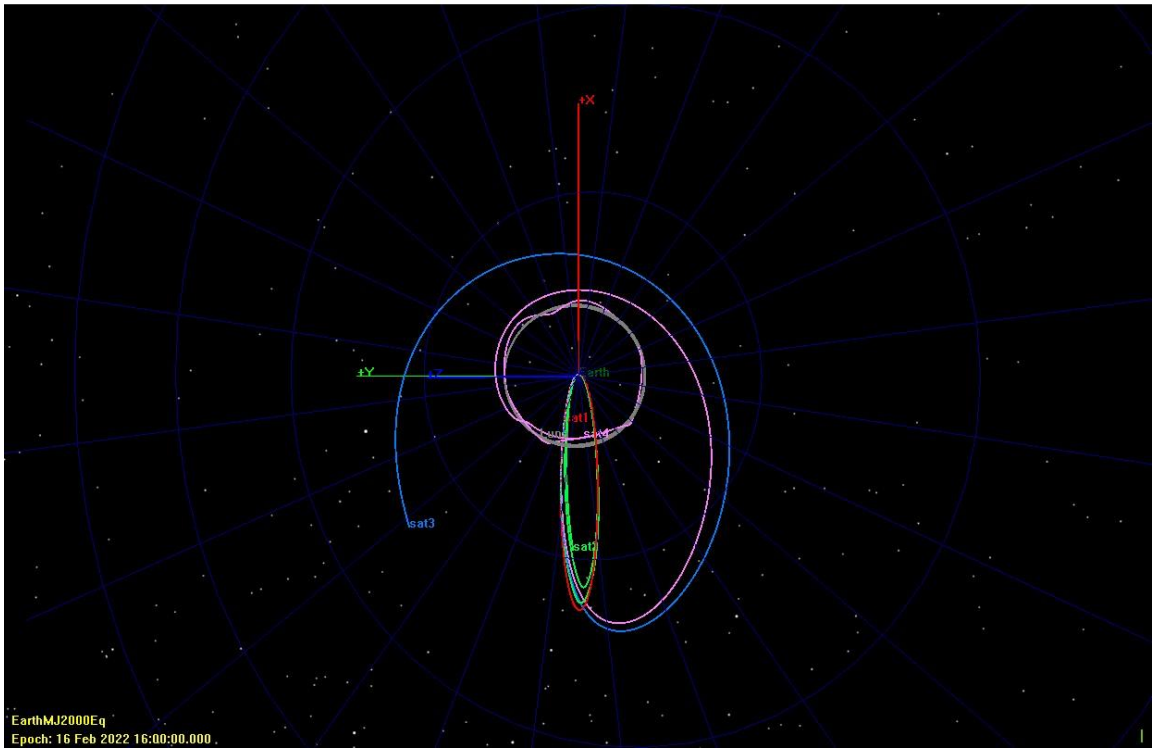

Figure 3 – October 19th, 2021, i = 0 degrees

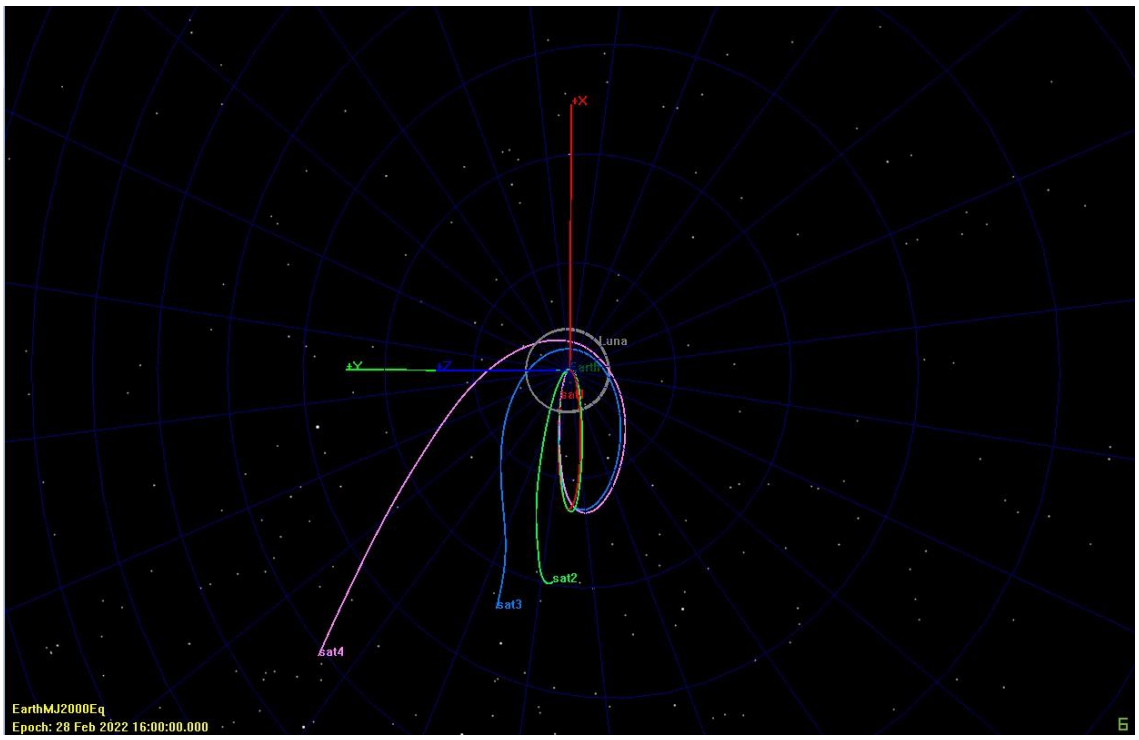

Figure 4 – October 31st, 2021, i = 0 degrees

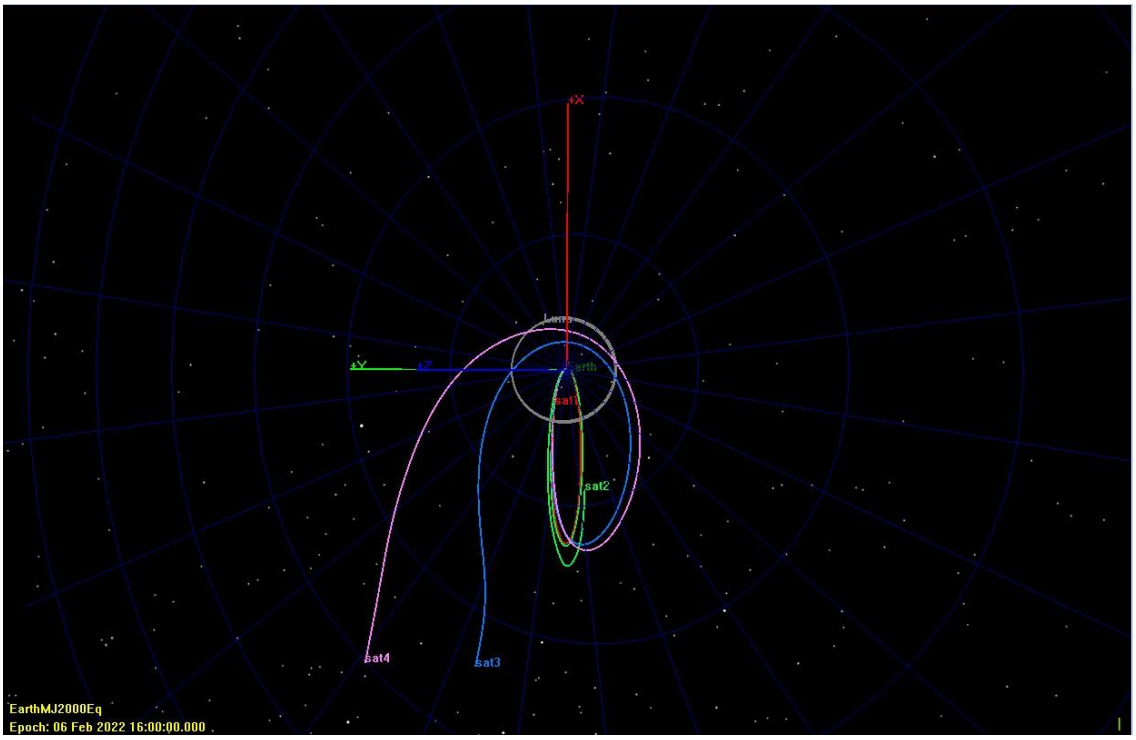

Figure 5 – October 9th, 2021, i = 30 degrees

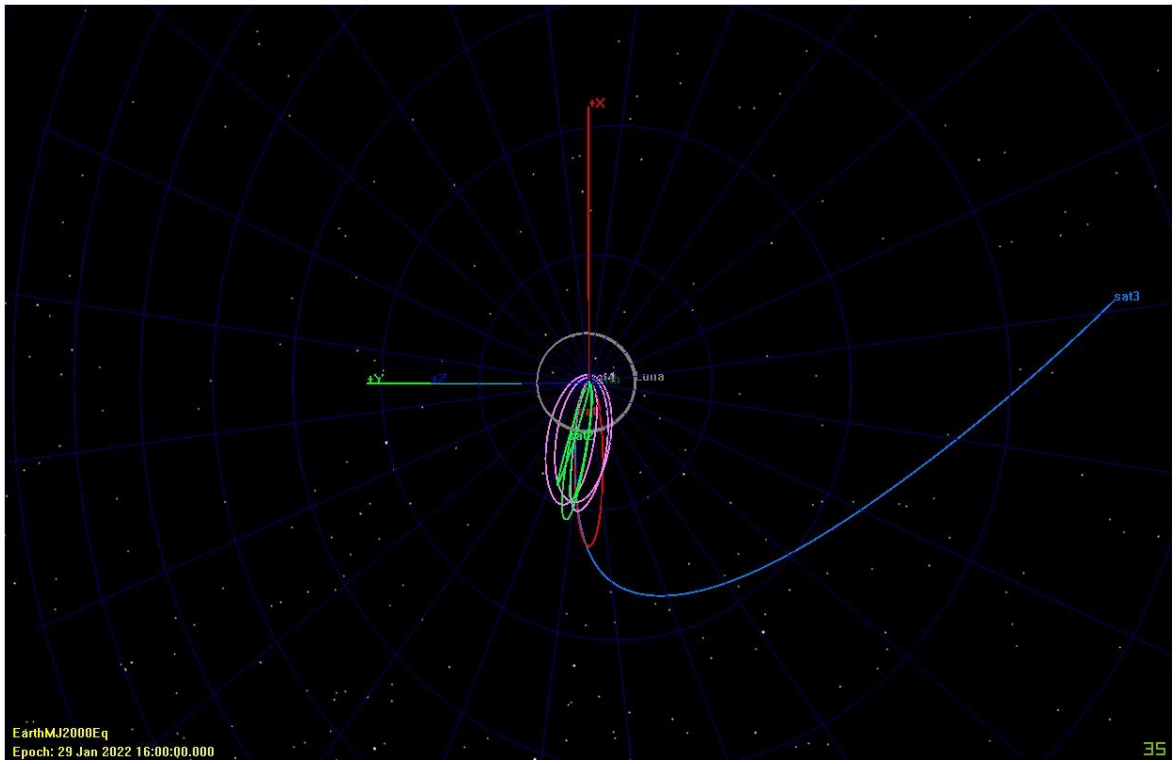

Figure 6 – October 1st. 2021, i = 30 degrees

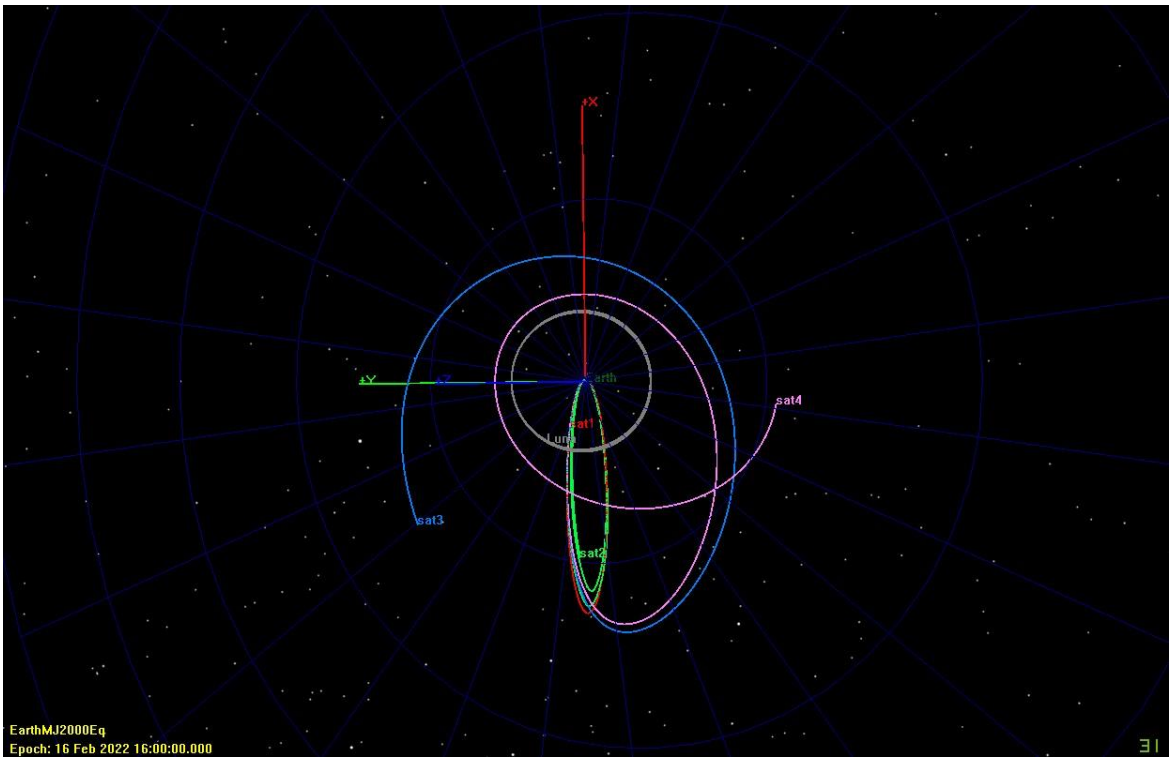

Figure 7 – October 19th, 2021, i = 30 degrees

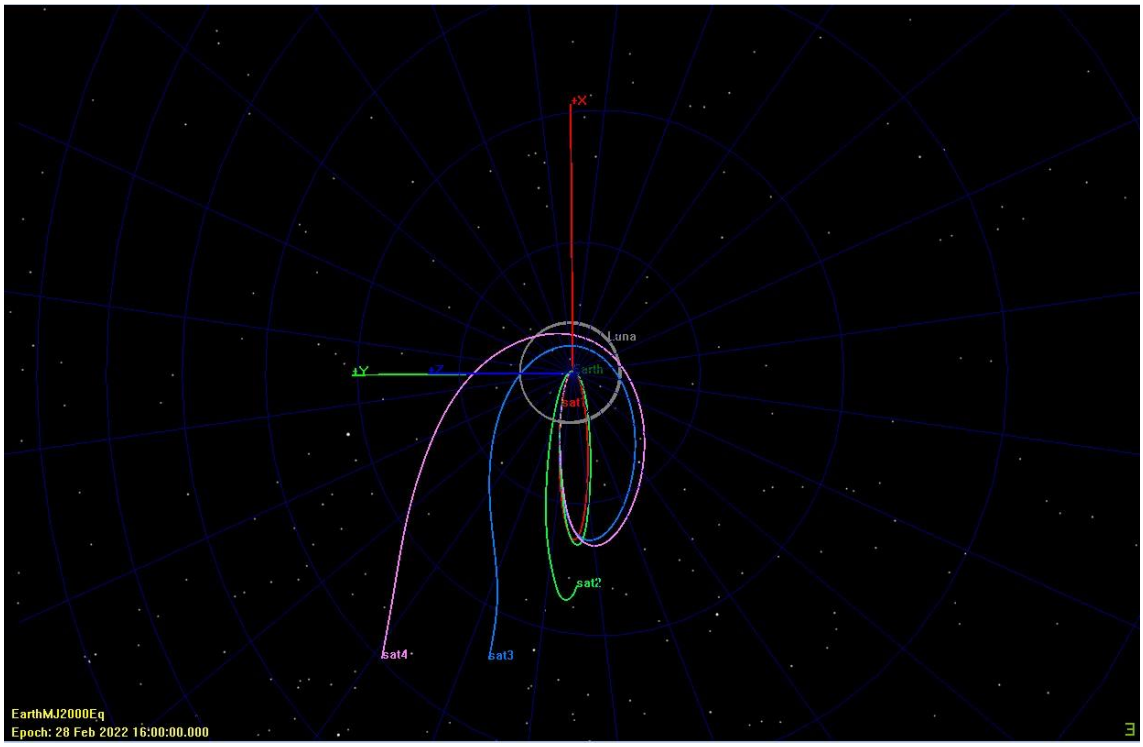

Figure 8 – October 31st. 2021, i = 30 degrees

Changing the propagators drastically changes the trajectories of each orbit. This can be seen in figures 1 through 4 which include different point masses for each propagator (Earth, EarthMoon, EarthSun, and EarthMoonSun) where each propagator completely changes the path of the satellites. Adding an inclination also changes the trajectories. This causes some of the orbits (namely the EarthSun and EarthMoonSun) orbits to being more in-line with the orbital plane of the moon. This effect can be seen in figures 4 through 8.

The model obviously makes a difference as described before. The addition of different large masses in the orbital calculations causes completely different orbits. The two-body model is not adequate for this particular problem because it can be seen that both the moon and the sun interact with the satellite in a nontrivial scale. A four-body problem would be needed to adequately model this problem which includes the Earth, Moon, Sun, and the satellite. This is because the Earth-Moon-Sat and Earth-Moon trajectories are similar, while the Earth-Sun-Sat trajectory is wildly different, and the Earth-Moon-Sun-Sat trajectory is even more so. The affect of different epoch dates dictates how the satellite is affected by the moon since the distance to the moon is closer than that of the sun. The moon causes such different paths because the moon is in the direct path of some of the trajectories which causes the distance between the satellites and the moon to decrease, thus increasing its effect on the satellite.

Part b)

October 1, 2021

i = 0 degrees

Sat	a (km)	e	Energy (km^2/s^2)	h (km/s)	r_f (km)	v_f (km/s)	TA_f (deg)	FPA_f	r_p
1	642590.000	0.985	-0.310	87040.264	265246.064	1.544	160.456	12.267	9574.591
2	614647.297	0.983	-0.324	91118.407	1215950.107	0.084	180.516	117.344	9027.329
3	-308454.769	8.413	0.646	2929038.839	4065806.911	1.220	59.311	36.193	9574.591
4	791994.798	0.984	-0.252	101136.534	1565337.020	0.077	179.369	56.544	9574.591

October 9, 2021

Sat	a (km)	e	Energy (km^2/s^2)	h (km/s)	r_f (km)	v_f (km/s)	TA_f (deg)	FPA_f	r_p
1	642590.000	0.985	-0.310	87040.264	265246.064	1.544	160.456	12.267	9574.591
2	715621.401	0.984	-0.278	92678.913	879466.072	0.591	187.893	169.731	9574.591
3	-639737.044	2.931	0.311534595	1391743.649	3002339.517	0.942	77.820	29.456	9574.591

4	-513059.757	3.788	0.3884	1652344.813	3235859.253	1.0116	72.854	30.318	9574.591

Oct 19, 2021

Sat	a (km)	e	Energy (km^2/s^2)	h (km/s)	r_f (km)	v_f (km/s)	TA_f (deg)	FPA_f	r_p
1	642590.000	0.985	-0.310	87040.264	265246.064	1.544	160.456	12.267	9574.591
2	609090.657	0.983	-0.327	90183.494	960820.508	0.419	174.612	12.955	7506.814
3	1518253.066	0.441	-0.131	698054.515	1249810.947	0.613	92.840	65.739	9574.591
4	328769.941	0.103	-0.606	360084.149	335169.746	1.080	253.351	95.800	9574.591

Oct 31, 2021

Sat	a (km)	e	Energy (km^2/s^2)	h (km/s)	r_f (km)	v_f (km/s)	TA_f (deg)	FPA_f	r_p
1	642590.000	0.985	-0.310	87040.264	265246.064	1.544	160.456	12.267	9574.591
2	983188.622	0.987	-0.203	100223.072	1939884.267	0.074	180.782	136.026	9574.591
3	1950577.747	0.996	-0.102	78151.823	2279136.055	0.381	175.712	5.159	9574.591
4	-599716.958	2.360	0.332	1045169.082	3453875.642	0.946	95.021	18.650	9574.591

i = 30 degrees

Oct 1, 2021

Sat	a (km)	e	Energy (km^2/s^2)	h (km/s)	r_f (km)	v_f (km/s)	TA_f (deg)	FPA_f	r_p
1	642590.000	0.985	-0.310	87040.264	265246.064	1.544	160.456	12.267	9574.591
2	427156.886	0.977	-0.467	87769.843	467331.165	0.879	168.842	12.337	4774.188
3	-299529.381	8.699	0.665	2986014.073	4128351.737	1.234	59.476	35.868	9574.591
4	518279.493	0.971	-0.385	108601.723	15479.823	7.123	20.171	80.064	9574.591

Oct 9, 2021

Sat	a (km)	e	Energy (km^2/s^2)	h (km/s)	r_f (km)	v_f (km/s)	TA_f (deg)	FPA_f	r_p
1	642590.000	0.985	-0.310	87040.264	265246.064	1.544	160.456	12.267	9574.591
2	716306.522	0.985	-0.278	92298.605	888663.738	0.584	187.759	169.749	9574.591
3	-605827.311	3.074	0.329	1428602.626	3061999.831	0.958	77.371	29.135	9574.591
4	-484069.190	4.029	0.412	1714229.546	3310757.668	1.032	72.271	30.126	9574.591

Oct 19, 2021

Sat	a (km)	e	Energy (km^2/s^2)	h (km/s)	r_f (km)	v_f (km/s)	TA_f (deg)	FPA_f	r_p
1	642590.000	0.985	-0.310	87040.264	265246.064	1.544	160.456	12.267	9574.591
2	611178.983	0.983	-0.326	91211.151	965858.714	0.416	174.585	13.116	7404.802
3	1444170.739	0.399	-0.138	695547.848	1208586.313	0.619	89.391	68.309	9574.591
4	824227.921	0.281	-0.242	550145.844	1049713.937	0.525	170.318	86.266	9574.591

Oct 31, 2021

Sat	a (km)	e	Energy (km^2/s^2)	h (km/s)	r_f (km)	v_f (km/s)	TA_f (deg)	FPA_f	r_p
1	642590.000	0.985	-0.310	87040.264	265246.064	1.544	160.456	12.267	9574.591
2	873487.866	0.986	-0.228	98925.688	1635111.576	0.177	182.395	159.976	9574.591
3	1999183.598	0.996	-0.100	77727.745	2286851.449	0.386	175.680	5.048	9574.591
4	-2701187.153	1.216	0.074	717061.045	2617031.078	0.672	114.656	24.046	9574.591

Almost all the satellites are clear of collision with the Earth except for one which was the Earth-Moon model starting on October 1 with an inclination of 30 degrees. Two others (Earth-Moon, October 19, 0 inclination and Earth-Moon, October 19, 30-degree inclination) had a close flyby of about 7450 km from the center of the Earth, these did not collide but were both affected by the Moon enough to come closer to the earth compared to the other trajectories. This infers that the moon's perturbation had the largest effect on the periapsis distance of the satellite to the Earth. As seen in the tables above, this does not occur at all starting epochs.