Q1

Wednesday, March 13, 2024 7:02 PM

a) The orbit needs to be at the same speed as earths rotation!

also needs to be at the equator (so that no latitudinal motion):

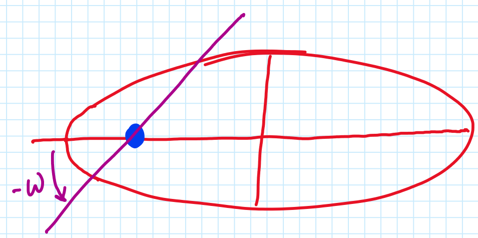
$i = 0°$, $e = 0$ ← circular, so no change in orbital velocity

i.e., geostationary orbit!

semi-major axis = semi-minor axis, google says:

$$\boxed{\begin{array}{l} 42{,}164 \text{ km from earth center} \\ 35{,}786 \text{ km from mean sea level} \end{array}}$$

b) an argument of periapsis ω produces equitorial symmetry when $\omega = 0°$ or $\omega = 180°$ because an orbit is parallel along the semi-major & semi-minor axes, so 180° rotation from the ascending node (or −180° from the semi-major axis), it results in a symmetric flip:

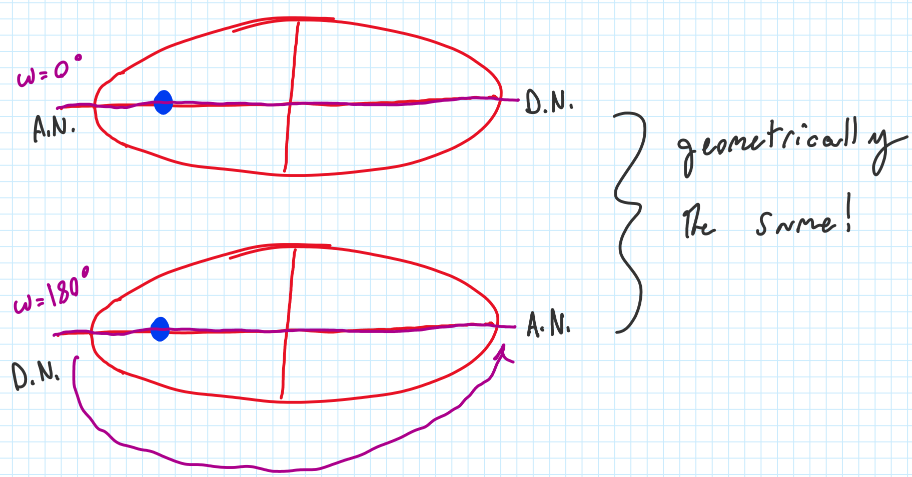


c) since molniya orbits are longitudinally symmetric, we must switch ω to it's opposite case to maintain the symmetry:

if $\omega = 270°$ for current config, $\omega = 90°$ is it's flipped config!

So we need to change $\underline{\underline{\omega}}$ from 270° to 90°!

↳ maintains groundtrack structure + longitudinal symmetry

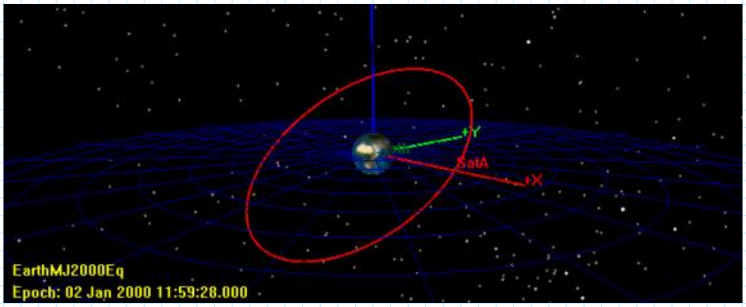


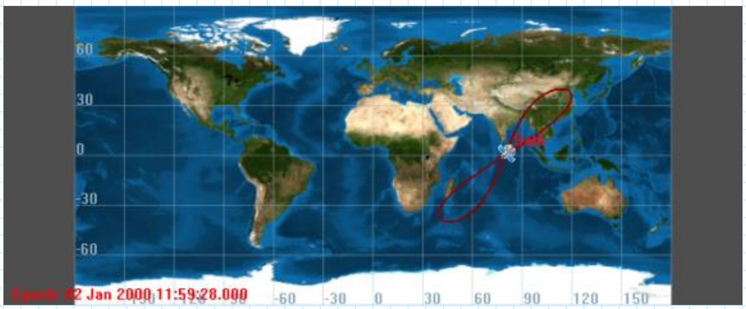
Q2

Thursday, March 14, 2024 5:32 AM

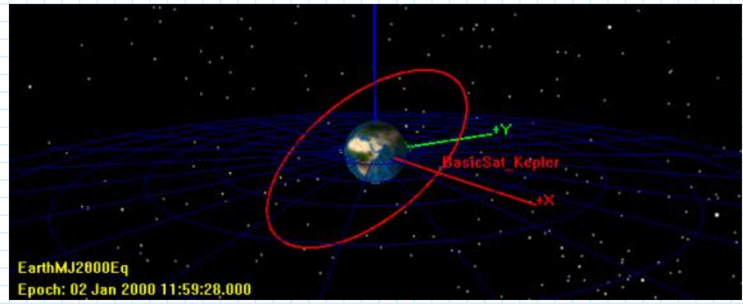
plotted using GMAT

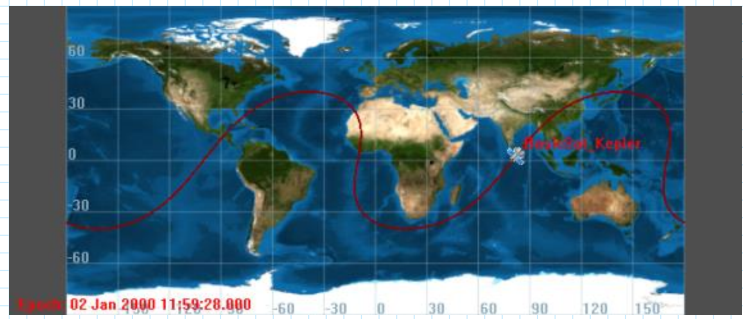
Sat orbit A:



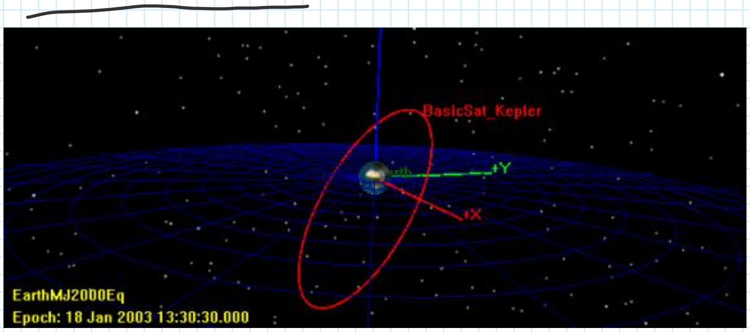


Sat orbit B:

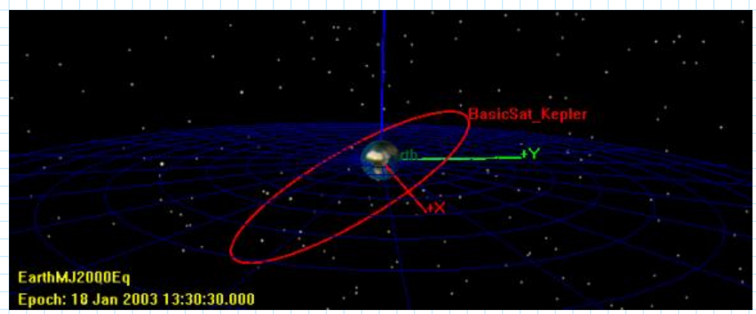


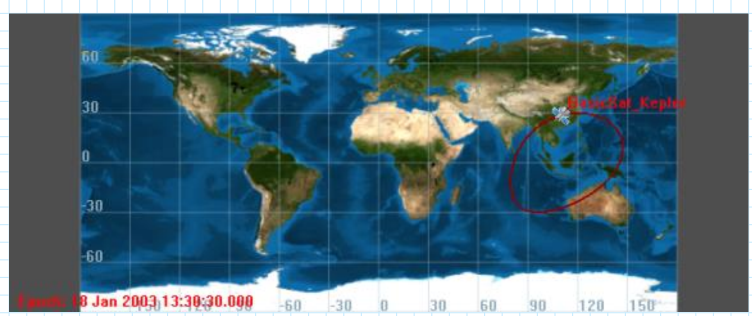


Sat C orbit:

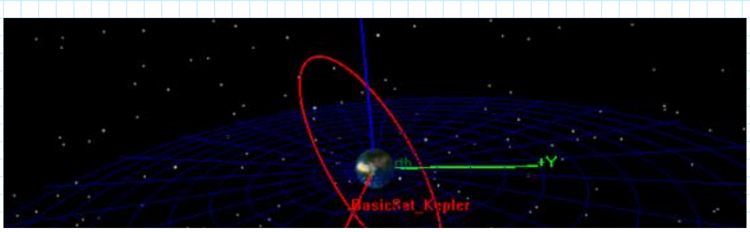


Sat D orbit:

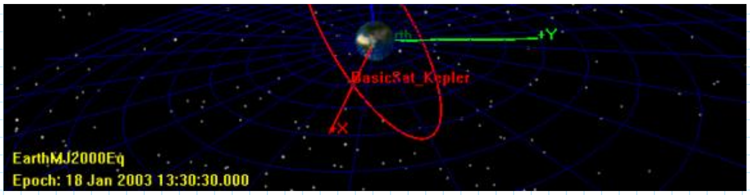


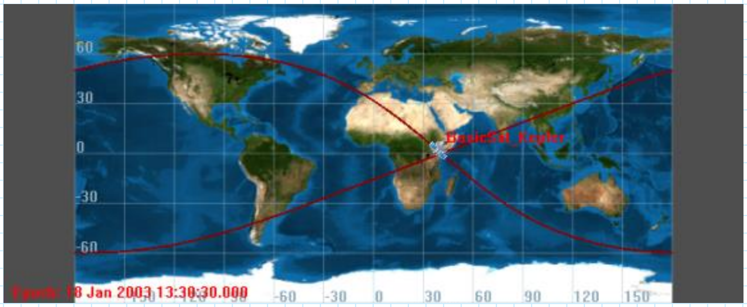


Sat E orbit:



The ground track of orbit E & orbit A is quite different considering there is a difference of inclination by about 80°! orbit A's





considering there is a difference of inclination by about 20°! orbit A's Ground track covers only a small portion of the earth's surface, meaning it's limited to doing science / surveillance in that region. orbit E, however, covers a signifigant poltion of the earth's surface, giving the satellite a more broad purpose! In theory, orbit E is also in retrograde, and both orbits are equitorially similar.

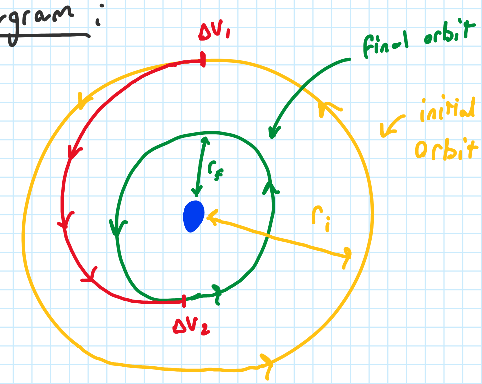
strange how an orbit in retrograde changes it's ground track so intersting.

Q3

Thursday, March 14, 2024 5:46 AM

GIVEN:

diagram:



initial:

$e_i = 0$

$r_i = 14{,}000$ km

final:

$e_f = 0$

$r_f = 8{,}000$ km

$\mu = \mu_{Earth}$

$= 3.986 \cdot 10^{14} \frac{m^3}{s^2}$

$= \frac{m^3}{s^2} \cdot \frac{10^{-3} km}{m} \cdot \frac{10^{-3} km}{m} \cdot \frac{10^{-3} km}{m} = \frac{10^{-9} km}{s^2}$, 14-9=5

$\boxed{= 3.986 \cdot 10^5 \frac{km^3}{s^2}}$

$\boxed{\Delta V_{tot} = \Delta V_1 + \Delta V_2}$

1

$V_{i_1} = \sqrt{\frac{\mu_E}{r_i}} = \sqrt{\frac{3.986 \cdot 10^5}{14{,}000}} = 5.33586$ km/s

$V_{i_2} = \sqrt{\frac{2\mu_E}{r_i} - \frac{2\mu_E}{r_i + r_f}} = \sqrt{\frac{2(3.986 \cdot 10^5)}{14{,}000} - \frac{2(3.986 \cdot 10^5)}{(14{,}000 + 8000)}}$ } from specific energy

$= 4.550439$ km/s

vel of transfer orbit at periapsis

2

$V_{f_1} = \sqrt{\frac{\mu_E}{r_f}} = 7.058683$ km/s

$V_{f_2} = \sqrt{\frac{2\mu_E}{r_f} - \frac{2\mu_E}{(r_i + r_f)}} = 7.96327$ km/s

vel of transfer orbit at apoapsis

$\Delta V_1 = V_{i2} - V_{i1} = 4.550439 - 5.33586 = -0.785424$ km/s

$\Delta V_2 = V_{f1} - V_{f2} = -0.904585$ km/s

$\boxed{\Delta V_{tot} = \Delta V_1 + \Delta V_2 = -1.69 \text{ km/s}}$

*checked using online calc, math is matching !!!

The manuvers decrease the space craft velocity. This initively makes sense, as in order to get closer to earth, the speed of the craft must be slower than another craft at a greater orbit (works in KSP too, wanna make your orbit bigger? throttle up in prograde direction)