Chapter 1

Force modelling

1.1 Atmospheric drag

The NRLMSISE-00 model 2001 ported to Python. Based off of Dominik Brodowski 20100516 version available here: http://www.brodo.de/english/pub/nrlmsise/

1.2 Earth gravity

EGM96 gravity field model at a spherical surface.

Ignore tides for simplicity.

EGM96 coefficients available at: https://cddis.nasa.gov/926/egm96/getit.html

The used expansion degree is defined by `MAX_DEGREE`. All the orders corresponding to a given degree are accounted for.

1.3 Solar radiation pressure

add SRP to the force model

1.4 Luni-solar gravity

add Luni-solar gravity to the force model

1.5 Gravity of other major planets

add gravity of other large planets in the solar system to the force model

Chapter 2

Propagation flow

there are a lot vector arrows missing here...

2.1 Initial conditions

2.1.1 State

Denote the initial state as r_0 (**N.B.** `state_0` is used in the code):

$$r_0 = \begin{bmatrix} x_0 \\ x_1 \\ x_2 \\ \dot{x_0} \\ \dot{x_1} \\ \dot{x_2} \end{bmatrix}^T ,$$

where x_i is the position of the object along the i^{th} direction of a Cartesian reference frame, and $\dot{x_i}$ is the rate of change of this position w.r.t. to time. The first thee elements of r, i.e. the *position* are denoted as p, while the last three (the *velocity*) as v. Metres and metres per second are used as the respective units.

2.1.2 Satellite properties

The following properties are associated with the satellite:

- Mass in kg (`satelliteMass`),
- Dimensionless drag coefficient C_d (`Cd`),
- Drag area in metres squared (`dragArea`).

should add C_R to the initial conditions when adding SRP

2.1.3 Environmental properties

These are the properties associated with the space environment, namely:

- 81 day-average F10.7 (`F10_7A`),
- Daily F10.7 from the previous day (`F10_7`),

- Daily magnetic index (`MagneticIndex`).

F10.7 and magnetic index should be time-dependent, they are currently held constant.

2.2 Propagation

The initial state r_0 is numerically propagated to the pre-defined epochs of interest (`epochsOfInterest`), which are equi-spaced in time as given by the propagator time-step (`INTEGRATION_TIME_STEP_S`). The states corresponding to all the time steps are saved in `propagatedStates`. The flow of propagating from time-step i to $i+1$ is as follows:

1. Compute geo-centric radius, latitude and longitude at r_i corresponding to t_i (colatitude,longitude,geocentricRadius),
2. Compute the gravity potential at the current geo-centric location using the EGM96 gravity model up to a pre-defined degree.
3. Compute the acceleration due to gravity, a_g.
4. Compute the acceleration due to drag, a_d.
5. Take a step using the 4^{th} order Runge-Kutta integration scheme by observing that the rate of change of position is equal to the current velocity ($\dot{p}_i = v_i$), and that the velocity itself is changing under the influence of the gravity and drag accelerations ($\dot{v} = a_g + a_d$).
6. Continue from the beginning at the next satellite position.