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Title: GNSS Lab Report

Lab 1: GNSS Positioning

Course:	AAE4203 — Guidance and Navigation
Group:	Group 9
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School:	The Hong Kong Polytechnic University
Date:	November 10, 2025

Abstract

This template demonstrates how to structure a PolyU lab report using the hkpolyu-labreport class. It includes examples of figures, tables, equations, code listings, and citations, while conforming to page and submission requirements.

Keywords: template, GNSS, SPP, least squares, figures, tables, citations, code

1 Data Collection

Hardware setup:

- Plug the U-blox ZED-F9P and Antenna into the computer USB port.

Software tools:

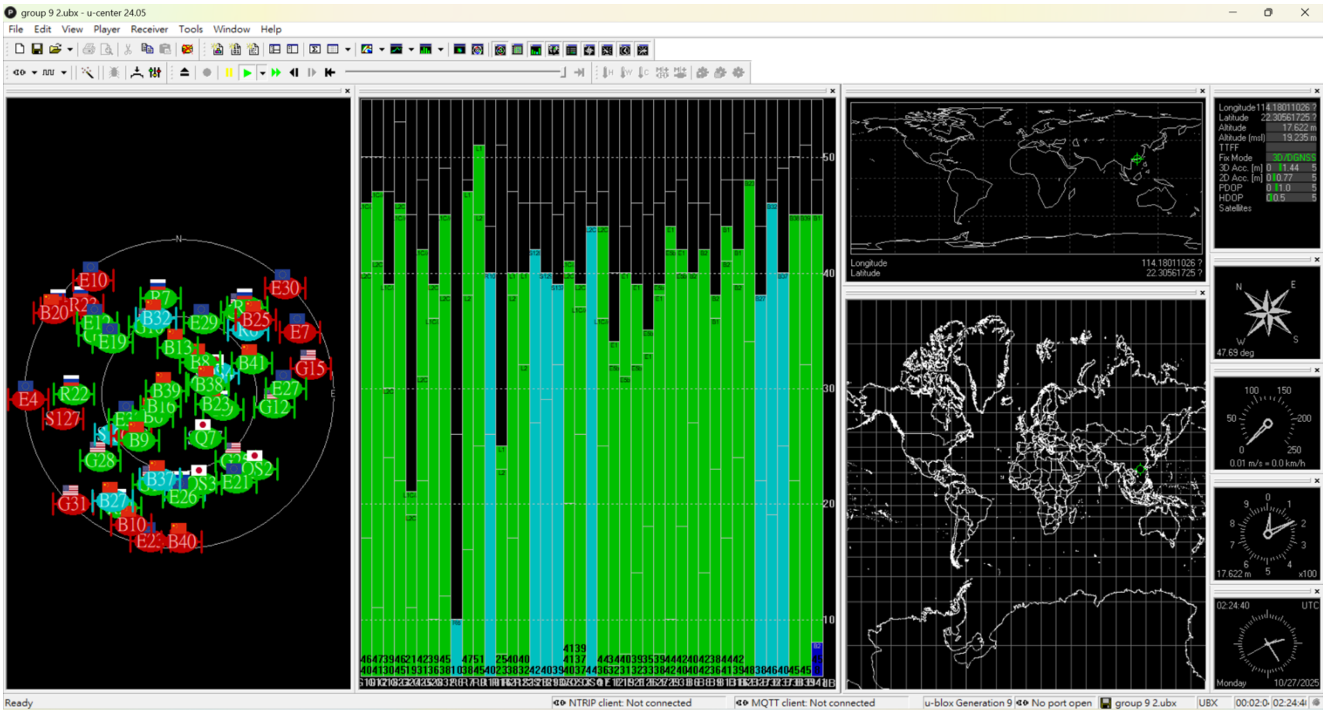
- Connect the receiver by using u-center. Select COM 1 and set the baud rate of 9600 to establish communication.
- Satellite visibility, signal strength (C/N0), and position coordinates will appear in u center.

Environmental conditions:

- Partial obstructions
- Sunny day
- 10:22am to 10:24am

Start data collection:

- Start recording by pressing the record button in u-center.
- Select the path of our computer to save the ubx file.
- Walk around near block X where is open-sky and go back to the starting point.
- Press the stop button in u-center when go back to the starting point.



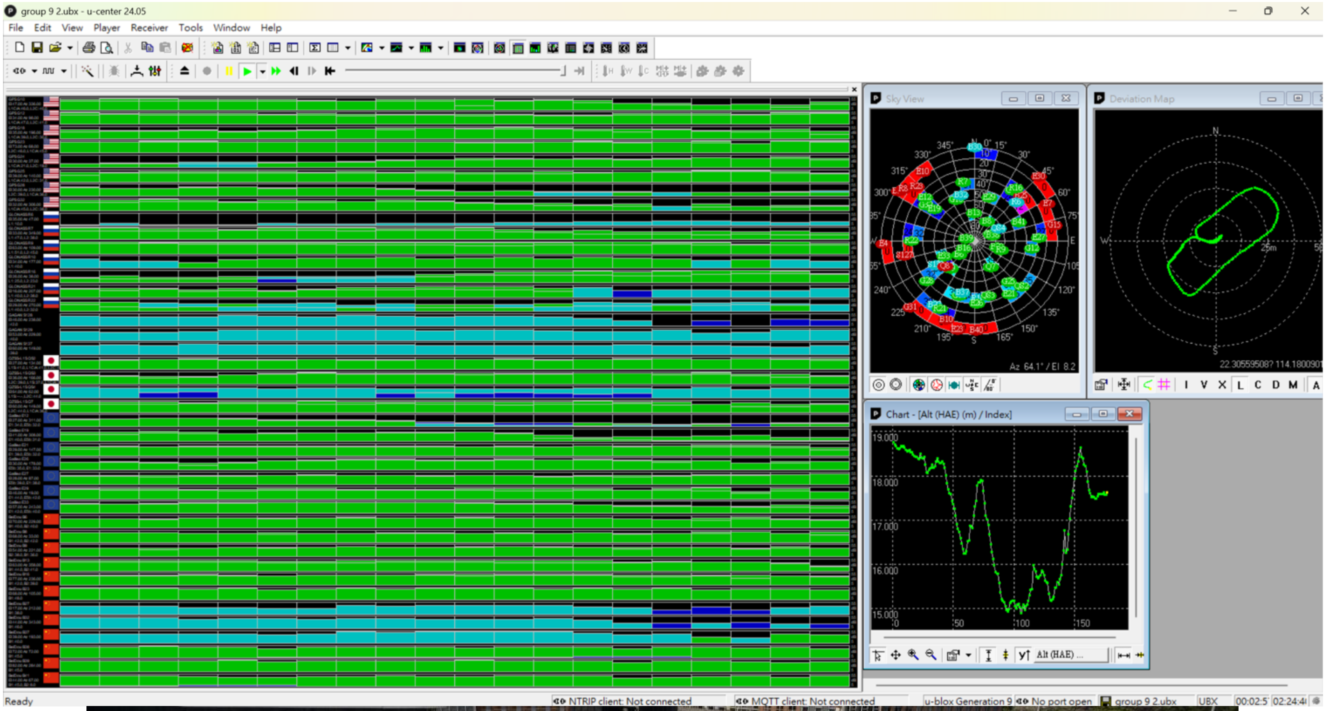
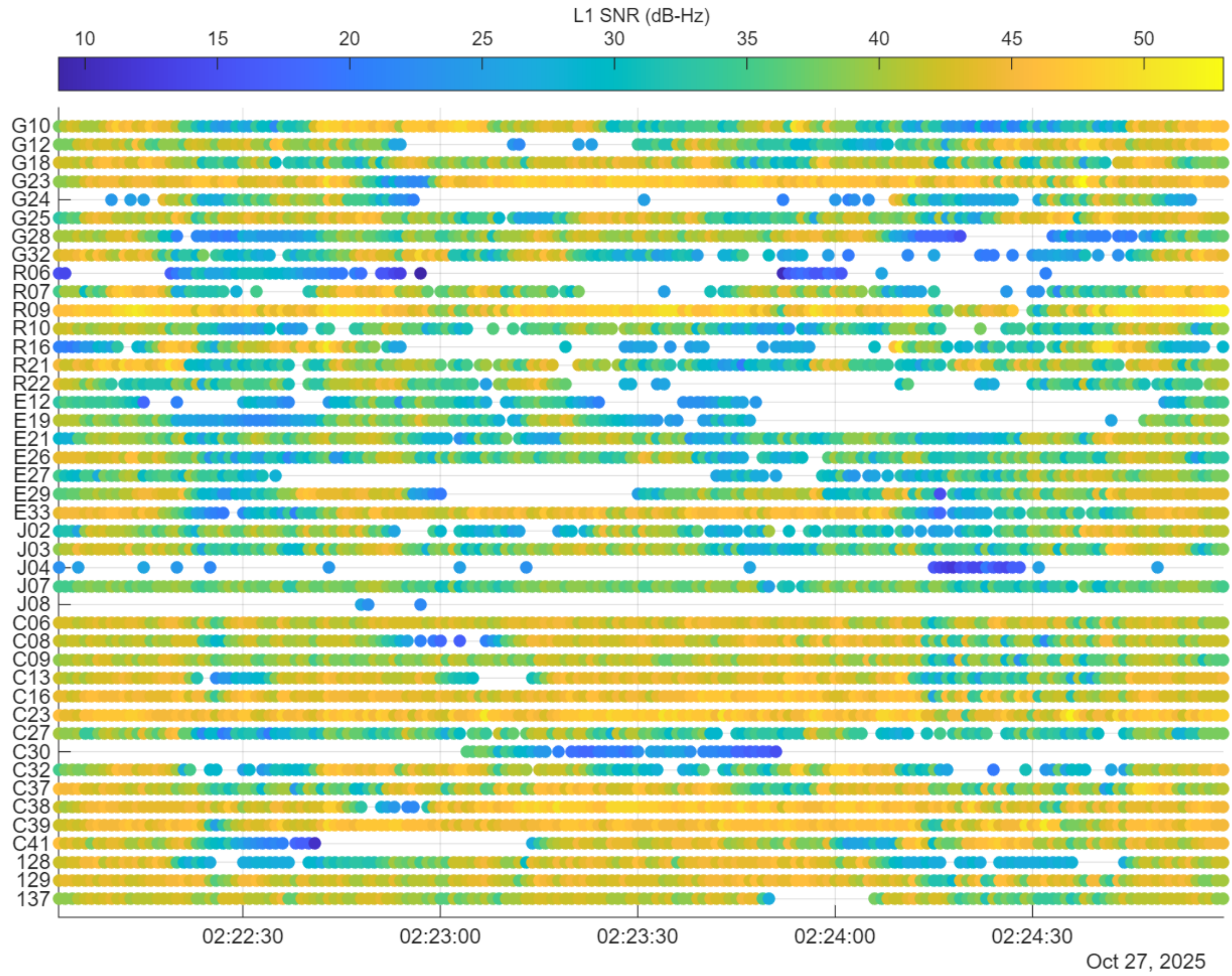

group 9 2.ubx - u-center 24.05
File Edit View Player Receiver Tools Window Help
Sky View
Deviation Map
Chart - [Alt (HAE) (m) / Index]
Ready
NTRIP client: Not connected
MQTT client: Not connected
u-blox Generation 9
No port open
group 9 2.ubx
UBX

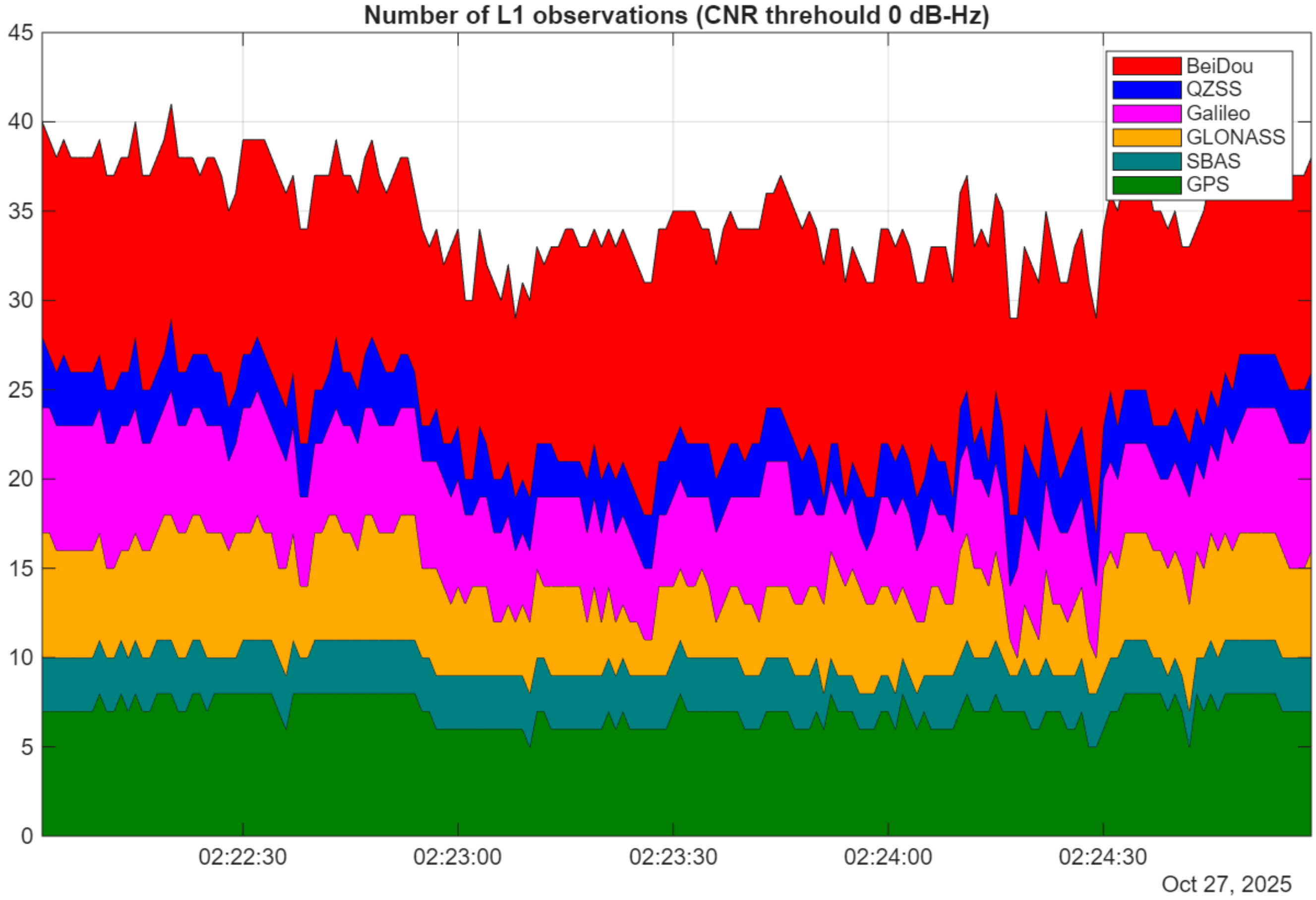
Table 1: Data collection summary.

Field	Value
Location	Vicinity of Block X
Duration	30 min @ 1 Hz
Receiver	U-blox ZED-F9P and Antenna
Conditions	Urban campus, partial obstruction

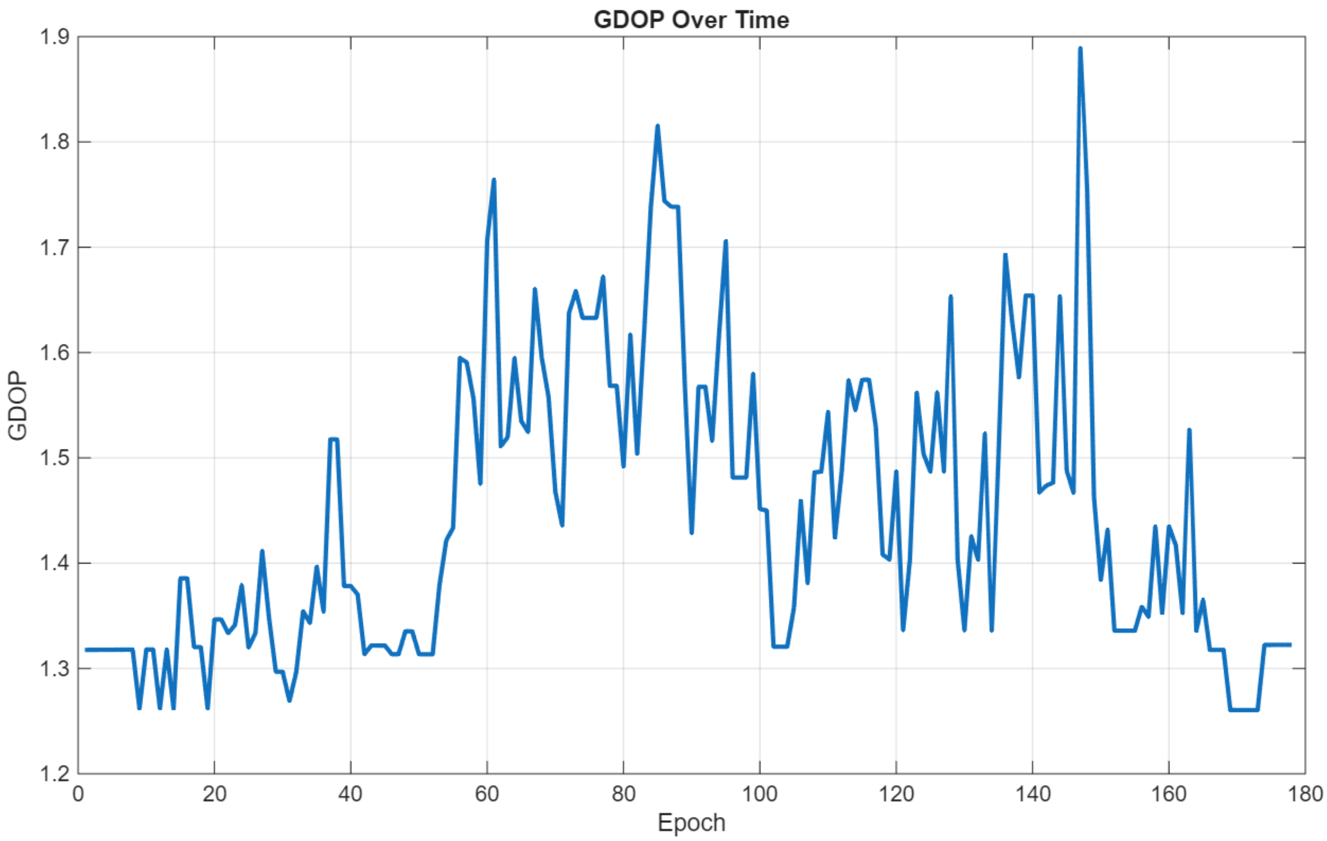
2 Raw Data Analysis



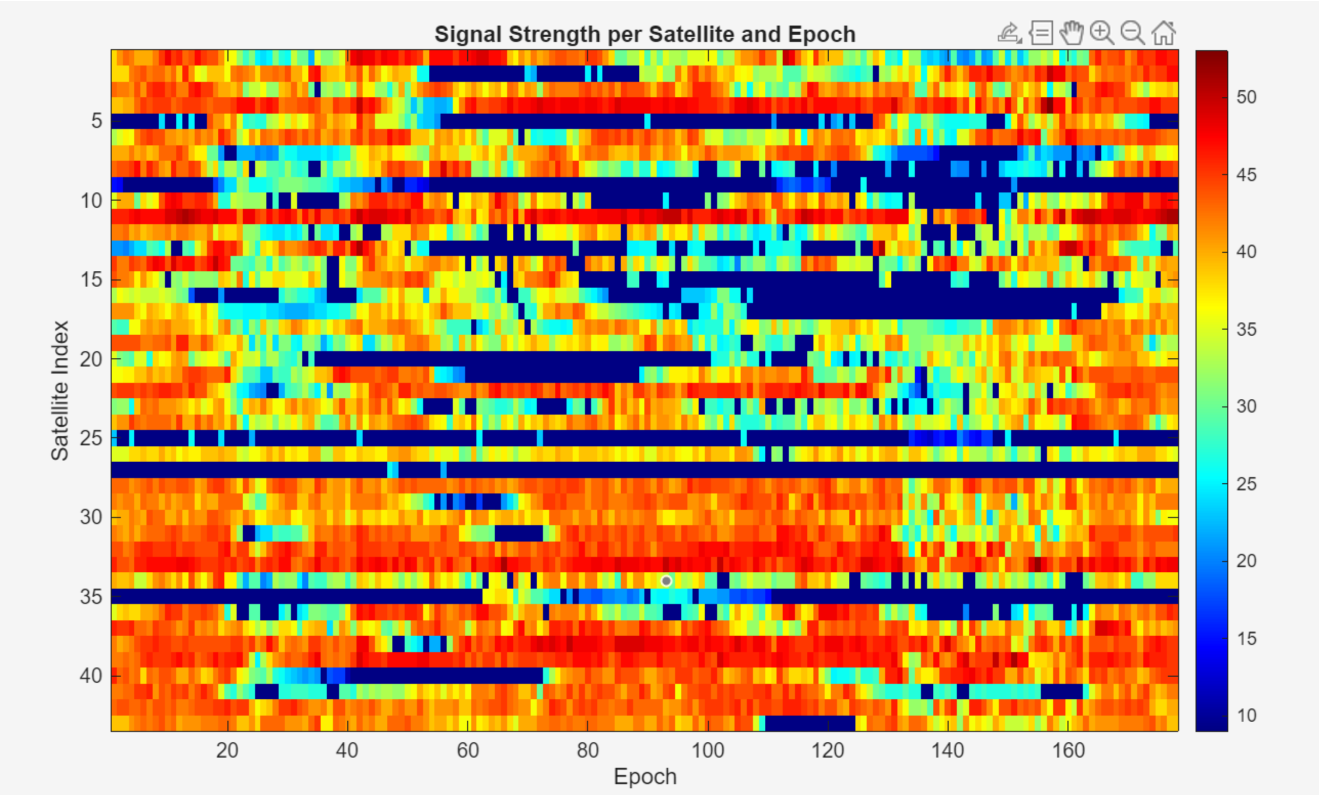
Observed satellites per epoch


Number of L1 observations (CNR threhould 0 dB-Hz)
BeiDou
QZSS
Galileo
GLONASS
SBAS
GPS
02:22:30
02:23:00
02:23:30
02:24:00
02:24:30
Oct 27, 2025

C/N0


GDOP Over Time
GDOP
Epoch

GDOP



flags

3 SPP Algorithm (Least Squares)

Briefly introduce the SPP model and provide a reference:

$$\rho_i = \|\mathbf{x} - \mathbf{s}_i\| + c\,\Delta t + \varepsilon_i, \tag{1}$$

Standard approach for determining a receiver's position using pseudorange measurements. Uses observations from at least four satellites to solve for 3D position and receiver clock error. Typically provides accuracy of 5-15 meters depending on conditions — Foundational algorithm implemented in most GNSS receivers

Linearization yields the normal equation

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \\ a_{31} & a_{32} \\ \vdots & \vdots \end{bmatrix} \begin{bmatrix} \Delta x \\ \Delta y \end{bmatrix} = \begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \end{bmatrix}$$

$$\delta = \mathbf{H}^\top \mathbf{W} \mathbf{H} \ {}^{-1} \mathbf{H}^\top \mathbf{W}\, \mathbf{v}, \qquad (2)$$

where $\mathbf{W}$ can be identity (unweighted) or designed from elevation/C/N0 [1, 2].

4 Code Listing

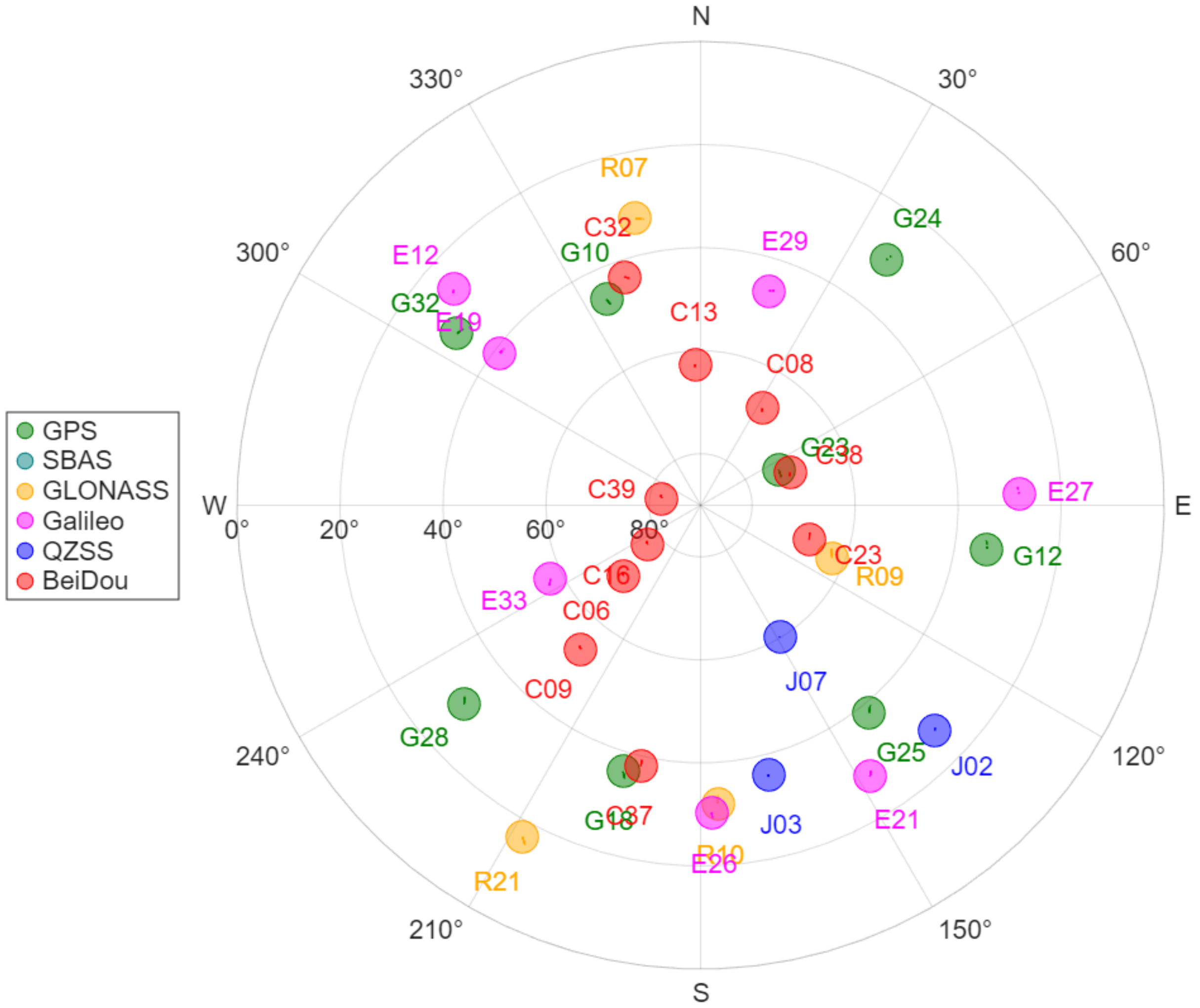
Keep code excerpts within 2 pages in the report; place full, documented code in GitHub.

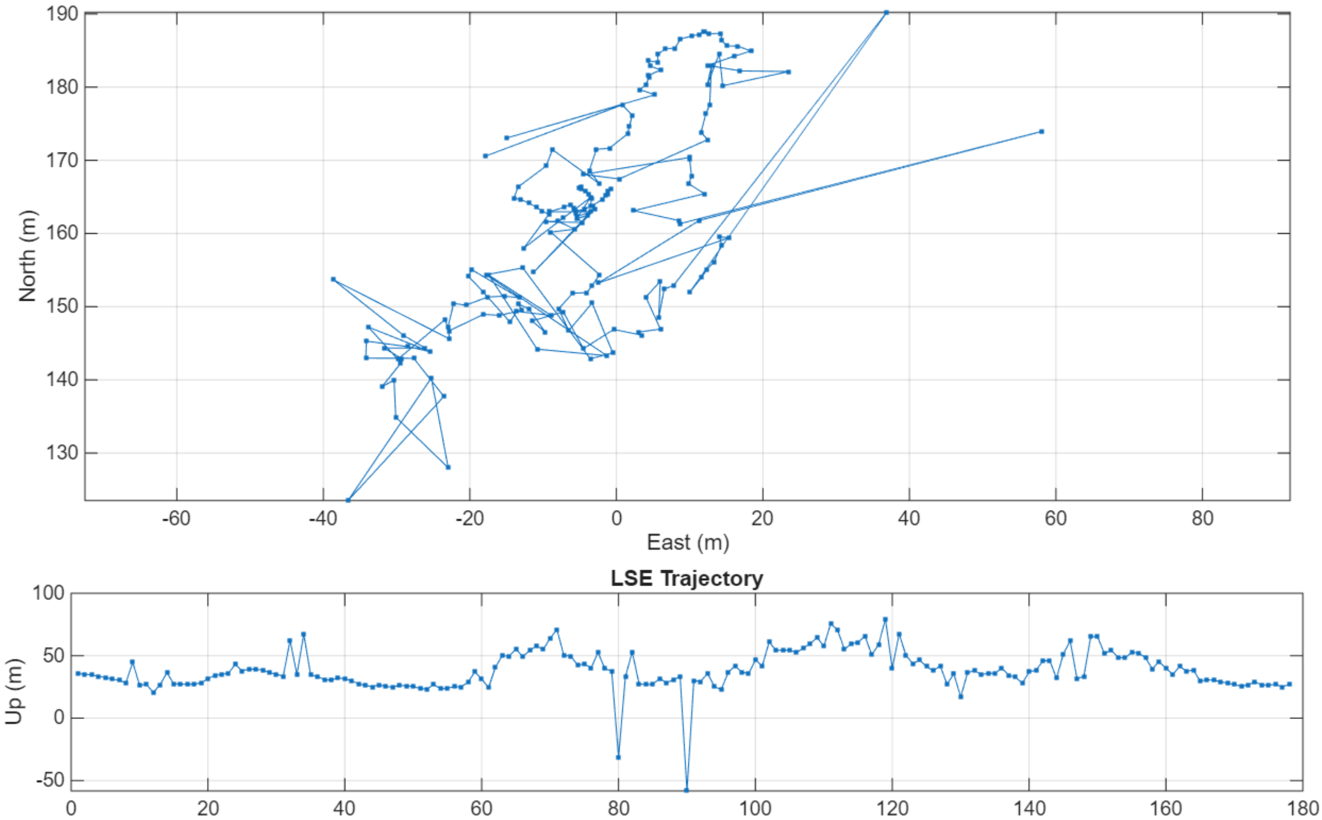
```
import numpy as np

def spp_ls(sat_ecef, pseudorange, x0, weights=None, max_iter=8, tol=1e
    -4):
    """
    sat_ecef: (N, 3) satellite ECEF positions [m]
    pseudorange: (N,) measured pseudoranges [m]
    x0: (4,) initial [x, y, z, c*dt] in meters
    weights: (N,) optional weights (e.g., elevation/CN0-based)
    """
    x = np.array(x0, dtype=float)
    for _ in range(max_iter):
        H, v = [], []
        for s, rho in zip(sat_ecef, pseudorange):
            r = np.linalg.norm(x[:3] - s)
            los = (x[:3] - s) / r
            rho_hat = r + x[3]
            v.append(rho - rho_hat)
            H.append(np.r_[los, 1.0])
        H = np.array(H); v = np.array(v)
        W = np.diag(weights) if weights is not None else np.eye(len(v))
        dx = np.linalg.solve(H.T @ W @ H, H.T @ W @ v)
        x += dx
        if np.linalg.norm(dx) < tol: break
    return x   # [x, y, z, c*dt]
```

Listing 1: Minimal SPP least-squares solver (example).

5 Results and Discussion





The u-blox receiver can receive different GNSS to increase accuracy.