Congratulations, you've made it to the next round of the interview process. For this round, we ask candidates to solve a product and technical focused problem. The deliverables are a solution to a technical problem prompt provided below. ***Note: Feel free to ask any clarifying questions if you are stuck or unsure about a part of the problem***

Deliverable Format: Please provide all relevant work (Includes code, handwritten work, assumptions made, and relevant outputs)

Please turn in all parts of the problem within 5 business days from receiving the problem set. If selected for the next stage, you will be asked to walkthrough your presentation and technical problem.

Technical Problem Prompt:

You are developing navigation software for a satellite. The satellite needs to maintain accurate knowledge of its position and velocity over time.

Solve the following technical problem as part of this take home:

You receive measurements of the satellite via two ground sensors and a GPS receiver on the satellite. The sensors provide the following information:

1. Two Ground Electro-Optical Sensors: Each ground station provides angular position measurements in the form of Right Ascension (RA) and Declination (Dec) and angular rate measurements, $\dot{RA}$ and $\dot{Dec}$ in the form shown below:

$$z_{GS} = \begin{bmatrix} RA \\ Dec \\ \dot{RA} \\ \dot{Dec} \end{bmatrix}$$

   The measurements are subject to noise, characterized by constant noise covariance:

$$R_{GS1} = \begin{bmatrix} 1 & & & \\ & 1 & & \\ & & 0.01 & \\ & & & 0.01 \end{bmatrix}, R_{GS2} = \begin{bmatrix} 0.01 & & & \\ & 0.01 & & \\ & & 0.0001 & \\ & & & 0.0001 \end{bmatrix}$$

   in units of square arcseconds and square arcseconds per square seconds.

2. A GPS Receiver on the Satellite: Provides periodic state measurements (position and velocity in Cartesian coordinates) when available with constant noise covariance shown below.

$$z_{GPS} = \begin{bmatrix} x \\ y \\ z \\ \dot{x} \\ \dot{y} \\ \dot{z} \end{bmatrix}, R_{GPS} = \begin{bmatrix} 5000^2 & & & & & \\ & 5000^2 & & & & \\ & & 5000^2 & & & \\ & & & 0.5^2 & & \\ & & & & 0.5^2 & \\ & & & & & 0.5^2 \end{bmatrix},$$

   in units of m and m/s.

The two ground sensors are located at the following geodetic coordinates:

G1 = -111.536°, +35.097°, 2.206 km

G2 = -70.692°, -29.016°, 2.380 km

Provided in the attached measurements.csv file are ~3.3 hours of measurements from the two ground stations and the GPS. The initial time t0 is '2024-11-24T05:04:30.000'.

Using the provided data, compute the following (assume Keplerian dynamics):

1. Predict the satellite's position tf + 2 hours into the future.
2. Estimate the satellite's state at tf + 5 hours.
3. For each step, briefly describe your approach and any key assumptions made.

As part of the solution, answer the following questions:

1. What are the steps to accomplish this problem?
2. Critical Thinking Exercise
    a. What are the physical mechanics that can explain the behavior seen in the dataset?
    b. What could the orbit explain about the mission of this spacecraft?
    c. What would a spacecraft need to operate like this?
    d. Create a high-level block diagram for the GNC system of this spacecraft.

<u>Instructions for completion:</u>

Make sure all relevant work is included with the technical problem. This should include assumptions made, intermediate steps, and code.