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Spatial NAV982 Reference Manual

Spatial NAV982 产品说明书

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0.1	31/07/2012	First Draft. Please email support@nuogeng.com.cn. if you notice any mistakes or anything is not explained clearly.

2 Foundation Knowledge /基础知识

This chapter is a learning reference that briefly covers knowledge essential to understanding Spatial and the following chapters. It explains the concepts in simple terms so that people unfamiliar with the technology may understand it.

本章主要讲述一些基础知识，用通俗易通的语言来帮助理解产品所涉及到的相关技术。

2.1 GNSS /卫星导航系统

GNSS stands for global navigation satellite system. A GNSS consists of a number of satellites in space that broadcast navigation signals. These navigation signals can be picked up by a GNSS receiver on the earth to determine that receiver's position and velocity. For a long time the only operational GNSS was the United States GPS. However the Russian GLONASS is now fully operational with similar performance to GPS. The Chinese COMPASS is in the process of becoming operational and the European Union's GALILEO should be operational within ten years.

GNSS 代理全球卫星导航系统。GNSS 包括很多颗发送导航数据的卫星，GNSS 接收机目前主要接收三种卫星信号，来解算自己的位置和速度。在很长的一段时间内，仅美国的 GPS 卫星能够覆盖全球，俄罗斯的 GLONASS 卫星目前也能够提供相同的性能。中国的 COMPASS 和欧盟的 GALILEO 也在逐步完善当中。

GNSS is excellent for navigational purposes and provides fairly accurate position (2.5 metres) and velocity (0.03 metres/second). The main drawback of GNSS is that the receiver must have a clear signal from at least 4 satellites to function. GNSS satellite signals are very weak and struggle to penetrate through buildings and other objects obstructing view of the sky. GNSS can also occasionally drop out due to disturbances in the upper atmosphere.

GNSS 能够提供相当可靠的位置精度（2.5m）和速度精度（0.03m/sec）。它的缺点是 GNSS 定位必须得收到至少 4 颗卫星，GNSS 卫星信号本身就很弱，同时容易被树木和建筑所干扰，上空的电离层也会对信号产生干扰。

2.2 INS /惯性导航系统

INS stands for inertial navigation system. An inertial navigation system can provide position and velocity similar to GNSS but with some big differences. The principle of inertial navigation is the measurement of acceleration. This acceleration is then integrated into velocity. The velocity is then integrated into position. Due to noise in the measurement and the compounding of that noise through the integration, inertial navigation has an error that increases exponentially over time. Inertial navigation systems have a very low relative error over short time periods but over long time periods the error can increase dramatically.

INS 代表惯性导航系统，同 GNSS 卫星导航系统相似，惯性导航系统也能提供位置和速度数据，但是运行原理却不同。惯性导航是通过加速度传感器积分出速度，速度积分出位置；通过角速度传感器积分出角度。由于测量上的噪声，以及积分的工作原理，惯性导航系统所产生的误差会随着时间的增加而放大。惯性导航系统在短时间内会有相对较小的误差，而随着时间的增加，误差会放大的更大。

2.3 GNSS/INS /GNSS 和惯性组合导航系统

By combining GNSS and INS together in a mathematical algorithm, it is possible to take advantage of the benefits of GNSS long-term accuracy and INS short-term accuracy. This provides an overall enhanced position and velocity solution that can withstand short GNSS drop outs.

用算法把 GNSS 和 INS 组合在一起，采用 GNSS 卫星导航系统的长期精度和 INS 惯性导航系统的短期精度，组合在一起可以提供增强的位置和速度性能，即使在 GNSS 信号短时间丢失也能够提供连续的导航数据。

2.4 AHRS /姿态方位参考系统

AHRS stands for attitude and heading reference system. An AHRS uses accelerometers, gyroscopes and magnetometers combined in a mathematical algorithm to provide orientation. Orientation consists of the three body angles roll, pitch and heading.

AHRS 代表姿态方位参考系统。典型的 AHRS 算法组合加速度传感器，陀螺仪和磁场计数据来提供角度，角度包括航向，俯仰和横滚。

2.5 The Sensor Co-ordinate Frame /传感器坐标轴

Inertial sensors have 3 different axes: X, Y and Z and these determine the directions around which angles and accelerations are measured. It is very important to align the axes correctly in installation otherwise the system won't work correctly. These axes are marked on the top of the device as shown in 1 below with the X axis pointing in the direction of the connectors, the Z axis pointing down through the base of the unit and the Y axis pointing off to the right.

惯性传感器包含三个坐标轴：X，Y 和 Z，在安装的时候必须遵循坐标轴原则，否则传感器将不能正常工作。坐标轴的方向在传感器上有定义，如图 1 所示，X 轴与连接头的指向相反，水平安装的时候，Z 轴朝下，Y 轴指向右方。

*Illustration 图 1: Bird's eye view of Spatial showing axes marked on top /*商标朝上的鸟瞰视图

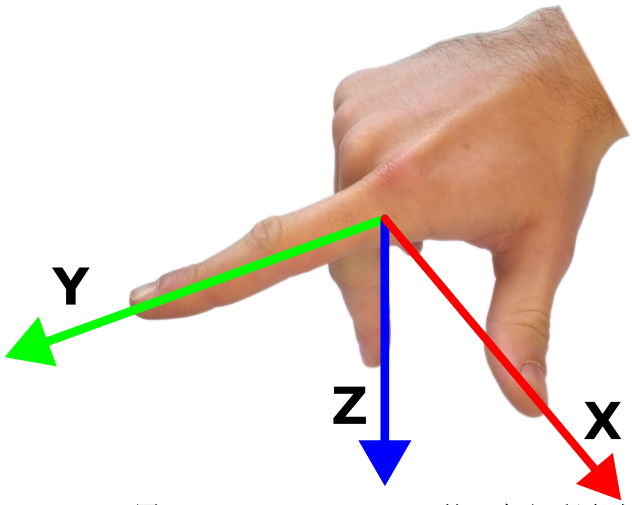


*Illustration 图 2: First right hand rule /*第一个右手原则

When installed in an application the X axis should be aligned such that it points forwards and the Z axis aligned so that it points down when level. A good way to remember the sensor axes is the right hand rule, which is visualised in 2. You take your right hand and extend your thumb, index and middle. Your thumb then denotes the X axis, your index denotes the Y axis and your middle denotes the Z axis.

在实际安装的时候，载体水平状态下，从后往前看，X 轴与载体前进的方向一致，Z 轴朝下，Y 轴朝

右。比较容易记忆坐标轴的方法是遵循右手原则，如图 2 所示，伸出您的大拇指，食指和中指，大拇指指向 X 轴，此时食指指向的是 Y 轴，中指指向的是 Z 轴。

2.6 Roll, Pitch and Heading /俯仰，横滚和航向

Orientation can be described by the three angles roll, pitch and heading, these are known as the euler angles. They are best described visually through the Illustrations below.

角度也定义为三个方向，俯仰，横滚和航向，同欧拉角的描述。下图更好的解释了三个角度的方向。

2.6.1 Roll /横滚

Roll is the angle around the X axis. See 3 for the positive direction of roll and 4 for an example of a roll of 90 degrees.

横滚代表绕着 X 轴的角度，图 3 代表横滚角度的正向方向，图 4 表示 90 度的横滚角。

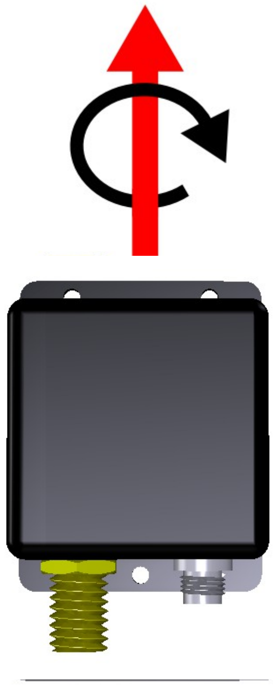


Illustration 图 3: Spatial with black arrow indicating positive direction of roll /横滚角度的正向

Illustration 图 4: Spatial after a roll of 90 degrees /横滚角度为 90 度

2.6.2 Pitch /俯仰

Pitch is the angle around the Y axis. See 5 for the positive direction of pitch and 6 for an example of a pitch of 90 degrees.

俯仰代表绕着 Y 轴的角度，图 5 表示俯仰角的正向方向，图 6 表示俯仰角为 90 度。

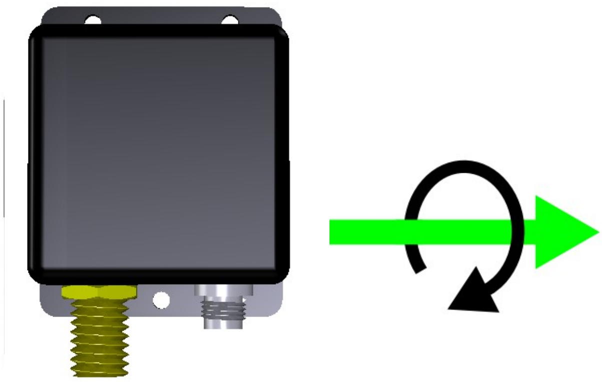


Illustration 图 *5: Spatial with with black arrow indicating positive direction of pitch /* 俯仰角的正向方向

Illustration 图 *6: Spatial after a pitch of 90 degrees /* 俯仰角度为 *90* 度

2.6.3 Heading /航向

Heading is the angle around the Z axis. See 7 for the positive direction of heading and 8 for an example of a heading change of 90 degrees. 0 degrees heading is when the positive X axis points North and 180 degrees heading is when the positive X axis points South.

航向角是绕着 Z 轴的角度，图 7 表示航向的正向方向，图 8 表示 90 度航向角。0 度航向角表示 X 轴指向正北，180 度航向角表示 X 指向正南。

Illustration 图 *7: Spatial with black arrow indicating positive direction of heading /* 航向角的正向方向

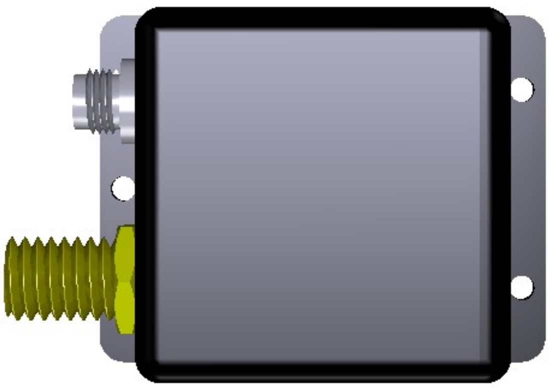


Illustration 图 *8: Spatial after a heading change of 90 degrees /*航向角为 90 度

2.6.4 Second Right Hand Rule /第二个右手原则

The two right hand rules are often the best way to memorise the sensor axes and directions of positive rotation. The first right hand rule gives the positive axis directions and is described in section 2.5. The second right hand rule shown in 9 provides the direction of positive rotation. To use it, point your thumb in the positive direction of that axis, then the direction that your fingers curl over is the positive rotation on that axis.

这里介绍第二个右手原则，以方便记忆传感器绕着坐标轴正向旋转的方向。第一个右手原则介绍了坐标轴的指向，详见章节 2.5。图 9 所示的第二个右手原则符合坐标轴的正向旋转方向，伸出右手，大拇指指向坐标轴的正向方向，此时其他手指自然弯曲的方向就是该坐标轴正向旋转的方向。

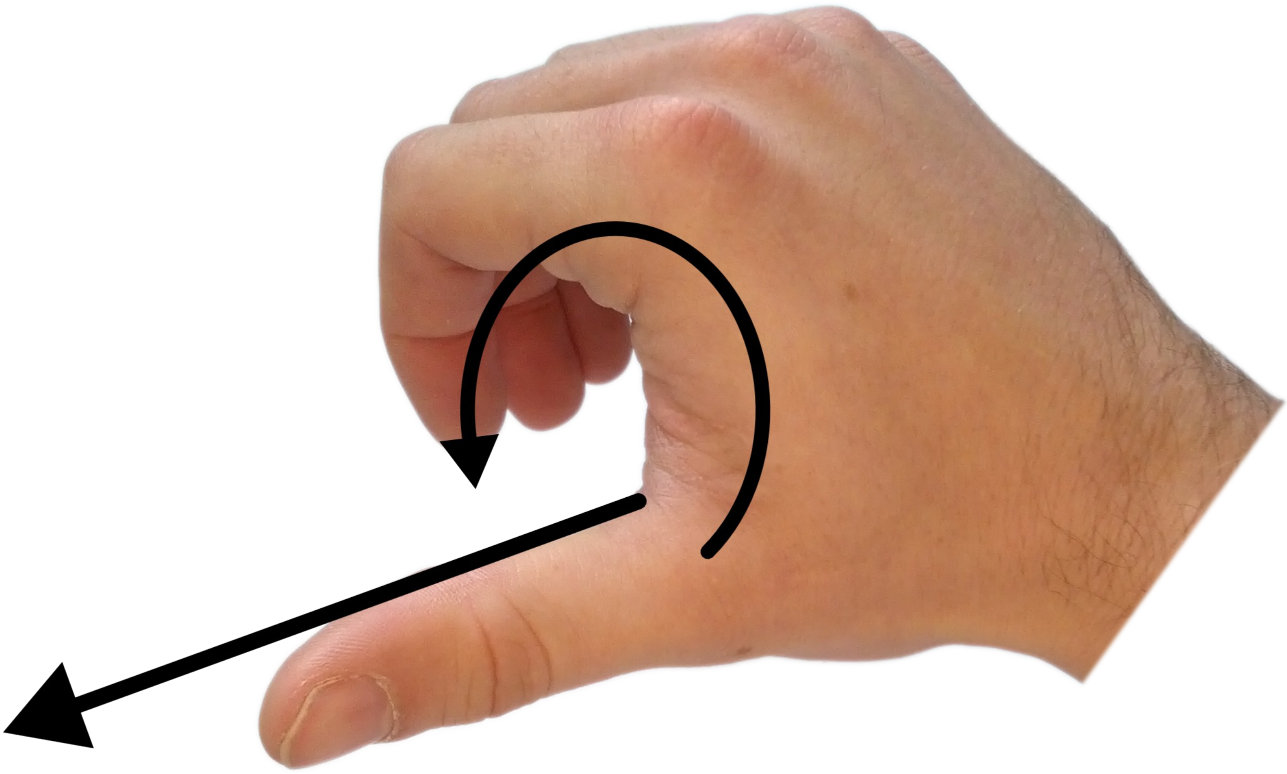


Illustration 图 *9: Second right hand rule* /第二个右手原则

2.6.5 Rotation Order /旋转次序

When multiple axes are rotated, to imagine the final orientation the three rotations must be performed in the order heading first, then pitch and then roll. To deduce the final orientation the unit should first be considered level with the X axis pointing north and the Z axis pointing down. Heading is applied first, then pitch is applied and finally roll is applied to give the final orientation. This can be hard for some people to grasp at first and is often best learned experimentally by rotating spatial with your hand whilst watching the orientation plot in real time on the computer.

当存在多个坐标轴旋转时，想象最后的方向存在一个旋转次序，首先是航向， 其次是俯仰，最后是横滚。为了便于记忆，首先认为传感器是水平状态，X 轴指向北，Z 轴朝下，首先航向旋转，其次是俯仰旋转，然后是横滚旋转到最后的方向。初次接触这些概念可能会觉得有些陌生，比较好的实验方法是连上传感器，一边旋转一边在电脑上实时观察角度的变化。

3 Introduction /简介

Spatial is a miniature GNSS/INS & AHRS system that provides accurate position, velocity, acceleration and orientation under the most demanding conditions. It combines temperature calibrated accelerometers, gyroscopes, magnetometers and a pressure sensor with an advanced GNSS receiver. These are coupled in a sophisticated fusion algorithm to deliver accurate and reliable navigation and orientation.

NAV982 是一款小体积的 GNSS/INS & AHRS 系统，它提供精确的位置，速度，加速度和角度数据。它组合了经过温度校正的加速度传感器，陀螺仪，磁场计，气压高度计，和 GNSS 接收机，经过算法把这些数据融合起来，提供精确可靠的导航和姿态方位数据。

Spatial can provide amazing results but it does need to be set up properly and operated with an awareness of it’s limitations. Please read through this manual carefully to ensure success within your application.

NAV982 可以提供高性能的数据，但是需要正确的安装，正确的操作和维护，并理解限制产品性能的因素，请仔细阅读说明书。

The Spatial Manager software is downloadable from the software section. It allows Spatial to be easily configured and tested. It is referenced throughout this manual.

Spatial 管理器软件可从网站上下载，通过它可以对传感器进行快速配置和监视。

If you have any questions please contact support@nuogeng.com.cn

如果有任何问题，请及时联系我们。技术支持邮箱：support@nuogeng.com.cn

4 Specifications /技术规范

4.1 Mechanical Drawings /外形尺寸

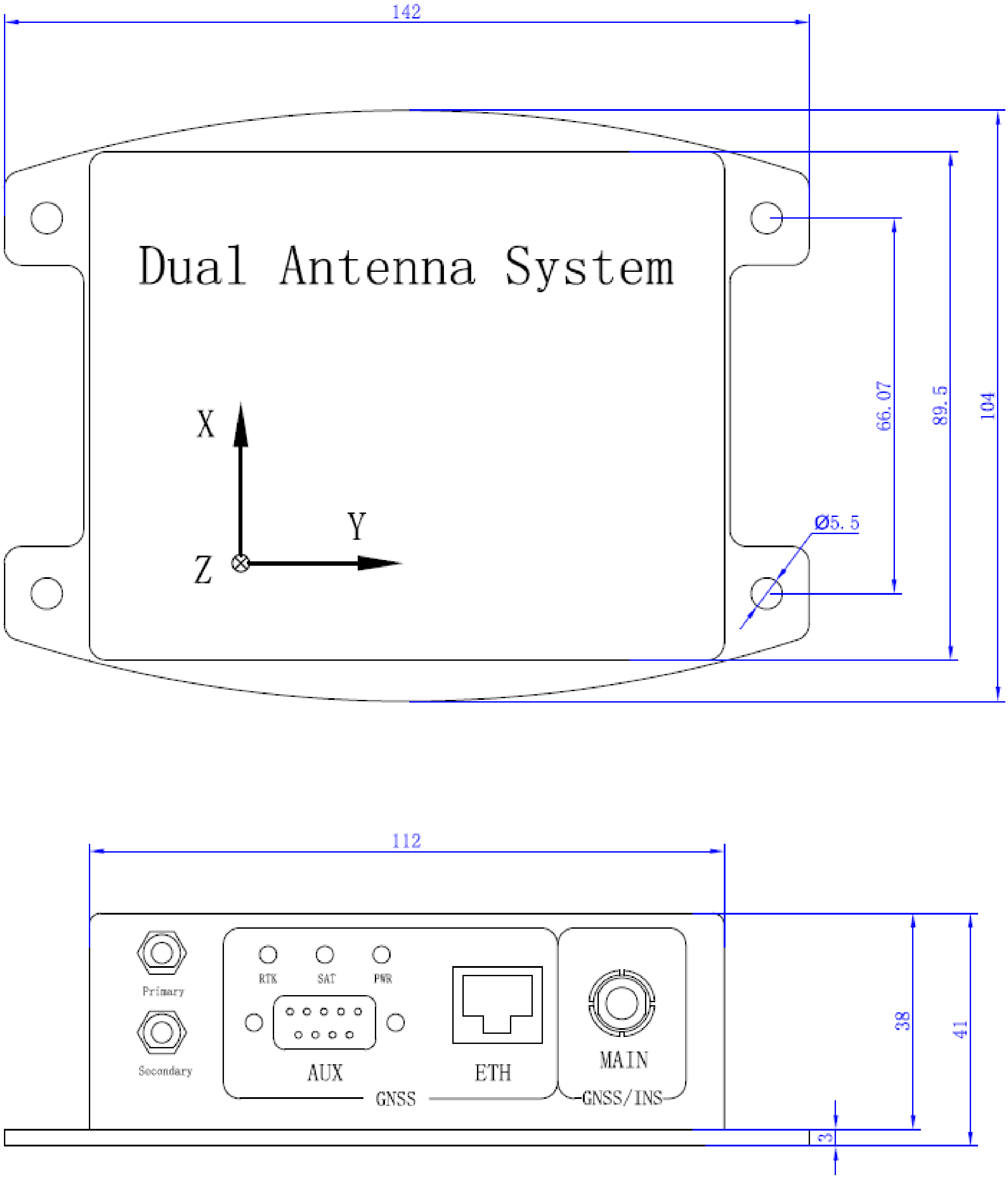


Illustration 图 *10: Mechanical drawings of Spatial NAV982 /*外形尺寸图

4.2 Navigation Specifications /导航性能参数

Parameter 参数	Value 数值
Horizontal Position Accuracy /水平位置精度	1.2 / 0.5 / 0.01 SPS/DGNSS/RTK (m)
Vertical Position Accuracy /垂直位置精度	2.0 / 0.8 / 0.02 SPS/DGNSS/RTK (m)
Velocity Accuracy /速度精度	0.007 m/s
Roll & Pitch Accuracy (Static) /俯仰和横滚精度（静态）	0.2 °
Heading Accuracy (Static) /航向精度（静态）	0.1 °
Roll & Pitch Accuracy (Dynamic) /俯仰和横滚精度（动态）	0.4 °
Heading Accuracy (Dynamic) /航向精度（动态）	0.1 °
Heave Accuracy /升沉值精度	5 % or 0.05 m
Orientation Range /角度范围	无限制
Hot Start Time /热启动时间	500 ms
Internal Filter Rate /内部滤波器	800 Hz
Output Data Rate /数据更新率	Up to /最高 800 Hz

Table 表 1: Navigation specifications /导航性能

4.3 Heading Accuracy /航向精度

Antenna Separation / 天线基线长度	Accuracy / 精度
1 m	0.1 °
2 m	0.07 °
10 m	0.05 °

4.4 Sensor Specifications /传感器性能参数

Parameter 参数	Accelerometers 加速度计	Gyroscopes 陀螺仪	Magnetometers 磁场计	Pressure 气压高度计
Range (dynamic) 量程（动态）	2 g 4 g 16 g	250 °/s 500 °/s 2000 °/s	2 G 4 G 8 G	30 至 110 KPa
Noise Density 噪声密度	400 ug/√Hz	0.005 °/s/√Hz	210 uG/√Hz	0.56 Pa/√Hz
Non-linearity 非线性	< 0.05 %	< 0.05 %	< 0.05 %	-
Bias Stability 偏差稳定性	60 ug	18 °/hr	-	100 Pa/yr
Scale Factor Stability 比例因子稳定性	< 0.05 %	< 0.05 %	< 0.05 %	-
Cross-axis Alignment Error 轴未对准误差	< 0.05 °	< 0.05 °	0.05 °	-
Bandwidth 带宽	256 Hz	256 Hz	75 Hz	32 Hz

Table 表 2: Sensor specifications /传感器性能参数

4.5 GNSS Specifications /GNSS 性能参数

Parameter 参数	Value 数值
Supported Navigation Systems 支持的导航卫星	GPS L1, L2, L5 GLONASS L1, L2 GALILEO E1, E5 BeiDou B1, B2
Supported SBAS Systems 支持的 SBAS 系统	WAAS EGNOS MSAS GAGAN QZSS Omnistar HP/XP/G2
Update Rate/更新率	20 Hz
Hot Start First Fix /热启动初次定位	3 s
Cold Start First Fix /冷启动初次定位	30 s
Horizontal Position Accuracy /水平位置精度	1.2 m
Horizontal Position Accuracy (with SBAS) 水平位置精度（带 SBAS）	0.5 m
Horizontal Position Accuracy (with RTK) 水平位置精度（带 RTK）	0.008 m
Velocity Accuracy /速度精度	0.007 m/s
Timing Accuracy /时间精度	20 ns

Table 表 3: GNSS Specifications /GNSS 性能参数

4.6 Communication Specifications /通讯接口参数

Parameter /参数	Value /数值
Interface /接口	RS232
Speed /速度	4800 至 1M baud
Protocol /协议	ANPP
Peripheral Interface /多功能 IO 口	2 x GPIO
GPIO Level /GPIO 电平	5V

Table 表 4: Communication specifications /通讯接口参数

4.7 Hardware Specifications /硬件技术参数

Parameter /参数	**Value /**数值
Operating Voltage /工作电压	4.2 to 17 V
Input Protection /电压保护	± 30 V
Power Consumption /功耗	1A @ 12 V （典型值）
Backup Battery Capacity /备份电池容量	> 24 hrs
Backup Battery Charge Time /备份电池充电时间	30 mins
Backup Battery Endurance /备份电池寿命	> 10 years
Operating Temperature /工作温度	-40 °C to 85 °C
Shock Limit /冲击限制	2000 g
Dimensions /外形尺寸	142 x 104 x 41 mm
Weight 重量	500 grams

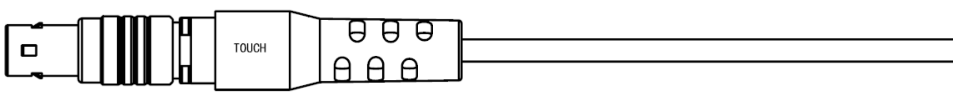
Table 表 *5: Hardware specifications* /硬件技术参数

4.8 Electrical Specifications /电气性能参数

Parameter 参数	Minimum 最小值	Typical 典型值	Maximum 最大值
Power Supply /供电电源			
Input Supply Voltage /供电电压	4.2 V		16.9 V
Input Protection Range /电压保护	-30 V		30 V
RS232			
Tx Voltage Low /Tx低电平		-5.7 V	-5 V
Tx Voltage High /Tx高电平	5 V	6.2 V	
Tx Short Circuit Current /Tx短路电流		±35 mA	±70 mA
Rx Threshold Low /Rx低电平阀值	0.8 V	1.3 V	
Rx Threshold High /Rx高电平阀值		1.7 V	2.5 V
GPIO			
Output Voltage Low /输出电压低电平	0 V		0.4 V
Output Voltage High /输出电压高电平	2.4 V		3 V
Input Threshold Low /输入低电平阀值			0.8 V
Input Threshold High /输入高电平阀值	2 V		
Input Voltage /输入电压	0 V		5.5 V
Output Current /输出电流			10 mA
GNSS Antenna /GNSS 天线			
Active Antenna Supply Voltage /供电电压	4.8 V		5.0 V
Antenna Supply Current /供电电流			100 mA

Table 表 6: Electrical specifications /电气性能参数

4.9 Connector Pin-out /接口定义



llustration 图 *11: connector pin-out* /接口定义

Spatial NAV982, Model description. /型号描述

Main Connector is DB9 (RS232) /主通讯端口为RS232 (DB9);
GPIO is CMOS Level;

MAIN Port / 主端口			
Pin / 管脚	**Colour** /颜色	**Function** /功能	**Connector** /连接器
1	Red /红	Power Supply /电源正	
2	Black /黑	GND /电源地	
3	Green /绿	GNSS/INS RS232 Tx / GNSS/INS RS232-发	DB9 Female / DB9母头 Pin 2 Pin 3 Pin 5
4	Brown /棕	GNSS/INS RS232 Rx / GNSS/INS RS232-收	
	Purple /紫	GND	
5	Yellow /黄	GPIO 3	DB9 Male / DB9 公头 Pin 1 Pin 9 Pin 2 Pin 3 Pin 5 & Pin 6
6	Orange /橙	GPIO 4	
7	Grey /灰	*GNSS-RS232 Tx (COM4) / GNSS-RS232 发 (COM4)*	
8	Blue /蓝	*GNSS-RS232 Rx (COM4) / GNSS-RS232 收 (COM4)*	
9	Purple /紫	GND	

AUX Port (GNSS Only) / 辅助端口（仅 GNSS）		
Pin / 管脚	**Function** /功能	**Connector** /连接器
1	EVENT IN /打标输入	DB9 Female / DB9母头
2	GNSS-RS232 Tx (COM1) / GNSS-RS232 发 (COM1)	
3	GNSS-RS232 Rx (COM1) / GNSS-RS232 收 (COM1)	
4	NC.	
5	GND	
6	GND	
7	NC.	
8	NC.	
9	1PPS OUT / 1PPS 输出	

Ethernet Port (GNSS Only) / 以太网端口（仅 GNSS）		
Pin /管脚	**Function /功能**	**Connector /连接器**
1	TD+	RJ45 Socket / RJ45插座
2	TD-	
3	RD+	
6	RD-	
4 5 7 8	NC.	

Power LED	**RTK LED**	**SV Tracking LED**	**Status**
On (continuous)	Off	Off	The receiver is turned on, but not tracking satellites.
On (continuous)	Off	Blinking at 1 Hz then a high-frequency blinking burst every 5 seconds	The receiver is tracking satellites on the position antenna and the vector antenna. However, no incoming RTK corrections are being received.
On (continuous)	Blinking at 1 Hz	Blinking at 1 Hz than a high-frequency blinking burst every 5 seconds	The receiver is tracking satellites on the position antenna and the vector antenna, and incoming RTK corrections are being received.
On (continuous)	Off or blinking (receiving corrections)	Blinking at 5 Hz for a short while	Occurs after a power boot sequence when the position antenna is searching for satellites.
On (continuous)	Off or blinking (receiving corrections)	Off, then a high-frequency blinking burst every 5 seconds	The receiver is tracking satellites on the vector antenna only. The position antenna is not tracking.
On (continuous)	Blinking at 1 Hz	Off	The receiver is receiving incoming RTK corrections, but not tracking satellites on either the position or vector antenna.
On (continuous)	Blinking at 5 Hz	Blinking at 1 Hz then a high-frequency blinking burst every 5 seconds	The position antenna is receiving Moving Base RTK corrections at 5 Hz.
On (continuous)	Continuously on	Blinking at 1 Hz then a high-frequency blinking burst every 5 seconds	The position antenna is receiving Moving Base RTK corrections at 10 or 20 Hz (the RTK LED turns off for 100 ms if a correction is lost).
On (continuous)	On, blinking off briefly at 1 Hz	Blinking at 1 Hz then a high-frequency blinking burst every 5 seconds	The position antenna is in a base station mode, tracking satellites and transmitting RTK corrections.
On (continuous)	Blinking at 1 Hz	On (continuous)	The receiver is in Boot Monitor Mode. Use the WinFlash utility to reload application firmware onto the board. For more information, contact technical support.

4.10 Sensor Calibration /传感器校正

Spatial's sensors are calibrated for bias, sensitivity, misalignment, cross-axis sensitivity, non-linearity and gyroscope linear acceleration sensitivity across the full operating temperature range and for each of the three sensor ranges.

所有的产品在出厂前，在全温度范围内，均对其偏差，灵敏度，轴对准，交叉轴，非线性，陀螺仪 g 灵敏度等进行校正。

5 Installation /安装

5.1 Position and Alignment /位置和方向

When installing Spatial into a vehicle, correct positioning and alignment are essential to achieve good performance. There are a number of goals in selecting a mounting site in your application, these are:

在安装传感器的时候，正确的位置和方向对提高其性能很关键。需要注意以下几点：

1. Spatial should be mounted close to the centre of gravity of the vehicle. 安装在载体尽量接近重心的位置。
2. Spatial should be mounted as far from sources of dynamic magnetic interference as possible i.e. high current wiring, large motors. 必须远离动态强磁场干扰源，比如动力电缆，电动机等。
3. Spatial should be mounted within several metres of the GNSS antenna where possible. 安装 GNSS 天线距离传感器在几米的范围内。
4. Spatial should be mounted away from vibration where possible. 尽量远离振动的位置。
5. Spatial should be mounted in an area that is not going to exceed it's temperature range. 避免安装在环境温度会超过其上下限的位置。
6. The two vents on the sides of Spatial must not be obstructed. 内部有气压高度计，需要注意不能遮挡通风孔。

5.1.1 Alignment /安装方向

The easiest way to align Spatial is by installing it with the sensor axes aligned with the vehicle axes. This means that the X axis points forward towards the front of the vehicle and the Z axis points down towards the ground.

最简单的方法是把传感器的方向和载体的方向对齐，即把 X 轴指向载体前进的方向，Z 轴朝下指向地面。

If aligning Spatial with the vehicle axes is not possible or not optimal, it may be mounted in a different alignment and the alignment offset must be configured using either the Spatial Manager software or the Installation Alignment Packet /安装对准数据包. For precise alignment, the Set Zero Orientation Alignment Packet /设定当前角度为零 can be used to set the current orientation as the zero orientation alignment.

如果无法采用上述的安装方法，而需要安装在不同的方向，此时需要使用 Spatial 管理器软件或者调用 Installation Alignment Packet /安装对准数据包指令进行安装角度偏移量设定。 用于精确对准， 调用 Set Zero Orientation Alignment Packet /设定当前角度为零可以设置当前方向为零位方向。

For more information on setting the alignment please see the Spatial Manager software manual or the alignment packet in section

更多关于安装方向的设定请参考安装方向对准章节 8.9.5.

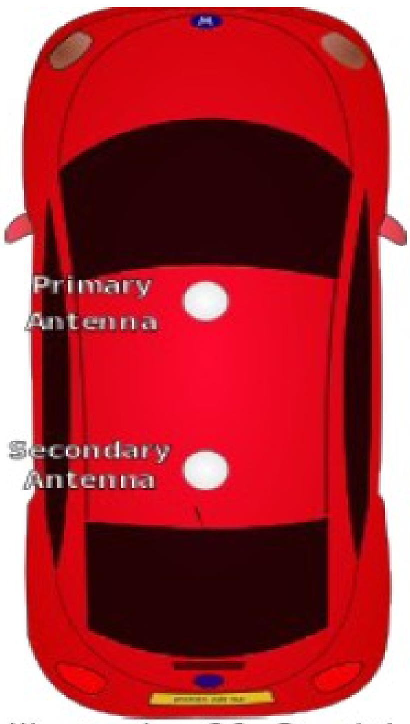
5.2 GNSS Antenna /GNSS 天线

The GNSS antenna should be installed level with a clear view of the sky and as close to the Spatial unit as possible. The antenna cable should be routed away from high energy noise sources. The optimum mounting configuration is above the Spatial unit. If the antenna has to be installed more than 1 metre away from the Spatial unit, this antenna offset should be configured in the Spatial unit by using either the Spatial Manager software or the packet protocol, see section 8.9.5. It is very important to set the antenna offset accurately as Spatial corrects for lever arm velocities. Incorrect GNSS antenna offset will lead to performance degradation under turning and angular rotations.

GNSS 天线需要水平安装，能清楚的看到天空，离传感器尽量靠近。天线馈线需要远离高频噪声源。典型的安装位置是位于传感器的正上方，如果天线需要安装在传感器 1m 以外的位置，需要使用 Spatial 管理器软件或者 ANPP 指令来设定天线位置偏移量，详见章节 8.9.5。正确的设定天线的位置偏移量非常重要，因为内部的算法会对天线杆臂速度进行校正，错误的偏移量会导致存在角度旋转的时候系统性能降低。

The secondary antenna should be mounted directly behind the primary antenna with as much separation as possible. The higher the separation the better the orientation accuracy. Both antennas should be mounted at exactly the same vertical height on the vehicle. See Illustration 12 for example mounting on a car. If it is impractical to mount the secondary antenna directly behind the primary antenna, it can be mounted in another position. In this case the secondary antenna offset must be accurately measured and entered using the secondary antenna configuration dialog at BD982 web application.

从天线需要安装在主天线的正后方，基线长度尽可能的长一些。基线长度越长，航向精度越高。两个天线需要安装在同一垂直高度上。参见图 12 的车载安装示意图。安装从天线在主天线的正后方，这一点非常重要，当然也可以把从天线安装在别的位置，这种情况下，需要精确测量从天线的安装参数并且输入到 BD982 GNSS 板卡的参数中。



lustration 图 12: Dual antenna placement /双天线位置摆放

It is important to note that most GNSS antennas contain magnets for mounting. If you are using an antenna with magnets you will need to either keep it a minimum distance away from Spatial or remove the magnets to ensure that it doesn't interfere with Spatial's magnetometers.
需要注意的是，通常天线带有磁吸座，如果您选择带有磁吸座的天线，请确保天线离传感器有些距离，或者卸掉磁吸座。如果您使用自己的天线，请确保天线不仅能接收 GPS 卫星信号，而且能接收 GLONASS 等其它卫星信号，否则会影响位置和速度精度。

5.3 Odometer /里程计

On ground vehicles, the use of an odometer input can greatly improve Spatial's navigation and orientation solution during GNSS dropouts. With a high resolution wheel encoder Spatial can be used to navigate indoors with GNSS disabled altogether.

对于地面的车辆，在 GNSS 卫星丢失的时候，使用轮速计能够大幅提升产品的性能，包括位置，速度和角度性能。通过使用高性能的轮速编码器，可以实现在户内进行导航。

To setup the odometer, the appropriate GPIO pin should be set to odometer input using either Spatial Manager or the GPIO Configuration Packet /GPIO 配置数据包. The odometer pulse length must then be set either manually or automatically, please see section 6.10 for more information.

为了正确连接轮速计，需要使用 Spatial 管理器软件或者调用 GPIO Configuration Packet /GPIO 配置数据包对相关 GPIO 进行设置，轮速计的脉冲可以手动输入，也可以选择自动计算，请参考章节 6.10 以获得更多信息。

5.4 Magnetics /磁场

Spatial contains magnetometers which it uses to measure the Earth's magnetic field in order to determine it's heading. The principle is the same as that of a compass. Sources of magnetic interference can degrade Spatial's solution if not compensated for. There are two types of magnetic interference, these are static and dynamic.

传感器内部有磁场计，用于敏感地球自身的磁场，来输出航向值，原理同磁罗盘。如果不对磁场进行校准补偿，磁场干扰会使产品性能降级，典型的磁场干扰包括静态和动态两种。

Static magnetic interference is caused by steel and other magnetic materials mounted in the vehicle. Static disturbances are easily compensated for by running a magnetic calibration, see section 6.6. A magnetic calibration should always be run after installation into a vehicle.

静态磁场干扰来源于附近的金属或者安装在载体上的其它磁敏感材料。静态磁场干扰可以很容易通过磁场校准来补偿掉，详见章节 6.6。在传感器安装到载体后，必须要做磁场校准。一旦变更了安装位置，也必须要做磁场校准。

Dynamic magnetic interference is generally a much bigger issue. Sources of dynamic magnetic interference include high current wiring, electric motors, servos, solenoids and large masses of steel that don't move with Spatial. Spatial should be mounted as far as possible from these interference sources.

动态磁场干扰通常比较难处理，干扰源可能是动力电缆，电动机，伺服，螺线管，不随传感器一起移动的大块金属等。请安装传感器的时候尽量远离这些干扰源。

Spatial contains a special algorithm to remove the effects of dynamic magnetic interference. This is able to compensate for most typical interference sources encountered, however certain types of prolonged dynamic interference cannot be compensated for. The best way to check for dynamic magnetic interference is to use the raw sensors view in Spatial Manager and watch the magnetometer outputs whilst the vehicle is operating but stationary. The values should be constant, if the values are fluctuating there is dynamic magnetic interference present.

内部的算法会移除动态磁场干扰，能够补偿大多数情况下的动态干扰源。然而有些长时间持续的动态干扰无法被补偿掉，有效的监测方法是使用 Spatial 管理器软件来观察原始磁场值。载体正常上电工作，但是保持不动，理论上原始磁场值会保持相对不变，如果磁场值此时上下波动比较大，说明存在动态磁场干扰。

If dynamic magnetic interference is causing performance problems and there is no way to mount Spatial away from the interference source, the magnetometers should be disabled, see section 6.6.3.

如果动态磁场干扰存在并影响产品性能，而又没有更好的办法去消除这些干扰源，需要禁用磁场计，详见章节 6.6.3。

5.5 Vibration /振动

Spatial is able to tolerate a high level of vibration compared to other inertial systems. This is due to a unique gyroscope design and a special filtering algorithm. There is however a limit to the amount of vibration that Spatial can tolerate and large levels of vibration will cause Spatial's accuracy to degrade.

相比较其它普通的惯性导航产品，我们的产品能够容忍更高的环境振动，这源于独特的陀螺仪设计和算法处理。但是环境振动也不能太大，否则会影响产品的性能。

When mounting Spatial to a platform with vibration there are several options. It is recommended to first try mounting Spatial and see whether it can tolerate the vibrations. The raw sensor view in the Spatial Manager software can give you a good idea of how bad the vibrations are. If the vibrations are causing the sensors to go over range you will need to increase the sensors range, see section 6.7.

安装传感器在振动比较大的载体时，可做如下选择。首先安装好传感器后，打开 Spatial 管理器软件，观察原始传感器值，将会看到环境振动到底有多坏。如果振动引起传感器超量程，此时需要选择更大一级的传感器量程，详见 6.7。

If Spatial is unable to tolerate the vibrations there are several options:

如果产品不能够承受环境振动，可做如下选择：

1. Try to find a mounting point with less vibration. 移到振动小一点的位置。
2. Spatial can be mounted with 3M foam rubber double sided tape or a small flat piece of rubber.使用 3M 泡沫双面胶或者橡胶垫。
3. Spatial can be mounted to a plate which is then mounted to the platform through vibration isolation mounts.采用振动隔离安装支架。

6 Operation /操作

6.1 Filter /滤波器

Spatial contains a very sophisticated filter which it uses to fuse all it's sensors into a state estimation. The filter is a set of custom algorithms that have similar principles to a kalman filter, but operate differently. Spatial's custom filter makes decisions based upon context and history which greatly improves performance and makes it more resilient to error sources than a standard kalman filter.

内部使用专有的滤波算法，类似卡尔曼滤波的工作原理，对传感器进行状态评估，组合所有传感器的数据。

Under rare conditions, when there are large errors present that Spatial's filter cannot compensate for, it can become unstable. If Spatial's filter does become unstable a monitoring process will immediately reset the filter to the last known good state. The filter initialised flag will remain reset until the filter stabilises again. In real time control applications it is very important to monitor Spatial's filter status, so that data can be ignored if a situation occurs causing the filter to reset.

在极特殊的情况下，当存在非常大的误差时，滤波器不能够补偿，此时滤波器会变得不稳定。当滤波器不稳定时，内部的监视程序将会启动自动复位滤波器到最后一次已知的稳定状态。滤波器初始化状态位也会保持复位状态，直到滤波器重新稳定后才解除。在实际应用中，读入滤波器的状态位非常重要，如果滤波器处于不稳定状态，需要舍弃这些不可靠的数据。

6.2 Initialisation /初始化

When Spatial starts up, it assumes that it can be in any orientation. To determine it's orientation it uses the accelerometers to detect the gravity vector. Whilst this is occurring, if there are random accelerations present these can cause an incorrect orientation to be detected. To prevent this, Spatial monitors the accelerometers and gyroscopes and restarts the orientation detection if there are sudden movements. It is however still possible under some circumstances for it to miss movements and start with a bad orientation. In this scenario Spatial will progressively correct the orientation error over a period of several seconds.

当产品启动后，内部的算法会认为它可能处于任意一个方向，为了判断它的方向，它使用加速度计去敏感重力的方向。当处于敏感重力方向的过程中时，如果此时有一些随机加速度存在，有可能就会计算出错误的角度值。为了防止这个错误，内部的算法会监视加速度计和陀螺仪的值。当开始评估角度时，此时如果发生载体突然运动，内部算法会重新启动方向计算。然而在某些特殊的情况下，仍然有可能会错过捕捉这个运动，给出相对较差的初始方向值，但是算法仍然会去校正它，时间可能需要几秒钟。

After orientation detection, Spatial's filter takes several minutes to achieve it's full accuracy. It is recommended to wait two minutes after power on for applications requiring high accuracy.

当方向确定后，内部的算法还需要几分钟的时间来全面评估内部传感器以达到更好的精度。对于有些应用，需要刚开始工作时系统就能提供高精度的数据，建议在上电后保持两分钟以上静止不动。

6.3 Hot Start /热启动

Spatial is the first GNSS/INS on the market with hot start functionality. This allows Spatial to start inertial navigation within 500 milliseconds and obtain a GNSS fix in as little as 3 seconds. Spatial's hot start is always on and fully automatic.

系统具有热启动功能，可以在 500ms 内启动惯性导航，在 3s 内获得 GNSS 定位数据。

6.4 Time /时间

Spatial was designed to provide a highly accurate time reference. When a GNSS fix is available Spatial's time is accurate to within 50 nanoseconds. When a GNSS fix is lost, Spatial's time accuracy typically remains within 10 microseconds over extended time periods. When Spatial hot starts the time accuracy is typically within 1 second immediately on startup and corrected to within 50 nanoseconds as soon as a GNSS fix is achieved. To synchronise with Spatial's high accuracy time, both the packet protocol and a 1PPS line must be used.

系统设计能够提供高精度的时间信息，当 GNSS 定位后，时间精度在 50ns。当 GNSS 失锁后，在一段时间内可以保证 10ms 的精度。当系统热启动时，初始时间精度会在 1s 以内，一旦 GNSS 定位后，时间精度在 50ns。如果需要高精度同步外部设备，需要同时使用 1PPS 和时间信息数据包。

6.5 Heading Source /航向参考源

There are three different heading sources available for Spatial.

系统可以使用下列三个不同的航向参考源。

1. Magnetic Heading 磁航向

   The magnetic heading source works well in the majority of cases. When using magnetic heading, calibration is required every time Spatial's installation changes. The downside of magnetic heading is that prolonged dynamic magnetic interference sources can cause heading errors. 磁航向在大多数的情况下会工作的很好。当使用磁航向时，每次安装位置改变都需要重新做磁场校准。磁航向的不利因素是长时间持续的动态磁场干扰源会影响其航向精度。

2. Velocity Heading 速度航向

   Velocity heading works by deriving heading from the direction of velocity and acceleration. Velocity heading works well with cars, boats, fixed wing aircraft and other vehicles that don't move sideways. Velocity heading does not work with helicopters and other 3D vehicles. The downside of velocity heading is that heading can not be measured until the vehicle moves at a horizontal speed of over 2 metres/second with a GNSS fix. The benefits of velocity heading are that it is immune to magnetic interference and no calibration is required when Spatial's installation changes. 速度航向来源于速度和加速度的方向。速度航向在全尺寸车，船，固定翼飞行器以及其它一些不能侧向移动的载体上工作的很好。速度航向在旋翼直升机或者其它 3D 飞行器上不能工作。速度航向不利的因素是需要 GNSS 定位，载体的 2D 综合水平移动速度在 2m/s 以上。速度航向的优点是不受磁场影响，不需要校准。

3. External Dual Antenna Heading 外部双天线航向

   This is the default heading source and provides very accurate heading while GNSS is available. Dual antenna heading only works while there is a good GNSS fix available. 使用外部双天线航向是系统的默认值，在 GNSS 搜星正常的情况下会工作的很好，双天线 GNSS 航向仅工作在搜星定位很好的情况下。

The heading source can be selected using the filter options dialog in Spatial Manager or the Filter Options Packet /滤波器选项数据包. It is possible to use multiple heading sources and this can often provide performance benefits.

航向参考源可以通过 Spatial 管理器软件或者调用 Filter Options Packet /滤波器选项数据包来设定。可以同时使用多个航向源来达到更好的性能效果。

6.6 Magnetics /磁场校准

Static magnetic interference is resolved through magnetic calibration and dynamic magnetic interference is compensated by a filter algorithm but should be minimised where possible through installation location. Please see section 5.4 for more information on magnetic interference. To compensate for static magnetic interference, magnetic calibration should be performed any time Spatial's installation changes.

静态磁场干扰通过磁场校准来解决，动态磁场通过内部的滤波算法来补偿，但是还需要调整安装位置尽量远离这些干扰源。请参考章节 5.4 以获取更多的关于磁场干扰的信息。为了补偿静态磁场干扰，一旦传感器安装发生改变，就必须做磁场校准。

Spatial contains a dynamic magnetic compensation filter that is able to mitigate the effects of short term magnetic interference sources while in operation. For example if Spatial is installed in a car and the car drives over a large piece of magnetised steel, this will be compensated for. Another example is driving through a tunnel which is built from heavily reinforced concrete. It is important to note that for Spatial's dynamic magnetic compensation filter to operate correctly, Spatial needs to get a GNSS fix at least once every time it is moved more than 50km. Each time Spatial moves more than 50km the new position is stored permanently and allows Spatial to update it's world magnetic model values.

传感器内部的算法能够补偿短时间的动态磁场干扰，比如传感器安装在车内，车子经过一大块被磁化了的金属板，此时系统算法能够校正它。另外一种典型情况是经过隧道，隧道周围都是很厚的混凝土。非常重要的一点是，要使内部算法能够很好的补偿动态磁场干扰，至少每隔 50km 要能够收实现一次 GNSS 卫星定位。每当传感器经过 50km，新位置将会被永久存储在内部的闪存里，用于更新内部的全球磁场模型。

There are two types of magnetic calibration available, these are 2D calibration and 3D calibration. 2D calibration involves three level rotations about the Z axis and is designed for vehicles that cannot easily or safely be turned upside down, such as full size cars, planes and boats. 3D calibration involves rotating through all orientations and is designed for vehicles that can easily and safely be rotated upside down, such as model size vehicles. 3D calibration offers slightly better performance and is recommended where possible.

有两种磁场校正方式，2D 校正和 3D 校正。2D 校正需要绕着 Z 轴进行连续三次水平旋转，设计用于底部不能翻转朝上的载体，比如全尺寸汽车，大飞机，船只。3D 校正需要在每个方向上进行旋转，设计用于底部可以翻转朝上的载体，比如模型飞机，模型车等。3D 校正可得到更好的性能，如果有可能，请尽量对产品进行 3D 校正。

Please note that if Spatial is going to be used in a vehicle, the calibration should be performed while Spatial is mounted in and fixed to that vehicle. This means that the whole vehicle must be moved to perform the calibration. The calibration needs to be performed in an area away from sources of magnetic interference. For example if Spatial is installed in a car, the calibration should not involve driving over steel drains or reinforced concrete etc. If Spatial is being calibrated to operate standalone, the calibration should not be done on a desk with a steel frame.
需要注意的是，如果准备把产品安装到载体上，只能是产品在载体上安装完成之后再进行磁场校准。也就是需要载体和产品一起运动，进行磁场校正时需要选择没有其它干扰源的场合。比如：把产品安装到汽车上，校正时需要避开大块金属块或者钢混结构等。如果校正是为了独立使用该产品，校正时也需要避开金属结构。

6.6.1 2D Magnetic Calibration /2D 磁场校正

The following procedure should be used to perform a 2D magnetic calibration.

下列步骤用于 2D 磁场校正。

6.6.1.1 Using the Spatial Manager Software /使用 Spatial 管理器软件

1. The unit should be powered in a level orientation and kept stationary. 传感器需要上电，保持水平静止不动。
2. After power on wait 5 minutes for the temperature and filter to stabilise. 上电后，等待 5 分钟的时间，让内部的温度和滤波器稳定。
3. Open Spatial Manager and connect to the device. Ensure that the device has a GNSS fix before proceeding. 打开软件，连接设备，注意在执行校正之前需要 GNSS 定位。
4. In the Tools menu, open Magnetic Calibration. Click the 2D Calibration button. 在工具菜单，打开 磁场校准，点击开始 2D 校准按钮。
5. Whilst keeping as level as possible, rotate the unit in either direction through three full rotations. 尽量保持水平，在一个方向旋转传感器，连续 3 圈。
6. Check the status in the Magnetic Calibration window to ensure that the calibration completed successfully. If not successful click Cancel, wait 2 minutes and repeat from step 4.在磁场校正窗口，检查状态提示，须要是磁场校正成功状态，如果不成功请点击取消，等待两分钟从步骤 4 重新开始。

6.6.1.2 Using the Packet Protocol /使用配置协议

1. The unit should be powered in a level orientation and kept stationary. 传感器需要上电，保持水平静止不动。
2. After power on wait 5 minutes for the temperature and filter to stabilise. 上电后，等待 5 分钟的时间，让内部的温度和滤波器稳定。
3. Ensure that the device has a GNSS fix before proceeding. 注意在执行校正之前需要 GNSS 定位。
4. Send the Magnetic Calibration Configuration Packet /磁场校正配置数据包 with the action Start 2D Magnetic Calibration. 发送 Magnetic Calibration Configuration Packet /磁场校正配置数据包，开始执行 2D 磁场校正。
5. Whilst keeping as level as possible, rotate the unit in either direction through three full rotations. 尽量保持水平，在一个方向旋转传感器，连续 3 圈。
6. Read the Magnetic Calibration Status Packet /磁场校正状态数据包 to ensure that the calibration completed successfully. If not successful, send the Magnetic Calibration Configuration Packet /磁场校正配置数据包 with the action Cancel, wait 2 minutes and repeat from step 4. 读取 Magnetic Calibration Status Packet /磁场校正状态数据包，检查状态提示，须要是磁场校正成功状态，如果不成功发送 Magnetic Calibration Configuration Packet /磁场校正配置数据包，取消校正，等待两分钟从步骤 4 重新开始。

6.6.2 3D Magnetic Calibration /3D 磁场校正

The following procedure should be used to perform a 3D magnetic calibration.

下列步骤用于 3D 磁场校正。

6.6.2.1 Using the Spatial Manager Software /使用 Spatial 管理器软件

1. The unit should be powered in a level orientation and kept stationary. 传感器需要上电，保持水平静止不动。

2. After power on wait 5 minutes for the temperature and filter to stabilise. 上电后，等待 5 分钟的时间，让内部的温度和滤波器稳定。
3. Open Spatial Manager and connect to the device. Ensure that the device has a GNSS fix before proceeding. 打开软件，连接设备，注意在执行校正之前需要 GNSS 定位。
4. In the Tools menu, open Magnetic Calibration. Click the 3D Calibration button. 在工具菜单，打开 磁场校准，点击开始 3D 校准按钮。
5. From a level orientation, slowly rotate the unit twice around the X axis (roll). 保持水平，绕着 X 轴（横滚）缓慢旋转两圈。
6. From a level orientation, slowly rotate the unit twice around the Y axis (pitch). 保持水平，绕着 Y 轴（俯仰）缓慢旋转两圈。
7. From a level orientation, slowly rotate the unit through as many orientations as possible. 保持水平，绕着 Z 轴（航向）缓慢旋转多圈。
8. Check the status in the Magnetic Calibration window to ensure that the calibration completed successfully. If not successful click Cancel, wait 2 minutes and repeat from step 4. 在磁场校正窗口，检查状态提示，须要是磁场校正成功状态，如果不成功请点击 取消，等待两分钟从步骤 4 重新开始。

6.6.2.2 Using the Packet Protocol /使用配置协议

1. The unit should be powered in a level orientation and kept stationary. 传感器需要上电，保持水平静止不动。
2. After power on wait 5 minutes for the temperature and filter to stabilise. 上电后，等待 5 分钟的时间，让内部的温度和滤波器稳定。
3. Ensure that the device has a GNSS fix before proceeding. 注意在执行校正之前需要 GNSS 定位。
4. Send the Magnetic Calibration Configuration Packet /磁场校正配置数据包 with the action Start 3D Magnetic Calibration. 发送 Magnetic Calibration Configuration Packet /磁场校正配置数据包，开始执行 3D 磁场校正。
5. From a level orientation, slowly rotate the unit twice around the X axis (roll). 保持水平，绕着 X 轴（横滚）缓慢旋转两圈。
6. From a level orientation, slowly rotate the unit twice around the Y axis (pitch). 保持水平，绕着 Y 轴（俯仰）缓慢旋转两圈。
7. From a level orientation, slowly rotate the unit through as many orientations as possible. 保持水平，绕着 Z 轴（航向）缓慢旋转多圈。
8. Read the Magnetic Calibration Status Packet /磁场校正状态数据包 to ensure that the calibration completed successfully. If not successful, send the Magnetic Calibration Configuration Packet /磁场校正配置数据包 with the action Cancel, wait 2 minutes and repeat from step 4. 读取 Magnetic Calibration Status Packet /磁场校正状态数据包，检查状态提示，须要是磁场校正成功，如果不成功发送 Magnetic Calibration Configuration Packet /磁场校正配置数据包，取消校正，等待两分钟从步骤 4 重新开始。

6.6.3 Disabling Magnetometers /禁用磁场计

In situations where there is strong dynamic magnetic disturbances present that cannot be avoided, it is recommended to disable the magnetometers. When the magnetometers are disabled a secondary heading source is required otherwise the heading will slowly drift. Please see section 6.5 for information on alternative heading sources. The magnetometers can be disabled using the filter options dialog in Spatial Manager or the Filter Options Packet /滤波器选项数据包.

在某些情况下，存在无法避免的动态强磁场干扰，建议禁用磁场计。当禁用磁场计后，需要选择第二个航向参考源，否则航向将会缓慢漂移。请参考章节 6.5 以获取更多信息。可以通过 Spatial 管理器软件或者调用 Filter Options Packet /滤波器选项数据包来禁用磁场计。

6.7 Sensors Range /传感器量程

Spatial supports dynamic ranging on it's sensors. Each of the three sensors have three different range levels. At lower ranges the sensor performance is better, but at higher ranges Spatial can be used in more extreme dynamics. It is important to choose a range that your application won't exceed.

产品支持动态调整内部传感器的量程，三种传感器均有三个量程可以调节。低量程的性能更好，但是高量程可以适应某些极端动态。请选择所需的最小量程，并且在实际使用中又不会超量程。

Sensor over range events can be detected through the Filter Status /滤波器状态. In Spatial manager the status indicator will go orange indicating that a sensor has gone over range. When a sensor goes over range this causes the filter to become completely inaccurate and in some cases it can cause the filter to reset.

可以通过读取 Filter Status /滤波器状态来获取传感器是否超量程。在 Spatial 管理器软件中，状态指示变黄色表示传感器超量程。当某个传感器超量程，会导致滤波器出错，在某些情况下还会引起滤波器复位。

By default Spatial comes configured in the lowest sensor ranges. In this configuration it is possible to send the gyroscopes over range by quickly rotating the unit in your hand. It is recommended to watch what happens in Spatial Manager when you do this.

默认情况下，出厂时传感器设定为较小的量程，用手快速旋转就会使陀螺仪超量程，可以用 Spatial 管理器软件来查看。

The sensor range can be set through the sensors option in the configuration menu in Spatial Manager or through the Sensor Ranges Packet /传感器量程数据包.

可以通过 Spatial 管理器软件或者调用 Sensor Ranges Packet /传感器量程数据包来改变传感器的量程。

6.8 Data Anti Aliasing /数据混叠

Internally Spatial's filters update at 800 Hz. When Spatial outputs data, most applications require the data at a much lower rate (typically < 100 Hz). This causes a problem for time based data such as velocities and accelerations where aliasing will occur at the lower rate. To prevent this problem, if the output rate is lower than 800 Hz, Spatial will low pass filter the values of the time dependent data between packets to prevent aliasing. This is only the case when a packet is set up to output at a certain rate. If the packet is simply requested no anti aliasing will occur. Additionally there is no anti aliasing for non time dependent fields such as position.

系统内部的滤波器更新为 800Hz，当输出数据的时候，绝大多数场合仅需要 100Hz 以下的更新率。降低更新率，这将会引起基于时间的数据，比如速度和加速度，出现混叠现象。为了阻止这个问题，如果设定输出更新率小于 800Hz，系统将会在数据包之间对基于时间的数据进行低通滤波。但是如果数据包是以请求的方式来发送，将不会存在混叠现象。位置之类的非基于时间的数据不会出现混

叠现象。

6.9 Vehicle Profiles /载体模型

Spatial supports a number of different vehicle profiles. These vehicle profiles impose constraints upon the filter that can increase performance. If your application matches one of the available vehicle profiles, it is recommended to select it for use in the filter options dialog in Spatial Manager or the Filter Options Packet /滤波器选项数据包. For a list of the different vehicle profiles please see section 8.9.6.1. Please note that if the wrong vehicle profile is selected it can cause a significant decrease in performance.

系统支持一些常见的载体模型，这些模型用于限制滤波器以获得更好的性能。如果您的应用符合预先设定的模型，请在 Spatial 管理器软件或者通过调用 Filter Options Packet /滤波器选项数据包来选择。详请参考章节 8.9.6.1。请注意如果选择错误的载体模型会导致性能降低。

6.10 Odometer Pulse Length /轮速计脉冲长度

For Spatial to use a wheel speed sensor or odometer input, it must know the pulse length of the signal. The pulse length is the distance in metres between low to high transitions of the signal. The odometer pulse length can either be entered manually or automatically calibrated by Spatial. To enter the pulse length manually, please use the odometer configuration dialog in Spatial Manager or the Odometer Configuration Packet /轮速计配置数据包. To automatically calibrate the odometer pulse length please use the procedure listed below in section 6.10.1. By default the odometer will automatically calibrate itself.

如果接入外部轮速计，必须要知道脉冲长度信息。脉冲长度的单位是米，指两个脉冲间的距离。可以手动输入脉冲长度，或者使用 Spatial 管理器软件来自动校正脉冲长度。手动输入脉冲长度，需要使用 Spatial 管理器软件的轮速计配置对话框或者通过调用 Odometer Configuration Packet /轮速计配置数据包来完成。自动校正脉冲长度，请按照章节 6.10.1 所列的步骤。系统默认状态下会自动校正轮速计。

6.10.1 Odometer Automatic Pulse Length Calibration Procedure /自动校正轮速计脉冲长度

1. Ensure that the signal is connected correctly and that the GPIO pin is configured as an odometer input using the GPIO configuration dialog or the GPIO Configuration Packet /GPIO 配置数据包. 确保轮速计信号可靠连接，相应的 GPIO 端口通过 Spatial 管理器软件或者调用 GPIO Configuration Packet /GPIO 配置数据包，被配置成使用轮速计。
2. Open Spatial Manager, connect to Spatial and open the odometer configuration dialog. In the odometer configuration dialog tick the automatic pulse length calibration check box and press the write button. If using the packet protocol this can be done using the Odometer Configuration Packet /轮速计配置数据包. 打开 Spatial 管理器软件，连接传感器，打开轮速计配置对话框。在轮速计配置对话框，选中 自动脉冲长度校正，点击写入按钮。如果使用配置协议，可以通过调用 Odometer Configuration Packet /轮速计配置数据包来完成。
3. Wait until Spatial has a continuous GNSS fix and then drive 1000 metres over flat terrain with as little turning as possible. 等待 GNSS 定位，然后在水平道路上前行 1000m，尽量保持直线行驶。
4. If Spatial loses a GNSS fix for any extended period of time during the calibration, the distance travelled will be reset. The distance travelled can be checked in the odometer configuration dialog to ensure that it has passed 1000m. 如果校正过程中出现 GNSS 丢星现

象，行驶距离将会自动复位，可以在轮速计配置对话框中看到累积行驶距离是否超过 1000m。

5. Once 1000 metres has been driven, press the read button and check that the automatic pulse length check box becomes un-ticked and the pulse length value is read. 一旦行驶距离达到 1000m，点击读取按钮，此时自动脉冲长度选框未被选中，可以查看自动计算出的脉冲长度值。

6.11 Reversing Detection /反向监测

Reversing detection is an algorithm that can detect when the vehicle is travelling in reverse. Knowledge of reverse motion is important when using velocity heading or odometer input to provide correct results. If Spatial is fitted to a vehicle that does not reverse or doesn't use velocity heading or odometer, this function should be disabled. Reversing detection is enabled by default and it can be disabled using the filter configuration dialog in Spatial Manager.

反向监测用于判断载体是否在反向移动。在使用速度方向或者轮速计输入的时候，知道是否反向移动很重要。如果 NAV982 所在的载体不会反向运行，或者不使用速度方向或者不适用轮速计，可以禁用该功能。默认情况下该功能处于打开状态。

6.12 Motion Analysis /运动分析

Motion analysis is an artificial intelligence algorithm that associates patterns in high frequency inertial data with the speed of the vehicle. After power on it takes some time to match patterns with speed before it will become active. Motion analysis only activates when dead reckoning and is most effective when the vehicle is near stationary. Motion analysis does not work in all situations and it's primary benefit is in ground vehicles. When active it can be recognised by 2Hz steps in velocity data. Motion analysis is disabled by default and can be enabled using the filter configuration window in Spatial Manager.

运动分析属于人工智能算法，通过结合惯性数据和载体的速度来分析。上电后，系统会花时间来分析运动模型，然后才会激活该功能。在航位推算和静止状态时起作用，不会工作在所有运动条件下，主要设计用于地面车辆。

6.13 RAIM /接收机自主完好性监测

RAIM stands for receiver autonomous integrity monitoring. It allows a GNSS receiver to detect and exclude both faulty and fraudulent satellite signals. Spatial's internal GNSS is equipped with RAIM and it is enabled by default.

RAIM 代表接收机自主完好性监视功能，它可以使 GNSS 接收机监测并排除故障的卫星信号。本产品内部的接收机带有 RAIM 功能，默认情况下该功能处于打开状态。

6.14 Underwater Navigation / 水下导航

Spatial is able to provide accurate absolute navigation underwater when combined with appropriate peripherals. There are several options for underwater navigation detailed below.

与一些外部设备相结合，传感器能提供精确的水下导航功能。详见下面描述。

6.14.1 DVL (Doppler Velocity Log) Peripheral /DVL（多普勒测速仪）接口

DVLs provide 3D velocity underwater and allow Spatial to provide positional accuracy of approximately 0.3% of distance travelled.

DVLs 能够在水下提供 3D 速度，与 DVLs 结合，位置精度能达到行走的距离的 0.3%。

A DVL works by tracking velocity relative to the sea floor. They typically have a range of approximately 100m. When the sea floor is beyond this range, the DVL provides velocity relative to the water layer, however this is unable to account for water currents which can cause positional accuracy to degrade faster.

DVLs 工作原理是提供相对于海床的速度，典型深度范围约在 100m。当海床在这个范围之外，DVL 提供相对于水层的速度，因为不能计算出水流的速度，此时位置精度会降级的很快。

When operating with a DVL, Spatial must have a starting position to navigate from. This can be achieved by either allowing Spatial to get a GNSS fix while the underwater vehicle is on the surface, or by manually entering the starting co-ordinates using the External Position Packet /外部位置数据包. The typical setup for obtaining a GNSS fix is a waterproof glass dome housing the GNSS antenna, mounted on the top of the vehicle.

与 DVL 结合使用的时候，传感器必须有一个起始位置。水下航行器在水面的时候可以通过 GNSS 得到起始位置，或者通过调用 External Position Packet /外部位置数据包来输入起始位置。如果用 GNSS 获得位置，通常的做法是把 GNSS 天线用防水玻璃外壳罩起来，安装在水下航行器顶部。

Spatial contains built in support for DVLs from Teledyne and Linkquest and these systems can be directly connected to Spatial using the GPIO pins. We recommends Teledyne DVL systems.

产品支持市面上常见的 DVLs，包括 Teledyne 和 Linkquest 的产品，可以直接通过 GPIO 与这些设备相连。

6.14.2 USBL (Ultra-short Baseline) Peripheral /USBL（超短基线）接口

USBLs provide relative 3D positioning underwater and allow Spatial to provide positional accuracy of approximately 4m.

USBLs 能够在水下提供相对的 3D 位置，与 USBL 结合，位置精度能达到 4m。

A USBL setup consists of a surface transponder, an underwater responder and two Spatial units. The surface transponder is typically mounted on a ship and is connected to a Spatial unit. Another Spatial unit is mounted on the underwater vehicle along with the responder. The surface Spatial unit communicates with the underwater Spatial unit over a serial connection through a tether. Please see 13. USBL systems typically have a maximum range from transponder to responder of between 500 and 4000 metres.

USBL 设备设置包括水面的发射器，水下的响应器和两个 NAV982 传感器。水面的发射器通常安装在水面的船上，与其中一个传感器相连，另外一个传感器和响应器一起安装在水下航行器上。水面的传感器和水下的传感器之间通过电台进行通讯，详见图 13。USBL 系统典型的工作范围是 500m 至 4000 米，指从发射器到响应器间的距离。

Spatial contains built in support for USBLs from Tritech and these systems can be directly connected to Spatial using the GPIO pins.

传感器支持 Tritech 公司的 USBL 系统，通过 GPIO 管脚与其相连。

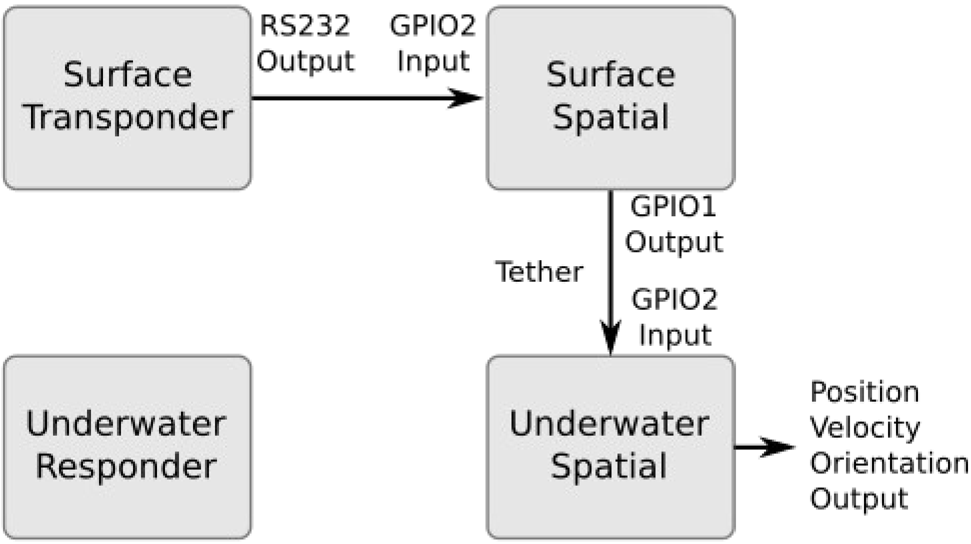


Illustration 图 13: Spatial USBL Setup /USBL 连接图

6.14.3 Depth /深度值

For Spatial's intelligent filter to operate correctly and provide maximum performance, Spatial requires continuous updates of depth information. This can be achieved by adding a pressure depth transducer to Spatial. Spatial supports frequency output pressure depth transducers using the GPIO pins, please see section 7.3.25. Alternatively if depth is already known, it can be fed into Spatial using the External Depth Packet /外部深度值数据包. Some Teledyne DVLs feature a built in pressure sensor, in this case Spatial will automatically use the DVL pressure to determine depth.

系统内部滤波器需要深度信息已获得更好的性能，传感器需要连续的深度值更新。可以把压力深度传感器与本传感器直接相连，支持频率输出型的压力深度传感器，通过 GPIO 管脚连接，详见 7.3.25。如果已经知道深度值，可以通过调用 External Depth Packet /外部深度值数据包发送给传感器。某些 Teledyne DVLs 内置了压力深度传感器，与它们相连，系统会自动从 DVLs 中获取深度值。

6.14.4 DVL and USBL Combined Systems /DVL 和 USBL 组合系统

For systems that require the highest accuracy, Spatial can be combined with both a DVL and USBL. By using both the DVL velocity and USBL position, Spatial is able to provide very accurate underwater navigation.

对于某些场合需要精度更高的导航数据，可以组合 DVL 速度和 USBL 位置，通过组合使用，可以在水下实现高精度导航。

6.15 Heave /升沉值

Spatial can provide vertical heave position at four different points on a ship. Spatial's heave filter is always on and fully automatic. After power on, Spatial requires approximately 5 minutes for it's heave filter to converge upon an accurate solution. Heave works without a GNSS fix, however best heave performance is achieved when Spatial has a GNSS fix.

系统能够输出四个测量点的垂直方向升沉值，升沉值滤波器自动计算。上电后，约需要 5 分钟的时间使内部算法稳定在精确的位置点上，即使 GNSS 没有定位，仍然能够输出升沉值，然而 GNSS 定

位后会获得更好的性能。

By default Spatial provides heave from the point at which the Spatial unit is mounted, however it can provide heave at four different offset points on the ship. To set the heave offsets, either use the heave configuration dialog in Spatial Manager or the Heave Offset Packet /升沉值偏移量数据包.

默认情况下，升沉值的输出点是传感器主体本身，系统支持可以设置 4 个不同输出点。通过 Spatial 管理器软件或者调用 Heave Offset Packet /升沉值偏移量数据包来完成。

6.16 Temperature /温度

Spatial should not be subjected to temperature's outside of it's operating range. If the temperature rises above 90 degrees Celsius, Spatial will automatically shut off power to it's sensors and GNSS in an attempt to prevent damage, this will also send the filters into reset. Subjecting Spatial to temperature's outside of the storage range can effect the factory sensor calibration which will cause a permanent performance degradation.

工作时请避免温度超量程使用，如果温度上升大于 90 摄氏度，系统将自动切断电源以避免对内部的传感器和 GNSS 接收机造成更大的伤害。如果温度超过存储温度，有可能会造成内部的出厂校正数据丢失，而造成产品永久性性能降级。

7 Interfacing /接口

7.1 Communication /通讯接口

All communication to the NAV982 module is over the serial interface in the Advanced Navigation Packet Protocol. The serial format is fixed at 1 start bit, 8 data bits, 1 stop bit and no parity. See section 8 for details on the protocol.

所有与传感器的通讯均通过串行通讯来实现，使用 ANPP 数据协议。串口通讯固定为 1 起始位，8 数据位，1 停止位，无奇偶校验，详见章节 8 中的描述。

7.1.1 Baud Rate /波特率

The default baud rate of NAV982 is 115200. The baud rate can be set anywhere from 100 to 1000000 baud and can be modified using the Spatial Manager software or the baud rate packet, see section 8.9.3. It is important to select a baud rate that is capable of carrying the amount of data that NAV982 is set to send. See packet rates in section 8.5 for more details on data output calculation. The data rate in bytes per second can be calculated by dividing the baud rate by 10. For example if the baud rate is 115200, then the data rate is 11520 bytes per second.

产品的默认波特率是 115200。波特率可以在 1000000 以内调整，可通过 Spatial 管理器软件或者调用章节 8.9.3 的 baud rate packet /波特率数据包来调整。请正确选择波特率，以足够完成设定的传输数据字节数。参考章节 8.5 方法来计算传输数据字节数。每秒能传输的字节数可以通过波特率除以 10 来计算，比如波特率是 115200，此时一秒能传输 11520 个字节。

7.2 External data /外部数据

External sources of position, velocity and/or orientation can be integrated into NAV982's filter solution. The data can be sent to NAV982 in the ANPP format over the main serial port or through one of the GPIOs in a number of different formats. If using the ANPP, please use 8 below to find the relevant section. If using the GPIO pins, please see section 7.3.

外部位置，速度和/或方向数据可以被集成到内部滤波算法当中。外部数据可以在主通讯端口以 ANPP 格式发送给传感器，也可以在辅助通讯端口中以其它的数据格式发送给传感器。如果使用 ANPP，请参考表 8 下的相关章节。如果使用辅助通讯端口，请参考章节 7.3。

Packet /数据包	Section /章节
External Position and Velocity /外部位置和速度	8.8.25
External Position /外部位置	8.8.26
External Velocity /外部速度	8.8.27
External Body Velocity /外部载体速度	8.8.28
External Heading /外部航向	8.8.29
External Time /外部时间	8.8.33
External Depth /外部深度	8.8.34
External Pitot Pressure /外部皮托管压力值	8.8.37

Table 表 7: ANPP External Data Reference /ANPP 外部数据

7.3 GPIO Pins /GPIO 管脚

NAV982 contains two general purpose input output pins on the main connector. These pins are multi function and can be used to extend NAV982 with additional peripherals, sensors and data formats. All pins have digital input, digital output, frequency input and frequency output functionality. The GPIO serial baud rate can be configured anywhere from 1200 to 1000000 baud by using the baud rate configuration dialog in Spatial Manager or the Baud Rates Packet /波特率数据包.

传感器包含 2 个通用输入输出 IO 口，这些管脚是多功能用途，可以用于和外部设备进行连接。所有的管脚均是数字量输入，数字量输出，频率输入，频率输出功能。GPIO 串口通讯波特率最高可以到 1000000，可以通过 Spatial 管理器软件或者调用 Baud Rates Packet /波特率数据包来更改设置。

The GPIO pin functions available are listed below. The function of a GPIO pin can be changed at any time using the GPIO configuration dialog in Spatial Manager or the GPIO Configuration Packet /GPIO 配置数据包.

GPIO 管脚的功能列表如下。可以通过 Spatial 管理器软件或者调用 GPIO Configuration Packet /GPIO 配置数据包来改变 GPIO 的功能。

Function /功能	**Type /**类型	**GPIOs**
Inactive /不用	Tristate /三态	所有
1PPS Output /1PPS 输出	Digital Output /数字量输出	3, 4
GNSS Fix Output /GNSS 定位输出	Digital Output /数字量输出	3, 4
Odometer Input /里程计输入	Frequency Input /频率输入	3, 4
Stationary Input /静止状态输入	Digital Input /数字量输入	3, 4
Pitot Tube Input /皮托管输入	Frequency Input /频率输入	3, 4
NMEA Input /NMEA 输入	Serial Receive /串口接收	3, 4
NMEA Output /NMEA 输出	Serial Transmit /串口发送	3, 4
Novatel GNSS Input /NovAtel GNSS 输入	Serial Receive /串口接收	3, 4
Topcon GNSS Input /Topcon GNSS 输入	Serial Receive /串口接收	3, 4
ANPP Input /ANPP 输入	Serial Receive/串口接收	3, 4
ANPP Output /ANPP 输出	Serial Transmit /串口发送	3, 4
Disable Magnetometers /禁用磁场计	Digital Input /数字量输入	3, 4
Disable Internal GNSS /禁用内部 GNSS	Digital Input /数字量输入	3, 4
Disable Pressure /禁用气压高度计	Digital Input /数字量输入	3, 4
Set Zero Orientation Alignment /当前角度置零	Digital Input /数字量输入	3, 4
System State Packet Trigger /系统状态数据包触发	Digital Input /数字量输入	3, 4
Raw Sensors Packet Trigger /原始传感器数据包触发	Digital Input /数字量输入	3, 4
RTCM Differential GNSS Corrections Input /RTCM 差分 GNSS 校正输入	Serial Receive /串口接收	AUX
Trimble GNSS Input /Trimble GNSS 输入	Serial Receive /串口接收	2
u-blox GNSS Input /u-blox GNSS 输入	Serial Receive /串口接收	3, 4
Hemisphere GNSS Input /Hemisphere GNSS 输入	Serial Receive /串口接收	3, 4
Teledyne DVL Input /Teledyne DVL 输入	Serial Receive /串口接收	3, 4
Tritech USBL Input /Tritech USBL 输入	Serial Receive /串口接收	3, 4
Linkquest DVL Input /Linkquest DVL 输入	Serial Receive /串口接收	3, 4
Pressure Depth Transducer Input /压力深度传感器输入	Frequency Input /频率输入	3, 4
Left Wheel Speed Sensor /左侧轮速计	Frequency Input /频率输入	3, 4
Right Wheel Speed Sensor /右侧轮速计	Frequency Input /频率输入	3, 4
1PPS Input /1PPS 输入	Digital Input /数字量输入	1
Wheel Speed Sensor /轮速计输入	Frequency Input /频率输入	3, 4
Wheel Encoder Phase A /轮速计 A 相输入	Frequency Input /频率输入	3, 4
Wheel Encoder Phase B /轮速计 B 相输入	Frequency Input /频率输入	3, 4
Event 1 Input /事件 1 输入	Digital Input /数字量输入	3, 4

Event 2 Input /事件 2 输入	Digital Input /数字量输入	3, 4
TSS1 Output /TSS1 输出	Serial Transmit /串口发送	3, 4
Simrad 1000 Output /Simrad 1000 输出	Serial Transmit /串口发送	3, 4
Simrad 3000 Output /Simrad 3000 输出	Serial Transmit /串口发送	3, 4

Table 表 8: GPIO pin functions /GPIO 管脚功能列表

7.3.1 1PPS Output /1PPS 输出

In this function, the pin is normally low and pulses high for 50 milliseconds to signal the precise second. The 1PPS line starts pulsing approximately 100 milliseconds after power up and always fires irrespective of whether NAV982 has accurate time or not. It is important to note that when NAV982 acquires time corrections from it's GNSS receiver, the 1PPS signal may fire at an interval of less than 1 second. This typically only occurs the first time the GNSS receiver obtains a fix after startup. The time initialised status flag can be used to determine whether the time and 1PPS line is accurate or not.

正常情况下，该管脚为低电平，秒变更时电平为高并持续 50ms。传感器上电 100ms 后就会有 1PPS 信号输出，无论 GNSS 是否定位，1PPS 始终存在。当传感器收到 GNSS 卫星的时间后，1PPS 脉冲信号有可能会在小于 1s 的时间内再次出现，原因是 GNSS 接收机是在上电几秒之后才开始定位。时间初始化状态位可以用来判断 1PPS 和时间是否精确与 GNSS 同步。

7.3.2 GNSS Fix Output /GNSS 定位输出

In this function, the pin is low when there is no GNSS fix or a 2D fix and high when there is a 3D, SBAS, Differential or RTK GNSS fix.

低电平表示 GNSS 未定位或者处于 2D 定位，高电平表示 3D，SBAS，伪距差分或者 RTK 定位模式。

7.3.3 Odometer Input /里程计输入

This function is designed for low resolution vehicle speed sensors and odometers . It expects a normally low input with a transition from low to high for the trigger. If the pulse length is more than 0.1 metres the odometer input function should be used, if it is less than 0.1 metres the wheel speed sensor function should be used. Please contact support team for help integrating with your speed sensor.

该管脚用于接收外部低分辨率轮速计或者里程计输入，正常情况下为低电平，由低到高触发一个脉冲。如果脉冲长度大于 0.1m 需要使用里程计输入功能，如果小于 0.1m 需要使用轮速计输入功能。请与技术部分联系已获得更多支持。

Parameter /参数	Value /数值
Voltage Level /电压等级	0 – 5V
Trigger /触发	低 Low → 高 High
Maximum Frequency /最大频率	600 Khz
Maximum Pulse Rate /最大脉冲数	4,000,000 pulses/metre

Table 表 9: Odometer Specifications /里程计技术规格

7.3.4 Stationary Input /静止状态输入

In this function, a high state indicates to NAV982 that the vehicle is stationary. The low state indicates that the vehicle could be moving. This can significantly improve performance when a GNSS signal is not available.

高电平表示载体是静止状态，低电平表示载体可能会运动。当 GNSS 信号无效或者很差时使用该功能可以抑制静止时的数据漂移。

7.3.5 Pitot Tube Input /皮托管输入

This function is designed for fixed wing aircraft to enhance navigation through the use of a pitot tube to measure airspeed. It requires a differential pressure sensor that has a frequency output such as the Kavlico P992 (frequency output option) or the Paroscientific series 5300. Please contact support team for help integrating with a pitot tube.

用于固定翼飞机，皮托管测量的空速值可增强其导航性能。它接收差压空速传感器的频率输出，例如 Kavlico P992（频率输出选项）或者 Paroscientific series 5300。

7.3.6 NMEA Input /NMEA 输入

This function accepts external data in the NMEA format. We recommends against using NMEA where possible due to the inefficiency, inaccuracy and poor error checking of the format. All NMEA messages received must have a valid checksum. Supported messages are listed below. The recommended combination of messages are GPGGA, GPVTG and GPZDA with optional messages GPGSV and GPGSA.

不建议使用 NMEA 语句作为输入，因为其采用 ASCII 码，效率不高，校验方式不够可靠。所有的 NMEA 语句输入必须带有有效的校验和。支持的语句如下。建议组合使用 GPGGA，GPVTG 和 GPZDA，可选使用 GPGSV 和 GPGSA。

Message ID /信息 ID	Description /说明
GPGGA	3D position /3D 位置
GPGLL	2D position /2D 位置
GPRMC	2D position, 2D velocity and coarse time /2D 位置，2D 速度和时间
GPVTG	2D velocity /2D 速度
GPHDT	Heading /航向
GPHDT	Heading /航向
GPGSV	Satellites /卫星信息
GPGSA	Dilution of Position /DOP信息
GPZDA	Time /时间

Table 表 10: Supported NMEA messages /支持的 NMEA 语句

7.3.7 NMEA Output /NMEA 输出

This function outputs a configurable combination of the NMEA messages GPZDA, GPGGA, GPVTG, GPRMC, GPHDT and PASHR at up to 20 Hz. The messages output and the output rate can be configured using the NMEA output configuration dialog in Spatial Manager. Advanced Navigation recommends against using NMEA where possible due to the inefficiency, inaccuracy and poor error checking of the format. An example output is shown below.

$GPZDA,031644.460,07,05,2013,00,00*52
$GPGGA,031644.460,3352.3501851,S,15112.2355488,E,6,00,1.4,150.0,M,0.0,M,,*7E
$GPVTG,089.19,T,089.19,M,000.00,N,000.00,K,E*27
$GPRMC,031644.460,A,3352.3501851,S,15112.2355488,E,0.0,89.2,070513,12.5,W,E*02
$GPHDT,89.2,T*06
$PASHR,031644.460,089.19,T,-00.01,-00.47,-00.00,,,,0,0*2E

该功能以 20Hz 的速率输出 NMEA 语句 GPZDA, GPGGA, GPVTG, GPRMC, GPHDT 和 PASHR。输出语句和更新率可以通过 Spatial 管理器中的 NMEA 配置对话框来修改，不建议使用 NMEA 语句作为输出，因为其采用 ASCII 码，效率不高，校验方式不够可靠。输出数据示例如下。

$GPZDA,031644.460,07,05,2013,00,00*52
$GPGGA,031644.460,3352.3501851,S,15112.2355488,E,6,00,1.4,150.0,M,0.0,M,,*7E
$GPVTG,089.19,T,089.19,M,000.00,N,000.00,K,E*27
$GPRMC,031644.460,A,3352.3501851,S,15112.2355488,E,0.0,89.2,070513,12.5,W,E*02
$GPHDT,89.2,T*06
$PASHR,031644.460,089.19,T,-00.01,-00.47,-00.00,,,,0,0*2E

7.3.8 Novatel GNSS Input /NovAtel GNSS 输入

This function is designed for interfacing NAV982 with a Novatel GNSS receiver. It can be used to interface with a Novatel RTK GNSS receiver for high positional accuracy. It accepts data in the Novatel binary format and requires messages BESTPOSB and BESTVELB at rates higher than 1 Hz. The message BESTSATS is optional to display detailed satellite information. The message HEADING is also supported for ALIGN capable receivers.

用于接收 NovAtel RTK GNSS 接收机的高精度导航数据。它接受 NovAtel 二进制格式，需要信息 BESTPOSB 和 BESTVELB 输入，频率大于 1Hz（建议 20Hz）。可选语句 BESTSATS 来显示详细的卫星信息。也支持带有 ALIGN 功能的接收机。

7.3.9 Topcon GNSS Input /Topcon GNSS 输入

This function is designed for interfacing NAV982 with a Topcon GNSS receiver. It can be used to interface with a Topcon RTK GNSS receiver for high positional accuracy. It accepts data in the GRIL TPS binary format and expects messages PG and VG at rates higher than 1 Hz.

用于接收 Topcon RTK GNSS 接收机的高精度导航数据。它接受 GRIL TPS 二进制格式，需要信息 PG 和 VG 输入，建议频率大于 1Hz。

7.3.10 ANPP Input /ANPP 输入

This function accepts data in the ANPP format as specified in section 8.

用于接收章节 8 所描述的 ANPP 协议数据格式。

7.3.11 ANPP Output /ANPP 输出

This function outputs data in the ANPP format as specified in section 8. For packets to be sent out they must be requested through another GPIO functioning as ANPP input.

用于输出章节 8 所描述的 ANPP 协议数据格式，此功能需要使用另外一个 GPIO 管脚定义为 ANPP 输入，通过输入 ANPP 来请求 ANPP 输出。

7.3.12 Disable Magnetometers /禁用磁场计

This function accepts a digital input with a low state enabling the magnetometers and a high state disabling the magnetometers.

低电平表示使能磁场计，高电平表示禁用磁场计。

7.3.13 Disable Internal GNSS /禁用内部 GNSS

This function accepts a digital input with a low state enabling the GNSS and a high state disabling the GNSS.

低电平表示使能内部 GNSS，高电平表示禁用内部 GNSS。

7.3.14 Disable Pressure /禁用气压高度计

This function accepts a digital input with a low state enabling the atmospheric pressure sensor and a high state disabling the atmospheric pressure sensor.

低电平表示使能气压高度计，高电平表示禁用气压高度计。

7.3.15 Set Zero Orientation Alignment /当前角度置零

This function accepts a digital input. The input is normally low and a transition from low to high causes NAV982 to set it's alignment so that the current orientation is zero. Due to the risk of exhausting the flash cycles, the change is not permanent and will disappear on reset. To make it permanent the Installation Alignment Packet /安装对准数据包 must be read and then sent back to NAV982 with the permanent flag set. This function requires de-bouncing if attached to a switch.

正常状态下为低电平，由低到高会使传感器把当前角度置零。为了避免耗尽内部闪存的循环周期，该功能默认情况下不主动记录到闪存中，断电后设置会丢失。如果需要永久记录，调用 Installation Alignment Packet /安装对准数据包先读取状态，然后使用永久记录标志位来写入。如果该管脚连接到按钮开关上，需要做去除抖动处理。

7.3.16 System State Packet Trigger /系统状态数据包触发

This function accepts a digital input. The input is normally low and a transition from low to high causes NAV982 to send the system state packet. This function requires de-bouncing if attached to a switch.

正常情况下为低，由低到高将会触发输出系统状态数据包。如果该管脚连接到按钮开关上，需要做去除抖动处理。

7.3.17 Raw Sensors Packet Trigger /原始传感器数据包触发

This function accepts a digital input. The input is normally low and a transition from low to high causes NAV982 to send the raw sensors packet. This function requires de-bouncing if attached to a switch.

正常情况下为低，由低到高将会触发输出原始传感器数据包。如果该管脚连接到按钮开关上，需要做去除抖动处理。

7.3.18 RTCM Differential GNSS Corrections Input /RTCM 差分 GNSS 校正输入

This function accepts RTCM differential GPS corrections. This allows for Differential GNSS with

NAV982's internal BD982 GNSS receiver to increase positional accuracy. The data feed through AUX port on NAV982 panel, its the COM1 port of BD982 GNSS card.

用于接收 RTCM 格式的差分 GPS 校正，对传感器内部的 GNSS 进行伪距差分，从而提高位置精度。需要连接差分信号至 NAV982 上面的 AUX 端口，AUX 端口为内部 BD982 GNSS 的 COM1 端口。

7.3.19 Trimble GNSS Input /Trimble GNSS 输入

This function is designed for interfacing Spatial with a Trimble GNSS receiver. It accepts data in the Trimble binary format GSOF and expects packet 0x40 with records 1, 2, 8, and 12 at rates higher than 1Hz (20Hz recommended) and optional records 9 and 34 at 1 to 2Hz.

用于接收 Trimble RTK GNSS 接收机的高精度导航数据。它接受 Trimble GSOF 二进制格式，需要数据包 0x40，语句 1, 2, 8 和 12，大于 1Hz（建议 20Hz），可选输入语句 9 和 34，1Hz 输入。

7.3.20 u-blox GNSS Input /u-blox GNSS 输入

This function is designed for interfacing NAV982 with a u-blox GNSS receiver. It accepts data in the u-blox binary format and expects message NAV-SOL at rates higher than 1Hz.

用于接收 u-blox GNSS 接收机的导航数据。它接受 u-blox 二进制格式，需要信息 NAV-SOL 输入，建议频率大于 1Hz。

7.3.21 Hemisphere GNSS Input /Hemisphere GNSS 输入

This function is designed for interfacing NAV982 with a Hemisphere GNSS receiver. It accepts data in the Hemisphere binary format and expects message Bin1 at rates higher than 1Hz. For Hemisphere receivers that provide heading using two antennas, NMEA should be used instead as the binary format does not allow for transmission of heading information.

用于接收 Hemisphere GNSS 接收机的高精度导航数据。它接受 Hemisphere 二进制格式，需要信息 Bin1，建议频率大于 1Hz。

对于 Hemispher 双天线接收机，需要使用 NMEA 语句，而不用二进制数据，因为它的航向信息不能以二进制格式输出。

7.3.22 Teledyne DVL Input /Teledyne DVL 输入

This function is designed for interfacing with Teledyne DVL systems. This allows NAV982 to navigate underwater. It accepts data in the PD0 output data format at rates 10Hz or higher. Please contact support team for more information on underwater navigation using NAV982. Please see section 6.14 for more information on underwater navigation using NAV982.

用于接收 Teledyne DVL 导航数据，使得传感器可以在水下实现导航。它接受 PD0 数据输入，建议频率为 10Hz。详见章节 6.14 以获得更过关于水下导航的信息。

7.3.23 Tritech USBL Input /Tritech USBL 输入

This function is designed for interfacing with a Tritech micronnav USBL system. This allows NAV982 to navigate underwater. It accepts data in the Raw XYZ format. Please note that the setup with a Tritech USBL requires two NAV982 units. Please contact support team for more information on underwater navigation using NAV982. Please see section 6.14 for more information on underwater navigation using NAV982.

用于接收 Tritech micronnav USBL 导航数据，使得传感器可以在水下实现导航。它接受原始 XYZ 数

据输入。需要注意如果与 Tritech USBL 结合使用，需要两个传感器。详见章节 6.14 以获得更过关于水下导航的信息。

7.3.24 Linkquest DVL Input /Linkquest DVL 输入

This function is designed for interfacing with Linkquest DVL systems. This allows NAV982 to navigate underwater. It accepts data in the NQ1 output data format at rates 1Hz or higher. Please see section 6.14 for more information on underwater navigation using NAV982.

用于接收 Linkquest DVL 的导航数据，使得传感器可以在水下实现导航。它接受 NQ1 数据输入，建议频率为 1Hz 以上。详见章节 6.14 以获得更过关于水下导航的信息。

7.3.25 Pressure Depth Transducer Input /压力深度传感器输入

This function is designed for interfacing with frequency output pressure depth transducers. It requires a pressure transducer with a frequency output such as the AST4700 from American Sensor Technologies. Please see section 6.14 for more information on underwater navigation using NAV982.

用于接收压力深度传感器的频率输出信号，使得传感器可以在水下实现导航。比如 American Sensor Technologies 公司的 AST4700 产品。详见章节 6.14 以获得更过关于水下导航的信息。

7.3.26 Left Wheel Speed Sensor /左侧轮速计

This function is designed for the left wheel of a vehicle with dual wheel speed sensors.

设计用于双轮速传感器的左侧轮速计输入。

7.3.27 Right Wheel Speed Sensor /右侧轮速计

This function is designed for the right wheel of a vehicle with dual wheel speed sensors.

设计用于双轮速传感器的右侧轮速计输入。

7.3.28 1PPS Input /1PPS 输入

This function is designed to allow external GNSS receivers to synchronise time with Spatial. It triggers on a transition from low to high..
设计用于同步外部GNSS接收机信号，由低到高触发一个脉冲。

7.3.29 Wheel Speed Sensor /轮速计输入

This function is designed for high resolution vehicle speed sensors and odometers . It expects a normally low input with a transition from low to high for the trigger. If the pulse length is more than 0.1 metres the odometer input function should be used, if it is less than 0.1 metres the wheel speed sensor function should be used. Please contact support team for help integrating with your speed sensor.

该管脚用于接收外部高分辨率轮速计或者里程计输入，正常情况下为低电平，由低到高触发一个脉冲。如果脉冲长度大于 0.1m 需要使用里程计输入功能，如果小于 0.1m 需要使用轮速计输入功能。请与技术部分联系已获得更多支持。

7.3.30 Wheel Encoder Phase A /轮速计 A 相输入

This function is designed for rotary incremental quadrature encoders. It should be used in combination with Wheel Encoder Phase B.
设计用于外部旋转增量编码器信号输入，需要与轮速计B相结合起来使用。

7.3.31 Wheel Encoder Phase B /轮速计 B 相输入

This function is designed for rotary incremental quadrature encoders. It should be used in combination with Wheel Encoder Phase A.
设计用于外部旋转增量编码器信号输入，需要与轮速计A相结合起来使用。

7.3.32 Event 1 Input /事件 1 输入

This function is designed to allow external events to be recorded inside Spatial's output. The event is recorded in the filter status, see section 7.3.32, and resets after the next packet is output. The event triggers on a transition from low to high.
设计用于记录外部事件输入，该事件显示在滤波器状态上，参见章节7.3.32，由低到高触发。

7.3.33 Event 2 Input /事件 2 输入

This function is designed to allow external events to be recorded inside Spatial's output. The event is recorded in the filter status, see section 7.3.33, and resets after the next packet is output. The event triggers on a transition from low to high.
设计用于记录外部事件输入，该事件显示在滤波器状态上，参见章节7.3.33，由低到高触发。

7.3.34 TSS1 Output /TSS1 输出

This function outputs the TSS1 format at 20Hz.
设计用于以20Hz输出TSS1格式。

7.3.35 Simrad 1000 Output /Simrad 1000 输出

This function outputs the Simrad 1000 format at 20Hz.
设计用于以20Hz输出Simrad 1000格式。

7.3.36 Simrad 3000 Output /Simrad 3000 输出

This function outputs the Simrad 3000 format at 20Hz.
设计用于以20Hz输出Simrad 3000格式。

8 Advanced Navigation Packet Protocol /ANPP 高级导航数据包协议

The Advanced Navigation Packet Protocol (ANPP) is a binary protocol designed with high error checking, high efficiency and safe design practices. It has a well defined specification and is very flexible. It is used across all existing and future products.

高级导航数据包协议（Advanced Navigation Packet Protocol ANPP）是二进制格式的数据协议。采用 CRC 校验，数据传输效率比较高。

8.1 Data Types /数据类型

The following data types are used in the packet protocol. All data types in the protocol are little endian byte ordering.

数据协议中用到下列数据类型，协议中的数据以 little endian 顺序发送。

Abbreviation 简写	Bytes 字节	Also known as 其它名字
u8	1	unsigned char, unsigned byte, uint8_t
s8	1	char, byte, int8_t
u16	2	unsigned short, uint16_t
s16	2	short, int16_t
u32	4	unsigned int, unsigned long, uint32_t
s32	4	int, long, int32_t
u64	8	unsigned long long, uint64_t
s64	8	long long, int64_t
fp32	4	float
fp64	8	double

Table 表 11: Data type abbreviations used in the ANPP /ANPP 协议中的数据类型简表

8.2 Packet Structure /数据包结构

The ANPP packet structure is shown in 27 and the header format is shown in 28. Example code can be downloaded from the software section.

ANPP 数据包结构如表 27，数据头如表 28。

Header /数据头				
Header LRC 数据头 LRC	Packet ID 数据包 ID	Packet Length 数据包长度	CRC16 CRC16 校验	Packet Data 数据内容

Table 表 12: ANPP Packet Structure /ANPP 数据包结构

ANPP Header Format ANPP 数据头格式				
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u8	1	Header LRC, /数据头 LRC，详见章节 8.2.1
2	1	u8	1	Packet ID, /数据包 ID，详见章节 8.2.2
3	2	u8	1	Packet Length, /数据包长度，详见章节 8.2.3
4	3	u16	2	CRC16, /CRC16 校验，详见章节 8.2.4

Table 表 13: ANPP header format /ANPP 数据头格式

8.2.1 Header LRC /数据头 LRC

The header LRC (Longitudinal Redundancy Check) provides error checking on the packet header. It also allows the decoder to find the start of a packet by scanning for a valid LRC. The LRC can be found using the following:

数据头 LRC（纵向冗余校验）用于对数据头进行校验。编程人员可以扫描一个有效的 LRC 来确定数据包的开始位置。可以通过如下方式来获得 LRC。

LRC = ((packet_id + packet_length + crc[0] + crc[1])^0xFF) + 1

8.2.2 Packet ID /数据包 ID

The packet ID is used to distinguish the contents of the packet. Packet IDs range from 0 to 255.
数据包 ID 用于区分数据包的内容，ID 的范围从 0 到 255.
Within this range there are three different sub-ranges, these are system packets, state packets and configuration packets.
在该范围内，有三个不同的子范围，分别是系统数据包，状态数据包和配置数据包。
System packets have packet IDs in the range 0 to 19. These packets are implemented the same by every device using ANPP.
系统数据包的 ID 范围从 0 到 19，每个使用 ANPP 协议的设备都使用这些 ID。
State packets are packets that contain data that changes with time, i.e. temperature. State packets can be set to output at a certain rate. State packets are packet IDs in the range 20 to 179.
状态数据包包含那些随时间而变化的数据，比如：温度。状态数据包可以以固定的更新率来发送。状态数据包的 ID 范围从 20 到 179。
Configuration packets are used for reading and writing device configuration. Configuration packets are packet IDs in the range 180 to 255.
配置数据包用于读写设备配置，配置数据包的 ID 范围从 180 到 255。

8.2.3 Packet Length /数据包长度

The packet length denotes the length of the packet data, i.e. from byte index 5 onwards inclusive. Packet length has a range of 0 – 255.

数据包长度定义接下来要发送的数据的长度。比如：从字节序号 5 向前包括。数据包长度的范围从 0 到 255。

8.2.4 CRC /CRC 校验

The CRC is a CRC16-CCITT. The starting value is 0xFFFF. The CRC covers only the packet data.

CRC 是 CRC16-CCITT 校验，开始值是 0xFFFF。CRC 校验仅对数据内容进行校验。

8.3 Packet Requests /请求数据包

Any of the state and configuration packets can be requested at any time using the request packet. See section 8.7.2.

通过请求数据包，可以在任意时间读取到状态和配置数据包内容。详见章节 8.7.2。

8.4 Packet Acknowledgement /确认数据包

When configuration packets are sent to NAV982, it will reply with an acknowledgement packet that indicates whether the configuration change was successful or not. For details on the acknowledgement packet, see section 8.7.1.

当发送配置数据包给传感器，传感器会返回确认数据包，用于说明配置是否被改变。详见 8.7.1

8.5 Packet Rates /数据包更新率

The packet rates can be configured either using Spatial Manager or through the rate configuration packet, see section 8.9.3. By default NAV982 is configured to output the System State Packet /系统状态数据包 at 50Hz. When configuring packet rates it is essential to ensure the baud rate is capable of handling the data throughput. This can be calculated using the rate and packet size. The packet size is the packet length add five to account for the packet overhead. For example to output the system state packet at 50Hz the calculation would be:

通过 Spatial 管理器软件或者更新率配置数据包来改变更新率，参见章节 8.9.3。默认状态传感器以 50Hz 输出 System State Packet /系统状态数据包。当改变数据更新率时，须要确认当前的通讯波特率是否能够处理这些数据流量，可以通过更新率和数据包总长度来计算数据流量，数据包总长度为数据包字节长度加上五个字节的固定数据头长度。比如以 50Hz 输出系统状态数据包，计算方式如下：

Data throughput = (100 (packet length) + 5 (fixed packet overhead)) * 50 (rate)

数据流量 =（100（数据包长度）+5（固定的数据头长度））*50（更新率）

Data throughput = 5250 bytes per second

数据流量 = 5250 字节每秒

Minimum baud rate = data throughput x 11 = 57750 Baud

最小波特率 = 数据流量 x11=57750 波特率

Closest standard baud rate = 115200 Baud

接近的标准波特率 = 115200 波特率

When multiple packets are set to output at the same rate, the order the packets output is from lowest ID to highest ID.

当多个数据包以相同的更新率输出，系统先输出 ID 号较小的数据包。

8.6 Packet Summary /数据包概览

Packet ID 数据包 **ID**	**Length** 长度	**R/W** 读/写	**Name** 名称
			System Packets /系统数据包
0	4	R	Acknowledge Packet /确认数据包
1	-	W	Request Packet /请求数据包
2	1	R/W	Boot Mode Packet /启动模式数据包
3	24	R	Device Information Packet /设备信息数据包
4	4	W	Restore Factory Settings Packet /恢复工厂设置数据包
5	4	W	Reset Packet /复位数据包
			State Packets /状态数据包
20	100	R	System State Packet /系统状态数据包
21	8	R	Unix Time Packet /Unix 时间数据包
22	14	R	Formatted Time Packet /格式化时间数据包
23	4	R	Status Packet /状态数据包
24	12	R	Position Standard Deviation Packet /位置标准差数据包
25	12	R	Velocity Standard Deviation Packet /速度标准差数据包
26	12	R	Euler Orientation Standard Deviation Packet /欧拉角度标准差数据包
27	16	R	Quaternion Orientation Standard Deviation Packet /四元数角度标准差数据包
28	48	R	Raw Sensors Packet /传感器原始数据数据包
29	36	R	Raw GNSS Packet /原始 GNSS 数据包
30	13	R	Satellites Packet /卫星信息数据包
31	-	R	Detailed Satellites Packet /卫星详细信息数据包
32	24	R	Geodetic Position Packet /大地位置数据包
33	24	R	ECEF Position Packet /ECEF 位置数据包
34	25	R	UTM Position Packet /UTM 位置数据包
35	12	R	NED Velocity Packet /NED 速度数据包
36	12	R	Body Velocity Packet /载体速度数据包
37	12	R	Acceleration Packet /加速度数据包
38	16	R	Body Acceleration Packet /载体加速度数据包
39	12	R	Euler Orientation Packet /欧拉角度数据包
40	16	R	Quaternion Orientation Packet /四元数角度数据包
41	36	R	DCM Orientation Packet /DCM 角度数据包
42	12	R	Angular Velocity Packet /角速度数据包

Packet ID 数据包 ID	Length 长度	R/W 读/写	Name 名称
43	12	R	Angular Acceleration Packet /角加速度数据包
44	60	R/W	External Position & Velocity Packet /外部位置和速度数据包
45	36	R/W	External Position Packet /外部位置数据包
46	24	R/W	External Velocity Packet /外部速度数据包
47	16	R/W	External Body Velocity Packet /外部载体速度数据包
48	8	R/W	External Heading Packet /外部航向数据包
49	8	R	Running Time Packet /运行时间数据包
50	12	R	Local Magnetic Field Packet /当地磁场强度数据包
51	20	R	Odometer State Packet /轮速计状态数据包
52	8	R/W	External Time Packet /外部时间数据包
53	8	R/W	External Depth Packet /外部深度值数据包
54	4	R/W	Geoid Height Packet /大地水准面高度数据包
55	-	W	RTCM Corrections Packet /RTCM 差分校正数据包
56	8	R/W	External Pitot Pressure Packet /外部皮托管压力值数据包
57	12	R	Wind Estimation Packet /风速推算值数据包
58	16	R	Heave Packet /升沉值数据包
Configuration Packets /配置数据包			
180	4	R/W	Packet Timer Period Packet /数据包定时器周期数据包
181	-	R/W	Packets Period Packet /数据包周期数据包
182	17	R/W	Baud Rates Packet /波特率数据包
184	4	R/W	Sensor Ranges Packet /传感器量程数据包
185	73	R/W	Installation Alignment Packet /安装对准数据包
186	17	R/W	Filter Options Packet /滤波器选项数据包
187	-	R/W	Advanced Filter Parameters Packet /高级滤波器参数数据包
188	13	R/W	GPIO Configuration Packet /GPIO 配置数据包
189	49	R/W	Magnetic Calibration Values Packet /磁场校正值数据包
190	1	W	Magnetic Calibration Configuration Packet /磁场校正配置数据包
191	3	R	Magnetic Calibration Status Packet /磁场校正状态数据包
192	8	R/W	Odometer Configuration Packet /轮速计配置数据包
193	1	W	Set Zero Orientation Alignment Packet /设定当前角度为零
194	49	R/W	Heave Offset Packet /升沉值偏移量数据包
195	13	R/W	NMEA Output Configuration Packet /NMEA 输出配置数据包

8.7 System Packets /系统数据包

8.7.1 Acknowledge Packet /确认数据包

Acknowledgement Packet /确认数据包				
Packet ID /数据包 ID				0
Length /长度				4
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u8	1	Packet ID being acknowledged /被确认数据包的 ID
2	1	u16	2	CRC of packet being acknowledged /被确认数据包的 CRC 校验
3	3	u8	1	Acknowledge Result, 确认结果，详见 8.7.1.1

Table 表 14: Acknowledge packet /确认数据包

8.7.1.1 Acknowledge Result /确认结果

Value /数值	Description /说明
0	Acknowledge Success /确认成功
1	Acknowledge failure, CRC error /确认失败，CRC 错误
2	Acknowledge failure, packet size incorrect /确认失败，数据包尺寸不正确
3	Acknowledge failure, values outside of valid ranges /确认失败，数值不在有效范围内
4	Acknowledge failure, system flash memory failure /确认失败，系统闪存失败
5	Acknowledge failure, system not ready /确认失败，系统未准备好
6	Acknowledge failure, unknown packet /确认失败，无法识别的数据包

Table 表 15: Acknowledge result /确认结果

8.7.2 Request Packet /请求数据包

Request Packet /请求数据包				
Packet ID /数据包 ID				1
Length /长度				1 x (number of packets requested /被请求的数据包数量)
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u8	1	Packet ID requested /被请求的数据包 ID
+				Field 1 repeats for additional packet requests /序号 1 重复表示其它被请求的数据包

Table 表 16: Request packet /请求数据包

8.7.3 Boot Mode Packet /启动模式数据包

Boot Mode Packet /启动模式数据包				
Packet ID /数据包 ID				2
Length /长度				1
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u8	1	Boot mode, /启动模式，详见 8.7.3.1

Table 表 17: Boot mode packet /启动模式数据包

8.7.3.1 Boot Mode Types /启动模式类型

Value /数值	Description /说明
0	Bootloader /内核启动
1	Main Program /主程序启动

Table 表 18: Boot mode types /启动模式类型

8.7.4 Device Information Packet /设备信息数据包

Device Information Packet /设备信息数据包				
Packet ID /数据包 ID				3
Length /长度				24
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u32	4	Software version /软件版本
2	4	u32	4	Device ID /设备 ID
3	8	u32	4	Hardware revision /硬件版本
4	12	u32	4	Serial number part 1 /序列号部分 1
5	16	u32	4	Serial number part 2 /序列号部分 2
6	20	u32	4	Serial number part 3 /序列号部分 3

Table 表 19: Device information packet /设备信息数据包

8.7.5 Restore Factory Settings Packet /恢复工厂设置数据包

Restore Factory Settings Packet /恢复工厂设置数据包				
Packet ID /数据包 ID				4
Length /长度				4
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u32	4	Verification Sequence (set to 0x85429E1C) /校验序号（设置值 0x85429E1C）

Table 表 20: Restore factory settings packet /恢复工厂设置数据包

8.7.6 Reset Packet /复位数据包

Reset Packet /复位数据包				
Packet ID /数据包 ID				5
Length /长度				4
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u32	4	Verification Sequence (set to 0x21057A7E) /校验序号（设置值 0x21057A7E）

Table 表 21: Reset packet /复位数据包

8.8 State Packets /状态数据包

NAV982 supports a large number of packets providing extensive functionality. However for the majority of users the easiest approach is to configure NAV982 using the Spatial Manager software and then support only the single system state packet shown below in section 8.8.1. Advanced functionality can be added through the other packets.

传感器可以输出多种类型的状态数据包，然而对于大多数用户，简单的方法是使用 Spatial 管理器软件来设定仅输出系统状态数据包，详见章节 8.8.1。更多功能可以通过增加别的数据包来实现。

8.8.1 System State Packet /系统状态数据包

System State Packet /系统状态数据包				
Packet ID /数据包 ID				20
Length /长度				100
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u16	2	System status, /系统状态，详见章节 8.8.1.1
2	2	u16	2	Filter status, /滤波器状态，详见章节 8.8.1.2
3	4	u32	4	Unix time seconds, /Unix 时间秒，详见章节 8.8.1.4
4	8	u32	4	Microseconds, /毫秒，详见章节 8.8.1.5
5	12	fp64	8	Latitude /纬度 (rad)
6	20	fp64	8	Longitude /经度(rad)
7	28	fp64	8	Height /高度(m)
8	36	fp32	4	Velocity north /北向速度 (m/s)
9	40	fp32	4	Velocity east /动向速度(m/s)
10	44	fp32	4	Velocity down /地向速度(m/s)
11	48	fp32	4	Body acceleration /载体加速度 XX(m/s/s)
12	52	fp32	4	Body acceleration /载体加速度 Y(m/s/s)
13	56	fp32	4	Body acceleration /载体加速度 Z(m/s/s)
14	60	fp32	4	G force /重力值(g)
15	64	fp32	4	Roll /横滚 (radians)
16	68	fp32	4	Pitch /俯仰 (radians)
17	72	fp32	4	Heading /航向 (radians)
18	76	fp32	4	Angular velocity /角速度 X (rad/s)
19	80	fp32	4	Angular velocity /角速度 Y (rad/s)
20	84	fp32	4	Angular velocity /角速度 Z (rad/s)
21	88	fp32	4	Latitude standard deviation /纬度标准差 (m)
22	92	fp32	4	Longitude standard deviation 经度标准差 (m)
23	96	fp32	4	Height standard deviation 高度标准差 (m)

Table 表 22: System state packet /系统状态数据包

8.8.1.1 System Status /系统状态

This field contains 16 bits that indicate problems with the system. These are boolean fields with a zero indicating false and one indicating true.
包含 16 位的系统状态信息，每一位代表一个状态，0 表示故障，1 表示正常。

Bit /位	Description /说明
0	System Failure /系统错误
1	Accelerometer Sensor Failure /加速度传感器错误
2	Gyroscope Sensor Failure /陀螺仪错误
3	Magnetometer Sensor Failure /磁场计错误
4	Pressure Sensor Failure /气压高度计错误
5	GNSS FailureGNSS /错误
6	Accelerometer Over Range /加速度超量程
7	Gyroscope Over Range /陀螺仪超量程
8	Magnetometer Over Range /磁场计超量程
9	Pressure Over Range /气压高度计超量程
10	Minimum Temperature Alarm /最小温度报警
11	Maximum Temperature Alarm /最大温度报警
12	Low Voltage Alarm /低电压报警
13	High Voltage Alarm /高电压报警
14	GNSS Antenna Disconnected /GNSS 天线未连接
15	Data Output Overflow Alarm /数据输出溢出报警

Table 表 23: System status /系统状态

8.8.1.2 Filter Status /滤波器状态

This field contains 16 bits that indicate the status of the filters. These are boolean fields with a zero indicating false and one indicating true.
包含 16 位的滤波器状态信息，每一位代表一个状态，0 表示故障，1 表示正常。

Bit /位	**Description** /说明
0	Orientation Filter Initialised /角度滤波器完成初始化
1	Navigation Filter Initialised /导航滤波器完成初始化
2	Heading Initialised /航向滤波器完成初始化
3	UTC Time Initialised /UTC 时间完成初始化
4	GNSS Fix Status /GNSS定位状态, see section 8.8.1.3
5	
6	
7	Event 1 Occurred /事件 1 发生
8	Event 2 Occurred /事件 2 发生
9	Internal GNSS Enabled /使能内部 GNSS
10	Magnetometers Enabled /使能磁场计
11	Velocity Heading Enabled /使能速度航向
12	Atmospheric Altitude Enabled /使能气压高度计
13	External Position Active /使能外部位置
14	External Velocity Active /使能外部速度
15	External Heading Active /使能外部航向

Table 表 *24: Filter Status* 滤波器状态

8.8.1.3 GNSS Fix Status /GNSS 定位状态

Value /值	**Bit** /位	**Bit** /位	**Bit** /位	**Description** /说明
0	0	0	0	No GNSS fix
1	0	0	1	2D GNSS fix
2	0	1	0	3D GNSS fix
3	0	1	1	SBAS GNSS fix
4	1	0	0	Differential GNSS fix
5	1	0	1	Omnistar/Starfire GNSS fix
6	1	1	0	RTK Float GNSS fix
7	1	1	1	RTK Fixed GNSS fix

Table 表 *25: GNSS Fix Status /GNSS* 定位状态

8.8.1.4 Unix Time Seconds /Unix 时间秒

This field provides UTC time in seconds since January 1, 1970, not counting leap seconds. 以秒为单位输出 UTC 时间，自 1970 年一月一日起，没有计算闰秒。

8.8.1.5 Microseconds /毫秒

This field provides the sub-second component of time. It is represented as microseconds since the last second. Minimum value is 0 and maximum value is 999999.
以毫秒为单位输出秒以下的时间，最小值是 0，最大值是 999999。

8.8.2 Unix Time Packet /Unix 时间数据包

Unix Time Packet /Unix 时间数据包				
Packet ID /数据包 ID				21
Length /长度				8
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u32	4	Unix time seconds, /Unix 时间秒，详见章节 8.8.1.4
2	4	u32	4	Microseconds, /毫秒，详见章节 8.8.1.5

Table 表 26: Unix 时间数据包

8.8.3 Formatted Time Packet /格式化时间数据包

Formatted Time Packet /格式化时间数据包				
Packet ID /数据包 ID				22
Length /长度				14
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u32	4	Microseconds /毫秒
2	4	u16	2	Year /年
3	6	u16	2	Year day /年天, 0 – 365
4	8	u8	1	Month /月, 0 – 11
5	9	u8	1	Month Day /日, 1 – 31
6	10	u8	1	Week Day /周天, 0 – 6
7	11	u8	1	Hour /小时, 0 – 23
8	12	u8	1	Minute /分钟, 0 – 59
9	13	u8	1	Second /秒, 0 – 59

Table 表 27: Formatted time packet /格式化时间数据包

8.8.4 Status Packet /状态数据包

Status Packet /状态数据包				
Packet ID /数据包 ID				23
Length /长度				4
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u16	2	System status, /系统状态，详见章节 8.8.1.1
2	2	u16	2	Filter status, /滤波器状态，详见章节 8.8.1.2

Table 表 28: Status packet /状态数据包

8.8.5 Position Standard Deviation Packet /位置标准差数据包

Position Standard Deviation Packet /位置标准差数据包				
Packet ID /数据包 ID				24
Length /长度				12
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Latitude standard deviation /纬度标准差 (m)
2	4	fp32	4	Longitude standard deviation /经度标准差 (m)
3	8	fp32	4	Height standard deviation /高度标准差 (m)

Table 表 29: Position standard deviation packet /位置标准差数据包

8.8.6 Velocity Standard Deviation Packet /速度标准差数据包

Velocity Standard Deviation Packet /速度标准差数据包				
Packet ID /数据包 ID				25
Length /长度				12
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Velocity north standard deviation /北向速度标准差 (m/s)
2	4	fp32	4	Velocity east standard deviation /东向速度标准差 (m/s)
3	8	fp32	4	Velocity down standard deviation /地向速度标准差 (m/s)

Table 表 30: Velocity standard deviation packet /速度标准差数据包

8.8.7 Euler Orientation Standard Deviation Packet /欧拉角度标准差数据包

Euler Orientation Standard Deviation Packet /欧拉角度标准差数据包				
Packet ID /数据包 ID				26
Length /长度				12
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Roll standard deviation /横滚标准差 (rad)
2	4	fp32	4	Pitch standard deviation /俯仰标准差 (rad)
3	8	fp32	4	Heading standard deviation /航向标准差 (rad)

Table 表 31: Euler orientation standard deviation packet /欧拉角度标准差数据包

8.8.8 Quaternion Orientation Standard Deviation Packet /四元数角度标准差数据包

Quaternion Orientation Standard Deviation Packet /四元数角度标准差数据包				
Packet ID /数据包 ID				27
Length /长度				16
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Q0 standard deviation /Q0 标准差
2	4	fp32	4	Q1 standard deviation /Q1 标准差
3	8	fp32	4	Q2 standard deviation /Q2 标准差
4	12	fp32	4	Q3 standard deviation /Q3 标准差

Table 表 32: Quaternion orientation standard deviation packet /四元数角度标准差数据包

8.8.9 **Raw Sensors Packet** /传感器原始数据数据包

Raw Sensors Packet /传感器原始数据数据包				
Packet ID /数据包 ID				28
Length /长度				48
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Accelerometer /加速度 X (m/s/s)
2	4	fp32	4	Accelerometer /加速度 Y (m/s/s)
3	8	fp32	4	Accelerometer /加速度 Z (m/s/s)
4	12	fp32	4	Gyroscope /陀螺仪 X (rad/s)
5	16	fp32	4	Gyroscope /陀螺仪 Y (rad/s)
6	20	fp32	4	Gyroscope /陀螺仪 Z (rad/s)
7	24	fp32	4	Magnetometer /磁场计 X (mG)
8	28	fp32	4	Magnetometer /磁场计 Y (mG)
9	32	fp32	4	Magnetometer /磁场计 Z (mG)
10	36	fp32	4	IMU Temperature /IMU 温度 (deg C)
11	40	fp32	4	Pressure /大气压 (Pascals)
12	44	fp32	4	Pressure Temperature /气压计温度 (deg C)

Table 表 33: Raw sensors packet /传感器原始数据数据包

8.8.10 **Raw GNSS Packet** /原始 **GNSS** 数据包

Raw GNSS Packet /原始 **GNSS** 数据包				
Packet ID /数据包 ID				29
Length /长度				36
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp64	8	Latitude /纬度 (rad)
2	8	fp64	8	Longitude /经度 (rad)
3	16	fp64	8	Height /高度 (m)
4	24	fp32	4	Velocity north /北向速度 (m)
5	28	fp32	4	Velocity east /东向速度 (m)
6	32	fp32	4	Velocity down /地向速度(m)

Table 表 34: Raw GNSS packet /原始 GNSS 数据包

8.8.11 Satellites Packet /卫星信息数据包

Satellites Packet /卫星信息数据包				
Packet ID /数据包 ID				30
Length /长度				13
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	HDOP /水平精度因子
2	4	fp32	4	VDOP /垂直精度因子
3	8	u8	1	GPS satellites /GPS 卫星数
4	9	u8	1	GLONASS satellites /GLONASS 卫星数
5	10	u8	1	COMPASS satellites /COMPASS 卫星数
6	11	u8	1	GALILEO satellites /GALILEO 卫星数
7	12	u8	1	SBAS satellites /SBAS 卫星数

Table 表 35: Satellites packet /卫星信息数据包

8.8.12 Detailed Satellites Packet /卫星详细信息数据包

Detailed Satellites Packet /卫星详细信息数据包				
Packet ID /数据包 ID				31
Length /长度				7 x number of satellites /卫星数
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u8	1	Navigation system, /导航系统，详见章节 8.8.12.1
2	1	u8	1	Satellite number /卫星编号
3	2	s8	1	Satellite frequencies, /卫星频率，详见章节 8.8.12.2
4	3	u8	1	Elevation /仰角 (deg)
5	4	u16	2	Azimuth /方位角 (deg)
6	6	u8	1	SNR /信噪比
+				Fields 1-6 repeat for additional satellites /如有多颗卫星，此处起重复序号 1-6 的内容

Table 表 36: Detailed satellites packet /卫星详细信息数据包

8.8.12.1 Navigation System /导航系统

Value /数值	**System** /系统
0	Unknown
1	GPS
2	GLONASS
3	Beidou
4	GALILEO
5	SBAS
6	QZSS
7	Starfire
8	Omnistar

Table 37: Navigation systems /导航系统

8.8.12.2 Satellite Frequencies /卫星频率

Value /数值	**System** /系统
1	L1 C/A
2	L1 C
3	L1 P
4	L1 M
5	L2 C
6	L2 P
7	L2 M
8	L5

Table 38: Satellite Frequencies /卫星频率

8.8.13 Geodetic Position Packet /大地位置数据包

Geodetic Position Packet /大地位置数据包				
Packet ID /数据包 ID				32
Length /长度				24
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp64	8	Latitude /纬度 (rad)
2	8	fp64	8	Longitude /精度 (rad)
3	16	fp64	8	Height /高度 (m)

Table 表 39: Geodetic position packet /大地位置数据包

8.8.14 ECEF Position Packet /ECEF 位置数据包

ECEF Position Packet /ECEF 位置数据包				
Packet ID /数据包 ID				33
Length /长度				24
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp64	8	ECEF X (m)
2	8	fp64	8	ECEF Y (m)
3	16	fp64	8	ECEF Z (m)

Table 表 40: ECEF position packet /ECEF 位置数据包

8.8.15 UTM Position Packet /UTM 位置数据包

UTM Position Packet /UTM 位置数据包				
Packet ID /数据包 ID				34
Length /长度				25
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp64	8	Northing /北 (m)
2	8	fp64	8	Easting /东 (m)
3	16	fp64	8	Height /高度 (m)
4	24	s8	1	Zone character /区域编号

Table 表 41: UTM position packet /UTM 位置数据包

8.8.16 NED Velocity Packet /NED 速度数据包

NED Velocity Packet /NED 速度数据包				
Packet ID /数据包 ID				35
Length /长度				12
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Velocity north /北向速度 (m/s)
2	4	fp32	4	Velocity east /东向速度 (m/s)
3	8	fp32	4	Velocity down /地向速度 (m/s)

Table 表 42: NED velocity packet /NED 速度数据包

8.8.17 Body Velocity Packet /载体速度数据包

Body Velocity Packet 载体速度数据包				
Packet ID /数据包 ID				36
Length /长度				12
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Velocity 速度 X (m/s)
2	4	fp32	4	Velocity 速度 Y (m/s)
3	8	fp32	4	Velocity 速度 Z (m/s)

Table 表 43: Body velocity packet /载体速度数据包

8.8.18 Acceleration Packet /加速度数据包

Acceleration Packet /加速度数据包				
Packet ID /数据包 ID				37
Length /长度				12
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Acceleration /加速度 X (m/s/s)
2	4	fp32	4	Acceleration /加速度 Y (m/s/s)
3	8	fp32	4	Acceleration /加速度 Z (m/s/s)

Table 表 44: Acceleration packet /加速度数据包

8.8.19 Body Acceleration Packet /载体加速度数据包

Body Acceleration Packet /载体加速度数据包				
Packet ID /数据包 ID				38
Length /长度				16
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Body acceleration /载体加速度 X (m/s/s)
2	4	fp32	4	Body acceleration /载体加速度 Y (m/s/s)
3	8	fp32	4	Body acceleration /载体加速度 Z (m/s/s)
4	12	fp32	4	G force /重力 (g)

Table 表 45: Body acceleration packet /载体加速度数据包

8.8.20 Euler Orientation Packet /欧拉角度数据包

Euler Orientation Packet /欧拉角度数据包				
Packet ID /数据包 ID				39
Length /长度				12
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Roll /横滚 (rad)
2	4	fp32	4	Pitch /俯仰 (rad)
3	8	fp32	4	Heading /航向 (rad)

Table 表 46: Euler orientation packet /欧拉角度数据包

8.8.21 Quaternion Orientation Packet /四元数角度数据包

Quaternion Orientation Packet /四元数角度数据包				
Packet ID /数据包 ID				40
Length /长度				16
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Q0
2	4	fp32	4	Q1
3	8	fp32	4	Q2
4	12	fp32	4	Q3

Table 表 47: Quaternion orientation packet /四元数角度数据包

8.8.22 DCM Orientation Packet /DCM 角度数据包

DCM Orientation Packet /DCM 角度数据包				
Packet ID /数据包 ID				41
Length /长度				36
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	DCM[0][0]
2	4	fp32	4	DCM[0][1]
3	8	fp32	4	DCM[0][2]
4	12	fp32	4	DCM[1][0]
5	16	fp32	4	DCM[1][1]
6	20	fp32	4	DCM[1][2]
7	24	fp32	4	DCM[2][0]
8	28	fp32	4	DCM[2][1]
9	32	fp32	4	DCM[2][2]

Table 表 48: DCM orientation packet /DCM 角度数据包

8.8.23 Angular Velocity Packet /角速度数据包

Angular Velocity Packet /角速度数据包				
Packet ID /数据包 ID				42
Length /长度				12
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Angular velocity /角速度 X (rad/s)
2	4	fp32	4	Angular velocity /角速度 Y (rad/s)
3	8	fp32	4	Angular velocity /角速度 Z (rad/s)

Table 表 49: Angular velocity packet /角速度数据包

8.8.24 Angular Acceleration Packet /角加速度数据包

Angular Acceleration Packet /角加速度数据包				
Packet ID /数据包 ID				43
Length /长度				12
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Angular acceleration /角加速度 X (rad/s/s)
2	4	fp32	4	Angular acceleration /角加速度 Y (rad/s/s)
3	8	fp32	4	Angular acceleration /角加速度 Z (rad/s/s)

Table 表 50: Angular acceleration packet /角加速度数据包

8.8.25 External Position & Velocity Packet /外部位置和速度数据包

External Position & Velocity Packet /外部位置和速度数据包				
Packet ID /数据包 ID				44
Length /长度				60
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp64	8	Latitude/ 纬度 (rad)
2	8	fp64	8	Longitude /经度 (rad)
3	16	fp64	8	Height /高度 (m)
4	24	fp32	4	Velocity north /北向速度 (m/s)
5	28	fp32	4	Velocity east /东向速度 (m/s)
6	32	fp32	4	Velocity down /地向速度 (m/s)
7	36	fp32	4	Latitude standard deviation /纬度标准差 (m)
8	40	fp32	4	Longitude standard deviation /经度标准差 (m)
9	44	fp32	4	Height standard deviation /高度标准差 (m)
10	48	fp32	4	Velocity north standard deviation /北向速度标准差 (m/s)
11	52	fp32	4	Velocity east standard deviation /东向速度标准差 (m/s)
12	56	fp32	4	Velocity down standard deviation /地向速度标准差 (m/s)

Table 表 51: External position & velocity packet /外部位置和速度数据包

8.8.26 External Position Packet /外部位置数据包

External Position Packet /外部位置数据包				
Packet ID /数据包 ID				45
Length /长度				36
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp64	8	Latitude /纬度 (rad)
2	8	fp64	8	Longitude /经度 (rad)
3	16	fp64	8	Height /高度 (m)
4	24	fp32	4	Latitude standard deviation /纬度标准差 (m)
5	28	fp32	4	Longitude standard deviation /经度标准差 (m)
6	32	fp32	4	Height standard deviation /高度标准差 (m)

Table 表 52: External position packet /外部位置数据包

8.8.27 External Velocity Packet /外部速度数据包

External Velocity Packet /外部速度数据包				
Packet ID /数据包 ID				46
Length /长度				24
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Velocity north /北向速度 (m/s)
2	4	fp32	4	Velocity east /东向速度 (m/s)
3	8	fp32	4	Velocity down /地向速度 (m/s)
4	12	fp32	4	Velocity north standard deviation /北向速度标准差 (m/s)
5	16	fp32	4	Velocity east standard deviation /东向速度标准差 (m/s)
6	20	fp32	4	Velocity down standard deviation /地向速度标准差 (m/s)

Table 表 53: External velocity packet /外部速度数据包

8.8.28 External Body Velocity Packet /外部载体速度数据包

External Body Velocity Packet /外部载体速度数据包				
Packet ID /数据包 ID				47
Length /长度				16
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Velocity /速度 X (m/s)
2	4	fp32	4	Velocity /速度 Y (m/s)
3	8	fp32	4	Velocity /速度 Z (m/s)
4	12	fp32	4	Velocity standard deviation /速度标准差 (m/s)

Table 表 54: External body velocity packet /外部载体速度数据包

8.8.29 External Heading Packet /外部航向数据包

External Heading Packet /外部航向数据包				
Packet ID /数据包 ID				48
Length /长度				8
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Heading /航向 (rad)
2	4	fp32	4	Heading standard deviation /航向标准差 (rad)

Table 55: External heading packet /外部航向数据包

8.8.30 Running Time Packet /运行时间数据包

Running Time Packet /运行时间数据包				
Packet ID /数据包 ID				49
Length /长度				8
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u32	4	Running time seconds /运行时间秒
2	4	u32	4	Microseconds /毫秒

Table 表 56: Running time packet /运行时间数据包

8.8.31 Local Magnetic Field Packet /当地磁场强度数据包

Local Magnetic Field Packet /当地磁场强度数据包				
Packet ID /数据包 ID				50
Length /长度				12
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Local magnetic field /当地磁场强度 X (mG)
2	4	fp32	4	Local magnetic field /当地磁场强度 Y (mG)
3	4	fp32	4	Local magnetic field /当地磁场强度 Z (mG)

Table 表 57: Local magnetic field packet /当地磁场强度数据包

8.8.32 Odometer State Packet /轮速计状态数据包

Odometer State Packet /轮速计状态数据包				
Packet ID /数据包 ID				51
Length /长度				20
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u32	4	Odometer pulse count /脉冲计数
2	4	fp32	4	Odometer distance /距离 (m)
3	8	fp32	4	Odometer speed /速度 (m/s)
4	12	fp32	4	Odometer slip (m)
5	16	u8	1	Odometer active /使能轮速计
6	17		3	Reserved /保留

Table 表 58: Odometer state packet /轮速计状态数据包

8.8.33 External Time Packet /外部时间数据包

External Time Packet /外部时间数据包				
Packet ID /数据包 ID				52
Length /长度				8
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u32	4	Unix time seconds, /Unix 时间秒，详见章节 8.8.1.4
2	4	u32	4	Microseconds, /毫秒，详见章节 8.8.1.5

Table 表 59: External time packet /外部时间数据包

8.8.34 External Depth Packet /外部深度值数据包

External Depth Packet /外部深度值数据包				
Packet ID /数据包 ID				53
Length /长度				8
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Depth /深度值 (m)
2	4	fp32	4	Depth standard deviation /深度值标准差 (m)

Table 表 60: External depth packet /外部深度值数据包

8.8.35 Geoid Height Packet /大地水准面高度数据包

This packet provides the offset between the WGS84 ellipsoid and the EGM96 geoid model at the current location. This can be used to determine mean sea level height and also depth through the following equations:
用于提供WGS84椭球体和EGM96大地水准面模型之间的偏移量，通过它可以计算出平均海平面高度和深度值，方程式如下：
Mean Sea Level Height = Height – Geoid Height
平均海平面高度 = 高度 - 大地水准面高度
Depth = Geoid Height – Height
深度值 = 大地水准面高度 - 高度

Geoid Height Packet /大地水准面高度数据包				
Packet ID /数据包 ID				54
Length /长度				4
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Geoid Height /大地水准面高度 (m)

Table 表 61: Geoid height packet /大地水准面高度数据包

8.8.36 RTCM Corrections Packet /RTCM 差分校正数据包

This packet is used to encapsulate RTCM SC-104 differential correction data to be sent to NAV982's internal GNSS receiver for differential GNSS functionality.

用于封装 RTCM SC-104 差分校正数据给传感器内部的 GNSS 接收机，以提高位置精度。

RTCM Corrections Packet /RTCM 差分校正数据包				
Packet ID /数据包 ID				55
Length /长度				Variable, up to 255 bytes
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0			RTCM corrections data /RTCM 差分校正数据

Table 表 62: RTCM corrections packet /RTCM 差分校正数据包

8.8.37 External Pitot Pressure Packet /外部皮托管压力值数据包

This packet is used to interface a pitot tube to NAV982 for enhanced navigation using aircraft airspeed. The packet should contain differential pressure in pascals. If outside air temperature is available it should be set in the message for increased accuracy, otherwise this field should be set to 15 degrees.

给传感器输入外部飞行器的皮托管空速值，可以提高其导航性能。输入皮托管的差压信号，单位是 pascals。如果有外部空气温度值，需要一起输入以提高其精度，如果没有温度数据，请输入 15 摄氏度。

External Pitot Pressure Packet /外部皮托管压力值数据包				
Packet ID /数据包 ID				56
Length /长度				8
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Differential pressure /差压信号 (pascals)
2	4	fp32	4	Outside air temperature /外部空气温度 (deg C)

Table 表 63: External pitot pressure packet /外部皮托管压力值数据包

8.8.38 Wind Estimation Packet /风速推算值数据包

This packet provides NAV982's current estimate of 3D wind velocity. These values are only valid when a pitot tube is interfaced to NAV982.

输出当前 3D 风速值，仅在有皮托管数据存在的情况下，才能推算出风速值。

Wind Estimation Packet /风速推算值数据包				
Packet ID /数据包 ID				57
Length /长度				12
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Wind velocity north /北向风速值
2	4	fp32	4	Wind velocity east /东向风速值
3	8	fp32	4	Wind velocity down /地向风速值

Table 表 64: Wind estimation packet /风速推算值数据包

8.8.39 Heave Packet /升沉值数据包

Heave Packet /升沉值数据包				
Packet ID /数据包 ID				58
Length /长度				16
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	fp32	4	Heave point 1 /测量点 1 升沉值 (m)
2	4	fp32	4	Heave point 2 /测量点 2 升沉值 (m)
3	8	fp32	4	Heave point 3 /测量点 3 升沉值 (m)
4	12	fp32	4	Heave point 4 /测量点 4 升沉值 (m)

Table 表 65: Heave packet /升沉值数据包

8.9 Configuration Packets /配置数据包

Configuration packets can be both read from and written to the device. On many of the configuration packets the first byte is a permanent flag. A zero in this field indicates that the settings will be lost on reset, a one indicates that they will be permanent.

配置数据即可读也可写，大多数数据包的第一个字节是永久写入标志，该字节输入 0 表示临时修改，断电后不会存储。输入 1 表示永久修改，断电后存储。

8.9.1 Packet Timer Period Packet /数据包定时器周期数据包

Packet Timer Period Packet /数据包定时器周期数据包				
Packet ID /数据包 ID				180
Length /长度				4
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u8	1	Permanent /永久标志
2	1	u8	1	UTC synchronisation, /UTC 同步，详见章节 8.9.1.1
3	2	u16	2	Packet timer period, /数据包定时器周期，详见章节 8.9.1.2

Table 表 66: Packet timer period packet /数据包定时器周期数据包

8.9.1.1 UTC Synchronisation /UTC 时间同步

This is a boolean value that determines whether or not the packet timer is synchronised with UTC time, with zero for disabled and one for enabled. For UTC Synchronisation to be enabled the packet timer period must multiply into 1000000 evenly. For example if the packet timer period is 10000 (10 ms), 1000000/10000 = 100 which is valid for UTC synchronisation. If the packet timer period is 15000 (15 ms), 1000000/15000 = 66.6666 which is not valid for UTC synchronisation. To get the rate use the following.

该位是布尔量，说明是否和 UTC 时间同步，0 表示不同步，1 表示同步。如果选择 UTC 时间同步，输入的数值必须能够被 1000000 整除。例如：如果定时器周期是 10000（10ms），1000000/10000=100 是能与 UTC 时间同步；如果定时器周期是 15000（15ms），1000000/15000=66.6666 不能与 UTC 时间同步。通过下面公式来计算数据包定时器更新率。

Packet Timer Rate = 1000000/(Packet Timer Period) Hz

数据包定时器更新率 = 1000000/（数据包定时器周期）Hz

8.9.1.2 Packet timer period /数据包定时器周期

This is a value in microseconds that sets the master packet timer period. The minimum value is 1000 (1 ms) or 1000 Hz and the maximum value is 65535 (65.535 ms) or 15.30 Hz.

输入以毫秒为单位的值，设置主数据包定时器周期，最小值是 1000（1ms）或者 1000Hz，最大值是 65535（65.535ms）或者 15.30Hz。

8.9.2 Packets Period Packet /数据包周期数据包

Packets Period Packet /数据包周期数据包				
Packet ID /数据包 ID				181
Length /长度				2 + (5 x number of packet periods /数据包数量)
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u8	1	Permanent /永久标志
2	1	u8	1	Clear existing packet periods, /清除当前数据包，详见章节 8.9.2.1
3	2	u8	1	Packet ID /数据包 ID
4	3	u32	4	Packet period, /数据包周期数，详见章节 8.9.2.2
+				Fields 3-4 repeat for additional packet periods /序号 3-4 重复输入其它多个数据包周期值

Table 表 67: Packets period packet /数据包周期数据包

8.9.2.1 Clear Existing Packets /清除当前数据包

This is a boolean field, when set to one it deletes any existing packet rates. When set to zero existing packet rates remain. Only one packet rate can exist per packet ID, so new packet rates will overwrite existing packet rates for the same packet ID.

设置为 1 表示删除所有当前存在的数据包，设为 0 表示保留当前存在的数据包。每个数据包 ID 只能有一个更新率，同 ID 的数据包，新输入的更新率将会覆盖以前的值。

8.9.2.2 Packet Period /数据包周期

This indicates the period in units of the packet timer period. The packet rate can be calculated as follows.

输入与定时器周期相同单位的数据包周期值，可以通过下面的公式来计算数据包更新率。

Packet Rate = 1000000/(Packet Period x Packet Timer Period) Hz

数据包更新率 = 1000000/（数据包周期 x 数据包定时器周期）Hz

For example if the packet timer period is set to 1000 (1 ms). Setting packet ID 20 with a packet period of 50 will give the following.

例如：如果数据包定时器周期设置为 1000（1ms），设定 ID 为 20 的数据包以周期为 50 输出数据值。

Packet 20 Rate = 1000000/(50 x 1000)

Packet 20 Rate = 20 Hz

ID20 数据包更新率 =1000000/（50x1000）

ID20 数据包更新率 = 20Hz

8.9.3 Baud Rates Packet /波特率数据包

Baud Rates Packet /波特率数据包				
Packet ID /数据包 ID				182
Length /长度				17
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u8	1	Permanent /永久标志
2	1	u32	4	Primary serial port baud rate /主端口波特率 (1200 to 1000000)
3	5	u32	4	GPIO 1 & 2 baud rate /GIP1 和 2 波特率 (1200 to 1000000)
4	9	u32	4	GPIO 3 & 4 baud rate /GIP3 和 4 波特率 (1200 to 1000000)
5	13	u32	4	Reserved (set to zero) /保留（输入零）

Table 表 68: Baud rates packet /波特率数据包

8.9.4 Sensor Ranges Packet /传感器量程数据包

Sensor Ranges Packet /传感器量程数据包				
Packet ID /数据包 ID				184
Length /长度				4
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u8	1	Permanent /永久标志
2	1	u8	1	Accelerometers range, /加速度量程，详见章节 8.9.4.1
3	2	u8	1	Gyroscopes range, /陀螺仪量程，详见章节 8.9.4.2
4	3	u8	1	Magnetometers range, /磁场计量程，详见章节 8.9.4.3

Table 表 69: Sensor ranges packet /传感器量程数据包

8.9.4.1 Accelerometers Range /加速度量程

Value /数值	**Description /说明**
0	2 g (19.62 m/s/s)
1	4 g (39.24 m/s/s)
2	16 g (156.96 m/s/s)

Table 表 70: Accelerometers range /加速度量程

8.9.4.2 Gyroscopes Range /陀螺仪量程

Value /数值	**Description /说明**
0	250 degrees/second
1	500 degrees/second
2	2000 degrees/second

Table 表 71: Gyroscopes range /陀螺仪量程

8.9.4.3 Magnetometers Range /磁场计量程

Value /数值	**Description /说明**
0	2 Gauss
1	4 Gauss
2	8 Gauss

Table 表 72: Magnetometers range /磁场计量程

8.9.5 Installation Alignment Packet /安装对准数据包

Installation Alignment Packet /安装对准数据包				
Packet ID /数据包 ID				185
Length /长度				73
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u8	1	Permanent /永久标志
2	1	fp32	4	Alignment /方向对准 DCM[0][0]
3	5	fp32	4	Alignment /方向对准 DCM[0][1]
4	9	fp32	4	Alignment /方向对准 DCM[0][2]
5	13	fp32	4	Alignment /方向对准 DCM[1][0]
6	17	fp32	4	Alignment /方向对准 DCM[1][1]
7	21	fp32	4	Alignment /方向对准 DCM[1][2]
8	25	fp32	4	Alignment /方向对准 DCM[2][0]
9	29	fp32	4	Alignment /方向对准 DCM[2][1]
10	33	fp32	4	Alignment /方向对准 DCM[2][2]
11	37	fp32	4	GNSS antenna offset /GNSS 天线偏移量 X (m)
12	41	fp32	4	GNSS antenna offset /GNSS 天线偏移量 Y (m)
13	45	fp32	4	GNSS antenna offset /GNSS 天线偏移量 Z (m)
14	49	fp32	4	Odometer offset /轮速计偏移量 X (m)
15	53	fp32	4	Odometer offset 轮速计偏移量 Y (m)
16	57	fp32	4	Odometer offset 轮速计偏移量 Z (m)
17	61	fp32	4	External data offset 外部数据偏移量 X (m)
18	65	fp32	4	External data offset 外部数据偏移量 Y (m)
19	69	fp32	4	External data offset 外部数据偏移量 Z (m)

Table 表 73: Installation alignment packet /安装对准数据包

8.9.5.1 Alignment DCM /方向对准 DCM

The alignment DCM (direction cosine matrix) is used to represent an alignment offset of NAV982 from it's standard alignment. A DCM is used rather than euler angles for accuracy reasons. To convert euler angles to DCM please use the formula below with angles in radians.

方向对准 DCM（方向余弦矩阵）数值用于设定跟标准安装所不同的安装方向的偏移量。出于精度的考虑这里使用 DCM 而不用欧拉角。如果需要转换欧拉角到 DCM，请使用下面的公式。

DCM[0][0] = cos(heading) * cos(pitch)

DCM[0][1] = sin(heading) * cos(pitch)

DCM[0][2] = -sin(pitch)

DCM[1][0] = -sin(heading) * cos(roll) + cos(heading) * sin(pitch) * sin(roll)

DCM[1][1] = cos(heading) * cos(roll) + sin(heading) * sin(pitch) * sin(roll)

DCM[1][2] = cos(pitch) * sin(roll)

DCM[2][0] = sin(heading) * sin(roll) + cos(heading) * sin(pitch) * cos(roll)

DCM[2][1] = -cos(heading) * sin(roll) + sin(heading) * sin(pitch) * cos(roll)

DCM[2][2] = cos(pitch) * cos(roll)

8.9.6 Filter Options Packet /滤波器选项数据包

Filter Options Packet /滤波器选项数据包				
Packet ID /数据包 ID				186
Length /长度				17
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u8	1	Permanent /永久标志
2	1	u8	1	Vehicle type, /载体模型，详见章节 8.9.6.1
3	2	u8	1	Internal GNSS enabled (boolean) /使能内部 GNSS（布尔量）
4	3	u8	1	Magnetometers enabled (boolean) /使能磁场计（布尔量）
5	4	u8	1	Atmospheric altitude enabled (boolean) /使能气压高度计（布尔量）
6	5	u8	1	Velocity heading enabled (boolean) /使能速度航向（布尔量）
7	6	u8	1	Reversing detection enabled (boolean) /使能反向监测
8	7	u8	1	Motion analysis enabled (boolean) /使能运动分析
9	8	u8	1	Reserved (set to zero) /保留（输入 0）
10	9	u8	1	Reserved (set to zero) /保留（输入 0）
11	10	u8	1	Reserved (set to zero) /保留（输入 0）
12	11	u8	1	Reserved (set to zero) /保留（输入 0）
13	12	u8	1	Reserved (set to zero) /保留（输入 0）
14	13	u8	1	Reserved (set to zero) /保留（输入 0）
15	14	u8	1	Reserved (set to zero) /保留（输入 0）
16	15	u8	1	Reserved (set to zero) /保留（输入 0）
17	16	u8	1	Reserved (set to zero) /保留（输入 0）

Table 表 74: Filter options packet /滤波器选项数据包

8.9.6.1 Vehicle Types /载体模型

Value /数值	**Description /说明**
0	Unconstrained /无限制
1	Bicycle or Motorcycle /自行车或者摩托车
2	Car /汽车
3	Hovercraft /旋翼飞行器
4	Submarine /水下潜艇
5	3D Underwater Vehicle /水下 3D 航行器
6	Fixed Wing Plane /固定翼飞行器
7	3D Aircraft /3D 飞行器
8	Human /人类

Table 表 75: Vehicle types /载体模型

8.9.7 Advanced Filter Parameters Packet /高级滤波器参数数据包

Please contact support team. 请与我们联系使用该功能。

8.9.8 GPIO Configuration Packet /GPIO 配置数据包

GPIO Configuration Packet /GPIO 配置数据包				
Packet ID /数据包 ID				188
Length /长度				13
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u8	1	Permanent /永久标志
2	1	u8	1	GPIO1 Function, /GPIO1 功能，详见章节 8.9.8.1
3	2	u8	1	GPIO2 Function, /GPIO2 功能，详见章节 8.9.8.2
4	3	u8	1	GPIO3 Function, /GPIO3 功能，详见章节 8.9.8.3
5	4	u8	1	GPIO4 Function, /GPIO4 功能，详见章节 8.9.8.4
6	5		8	Reserved /保留

Table 表 76: GPIO configuration packet /GPIO 配置数据包

8.9.8.1 GPIO1 Functions /GPIO1 功能列表

Value /数值	**Description** /说明
0	Inactive /不用
1	1PPS Output /1PPS 输出
2	GNSS Fix Output /GNSS 定位输出
3	Odometer Input /里程计输入
4	Stationary Input /静止状态输入
5	Pitot Tube Input /皮托管输入
7	NMEA Output /NMEA 输出
12	ANPP Output /ANPP 输出
13	Disable Magnetometers /禁用磁场计
14	Disable Internal GNSS /禁用内部 GNSS
15	Disable Pressure /禁用气压高度计
16	Set Zero Orientation Alignment /当前角度置零
17	System State Packet Trigger /系统状态数据包触发
18	Raw Sensors Packet Trigger /原始传感器数据包触发
26	Pressure Depth Transducer Input /压力深度传感器输入
27	Left Wheel Speed Sensor /左侧轮速计
28	Right Wheel Speed Sensor /右侧轮速计
29	1PPS Input /1PPS输入
30	Wheel Speed Sensor /轮速计输入
31	Wheel Encoder Phase A /轮速计A相输入
32	Wheel Encoder Phase B /轮速计B相输入
33	Event 1 Input /事件1输入
34	Event 2 Input /事件2输入
39	TSS1 Output /TSS1输出
40	Simrad 1000 Output /Simrad 1000输出
41	Simrad 3000 Output /Simrad 3000输出

Table 表 77: GPIO1 functions /GPIO1 功能列表

8.9.8.2 GPIO2 Functions /GPIO2 功能列表

Value /数值	Description /说明
0	Inactive /未用
1	1PPS Output /1PPS 输出
2	GNSS Fix Output /GNSS 定位输出
3	Odometer Input /里程计输入
4	Stationary Input /静止状态输入
5	Pitot Tube Input /皮托管输入
6	NMEA Input /NMEA 输入
8	Novatel GNSS Input /NovAtel GNSS 输入
9	Topcon GNSS Input /Topcon GNSS 输入
11	ANPP Input /ANPP 输入
13	Disable Magnetometers /禁用磁场计
14	Disable Internal GNSS /禁用内部 GNSS
15	Disable Pressure /禁用气压高度计
16	Set Zero Orientation Alignment /当前角度置零
17	System State Packet Trigger /系统状态数据包触发
18	Raw Sensors Packet Trigger /原始传感器数据包触发
19	RTCM Differential GNSS Corrections Input /RTCM 差分 GNSS 校正输入
20	Trimble GNSS Input /Trimble GNSS 输入
21	u-blox GNSS Input /u-blox GNSS 输入
22	Hemisphere GNSS Input /Hemisphere GNSS 输入
23	Teledyne DVL Input /Teledyne DVL 输入
24	Tritech USBL Input /Tritech USBL 输入
25	Linkquest DVL Input /Linkquest DVL 输入
26	Pressure Depth Transducer Input /压力深度传感器输入
27	Left Wheel Speed Sensor /左侧轮速计
28	Right Wheel Speed Sensor /右侧轮速计
29	1PPS Input /1PPS 输入
30	Wheel Speed Sensor /轮速计输入
31	Wheel Encoder Phase A /轮速计 A 相输入
32	Wheel Encoder Phase B /轮速计 B 相输入
33	Event 1 Input /事件 1 输入
34	Event 2 Input /事件 2 输入

Table 表 78: GPIO2 functions /GPIO2 功能列表

8.9.8.3 GPIO3 Functions /GPIO3 功能列表

Value /数值	**Description** /说明
0	Inactive /未用
1	1PPS Output /1PPS 输出
2	GNSS Fix Output /GNSS 定位输出
3	Odometer Input /里程计输入
4	Stationary Input /静止状态输入
5	Pitot Tube Input /皮托管输入
7	NMEA Output /NMEA 输出
12	ANPP Output /ANPP 输出
13	Disable Magnetometers /禁用磁场计
14	Disable Internal GNSS /禁用内部 GNSS
15	Disable Pressure /禁用气压高度计
16	Set Zero Orientation Alignment /当前角度置零
17	System State Packet Trigger /系统状态数据包触发
18	Raw Sensors Packet Trigger /原始传感器数据包触发
30	TSS1 Output /TSS1 输出
40	Simrad 1000 Output /Simrad 1000 输出
41	Simrad 3000 Output /Simrad 3000 输出

Table 表 79: GPIO3 functions /GPIO3 功能列表

8.9.8.4 GPIO4 Functions /GPIO4 功能列表

Value /数值	**Description** /说明
0	Inactive /未用
1	1PPS Output /1PPS 输出
2	GNSS Fix Output /GNSS 定位输出
3	Odometer Input /里程计输入
4	Stationary Input /静止状态输入
5	Pitot Tube Input /皮托管输入
6	NMEA Input /NMEA 输入
8	Novatel GNSS Input /NovAtel GNSS 输入
9	Topcon GNSS Input /Topcon GNSS 输入
11	ANPP Input /ANPP 输入
13	Disable Magnetometers /禁用磁场计
14	Disable Internal GNSS /禁用内部 GNSS
15	Disable Pressure /禁用气压高度计
16	Set Zero Orientation Alignment /当前角度置零
17	System State Packet Trigger /系统状态数据包触发
18	Raw Sensors Packet Trigger /原始传感器数据包触发
19	RTCM Differential GNSS Corrections Input /RTCM 差分 GNSS 校正输入
20	Trimble GNSS Input /Trimble GNSS 输入
21	u-blox GNSS Input /u-blox GNSS 输入
22	Hemisphere GNSS Input /Hemisphere GNSS 输入
23	Teledyne DVL Input /Teledyne DVL 输入
24	Tritech USBL Input /Tritech USBL 输入
25	Linkquest DVL Input /Linkquest DVL 输入
26	Pressure Depth Transducer Input /压力深度传感器输入
27	Left Wheel Speed Sensor /左侧轮速计
28	Right Wheel Speed Sensor /右侧轮速计

Table 表 80: GPIO4 functions /GPIO4 功能列表

8.9.9 Magnetic Calibration Values Packet /磁场校正值数据包

Magnetic Calibration Values Packet /磁场校正值数据包				
Packet ID /数据包 ID				189
Length /长度				49
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u8	1	Permanent /永久标志
2	1	fp32	4	Hard iron bias /硬铁偏差值 X
3	5	fp32	4	Hard iron bias /硬铁偏差值 Y
4	9	fp32	4	Hard iron bias /硬铁偏差值 Z
5	13	fp32	4	Soft iron transformation /软铁变换 XX
6	17	fp32	4	Soft iron transformation /软铁变换 XY
7	21	fp32	4	Soft iron transformation /软铁变换 XZ
8	25	fp32	4	Soft iron transformation /软铁变换 YX
9	29	fp32	4	Soft iron transformation /软铁变换 YY
10	33	fp32	4	Soft iron transformation /软铁变换 YZ
11	37	fp32	4	Soft iron transformation 软铁变换 ZX
12	41	fp32	4	Soft iron transformation 软铁变换 ZY
13	45	fp32	4	Soft iron transformation 软铁变换 ZZ

Table 表 81: Magnetic calibration values packet /磁场校正值数据包

8.9.10 Magnetic Calibration Configuration Packet /磁场校正配置数据包

Magnetic Calibration Configuration Packet /磁场校正配置数据包				
Packet ID /数据包 ID				190
Length /长度				1
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u8	1	Magnetic calibration action, /磁场校正动作，详见章节 8.9.10.1

Table 表 82: Magnetic calibration configuration packet /磁场校正配置数据包

8.9.10.1 Magnetic calibration Actions /磁场校正动作

Value /数值	Description /说明
0	Cancel magnetic calibration /取消磁场校正
1	Stabilise heading /稳定航向
2	Start 2D magnetic calibration /开始 2D 磁场校正
3	Start 3D magnetic calibration /开始 3D 磁场校正

Table 表 83: Magnetic calibration action /磁场校正动作

8.9.11 Magnetic Calibration Status Packet /磁场校正状态数据包

Magnetic Calibration Status Packet /磁场校正状态数据包				
Packet ID /数据包 ID				191
Length /长度				3
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u8	1	Magnetic calibration status, /磁场校正状态 8.9.11.1
2	1	u8	1	Magnetic calibration progress /磁场校正进程 (%)
3	2	u8	1	Local magnetic error /当地磁场误差 (%)

Table 表 84: Magnetic calibration status packet /磁场校正状态数据包

8.9.11.1 Magnetic Calibration Status /磁场校正状态

Value /数值	Description /说明
0	Magnetic calibration not completed /磁场校正未完成
1	2D magnetic calibration completed /2D 磁场校正完成
2	3D magnetic calibration completed /3D 磁场校正完成
3	Custom values magnetic calibration completed /用户磁场校正完成
4	Stabilising in progress /稳定进行中
5	2D calibration in progress /2D 校正进行中
6	3D calibration in progress /3D 校正进行中
7	2D calibration error: excessive roll /2D 校正错误：横滚角过大
8	2D calibration error: excessive pitch /2D 校正错误：俯仰角过大
9	Calibration error: sensor over range event /校正错误：传感器超量程
10	Calibration error: time-out /校正错误：超时
11	3D calibration error: not enough points /3D 校正错误：测量点数不够

Table 表 85: Magnetic calibration status /磁场校正状态

8.9.12 Odometer Configuration Packet /轮速计配置数据包

Odometer Configuration Packet /轮速计配置数据包				
Packet ID /数据包 ID				192
Length /长度				8
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u8	1	Permanent /永久标志
2	1	u8	1	Automatic pulse measurement active /使能自动计算脉冲长度
3	2	u8	1	Reserved (set to zero) /保留（输入 0）
4	3	u8	1	Reserved (set to zero) /保留（输入 0）
5	4	fp32	4	Pulse length /脉冲长度数 (m)

Table 表 *86: Odometer configuration packet* /轮速计配置数据包

8.9.13 Set Zero Orientation Alignment Packet /设定当前角度为零

Set Zero Orientation Alignment Packet /设定当前角度为零				
Packet ID /数据包 ID				193
Length /长度				1
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u8	1	Permanent /永久标志

Table 表 *87: Set zero orientation alignment packet* /设定当前角度为零

8.9.14 Heave Offset Packet /升沉值偏移量数据包

Heave Offset Packet /升沉值偏移量数据包				
Packet ID /数据包 ID				194
Length /长度				49
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u8	1	Permanent /永久标志
2	1	fp32	4	Heave point 1 offset /升沉值测量点 1 偏移量 X (m)
3	5	fp32	4	Heave point 1 offset /升沉值测量点 1 偏移量 Y (m)
4	9	fp32	4	Heave point 1 offset /升沉值测量点 1 偏移量 Z (m)
5	13	fp32	4	Heave point 2 offset /升沉值测量点 2 偏移量 X (m)
6	17	fp32	4	Heave point 2 offset /升沉值测量点 2 偏移量 Y (m)
7	21	fp32	4	Heave point 2 offset /升沉值测量点 2 偏移量 Z (m)
8	25	fp32	4	Heave point 3 offset /升沉值测量点 3 偏移量 X (m)
9	29	fp32	4	Heave point 3 offset /升沉值测量点 3 偏移量 Y (m)
10	33	fp32	4	Heave point 3 offset /升沉值测量点 3 偏移量 Z (m)
11	37	fp32	4	Heave point 4 offset /升沉值测量点 4 偏移量 X (m)
12	41	fp32	4	Heave point 4 offset /升沉值测量点 4 偏移量 Y (m)
13	45	fp32	4	Heave point 4 offset /升沉值测量点 4 偏移量 Z (m)

Table 表 88: Heave offset packet /升沉值偏移量数据包

8.9.15 NMEA Output Configuration Packet /NMEA 输出配置数据包

NMEA Output Configuration Packet /NMEA 输出配置数据包				
Packet ID /数据包 ID				195
Length /长度				13
Field # 序号	Bytes Offset 偏移	Data Type 类型	Size 大小	Description 说明
1	0	u8	1	Permanent /永久标志
2	1	u8	1	NMEA Period /NMEA更新率, see section 8.9.15.1
3	2	u8	1	GPZDA Enabled /使能
4	3	u8	1	GPGGA Enabled /使能
5	4	u8	1	GPVTG Enabled /使能
6	5	u8	1	GPRMC Enabled /使能
7	6	u8	1	GPHDT Enabled /使能
8	7	u8	1	PASHR Enabled /使能
9	8	u8	1	GPGSA Enabled /使能
10	9	u8	1	Output Fix Mode /输出持续模式, see section 8.9.15.2
11	10	u8	1	Reserved (set to zero) /保留（置零）

Table 表 89: NMEA Output Configuration Packet /NMEA 输出配置数据包

8.9.15.1 NMEA Period /NMEA 输出周期

The NMEA period is specified in units of 50ms. An NMEA period of 1 therefore equates to a period of 50ms and rate of 20Hz. An NMEA period of 20 equates to a period of 1000ms and a rate of 1Hz.

NMEA 输出周期的单位为 50ms。NMEA 周期为 1，就等于周期为 50ms，相当于 20Hz。NMEA 周期为 20，就等于周期为 1000ms，相当于 1Hz。

8.9.15.2 Output Fix Mode /输出持续模式

When set to zero the output fix behaviour is normal and in line with NMEA standards. When set to one the output fix type remains as 3D GPS fix even when the system is dead reckoning. This behaviour is required to continue operating with some software while dead reckoning.

如果设为,0，输出持续模式为常规输出，与 NMEA 标准一致。如果设为 1，输出持续模式为 3D GPS 定位，及时此时系统处于完全惯性导航状态。

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