CSNS-3000 Integrated Navigation System

1. Overview

CSNS-3000 is a new generation integrated navigation system. It is primarily composed of three core underwater sensing units: an **Underwater Inertial Navigation System (INS)**, an **Doppler Velocity Log (DVL)**, and an **Underwater Pressure Sensor**. The system provides high-precision positioning, attitude computation, and depth monitoring for underwater vehicles through multi-source data fusion algorithms.

After obtaining the initial latitude and longitude, the device achieves self-alignment by sensing the Earth's rotational angular velocity for north-seeking.

The product features a titanium alloy pressure-resistant housing and integrates a high-performance phased array DVL and a high-resolution pressure sensor module. It supports combined positioning with DVL, GPS, and USBL, and outputs attitude, position, velocity, and depth information. With a standard pressure-resistant housing, it can be directly used for underwater navigation of AUVs/ROVs without any modifications.

The CSNS-3000 integrated navigation system employs an improved IMU solution and data fusion method, significantly enhancing attitude and heading accuracy. When combined with DVL, the navigation accuracy reaches 0.**5%** of the distance traveled under straight-line conditions, and **0.1%** of the distance traveled during area mapping missions. The depth sensor has a resolution of **0.0005%** of the full range and an accuracy of **0.05%** of the full range.

2. TECHNICAL SPECIFICATIONS

2.1.Technical Specifications

SPECIFICATIONS	
Dimensions	Max. diameter: 193 mm, height: 277 mm
Weight in air	14.2 kg
Max. operating depth	3000 m
External sensor support	GPS (NMEA0183)/USBL position system
Depth sensor accuracy	0.0005% of full scale (1.5 cm at 3000 m)
Depth sensor resolution	Pitch/roll: 0.03° (RMSE)
Attitude accuracy	1mm/s
Heading accuracy (moored, no DVL/GPS)	0.25° (RMSE)
Heading accuracy (INS/DVL)	1 - 255
Travel distance error (Z-shaped survey)	≤0.1% of distance
Travel distance error (straight line)	≤0.5% of distance
Power supply	24 V ±1 V

2.2. Performance Parameters

Key Features:

(1) Compact size, high accuracy, autonomous north-seeking, immune to magnetic interference.

(2) Straight-line navigation accuracy: ≤0.5% of distance; Z-shaped survey pattern accuracy: ≤0.1%.

(3) Integrated high-resolution pressure sensor, 3000 m depth-rated version with 1.5 cm resolution.

(4) Phased array DVL, navigation accuracy unaffected by sound speed variations.

(5) Automatically switches to water-track mode when bottom-track is lost in deep water.

(6) Supports USBL position aiding with automatic outlier rejection.

(7) Built-in Wi-Fi module for configuration and data access.

2.3. Mechanical Dimensions

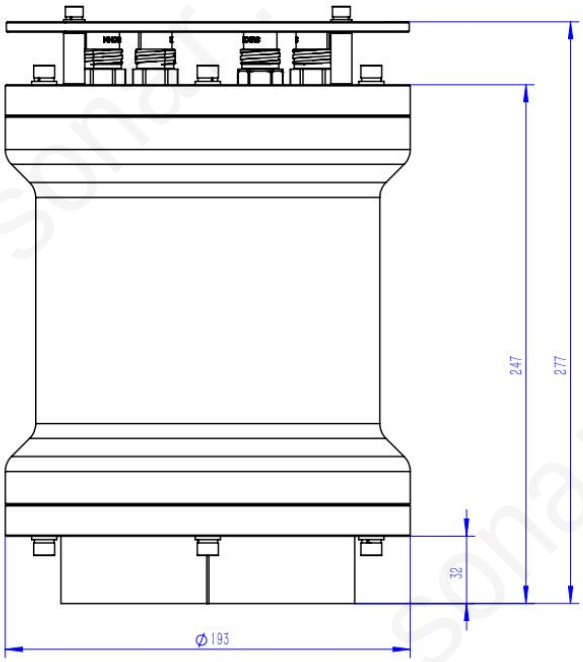

Figure 2.3.1 Side View

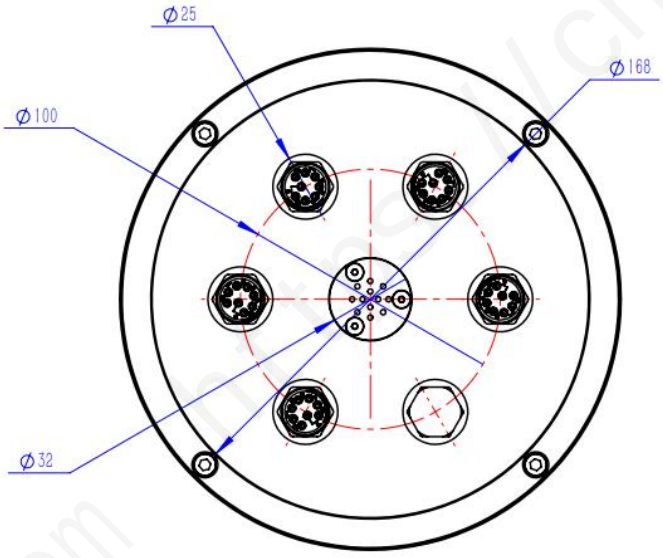

Figure 2.3.2 Top View

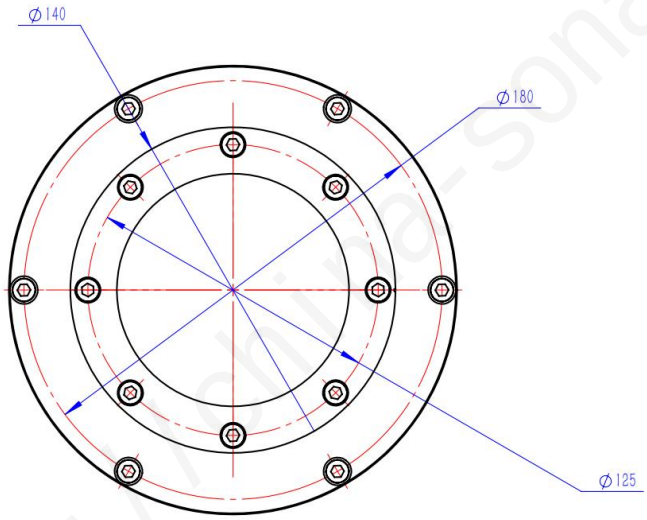

Figure 2.3.3 Bottom View

2.4. Connector & Pin Definition

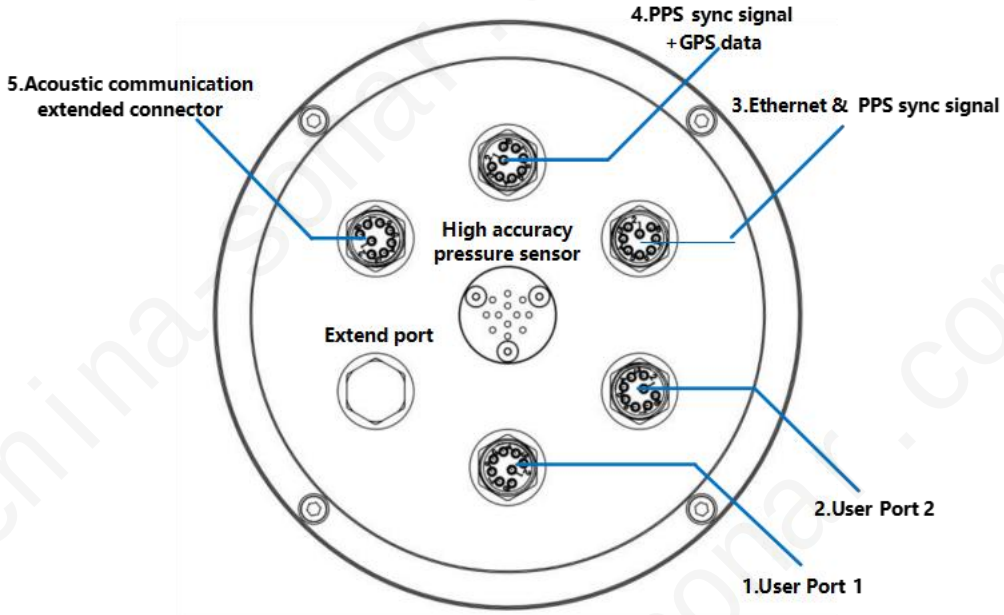

Figure 2.4 Connector Definition

Table2.4 Connector Definition

Connector	Pin Function
1. User Port 1	1. Power +24 V
	2. Power GND
	3. User UART1 RS232 TX (INS out) / RS422 TX+
	4. User UART1 RS232 RX (INS in) / RS422 RX+
	5. UART1 RS422 TX-
	6. UART1 RS422 RX-
	7. GPS RS485 RX+
	8. GPS RS485 RX-
2. User Port 2	1. Power +24 V
	2. Power GND
	3. User UART2 RS232 TX (INS out) / RS422 TX+
	4. User UART2 RS232 RX (INS in) / RS422 RX+
	5. UART2 RS422 TX-
	6. UART2 RS422 RX-
	7. GPS RS485 RX+
	8. GPS RS485 RX-
3. Ethernet & Sync	1. Power output +24 V
	2. Power output GND
	3. PPS2 RS485 TX+
	4. PPS2 RS485 TX-

	5. Ethernet TX+
	6. Ethernet TX-
	7. Ethernet RX+
	8. Ethernet RX-
4. PPS Port	1. Power output +24 V
	2. Power output GND
	3. GPS RS485 RX+
	4. GPS RS485 RX-
	5. PPS1 RS485 RX+ (GPS PPS in)
	6. PPS1 RS485 RX- (GPS PPS in)
	7. PPS1 RS485 TX+
	8. PPS1 RS485 TX
5. Acoustic Communication Extension	1. Switched power output +24 V
	2. Switched power output GND
	3. UART3 RS232 TX (INS out) / RS422 TX+
	4. UART3 RS232 RX (INS in) / RS422 RX+
	5. UART3 RS422 TX-
	6. UART3 RS422 RX-
	7. PPS3 RS485 TX+
	8. PPS3 RS485 TX-

3. BASIC FUNCTIONS

SINS/DVL/GPS/Depth Sensor Integrated Navigation Mode

(1) This is the default operating mode of the system.
(2) When GPS velocity data are valid, the SINS integrates with GPS.
(3) When GPS is invalid, SINS integrates with depth sensor and DVL. If both water-track and bottom-track are valid, bottom-track velocity is used. In deep water, if only water-track is available, SINS integrates with water-track velocity.
(4) If both DVL and GPS data are unavailable, the system switches to vertical gyro mode, maintaining accurate attitude while setting velocity to zero.
(5) When valid USBL position is received, outliers are automatically rejected and navigation error is corrected.

4. TEST REPORT

4.1. Trajectory Comparison

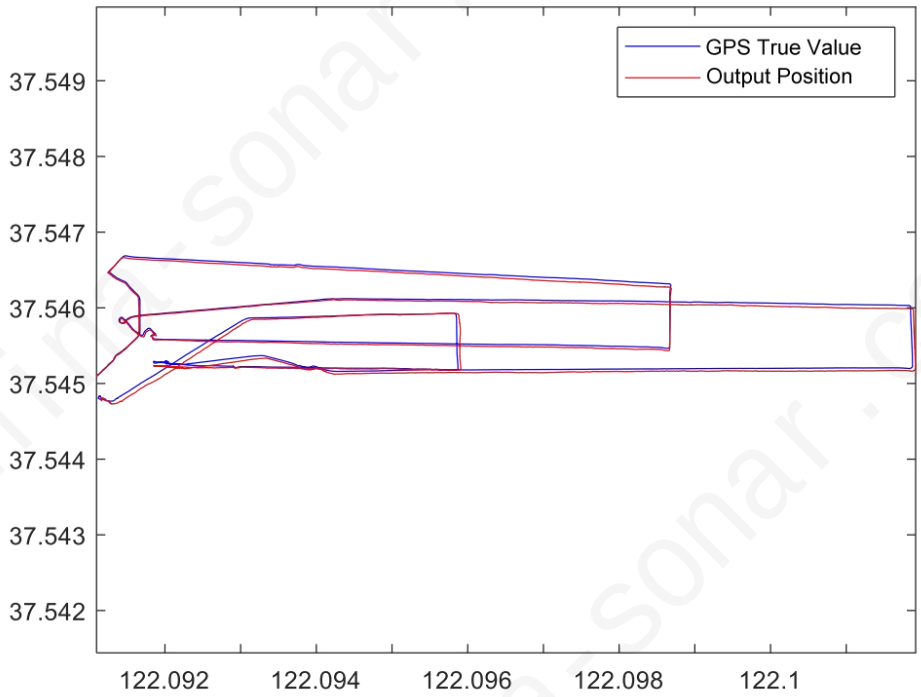

Figure 4.1.1 Comparison of Integrated Navigation Position Trajectory and GPS Truth

4.2. Error Analysis

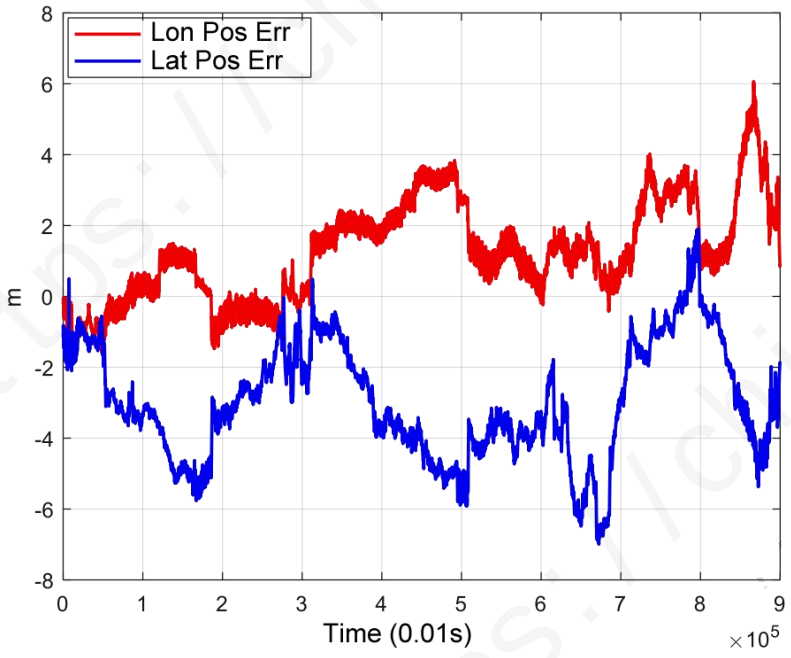

Figure 4.1.2 Position Error (Total Time ≈ 9000 s)

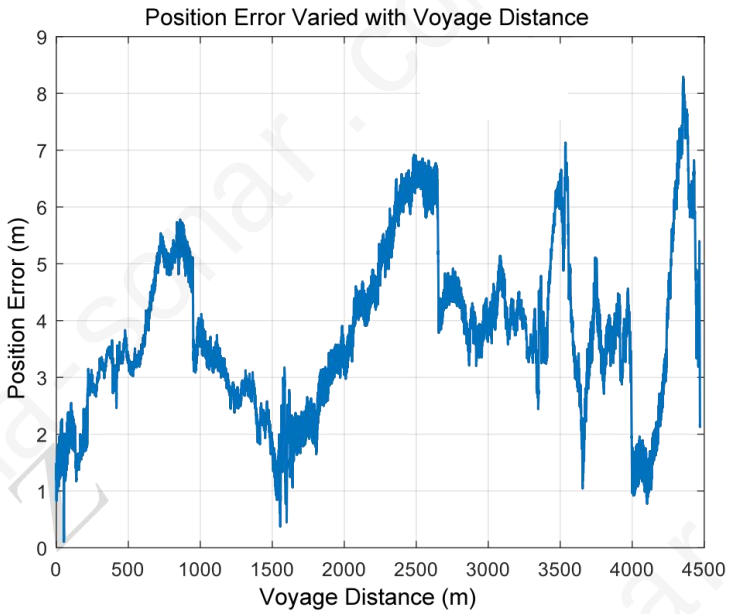

Figure 4.1.3 Position Error vs. Distance Traveled

During the 4.47 km mission, the system's maximum position drift did not exceed 8.3 m, with an average of 3.8 m, corresponding to 0.085 % travel-distance error on reciprocal legs and 0.38 % on the initial 824 m straight segment.