Thomas Todaro
Professor A. Abraham
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A Study of Perturbations

Satellite Details:
- Mass: 0.01 kg
- Cross Sectional Area: 0.008 m^2
- Drag Coefficient: 2.2
- Coordinate System: EarthMJ2000Eq

Study 1: LEO

Orbit Details:
- Orbital Altitude: 500 km
- Inclination: 45 degrees

Position and Velocity Results after 3 Days of Propagation

	Kepler 2 Body	J2	70x70	70 x 70 w/ Drag	70 x 70 w/ Drag, Solar pressure, Solar/Lunar, and Tides	
x	-3705.143637	-459.8612674	-456.0969493	4331.287108	6172.829586	[km]
y	-4097.486708	-4886.374496	-4887.053437	-4391.596056	-2765.406053	[km]
z	-4097.486708	-4805.664489	-4805.346248	-2981.330857	-898.6865531	[km]
Vx	6.413693201	7.448250326	7.44867003	5.716014781	2.723203691	[km/s]
Vy	-2.899784215	-1.423336084	-1.418944934	2.742593455	4.753466417	[km/s]
Vz	-2.899784215	0.7238095791	0.7275347637	4.238800285	5.318768689	[km/s]

Analysis:
As can be observed from the above data, in the orbital situation layed out in this case, J2 created a large change in values from pure Keplerian propagation, however the difference between J2 and 70x70 is far less significant. This implies that using a more advanced Earth gravity model is useful for high fidelity mapping but for rough determinations, J2 is sufficient for quick pre-processing. From here, the addition of drag creates another fairly massive difference in vector values. This makes sense given the low altitude combined with the extremely low mass of the satellite. Finally, adding in the remaining relevant perturbations does indeed have a large effect on the final position and velocity vectors.. Given the small cross sectional profile of the satellite as well as its low mass, the additional perturbations expectedly make up a smaller difference than drag would make due to its close distance to atmospheric effects.

Study 2: GEO

Orbit Details:

- Orbital Altitude: 42164 km
- Inclination: 0 degrees
- True Anomaly: 75.370459 degrees

Position and Velocity Results after 21 Days of Propagation

	Kepler 2 Body	J2	70x70	70 x 70 w/ Drag	70 x 70 w/ Drag, Solar pressure, Solar/Lunar, and Tides	
x	-4491.347586	-4902.266154	-4729.084225	-4729.084226	-37811.3432	[km]
y	41924.10635	41877.94032	41899.59846	41899.59846	-35575.5594	[km]
z	6.34E-13	-0.5038508381	-0.5031332518	-0.5031332518	-563.5036067	[km]
Vx	-3.057172854	-3.053816699	-3.055207545	-3.055207545	0.197094894	[km/s]
Vy	-0.3275162458	-0.3575235677	-0.3448727499	-0.34487275	-2.398172591	[km/s]
Vz	-1.20E-16	3.77E-06	3.66E-06	3.66E-06	0.01861274615	[km/s]

Analysis:
The above results show that in this circumstance, while Earth's gravitational mapping does add precision to the vector calculations, they do not make a huge difference from the plain Keplerian propagation, this is because adding the J2 and 70x70 perturbations generally pull orbits towards the equator, and in this special circumstance, the satellites orbit is already positioned over the equator with an inclination of 0 degrees. Similarly, drag also has a minor effect on the outcome of the propagation. This time, however, it is due to the satellite's altitude, being that it is tens of thousands of kilometers away from the atmosphere, the effects of drag are reasonably very low. The largest effect by a factor of magnitude was included in the final set of perturbations. After taking a closer look at the set, solar pressure is the culprit behind the huge difference. Considering the huge distances the satellite has from both the sun and moon as well as Earth's tides in its geostationary distanced orbit, these can be reasonably ruled out as the main factors of change. Thus leaving solar pressure that, with the satellites miniscule mass, would have a large effect over the 3 week propagation time.