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ME 356
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Final Project- Europa Clipper Capture

Part 1

Using Excel, I determined the Keplarian elements of the approach and capture orbits as well as the delta V required to capture the first Europa Clipper orbit. The values are as follows:

Keplerian Elements	Approach Trajectory	Initial Capture Orbit
a, km	-3.6510201E+6	9.8598416E+06
i, degrees	0.47 (to Jupiter's Equator) 1.791 (to ecliptic plane)	0.47 (to Jupiter's Equator) 1.791 (to ecliptic plane)
Ω, degrees	230.931	230.931
ω, degrees	45	45
e	1.2066	0.9235
θ, degrees	345.4 deg	345.4 deg

*The above values were determined by either Europa's orbital elements or the calculations from the excel file pictured in Figure 1.

Delta V required at hyperbolic periapsis to capture around Jupiter: 1.27743 km/s

The process for determining the values depicted in Figure 1 required determining H/m and semi-major axis from the provided radii, velocities, and mu of Jupiter. Following this, the specific angular momentum, h, and eccentricity, e, were calculated from the radius and velocity at apoapsis, then using these values along with the semi major axis, I solved for periapsis. With periapsis now known, the hyperbolic and elliptical orbital values can be calculated in reference to it. The required delta V at periapsis was then calculated by taking the difference in specific angular momentum, h, from the approach orbit to the capture orbit, then dividing by the radius of periapsis.

mu	126,687,000	km^3/s^2				
Date	v, km/sec	r, km	H/m, km^2/sec^2	a, km	h, km^2/sec	e
3/27/2030	7.514	11,643,423	17.350	-3.6510201E+06	14522364.55	1.2066
3/31/2030	7.926	9,005,084	17.342	-3.6525323E+06	14522083.04	1.2065
4/4/2030	8.685	6,210,385	17.315	-3.6582188E+06	14521026.48	1.2062
4/8/2030	10.749	3,117,750	17.136	-3.6964321E+06	14514008.74	1.2041
4/12/2030	13.819	1,257,411	-5.270	1.2019914E+07	13607037.92	0.9372
4/16/2030	7.295	3,842,072	-6.365	9.9516870E+06	13561150.16	0.9242
4/20/2030	5.560	5,792,726	-6.413	9.8770286E+06	13559130.78	0.9236
4/24/2030	4.625	7,392,697	-6.441	9.8337109E+06	13557944.91	0.9233
4/28/2030	4.004	8,765,040	-6.438	9.8395186E+06	13558104.52	0.9233
5/2/2030	3.541	9,969,939	-6.438	9.8396788E+06	13558108.92	0.9233
5/6/2030	3.175	11,043,451	-6.431	9.8491406E+06	13558368.53	0.9234
5/10/2030	2.869	12,007,715	-6.435	9.8437635E+06	13558221.05	0.9234
5/14/2030	2.609	12,878,967	-6.433	9.8461976E+06	13558287.83	0.9234
5/18/2030	2.383	13,668,193	-6.429	9.8521622E+06	13558451.33	0.9234
5/22/2030	2.180	14,384,634	-6.431	9.8498559E+06	13558388.13	0.9234
5/26/2030	2.000	15,035,026	-6.426	9.8571854E+06	13558588.86	0.9235
5/30/2030	1.835	15,624,423	-6.425	9.8594400E+06	13558650.55	0.9235
6/3/2030	1.685	16,157,328	-6.421	9.8647049E+06	13558794.48	0.9235
6/7/2030	1.543	16,636,905	-6.424	9.8598416E+06	13558661.53	0.9235
6/11/2030	1.415	17,066,865	-6.422	9.8637193E+06	13558767.55	0.9235
6/16/2030	1.296	17,448,806	-6.421	9.8655303E+06	13558817.03	0.9235
6/20/2030	1.184	17,784,994	-6.422	9.8630179E+06	13558748.38	0.9235
6/24/2030	1.083	18,076,906	-6.422	9.8638553E+06	13558771.26	0.9235
6/28/2030	0.991	18,326,316	-6.422	9.8638148E+06	13558770.15	0.9235
7/2/2030	0.912	18,534,249	-6.419	9.8674806E+06	13558870.3	0.9235
7/6/2030	0.838	18,700,944	-6.423	9.8616090E+06	13558709.86	0.9235
7/10/2030	0.781	18,827,772	-6.424	9.8608293E+06	13558688.54	0.9235
7/14/2030	0.739	18,914,906	-6.425	9.8594123E+06	13558649.79	0.9235
7/18/2030	0.715	18,963,122	-6.425	9.8587705E+06	13,558,632.23	0.9235
7/22/2030	0.743	18,971,759	-6.402	9.8948897E+06	13559616.69	0.9238
km/s			rp, km			
19.24	Velocity at hyperbolic periapsis		754419.0182	Periapsis Determined through calculation		
1.27743	dV required to capture		670900	Radius of Europa		
			83519.0182	Difference between for comparison of SOI		

Figure 1: Excel calculations

Part2

a)
Europa's sphere of influence is approximately 9725.6 km. At an orbital periapsis of 754,419.01 km and Europa's mean orbital radius of 670,900 km, the difference between is 83519.02 km. This means that in this particular trajectory the Europa clipper does not interact with Europa in the first orbit about Jupiter. It is likely that the maneuver is done independently of Europa to ensure the proper orbit is achieved, then the periapsis is lowered to begin the flyby gravity assist orbits. This is supported by the fact the second pass at periapsis appears noticeably closer to Europa's orbital radius in Figure 2.

b)
Figures 2 and 3 are the comparison images of the planned Europa Clipper mission from the given gif and the STK simulation I created, respectively. It can be seen that the orbits are nearly identical. In my STK scenario, I chose to depict the approach orbit in green so that the moment of the capture maneuver can be more clearly seen.

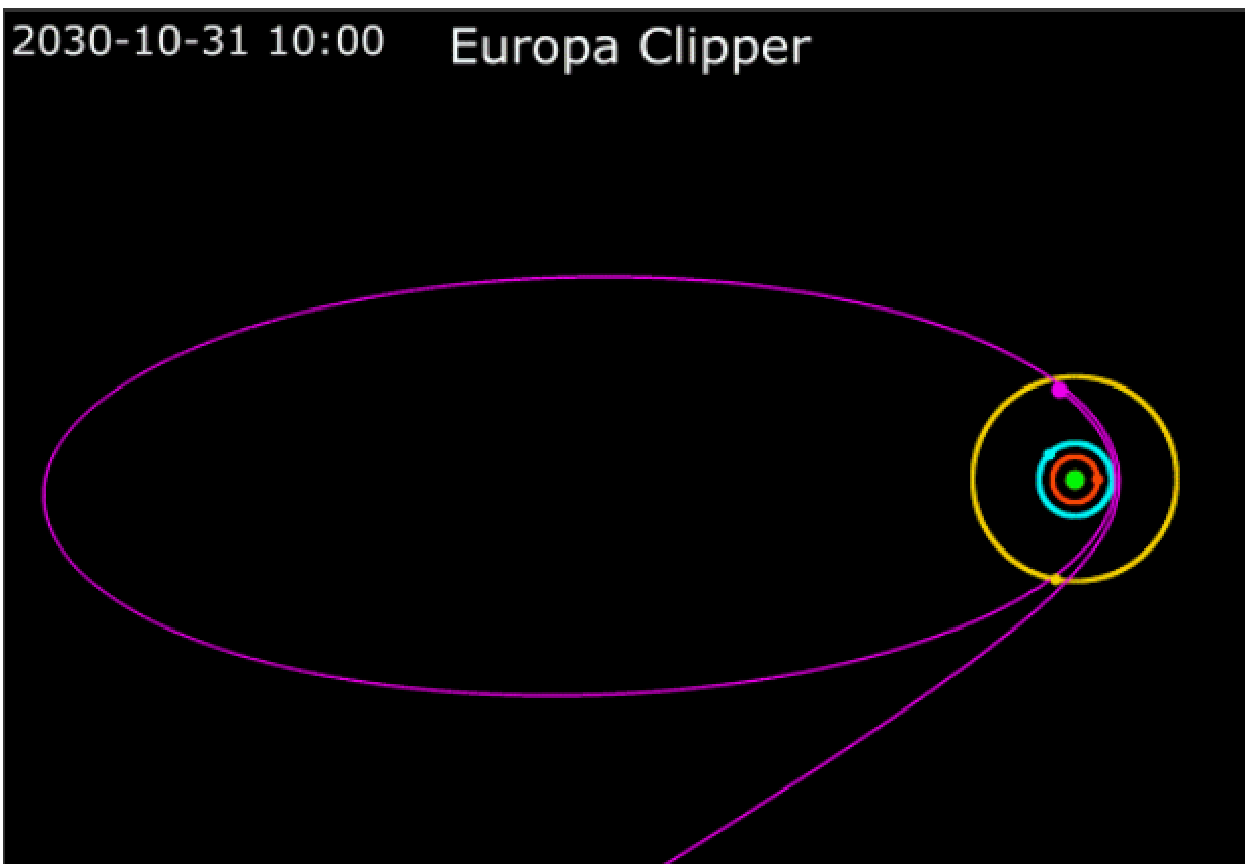

Figure 2: Europa Clipper official trajectory taken from GIF

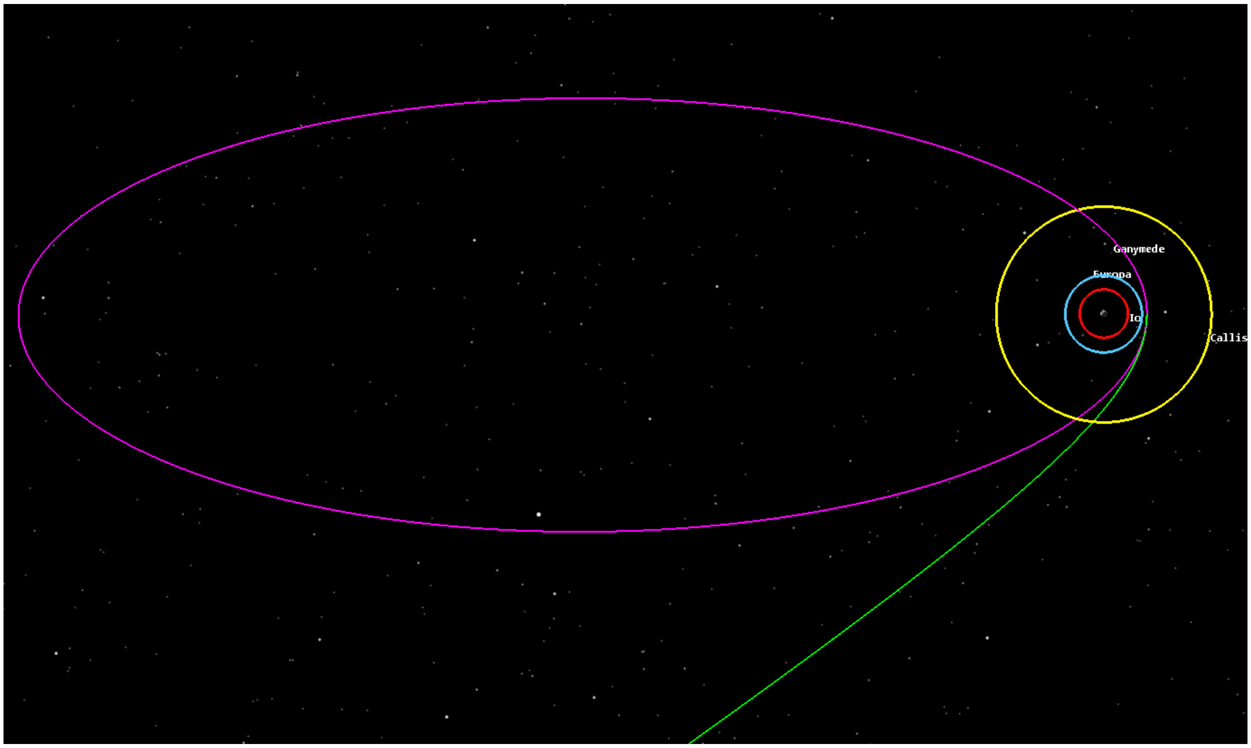

Figure 3: Europa Clipper trajectory simulation using STK

c) As seen in Figure 4, the required maneuver delta V at periapsis about Jupiter is 1276 m/s. Compared to the delta V calculated in excel, 1277.43 m/s, these values are nearly exact. This implies the STK simulation lines up well with the actual planned maneuver for the Europa Clipper mission. While this is an expensive maneuver for deep space, it is very reasonable.

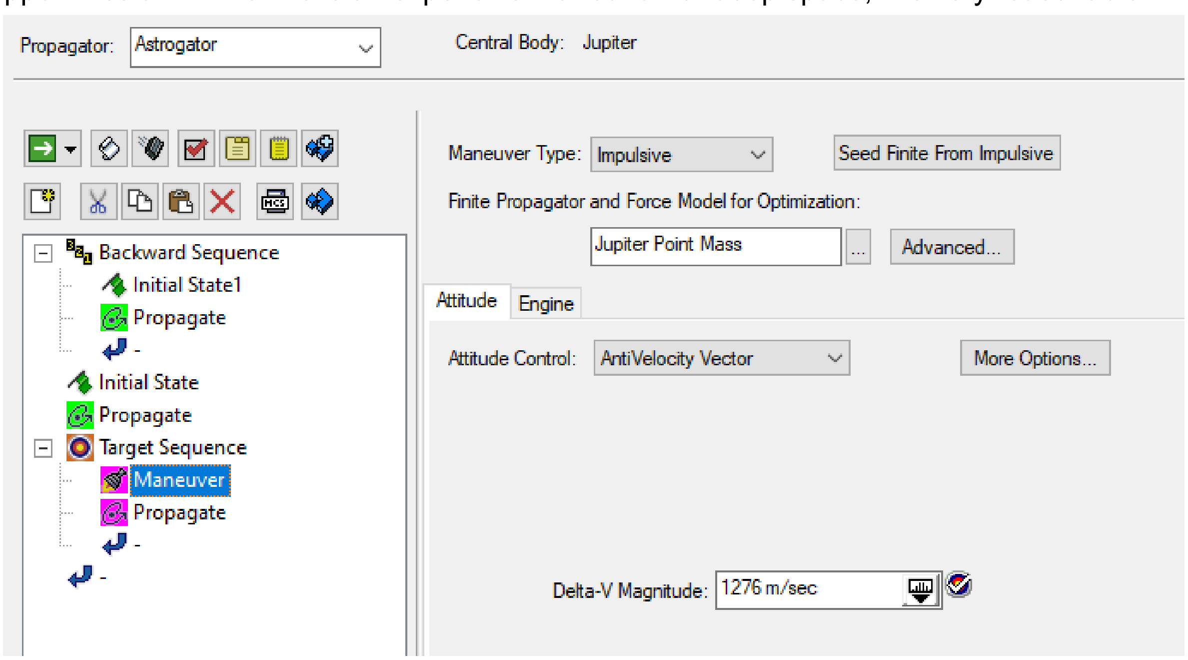

Figure 4: STK mission control sequence and capture maneuver delta V