



**PLANET · SmartPNT**  
**多源融合智能导航**

# **Data01\_20240709\_100C\_CAR\_complex Data Description**

**School of Geodesy and Geomatics, Wuhan University**

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# 1 Overview

**Data Packet Name:** Data01\_20240709\_100C\_CAR\_complex

**Collection Date:** 2024.07.09

**Collection Location:** Wuhan City, Hubei Province, China

**Collection Scene:** Elevated Road; Open Sky; Urban Area; Street Trees; Tunnels

**Collection Method:** SUV-mounted Collection

## 2 Collection Devices

### 2.1 Devices Overview

This data packet was collected using the SmartPNT-mate multi-source navigation sensor platform (which integrates various sensors including visual cameras, LiDAR, inertial navigation systems, and GNSS receivers), along with the HGuide I300 inertial/GNSS navigation data acquisition unit and two GNSS receivers. All equipment was mounted on an SUV vehicle. Additionally, this data packet includes GNSS Observation Data from a base station collected by the School of Geodesy and Geomatics at Wuhan University. Schematic diagrams of the collection vehicle and equipment are shown in Figures 2-1 and 2-2 (detailed equipment models corresponding to abbreviations in the figures are listed in Table 2-1).

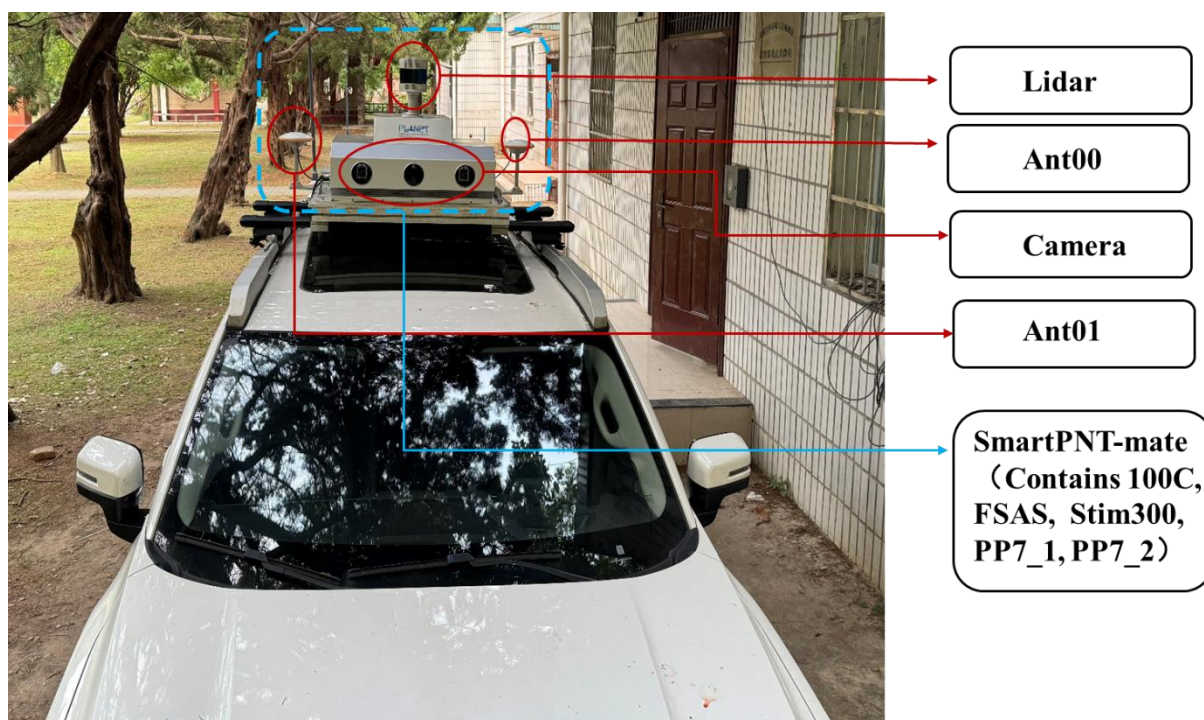


Figure2-1 Front view of the collection device

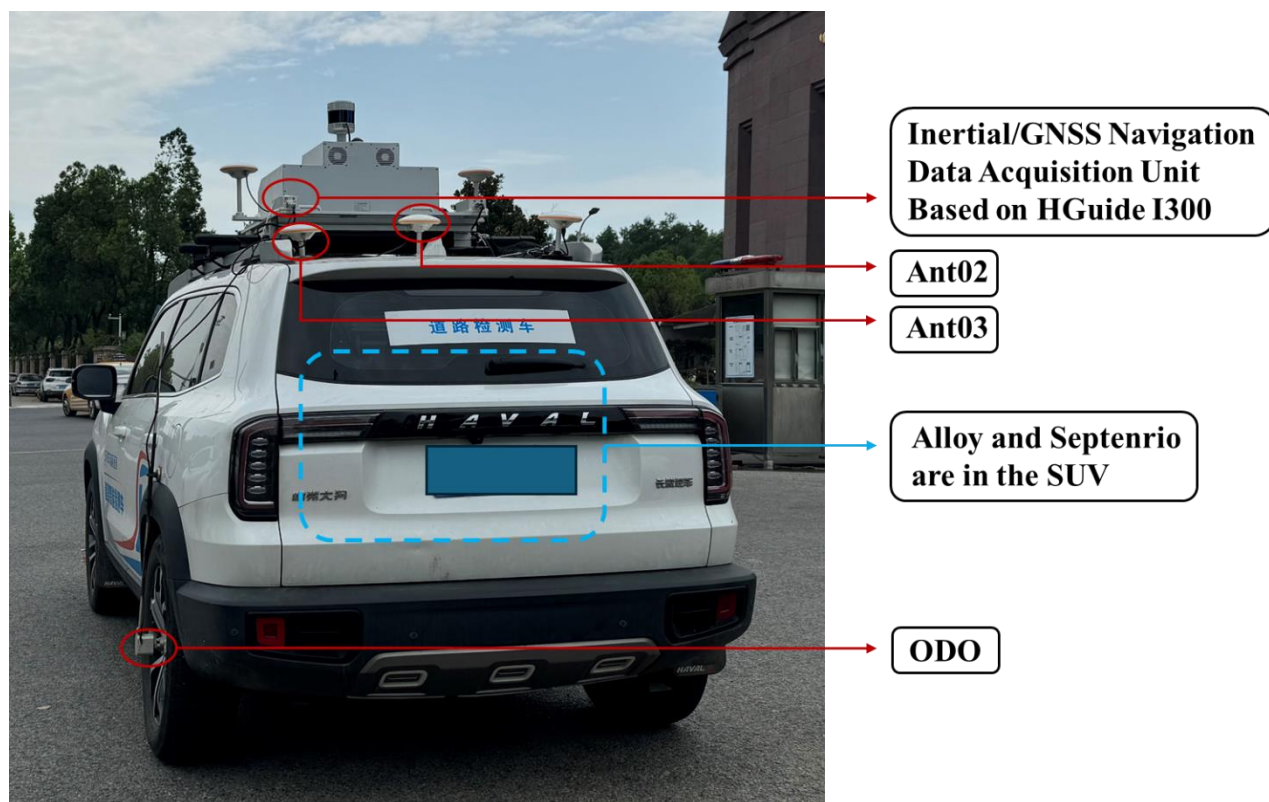


Figure2-2 Behind view of the collection device

## 2.2 Devices Lists

Table 2-1 Devices Inventory List

| Type         | Model                 | Abbreviation (The devices' names in the text are all referred to by the abbreviations in this table) | Quantity |
|--------------|-----------------------|------------------------------------------------------------------------------------------------------|----------|
| IMU          | iMAR iIMU-FSAS        | FSAS                                                                                                 | 1        |
|              | Novatel SPAN-ISA-100C | 100C                                                                                                 | 1        |
|              | Safran STIM300        | Stim300                                                                                              | 1        |
|              | HGuide I300           | I300                                                                                                 | 1        |
| GNSS Reciver | Novatel PwrPak7       | PP7_1, PP7_2                                                                                         | 2        |
|              | Septentrio mosaic-X5  | Septentrio                                                                                           | 1        |
|              | Trimble Alloy         | Alloy                                                                                                | 1        |
| Antenna      | bynav BY500           | Ant00, Ant01, Ant02, Ant03                                                                           | 4        |
| Odometer     |                       | ODO                                                                                                  | 1        |

## 2.3 Introduction to the Main Devices

### 2.3.1 Novatel SPAN-ISA-100C



**Figure 2-3** Novatel SPAN-ISA-100C

The SPAN-ISA-100C is an inertial measurement unit with navigation-grade performance, integrating a three-axis fiber optic gyroscope and full-temperature-compensated MEMS accelerometers. During this data collection, the SPAN-ISA-100C communicates with NovAtel's PwrPak7 receiver via a high-reliability IMU interface. The PwrPak7 receiver fuses GNSS, IMU, and odometer measurement data and outputs high-precision three-dimensional position, velocity, and attitude information at a frequency of 200 Hz.

### 2.3.2 iMAR iIMU-FSAS



**Figure 2-4** iMAR iIMU-FSAS

The iIMU-FSAS is a tactical-grade inertial measurement unit from the German company iMAR. NovAtel users can easily connect the IMU to receivers with NovAtel SPAN functionality, such as the PwrPak or SPAN-SE. The IMU measurement data from the iIMU-FSAS is sent to the GNSS/INS receiver, where it is fused to provide position, velocity, and attitude information with a 200 Hz update

rate. Additionally, the system offers optional interfaces for magnetic or optical wheel sensors for ground applications.

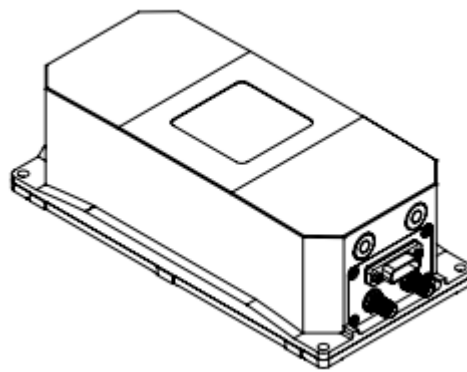
### 2.3.3 Safran STIM300



**Figure 2-5 Safran STIM300**

The STIM300 is a compact, tactical-grade, lightweight, high-performance non-GPS-assisted inertial measurement unit (IMU). It includes three high-precision MEMS gyroscopes, three high-stability accelerometers, and three inclinometers. The IMU is factory-calibrated and compensated across its entire operating temperature range. During this data collection, the STIM300 outputs inertial data independently at a frequency of 200 Hz without interfacing with other external devices.

### 2.3.4 Inertial/GNSS Navigation Data Acquisition Unit Based on HGuide I300



**Figure 2-6 Inertial/GNSS Navigation Data Acquisition Unit Based on HGuide I300**

The School of Geodesy and Geomatics at Wuhan University developed a custom device that integrates GNSS data reception and the HGuide I300 inertial navigation system, capable of outputting both raw GNSS Observation Data and inertial navigation data. The HGuide I300 is a tactical-grade inertial navigation system that can be easily integrated into various architectures due

to its industry-standard communication interfaces and wide input voltage range. It features a compact size, light weight, and low power consumption. The HGuide I300 includes MEMS gyroscopes and accelerometers and uses an internal environmental isolation system to attenuate common unwanted inputs in real-world applications, ensuring its robustness. During this data collection, the device outputs GNSS Observation Data at 1 Hz and inertial navigation data at 200 Hz.

### 2.3.5 Novatel PwrPak7



**Figure2-7 Novatel PwrPak7**

The PwrPak7 is a compact receiver capable of receiving expandable GNSS signals, with internal storage and INS options. It can track all current and upcoming GNSS constellations and satellite signals. Additionally, it offers optional integrated INS support for continuous position, velocity, and attitude determination during short GNSS interruptions. It features a robust GNSS engine, onboard NTRIP v1.0 and v2.0 client and server support, 16 GB of internal storage, and enhanced connectivity options (including serial, USB, CAN, and Ethernet). During this data collection, two PwrPak7 receivers were used, both placed inside the SmartPNT-mate platform. They were connected to two different antennas and inertial navigation systems, outputting fused raw observation data from GNSS, IMU, and ODO.

### 2.3.6 Septentrio mosaic-X5



**Figure2-8 Septentrio mosaic-X5**

The Septentrio mosaic-X5 is a high-precision GNSS module with full constellation and multi-frequency capability, designed with a low-power surface-mount package and multiple interfaces. It is specifically built for mass applications such as robotics and autonomous systems, capable of tracking all GNSS constellations and supporting both current and future signals. With its built-in AIM+ anti-jamming technology, Septentrio provides robust support for industrial high-precision GNSS positioning applications. During this data collection, the Septentrio was primarily used to receive base station data provided by the FindCM service from Qianxun Positioning.

### 2.3.7 Trimble Alloy



**Figure2-9 Trimble Alloy**

The Alloy receiver is a multifunctional device suitable for infrastructure and field development applications. It can serve as a CORS base station, radio or cellular RTK or DGNSS base station for Trimble Pivot software or other software applications, providing correction signals via TCP/IP, UDP/IP, or serial output. It can also function as a mobile receiver for field surveys. The receiver includes a GNSS receiver and up to two internal batteries, supporting GNSS and Wi-Fi antenna connections. Users can monitor satellite tracking, data recording status, Wi-Fi, and power conditions through a 4-line OLED display.

In addition to its evident base station capabilities, the Alloy receiver can be used as an RTK mobile station or a static mobile station for measurement projects. The device can record GNSS data to internal memory and download it to a computer via serial (cable or Bluetooth), Ethernet, or Wi-Fi connections. The receiver can be configured through its front panel display, Ethernet or Wi-Fi network interfaces, or via mobile network interfaces on a smartphone. During this data collection, GNSS Observation Data received by the Alloy receiver was used as mobile station data for processing.

## 2.4 Devices Connections Relationship

Table2-2 Device Connection Relationships

| Combinations | GNSS Receiver | IMU     | Antenna | Odometer |
|--------------|---------------|---------|---------|----------|
| ①            | PP7_1         | 100C    | Ant00   | ODO      |
| ②            | PP7_2         | FSAS    | Ant01   | ODO      |
| ③            | Alloy         | ×       | Ant02   | ×        |
| ④            | Septentrio    | ×       | Ant02   | ×        |
| ⑤            | ×             | I300    | Ant03   | ×        |
| ⑥            | ×             | Stim300 | ×       | ×        |

## 2.5 Devices Installation Relationship

### 2.5.1 Coordinate System Definition

Table2-3 Coordinate System Definition

| Object         | Coordinate System  | Placement Angles (X, Y, Z) in the Carrier System |
|----------------|--------------------|--------------------------------------------------|
| Carrier System | Right-Forward-Up   | -                                                |
| FSAS           | Forward-Left-Up    | (0, 0, 90)                                       |
| 100C           | Right-Back-Down    | (180, 0, 0)                                      |
| STIM300        | Forward-Right-Down | (180, 0, 90)                                     |
| I300           | Down-Forward-Right | (0, -90, 0)                                      |

### 2.5.2 Lever Arm Relationship

Table2-4 Lever Arm between devices

| IMU                        | Device  | Lever Arm (X,Y,Z) (m)      |
|----------------------------|---------|----------------------------|
| 100C<br>(Right-Forward-Up) | FSAS    | (-0.012 , -0.002 , 0.166)  |
|                            | STIM300 | (-0.012 , -0.002 , 0.244)  |
|                            | I300    | (-0.501 , -0.576 , -0.052) |
|                            | Ant00   | (-0.512 , -0.284 , 0.187)  |
|                            | Ant01   | (0.488 , -0.284 , 0.187)   |
|                            | Ant02   | (-0.575, -1.16 , -0.245)   |
|                            | Ant03   | (0.0 , -1.123 , -0.123)    |

(Note: Here, only the lever arm relationships from the 100C to other inertial navigation systems and antennas are provided. The lever arm relationships from other inertial navigation systems to each antenna can be derived from these.)

### 3 Data Collection Trajectory

The data collection trajectory for this set is shown in Figure 3-1.



Figure3-1 Data Collection Trajectory

## 4 Data Inventory

**Table4-1 Data Inventory**

| Device                             | Type                                                                                                                                                          | Whether Included | File Name                                  |
|------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|--------------------------------------------|
| Base Station of Wuhan University   | GNSS Observation Data                                                                                                                                         | ✓                | BASE_SGG.24O                               |
| Septenrio+Ant02                    | GNSS Observation Data<br>(Base station data from Qianxun Position's FindCM service, which may include multiple GNSS observation files due to station changes) | ✓                | BASE_01.24O                                |
| Alloy+Ant02                        | GNSS Observation Data                                                                                                                                         | ✓                | ROVE_01.24o                                |
| 100C+pp7_1+ODO<br>+Ant00           | Inertial Navigation Data                                                                                                                                      | ✓                | 100C.imr                                   |
|                                    | GNSS Observation Data                                                                                                                                         | ✓                | ROVE_02.24O                                |
|                                    | Odometer Data                                                                                                                                                 | ✓                | 100C.dmr                                   |
| FSAS+pp7_2+ODO<br>+Ant01           | Inertial Navigation Data                                                                                                                                      | ✓                | FSAS.imr                                   |
|                                    | GNSS Observation Data                                                                                                                                         | ✓                | ROVE_03.24O                                |
|                                    | Odometer Data                                                                                                                                                 | ✓                | FSAS.dmr                                   |
| I300+Ant03                         | Inertial Navigation Data                                                                                                                                      | ✓                | I300.imr                                   |
|                                    | GNSS Observation Data                                                                                                                                         | ✓                | ROVE_04.24O                                |
| STIM300                            | Inertial Navigation Data                                                                                                                                      | ✓                | STIM300.imr                                |
| Broadcast Satellite Ephemeris Data |                                                                                                                                                               | ✓                | brdm1910.24p                               |
| Precise Satellite Ephemeris Data   |                                                                                                                                                               | ✓                | WUM0MGXFIN_20241910<br>000_01D_05M_ORB.SP3 |
| Satellite Clock Offset Data        |                                                                                                                                                               | ✓                | WUM0MGXFIN_20241910<br>000_01D_30S_CLK.CLK |

## 5 Data Overview

Table5-1 Data Overview

| File Name    | Format    | Recording Time (GPST)      | Output Frequency | Data Quality                                   |
|--------------|-----------|----------------------------|------------------|------------------------------------------------|
| BASE_SGG.24O | RINEX3.04 | 00:00:00.000--23:59:59.000 | 1HZ              | Normal                                         |
| BASE_01.24O  | RINEX3.04 | 08:08:35.000--09:33:34.000 | 1HZ              | Normal                                         |
| ROVE_01.24O  | RINEX3.04 | 08:06:14.000-09:59:59.000  | 1HZ              | Approximately<br>15 Minutes of<br>Interruption |
| ROVE_02.24O  | RINEX3.04 | 08:06:51.000--09:31:08.000 | 1HZ              | Normal                                         |
| ROVE_03.24O  | RINEX3.04 | 08:06:51.000--09:30:46.000 | 1HZ              | Normal                                         |
| ROVE_04.24O  | RINEX3.04 | 08:06:17.000--09:29:57.000 | 1HZ              | Normal                                         |
| 100C.imr     | IMR       | 08:06:52.003--09:31:08.759 | 200HZ            | 2 large gap<br>(0.020s+0.019s)                 |
| FSAS.imr     | IMR       | 08:06:51.496--09:30:46.165 | 200HZ            | Normal                                         |
| I300.imr     | IMR       | 08:06:16.141--09:30:11.789 | 200HZ            | Normal                                         |
| STIM300.imr  | IMR       | 08:13:04.335--09:27:39.670 | 200HZ            | 1 large gap<br>(1.575s)                        |
| 100C.dmr     | DMR       | 08:16:05.000--09:31:08.000 | 1HZ              | Normal                                         |
| FSAS.dmr     | DMR       | 08:16:05.000--09:30:46.000 | 1HZ              | Normal                                         |

(Note: All data recorded in Table 5-1 is dated GPST: 2024/07/09)

## **6 True Value Processing**

### **6.1 Processing Methods**

**Processing Software:** Inertial Explorer 8.90.8304 [64-bit]

**Processing Mode:** GNSS/IMU Tight Integration

**Use of Precise Ephemeris:** No

**Use of Odometer:** Yes

**Data Used:**

- **Base station data from Wuhan University's base station:** BASE\_SGG.24O
- **Alloy's Rover Station Data:** ROVE\_01.24O
- **100C's Inertial Navigation Data:** 100C.imr
- **Odometer Data:** 100C.dmr

## 6.2 Computation Results

### 6.2.1 Ambiguity Fixed Situation

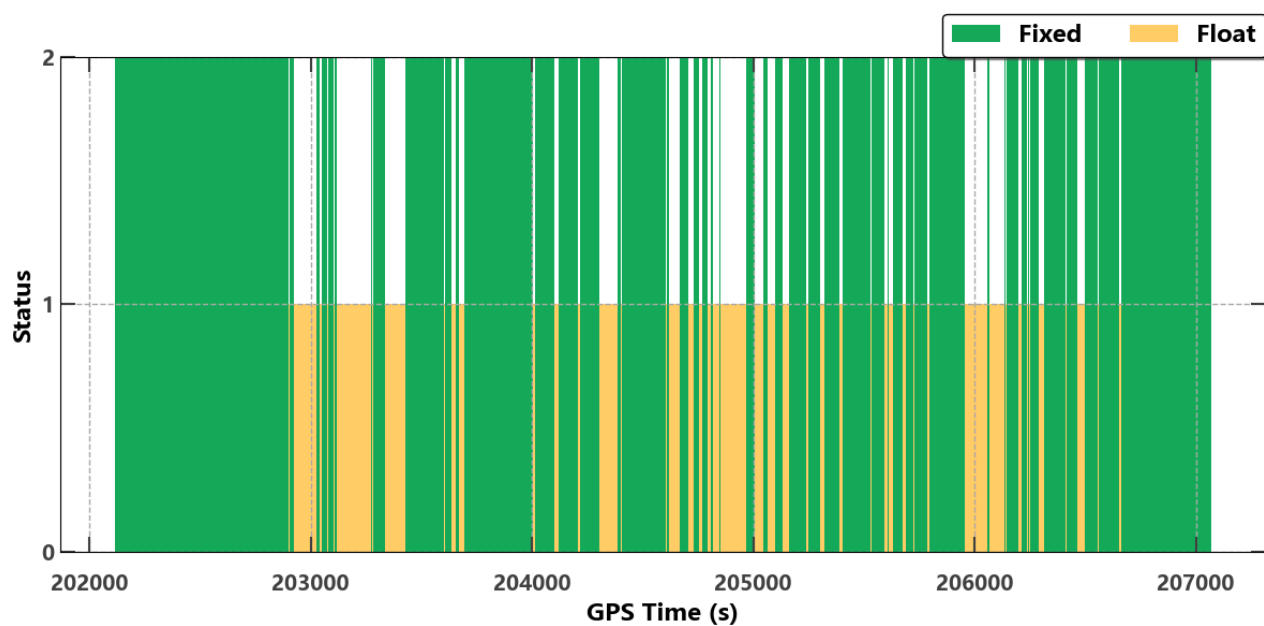


Figure6-1 Ambiguity Fixed Situation

### 6.2.2 IMU flag

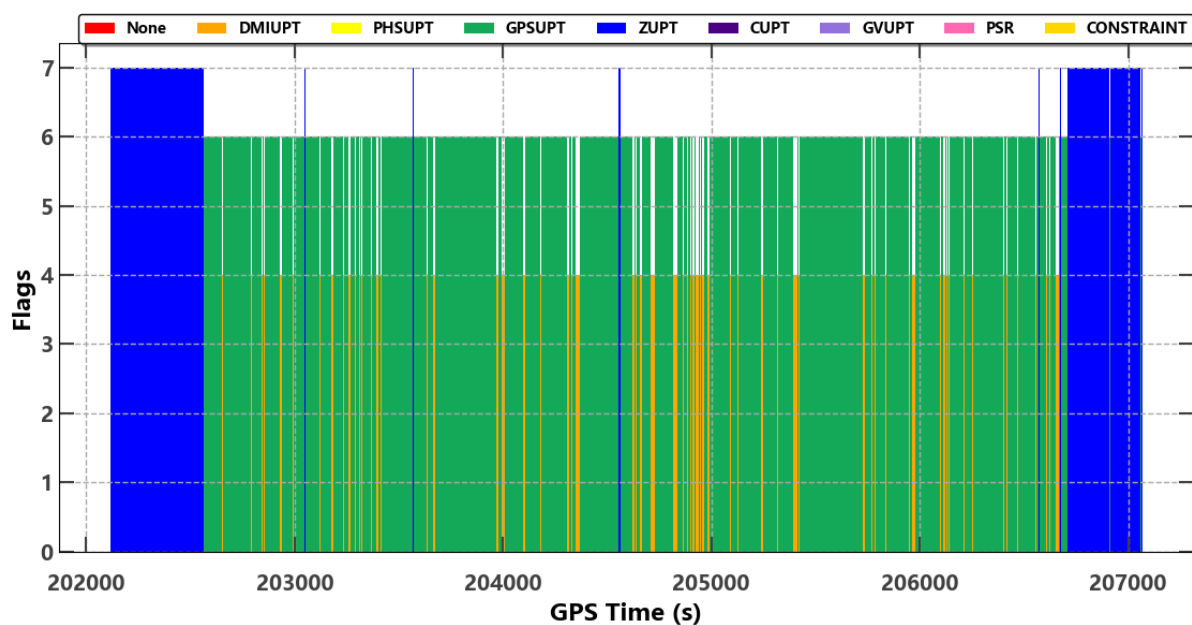


Figure6-2 IMU Flag

### 6.2.3 Forward/Backward Position Discrepancy

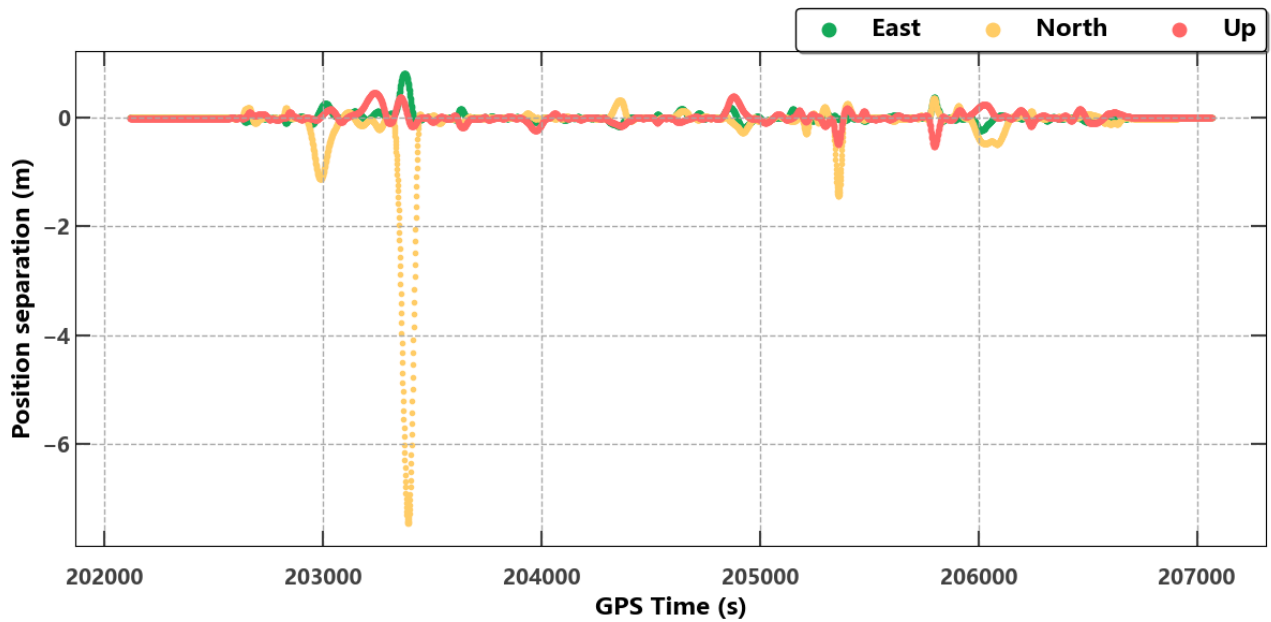


Figure6-3 Forward/Backward Position Discrepancy

### 6.2.4 Forward/Backward Attitude Discrepancy

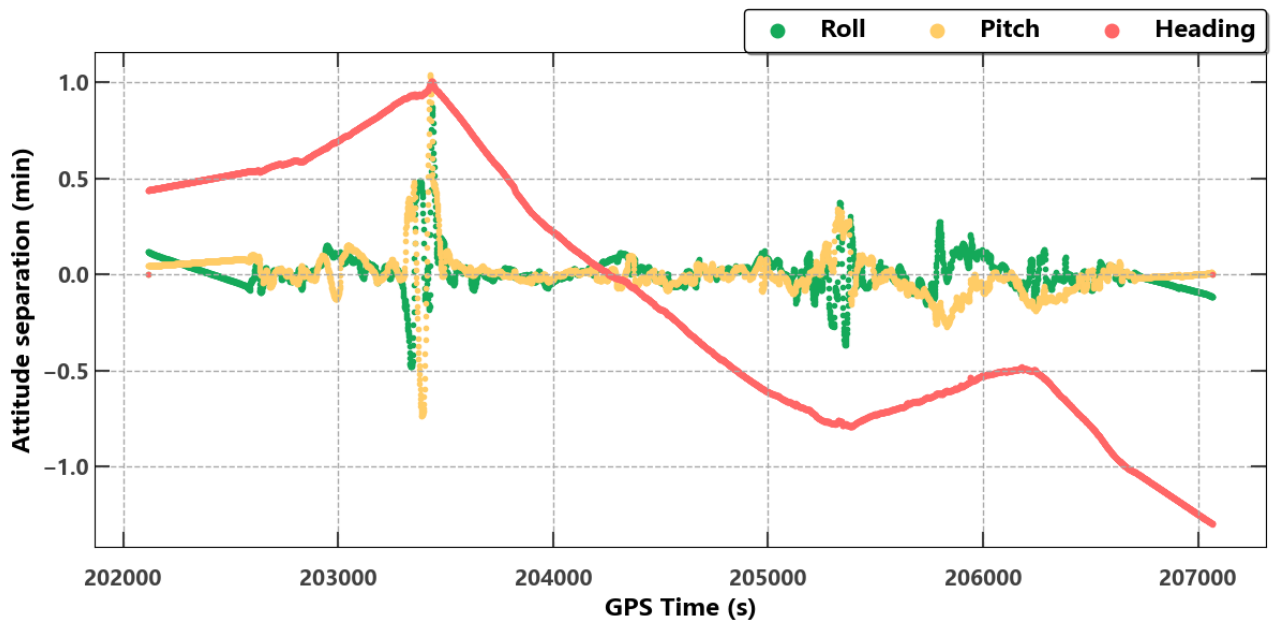


Figure6-4 Forward/Backward Attitude Discrepancy