Orbital Mechanics Project - Megaconstellation Design

ASEN 3200 Orbital Mechanics and Attitude Dynamics
Fall 2021
Assigned November 12, 2021
Due at beginning of lab, December 7 & 9, 2021
This assignment has a total of 100 points and is worth 20% of your final grade

Prof. M. J. Holzinger

1 Learning Objectives

- Reinforce fundamental orbital mechanics material, particularly orbit geometry, Kepler's Time of Flight, and J_2 perturbations, then connect them to real commercial uses
- Write a program containing several functions, input files, and generate complex outputs
- Engage in an open-ended team design experience
- Experience in team presentations covering technical material

2 Overview

You are a technical member of a boutique 'new space' company that specializes in constellation design. A fabulously wealthy tech entrepreneur is interested in soliciting concepts for a large spacecraft constellation to provide worldwide ubiquitous internet. You want to win this competition!

2.1 Organization

This project is composed of three parts. Part 1 will involve individual team members each developing their own code to conduct detailed constellation design analyses. . Part 2 will involve team members collectively designing a mega constellation to try and meet multiple objectives articulated by the customer. Part 3 will involve recording a 3-minute pitch video for the customer.

2.2 Resources.

A database of cities is provided on Canvas (the link allows separate download, and also includes the field labels and descriptions). World coastlines are available on Canvas and at the NOAA website.

2.3 Due Dates and Submission

Code for Part 1 will be submitted via GradeScope and will be due before lab on November 30 and December 2 (depending on lab section). Both Part 2 and Part 3 are due before lab on December 7 and 9. Part 2 will be submitted on Canvas, and Part 3 will be submitted via Canvas / YouTube.

3 Project Components

3.1 Part 1: Building Blocks (Individual Assignment)

You will need to write your own code to specify a constellation design, propagate spacecraft, account for J_2 perturbations, and compute line-of-sight from the ground.

Part 1 Rubric [45 points]:

a. [5 points] A function to read a JSON file specifying your constellation design. The JSON specification will be posted on the Canvas assignment page.

b. [10 points] A function to propagate orbit elements with J_2 perturbations and compute the position and velocity vectors in ECI at a given time t.

c. [5 points] A function to compute whether spacecraft j has line of sight to a specified position i in ECEF.

d. [25 points] A main script / simulation to i) read in a JSON constellation design file, ii) propagate the constellation in time for a full mean solar day (30 second time steps), iii) compute the number of spacecraft in line of sight of each city i at each time step, iv) plot a 3D rendering of your constellation orbits and the Earth (with coastlines and cities) at the final time. Functionality will count for 15 points, and style / legibility will count for 10 of the 25 points.

Assumptions

- For line of sight to exist between spacecraft j and city i, the local elevation angle must be at least 15 deg.
- Please assume Keplerian + J_2 dynamics. Note, as an approximation to these dynamics, you can determine the effect of J_2 on the orbit elements first, then use that instantaneous orbit and Kepler's Time of Flight problem to compute an instantaneous $\mathbf{r}(t)$ and $\dot{\mathbf{r}}(t)$.

Because we're using GradeScope to validate your programs, you will be able to submit your code multiple times to verify correction functionality.

Part A is due before lab on November 30 and December 2. Note, you'll be able to start submitting your code via GradeScope for auto-verification starting the week of November 15.