



PLANET · SmartPNT
多源融合智能导航

Data01_20240715_100C_CAR_complex Data Description

School of Geodesy and Geomatics, Wuhan University

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1 Overview

Data Packet Name: Data01_20240715_100C_CAR_complex

Collection Date: 2024.07.15

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).

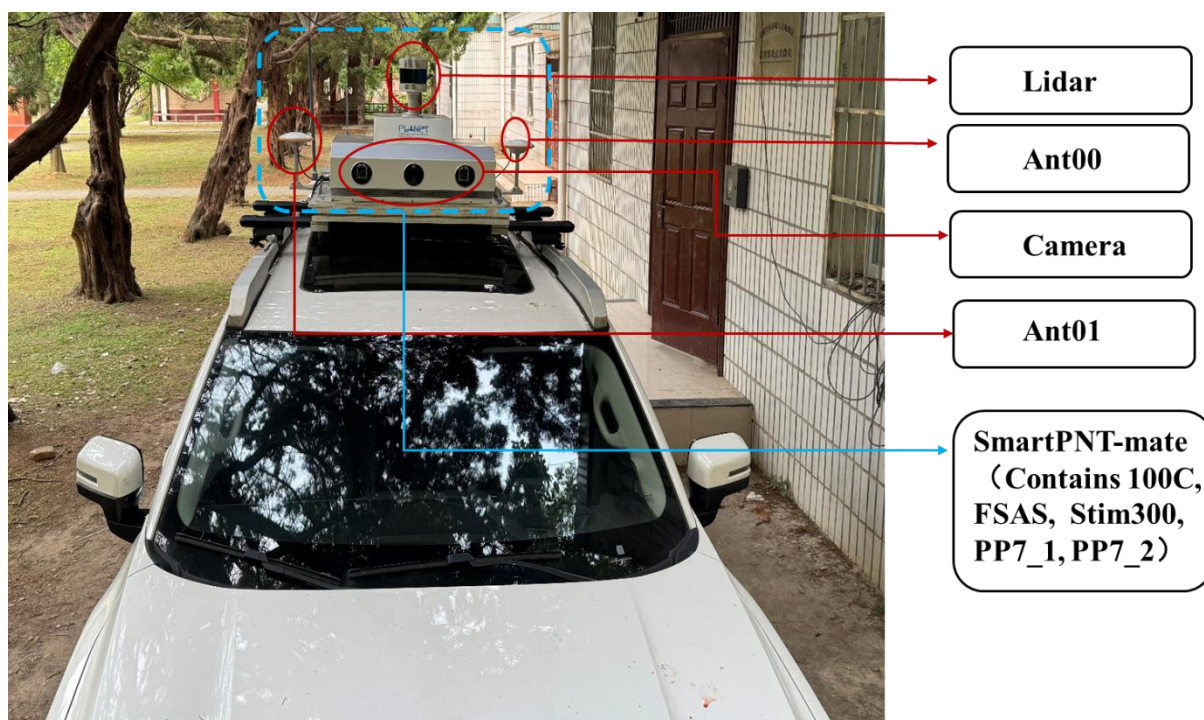


Figure2-1 Front view of the collection device

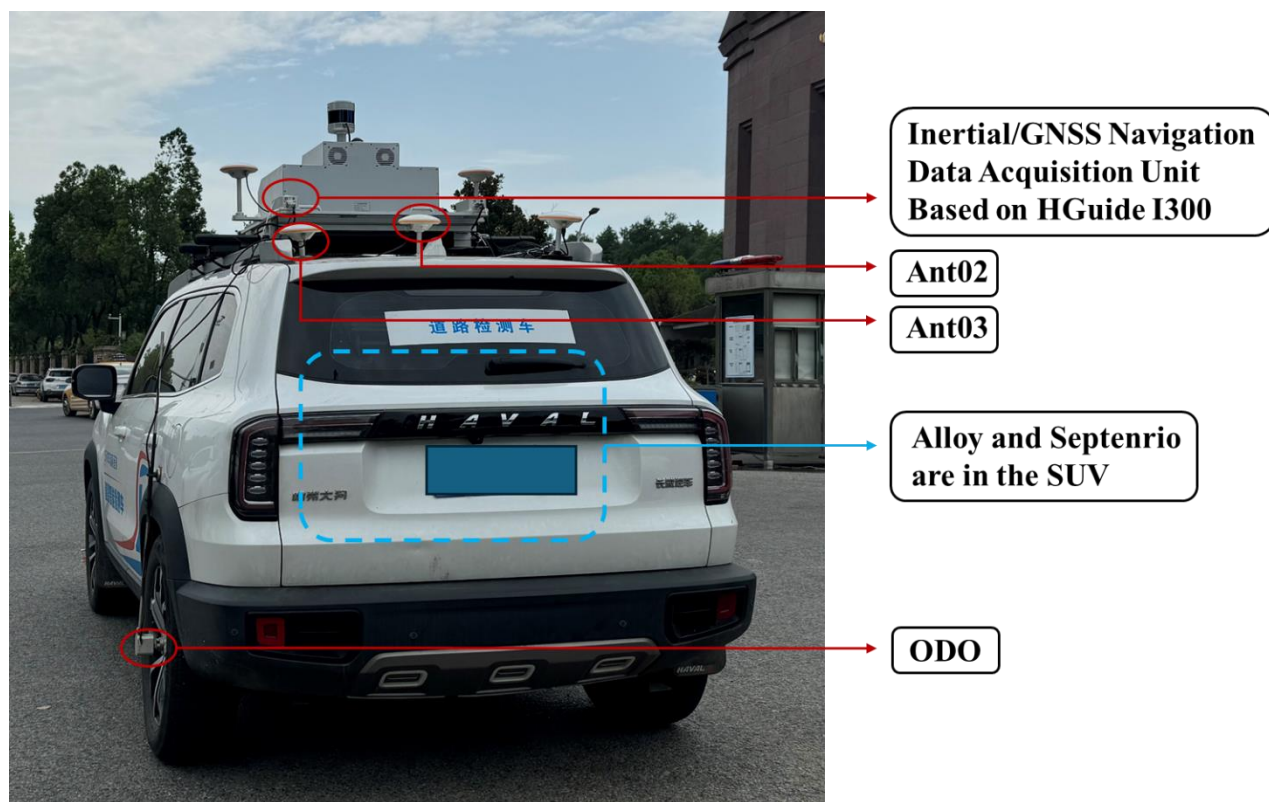


Figure2-2 Behind view of the collection device

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

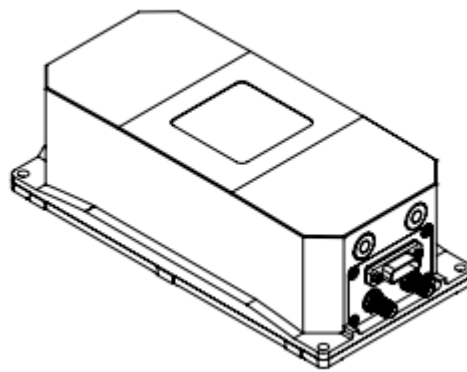


Figure 2-6 Inertial/GNSS Navigation Data Acquisition Unit Based on HGuide I300

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 (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 (Base station data from Qianxun Position's FindCM service, which may include multiple GNSS observation files due to station changes)	✓	BASE_01.24O, BASE_02.24O, BASE_03.24O, BASE_04.24O, BASE_05.24O, BASE_06.24O
Alloy+Ant02	GNSS Observation Data	✓	ROVE_01.24o
100C+pp7_1+ODO +Ant00	Inertial Navigation Data	✓	100C.imr
	GNSS Observation Data	✓	ROVE_02.24O
	Odometer Data	×	
FSAS+pp7_2+ODO +Ant01	Inertial Navigation Data	✓	FSAS.imr
	GNSS Observation Data	✓	ROVE_03.24O
	Odometer Data	×	
I300+Ant03	Inertial Navigation Data	✓	I300.imr
	GNSS Observation Data	✓	ROVE_04.24O
STIM300	Inertial Navigation Data	✓	STIM300.imr
Broadcast Satellite Ephemeris Data		✓	brdm1970.24p
Precise Satellite Ephemeris Data		✓	WUM0MGXFIN_20241970 000_01D_05M_ORB.SP3
Satellite Clock Offset Data		✓	WUM0MGXFIN_20241970 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	07:27:21.000--07:54:02.000	1HZ	Normal
BASE_02.24O	RINEX3.04	07:54:03.000--08:04:12.000	1HZ	Normal
BASE_03.24O	RINEX3.04	08:04:13.000--08:11:58.000	1HZ	Normal
BASE_04.24O	RINEX3.04	08:12:00.000--08:15:33.000	1HZ	Normal
BASE_05.24O	RINEX3.04	08:15:34.000--08:30:10.000	1HZ	Normal
BASE_06.24O	RINEX3.04	08:30:11.000--08:50:08.000	1HZ	Normal
ROVE_01.24O	RINEX3.04	07:28:44.000--08:49:55.000	1HZ	Interruptions in tunnel section
ROVE_02.24O	RINEX3.04	07:28:48.000--08:49:11.000	1HZ	Interruptions in tunnel section
ROVE_03.24O	RINEX3.04	07:29:08.000--08:50:59.000	1HZ	Interruptions in tunnel section
ROVE_04.24O	RINEX3.04	07:26:55.000--08:48:40.000	1HZ	Interruptions in tunnel section
100C.imr	IMR	07:28:47.832--08:49:11.872	200HZ	Normal
FSAS.imr	IMR	07:29:07.498--08:50:59.350	200HZ	1 Large gap (0.107s) 1 Small gap (0.017s)
I300.imr	IMR	07:26:54.560--08:48:51.702	200HZ	Normal
STIM300.imr	IMR	07:30:27.995--07:38:25.000	200HZ	1 Large gap (1.575s)

(Note: All data recorded in Table 5-1 is dated GPST: 2024/07/15)

6 True Value Processing

6.1 Processing Methods

Processing Software: Inertial Explorer 8.90.8304 [64-bit]

Processing Mode: GNSS/IMU Loose Integration

Use of Precise Ephemeris: No

Use of Odometer: No

Data Used:

- **Base station data from Qianxun Position's FindCM service:** BASE_01.24O -- BASE_06.24O
- **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

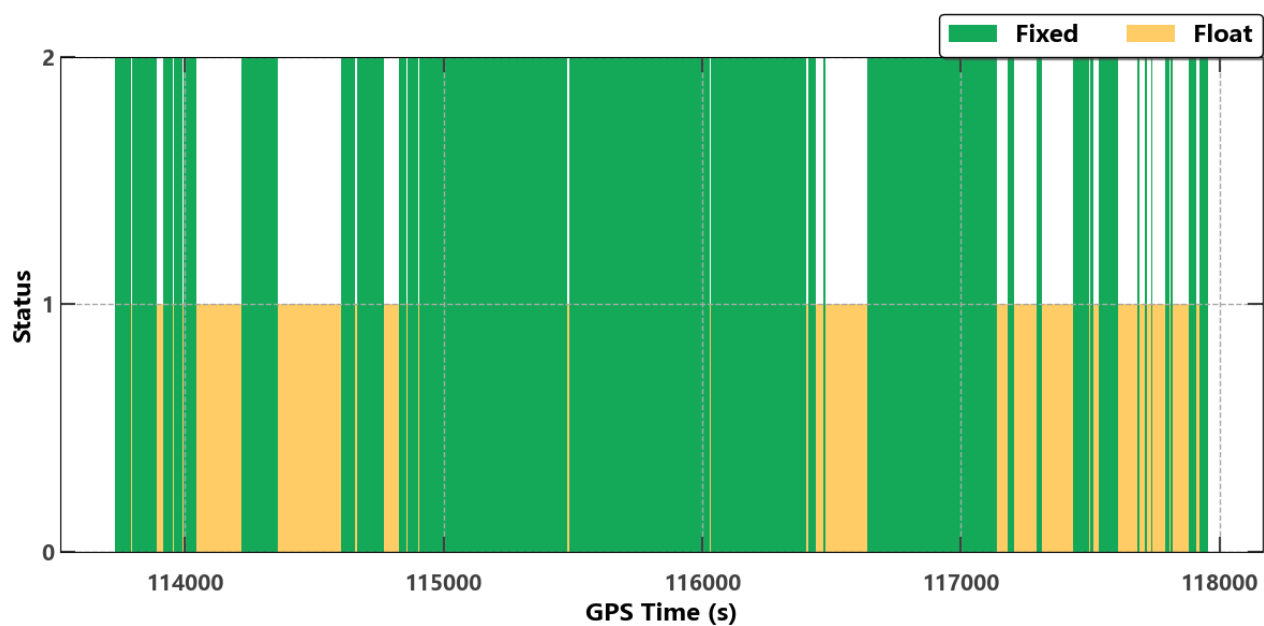


Figure6-1 Ambiguity Fixed Situation

6.2.2 IMU flag

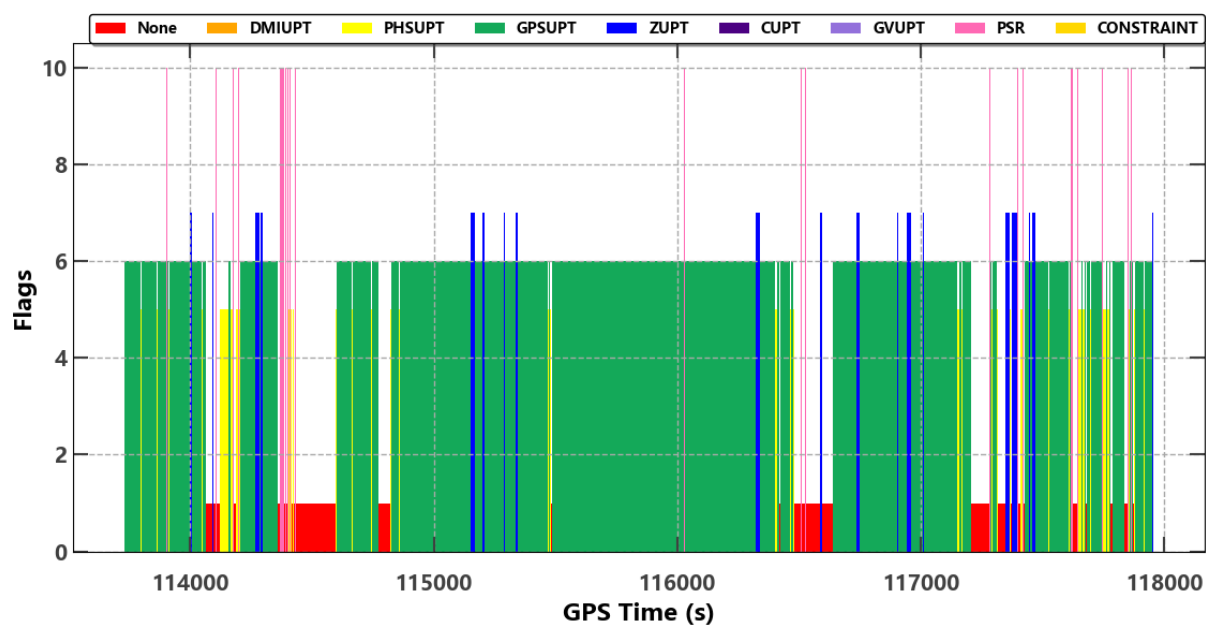


Figure6-2 IMU Flag

6.2.3 Forward/Backward Position Discrepancy

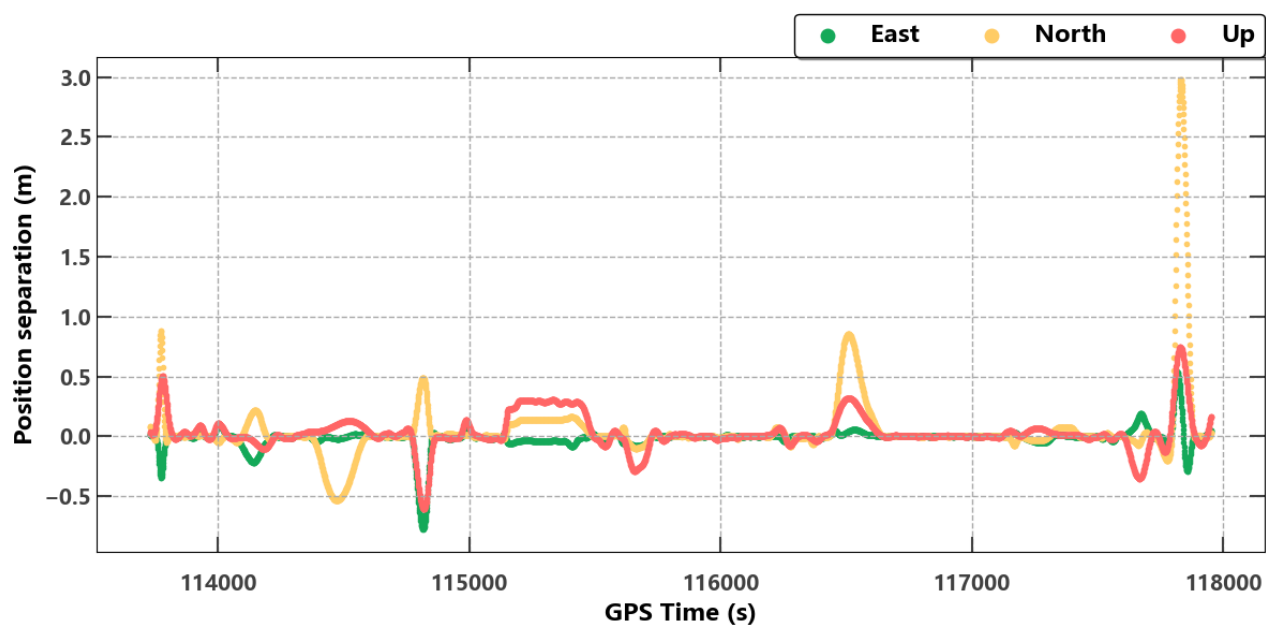


Figure6-3 Forward/Backward Position Discrepancy

6.2.4 Forward/Backward Attitude Discrepancy

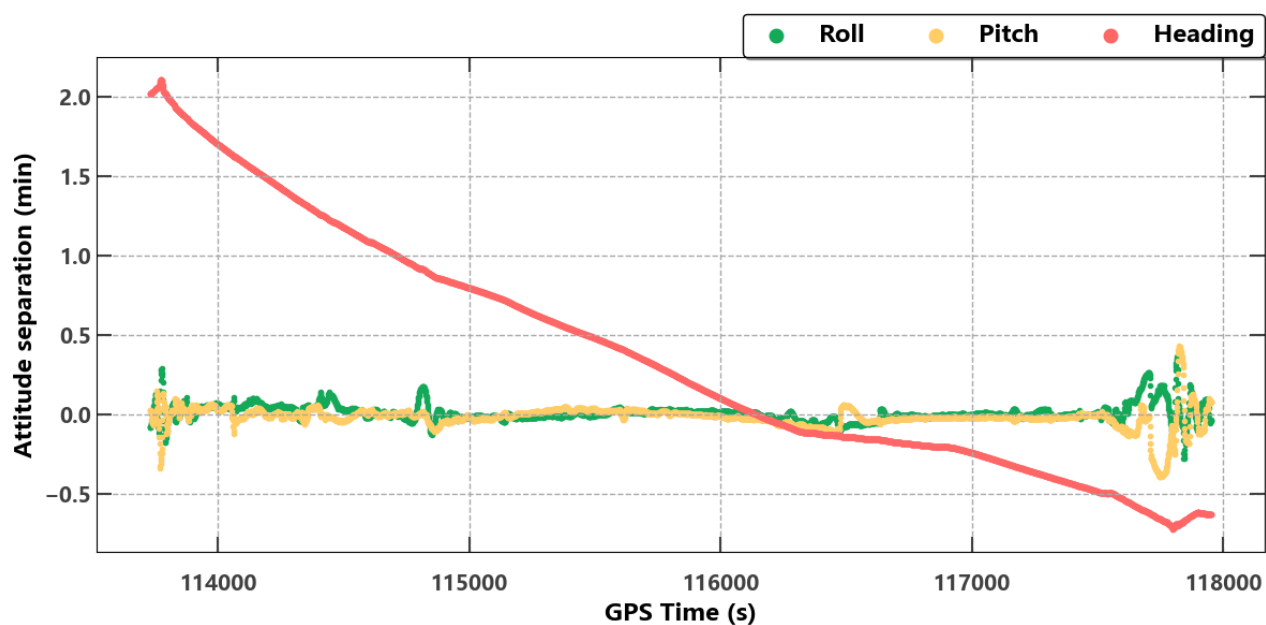


Figure6-4 Forward/Backward Attitude Discrepancy