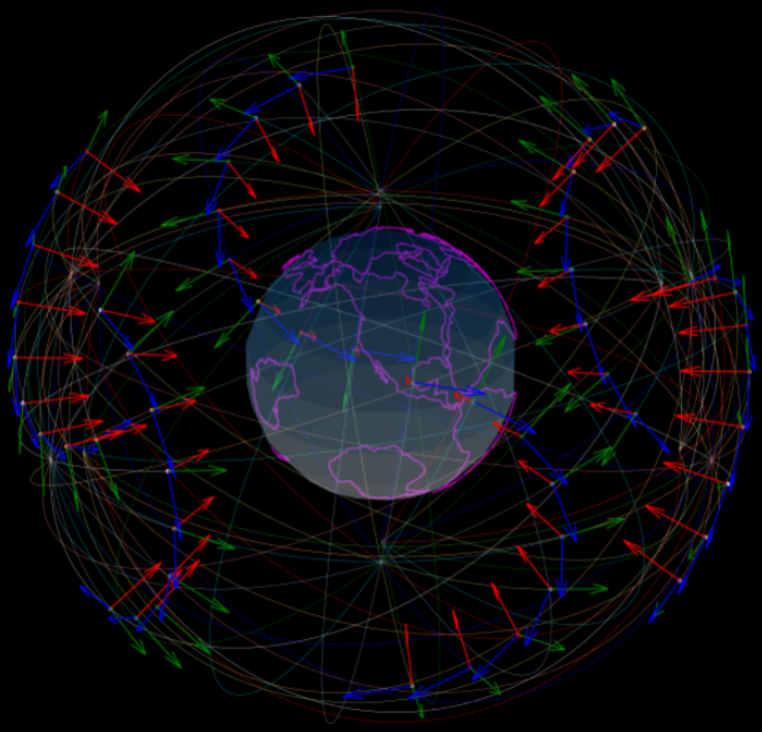
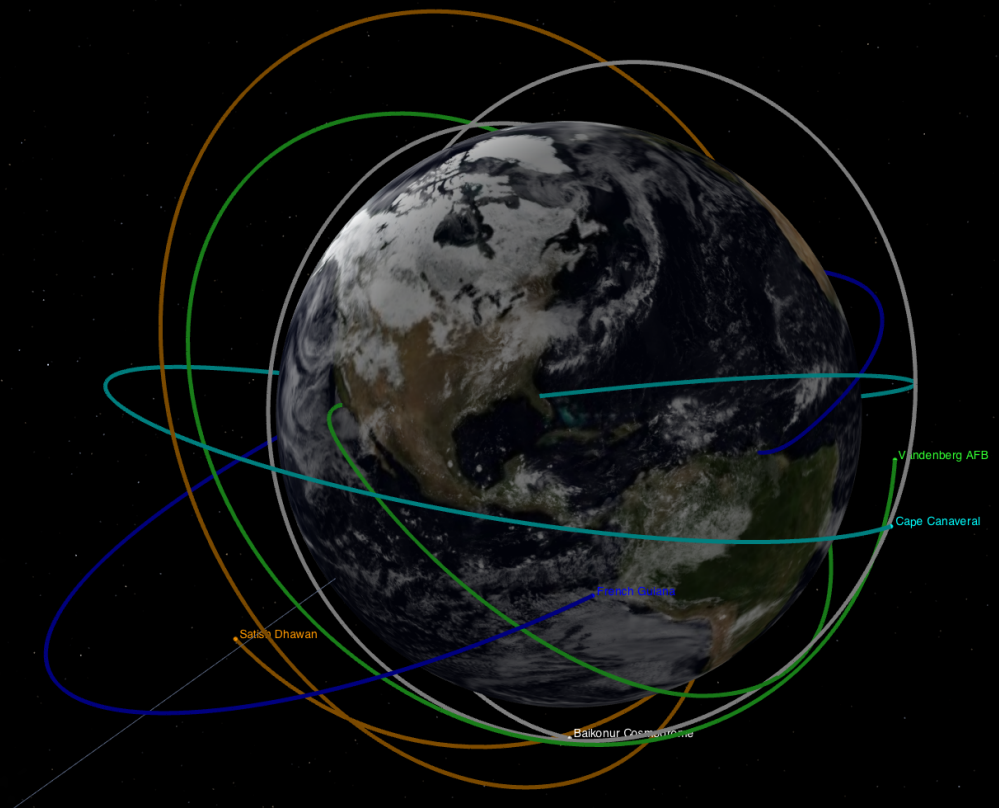
Astrodynamics with Python

Alfonso Gonzalez





To: Mom (Veronica), Dad (Carl), Brother (Alberto) and all past, present, and future humans of Earth, Earth's Moon, Mars, and Beyond. Original writing began in year 2021.

Contents

1 Preface

The Astrodynamics with Python book, YouTube videos, and GitHub repository are all products of the simple belief that all information should be free to anyone with access to the internet. They are collectively my attempt at providing useful information to the world.

Also because of that belief, if you'd like to help me by translating this project to your native language, don't hesitate to contact me at: spaceengineeringpodcast@gmail.com

This book is unlike other books, given that (for now) it is solely electronic, is being released as its being written (chapter by chapter), and will be a very iterative process (hence why it is being version controlled via Git). This is for multiple reasons:

- Free to anyone with access to the internet
- Easy to publish (git push, merge to main)
- This is a collaboration with other engineers who contribute by translating
- This is a collaboration with readers (you)
  - If you see a mistake or are confused by an explanation, reach out via email or open up Git Issue, so that when the book is updated, your Git Issue will be attached to the fix/improvement git commit, thus you will have directly contributed to this project!
  - This applies to the book as well as the software in this repository.

Now lets get to the technical work.

2 Chapters and Material

The following are general guidelines of how this book will be written:

- Visuals and software will be at the center of every explanation / derivation
  - In general, I don't consider myself to truly understand a problem until I can solve it on paper **AND** implement it in software.

The current plan is to separate the book by the following topics:

- Orbital mechanics
- Spacecraft attitude control
- Rocket trajectories
- Numerical methods
- Trajectory optimization
- Prerequisites

The book, videos, and software will all be complementing each other, and will be continuously updated as needed / requested from the readers.

2.1 Orbital Mechanics

This section of the book will be organized in the same order as the Fundamentals of Orbital Mechanics video series (link to YouTube playlist)
The following are the planned topics:

- The two-body problem / Newton's universal law of gravitation (link)
- Ordinary differential equations (ODEs) (link)
- Introduction to ODE solvers (Runge-Kutta 4) (link)
- Solving 2nd Order ODEs with 1st Order ODE Solvers / Propagating Orbits (link)
- Introduction to the Keplerian / Classical Orbital Elements
- How to Identify Keplerian Orbital Elements in 3D Orbit Plots
- Earth Inertial and Body Fixed Reference Frames
- Introduction to SPICE (Spacecraft Planet Instrument C-matrix Events)
- Converting between Earth Centered Inertial (EME2000) and Earth Centered Earth Fixed (IAU EARTH) Frames
- Groundtracks calculations
- How to Identify Keplerian Orbital Elements in Groundtracks Plots
- Two-Line Element Sets (TLEs)
- Hohmann Transfers
- Introduction to Lambert's Problem
- Universal Variables Lambert's Solver
- Interplanetary Trajectories (Synodic Periods, Earth to Mars, Earth to Jupiter, etc.)
- Porkchop Plots
- Sphere of Influence
- Patched Conics
- Gravity Assist Trajectory Design (Zero-Sphere of Influence V-Infinity Matching)
- Circular Restricted 3 Body Problem (CR3BP)