Ground Tracks

If we have a satellite in ECI coordinate frame, the Earth is spinning in the frame.

Can't get a groundtrack!

Instead we need Earth-centered Earth-fixed (ECEF) coordinates.

Θ_{ERA} :

Let $Tu =$

$$\Theta_{ERA} = 2\pi (0.7790572732640 + 1.00273781191135448\, Tu)$$

To go from ECI to ECEF, we need to rotate about $\hat{z}$ by θ_{ERA}

what is the rotation matrix?

Now we have a vector in ECEF!

Latitude: $\phi =$

Longitude

What if you don't have $\bar{r}_{ECI}$?

Need some spherical geometry

Latitude:

$\lambda =$

We can either continuously find θ_{ERA} or define θ_{ERA_0} at Epoch and

$\lambda =$

$\omega_\oplus = 7.2921151467 \times 10^{-5}$ rad/s

South East Zenith

While having a ground-track is important, it's just as useful to determine where a satellite is located based on a ground station

("$\hat{x}$")
South

You need to know h_{gs}, λ_{gs}, ϕ_{gs}.

$\bar{r}_{\oplus gs} =$

$\bar{\omega}_{\oplus} =$

$\bar{V}_{\oplus gs} =$

$\bar{r}_{gs\,SIC} =$

Need $\bar{r}_{\oplus\,SIC}$ in SEZ.

$$A = \begin{bmatrix} s\phi_{gs}\, c\lambda_{gs} & s\phi_{gs}\, s\lambda_{gs} & -c\phi_{gs} \\ -s\lambda_{gs} & c\lambda_{gs} & 0 \\ c\phi_{gs}\, c\lambda_{gs} & c\phi_{gs}\, s\lambda_{gs} & s\phi_{gs} \end{bmatrix}$$

To find the azimuth and elevation of s/c wrt ground station,

Azimuth :

Elevation :

To find velocity of s/c wrt ground station,

$\overline{V}_{gs\ s/c}$ =

Example:

Given the Moon's position in ECI of

$$\bar{r}_{\oplus c}^{ECI} = -76,290.6\,\hat{x} - 375,924\,\hat{y} - 126,306\,\hat{z} \text{ km}$$

Find the latitude, longitude, azimuth and elevation.

Let $\theta_{ERA} = 339.1^\circ$ and a Prescott ground station with

$\phi_{gs} = 34.54^\circ$, $\lambda_{gs} = -112.46^\circ$, $h_{gs} = 1.64$ km

1. Find $\bar{\bar{r}}_{\oplus\mathcal{C}}^{ECEF}$.

$$A_{ECI}^{ECEF} =$$

2. Find λ and ϕ.

$$\phi =$$

$$\lambda =$$

3. Find $\bar{r}^{SEZ}_{\oplus\mathbb{C}}$

$\bar{r}^{SEZ}_{\oplus\mathbb{C}}$ =

4. Find $\bar{r}^{SEZ}_{gs\mathbb{C}}$

$\bar{r}^{SEZ}_{\oplus gs}$ =

$\bar{r}^{SEZ}_{gs\mathbb{C}}$ =

=

5. Find θ_A and θ_E

$\theta_E =$

$\theta_A =$