RPR 110
INSTALLATION
AND
SERVICE MANUAL

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INTRODUCTION

The Raven RPR 110 GPS receiver provides highly accurate and reliable DGPS navigation using WAAS satellite based DGPS corrections. This receiver is ideal for GIS, precision farming or any other application where a high performance, rugged, and simple to operate receiver is required.

FUNCTIONAL DESCRIPTION

The Raven RPR 110 is a 10 channel high-performance GPS receiver with a built-in DGPS correction receiver. You can select the built-in WAAS receiver or use an external RTCM source for your DGPS corrections. You can even let the receiver automatically select its correction source by using the auto DGPS input mode

DGPS corrections are needed to improve the accuracy of standard GPS. If you operate without DGPS corrections, the accuracy will be about 4 meters RMS. This means the receiver would have an accuracy of about 12 feet in any direction 67% of the time, or about 24 feet 95% of the time. Prior to the government turning off Selective Availability (SA), this error was 100 meters RMS. With DGPS corrections, the receiver can give you positions with a RMS accuracy of 1.4 meters, about 4 feet. If the receiver is operated with a DGPS correction source like USCG or OmniStar service the accuracy would be about 3 feet (sub-meter) RMS.

Accuracy depends on many factors including the correction method and your range from the source. With systems like OmniStar the range from reference station is not as major a factor as it is for the USCG or WAAS systems. We are primarily concerned with WAAS as the 110 is designed to use this as the primary source of DGPS corrections. Considering that today there is a limited number of WAAS reference stations, the accuracy will vary from about 1 meter to 1.4 meters RMS depending on your location.

In addition to improved accuracy, DGPS corrections keep the calculated position from jumping around when the receiver loses or picks up a new satellite. Without DGPS these common occurrences will cause the position to suddenly jump to a new point. Applications such as crop guidance will see accuracies of about 0.75 feet RMS swath to swath when in WAAS DGPS. In this application the DGPS correction source is critical, you don’t want the position to jump around while your spraying a field.

For the functional description we can break the RPR 110 into several parts. Each is described in the following sections.

GPS RECEIVER

The RPR 110 GPS receiver can generate real-time position solutions at a rate of 5 solutions per second. You can purchase an option that enables the 110 to output up to 10 solutions per second. Position solutions are output via RS232 in NMEA format messages.

The RPR 110 has two RS232 ports and can communicate at 1200, 2400, 4800, 9600, 19.2K, or 38.4K BPS on either/both port(s). The baud rate and the desired output messages can be configured via the serial port using configuration messages.

NMEA format messages are standard for most GPS receivers and therefore should be compatible with almost any software or hardware application designed to work with GPS.

The receiver comes from the factory with messages settings that should be compatible with most applications. Refer to the connecting equipment manuals for information about what message types and serial settings they require. By default, the 110 will output GGA and VTG messages on both ports. On port A these messages are output at 19.2K BPS with 5 solutions per second. This is the optimum setting for connection a guidance smart bar such as the Raven LB-5. Port B outputs the same messages at 4800 BPS with 1 solution per second. This is optimum for applications such as GIS or yield monitors.

WAAS RECEIVER

The 110 provides real time differential solutions using free corrections (WAAS) broadcast from satellite. WAAS corrections are available without a subscription free everywhere in the US, parts of Canada, Mexico and Europe using a compatible system called EGNOS. These corrections are available 24 hours a day in all weather conditions.

GPS ANTENNA

The GPS antenna is a low profile patch antenna, which receives both GPS and WAAS signals. The antenna can be mounted to a metal surface using the internal magnetic mount. The antenna is supplied with a 15-foot cable with a BNC connector.

UTILITY SOFTWARE

Utility software is not required to setup or use the receiver in most applications. However, a utility program is available from Raven.

RECEIVER FIRMWARE UPDATES

Firmware is software, which resides inside the receiver. Raven continues to improve the performance of its receiver products and sometimes makes special features available. When this happens, a new version of firmware is created. You can request this firmware from Raven. You will need to connect the receiver to a PC and run the included programming software to update the unit. You should check with your dealer for a new versions of firmware.

It should be noted that updates cover such things as bug fixes and performance enhancements. Sometimes upgrades can also be programmed into the receiver using the utility software. Up-grades also include things such as the 10 position solutions per second option, which does have additional cost. The good thing is that you can install these upgrades and updates. You will need to get a code from your dealer or directly from Raven to install the upgrades but the process is simple.

SPECIAL FEATURES

The RPR 110 has several special features that make it ideal for some applications. Raven is always interested in adding special features to the receiver. If you have a good idea, please send us an email at fcdinfo@ravenind.com or give us a call at 800-243-5435. We can’t guarantee that your idea will be implemented but we do want to consider it.

PPS OUT

The PPS output is normally used to provide a timing signal to another device. PPS stands for Pulse Per Second and that's what the signal does. Once each second the signal pulses to indicate the start of a GPS second. The GPS second is a time reference, which can be used to synchronize systems. If your application requires very accurate time then the PPS output may be required.

The PPS output can also be used as a RADAR or Speed Log output as described in the following sections.

RADAR OUT

The receivers can simulate a Doppler RADAR commonly used on agricultural equipment for detecting speed. The GPS receiver is always calculating speed and can generate the signals, which can be used by equipment requiring RADAR input. The receiver is normally configured at the factory for RADAR output.

To use this feature you will need a special cable from Raven. It should be noted that the GPS can only determine speed when it's navigating. If a tree line blocks too many satellites or if for some other reason the Receiver is unable to navigate, then the RADAR output could become invalid.

The scaling factors and timing controls that govern the operation of this feature can be controlled via a serial configuration message as defined in the Serial Protocol Definition document. The receiver uses default settings that should provide reasonable operation without the need for special configuration.

ADVANCED MESSAGE FORWARDING

The RPR 110 receiver supports advanced message forwarding in systems where the application is designed to take full advantage of this feature. When enabled, all messages received on Port B of the receiver will be time tagged with GPS time and output on Port A in a special format.

The special format is basically just a prefix that includes the time tag. The time tag is very important since it is referenced to GPS time and provided with millisecond resolution. It can be used to completely eliminate latency issues. Latency is usually only an issue in systems where GPS positions are used to locate data coming from another sensor. If not accounted for, the latency of output can show up as positional errors.

The advanced message forwarding takes care of latency problems in systems where the other sensor can output NMEA style messages. This feature would also be useful in systems with limited serial ports if the application developer were to take advantage of this feature.

INSTALLATION

Start by selecting a location for each of the various parts of the system. The antenna, for example, should be carefully located per the guidelines given below. Do not route the cables or permanently mount the antenna or receiver yet. Once the system is operating, then you can route the cables and permanently mount the receiver and antenna. This way, you won't have as much trouble if a problem is found in your initial locations.

INITIAL POWER UP

RPR receivers are reverse power protected so you should not hurt the receiver if you follow these steps:

Make sure the receiver is not touching any metal surfaces. Place a piece of paper or something between the receiver and the metal surface if necessary. If you have the power backwards, a short will exist between the grounded metal surface and the ground lead (which is power by accident). This short could burn up the ground wire or blow a fuse. It's a good idea to isolate the receiver from your chassis the first time it's powered up.

Connect the antenna to the receiver but don't connect any of the other cables. Right now you should have the antenna temporarily mounted and connected to the RPR. You should be ready to apply power.

Turn off all the equipment on your machine. The receiver draws very little power and this test will only take a few minutes. You want the other equipment off because it might interfere with the receiver. Once you get the RPR working, you will turn on the other equipment and watch for problems.

Apply power to the receiver. Watch the red LED power indicator. It should light up. If it does not, you either don't have power or power is connected backwards. If you're in a car, try turning the key on. Check the connections and try again. If you still have trouble, refer to the Power section below. The yellow RTCM status LED should blink then go out until a correction signal is located. If the RTCM status light is flashing rapidly (4 times per second), the antenna cable is either open or shorted.

Once you have the receiver power connected correctly go ahead and shut the power off. Mount the receiver and repeat the previous step. If the power does not work when you mount the receiver then you may have a positive ground system. If so, the fuse in your machine is probably blown. You will need to isolate the receiver from your chassis at all times in systems with positive grounds.

At this point, we have the power connected to the mounted receiver and the antenna is connected. Watch the green LED GPS satellite-tracking indicator. The RPR 110 will be looking for satellites, which may take a few minutes. Eventually, if your antenna has a clear view of the sky, the GPS light will flash once for each satellite in view that it is using to calculate its position.

Wait for the receiver to find and track the WAAS signal, it could take 15 or more minutes before the receiver gets the necessary almanac data from the selected WAAS satellite. This initial startup time is necessary only during the first time you use the receiver. Once the broadcast is found the receiver will power up and start receiving signals after about 5 seconds. If you don't get a signal within about 30 minutes there could be some form of interference or you may not be in the coverage area of the selected WAAS satellite. You should see the RTCM light come on and remain steady if your getting corrections.

At this point, your receiver should be tracking satellites and generating good differential positions. Start turning on the other equipment on your machine. As each device is turned on, watch the LED status indicators for problems. A device could interfere with the GPS satellites or WAAS signals. You should wait about 30 seconds after each device is turned on to see if the receiver stops tracking satellites or if the RTCM indicator goes out. Finally, start up the machine and again watch for any problems.

If after you turn something on, a problem is found, you can try moving the antenna further away from that device. Check that the device is functioning properly and also check its power connections. Some devices can generate too much noise naturally or because of defective components.

Now you have the receiver working with everything that could interfere. Shut everything off, mount the antenna, and route the cables. Once this is done, repeat the power up steps.

The last few steps deal with connecting the other equipment that gets data from the RPR 110. Refer to the manufacturer's documentation for details such as baud rates and required messages. It is very likely that you only need to connect the interface cable to the device. The RPR 110 is configured, by default, to work with most systems without any adjustments.

All configuration and WAAS data is stored in non-volatile memory inside the RPR 110. If you need to change the WAAS or GPS setups, you can run the receiver software to make the changes.

POWER

The RPR 110 receiver needs DC power between 9 and 16 Volts. DC power is usually provided by a battery on the machine or via a power adapter of some type. If your unit came with an automotive power adapter, verify that your vehicle has a negative ground system before you connect to power. If your unit came with an AC adapter, you need only connect the adapter to an AC source.

GPS ANTENNA

GPS is a line-of-sight system, which means in order for the receiver to track the satellites there must be an unobstructed path directly to them. Buildings, trees, machinery, and human bodies are common obstructions. When locating the antenna, find a place where the antenna will have an unobstructed view of the sky.

Items such as electrical motors, generators, alternators, strobe lights, radio transmitters, cellular phones, microwave dishes, radar, active antennas, etc., all generate electrical and magnetic fields which can interfere with the GPS or WAAS signal. Mount the antenna away from such potential sources of interference.

The GPS can be de-tuned by close proximity to other objects. For example, if you place the antenna under fiberglass its performance could be degraded. Usually, if you lower the antenna so that at least a quarter of an inch gap is made between the antenna and the covering plastic or fiberglass, acceptable performance can be achieved. Metal or other dense materials will completely block the GPS signals.

ANTENNA CABLE

The antenna cable should be routed around your machine so that it's out of the way. Make sure it is not subject to scraping or excessively sharp bending. Also, make sure the antenna cable has some slack. It needs just enough to prevent strain on the connections.

It's important that the cable's outer insulation jacket is never broken. Make sure that the cable is routed away from sharp or abrasive surfaces. Also, make sure the metal surfaces of the connectors on the cable do not come in contact with the chassis of your machine.

OPERATION

INITIAL STARTUP

Both the internal GPS and WAAS receiver must perform a **Cold Start** the first time you power up the system. The GPS receiver will search the sky for satellites and download data necessary for operation. The WAAS receiver will wait until the required almanac data is received. The cold start will take up to 15 minutes but is only required during the initial power up.

Always make sure the antenna is connected to the receiver before powering the unit. Connect the serial cable provided between the RPR 110 and your computer, apply power and verify that the red power LED is on. Allow the receiver to operate while you install the software program on your computer. Turn off all unnecessary electrical equipment to minimize electrical noise interference.

NORMAL OPERATION

Upon completion of the initial “Cold Start”, the receiver begins to operate in “Normal Mode”. The unit should be operating in full DGPS mode within a few minutes of power on.

All configuration and WAAS data is stored in nonvolatile memory inside the RPR 110 110. Configuration changes are made with utility software.

Be aware of possible satellite obstructions, which may interfere with GPS operation. For high precision applications, watch your Horizontal Dilution of Precision (HDOP) and WAAS Age of Data (AOD). The HDOP should be 2 or less and the AOD less than 15 seconds.

TROUBLESHOOTING

*Make certain the antenna is mounted so that it has a clear view of the sky and is as far away from electrical noise sources as possible.

Attempt to isolate all problems as either:

- Receiver
- Antenna (including cables)
- Power
- Transmitting Site
- Serial Communications

  a. Receiver

  b. Peripheral device

CHECKING YOUR INSTALLATION

Monitor the effects on the beacon and GPS receiver performance as each device on your vehicle is powered on. If the receiver stops operating properly when a device is powered on, that device is causing interference and your antenna location may need to change. For example, if running your engine causes interference, then ignition noise or alternator noise is interfering with signal reception. Move the antenna further away from the engine.

Receiver - Normally only 5 GPS satellites are required for good accuracy. View the LED status indicator on the front panel and check the number of satellites being tracked. Also look for the yellow RTCM light indicating good differential reception.

Antenna - Check connections between the antenna and receiver. Verify the connectors and cable are in good condition. An ohmmeter can be used to determine if the antenna cable is open or shorted.

Power - Red power LED remains lit while power is applied.

Transmitting -If the receiver is operating in WAAS Mode, you may be out of range of a satellite or the satellite may be off air. WAAS status information is available on the Internet at www.FAA…

Serial Coms -Using GPS Mon software, check for proper communication settings baud rate, and COM port number. Make sure the cable you use, if not provided by Raven, is wired correctly. See section titled “Rear Panel Serial Interface”.

RECEIVER SPECIFICATIONS

Size	7.63″ x 4.13″ x 1.75″	**Protocols**	NMEA v2.2
Weight	20 ounces	**Position Accuracy**	50 meter RMS, SA on
Operating Temperature	-40°C to +70°C		4 meter RMS, SA off
Operating Humidity	5% to 95% R.H., Non-condensing, at +60°C	**Antenna Size**	1.4 meter RMS, WAAS DGPS 1.9″W x 0.6″H x 2.3″L
Channels	10 GPS, 1 WAAS	**Antenna Weight**	65 grams
Update Rate	5/second (10/second optionally)	**Mounting**	Magnetic
Power Consumption	4 Watts Typical	**Ant. Operating Temp.**	-40°C to +85°C
Voltage	9-16 VDC	**Ant. Operating Humid.**	100% Condensing

ANTENNA

The ANT connector is used for interfacing between the RPR 110 and its Antenna/ Preamplifier assembly.

Pin	**Description**
Center	RF Input and +5VDC Output for Antenna Preamplifier
Shield	Signal Ground

CONFIGURATION

REAR PANEL SERIAL INTERFACE

The RPR 110 has two bi-directional RS232 serial interfaces available on a single external DB9 female connector. Each port is assigned a single letter in uppercase, '**A**' or '**B**' and each one provides the necessary interfacing between the RPR 110 and your navigation equipment.

DB9-F

Port A	Signal Name
1	RAD/PPS
2	Port "A" TX
3	Port "A" RX
4	Port "B" RX
5	GND
6	Port "B" TX
7	No connect
8	+12 VDC Pwr Input
9	GND

GLOBAL POSITIONING SYSTEM (GPS)

GPS is a satellite-based global navigation system created and operated by the United States Department of Defense (DOD). Originally intended solely to enhance military defense capabili-ties, GPS capabilities have expanded to provide highly accurate position and timing information for many civilian applications.

An in-depth study of GPS is required to fully understand it, but not to see how it works or appreciate what it can do for you. Simply stated, twenty-four satellites in six orbital paths circle the earth twice each day at an inclination angle of approximately 55 degrees to the equator. This constellation of satellites continuously transmits coded positional and timing information at high frequencies in the 1500 Megahertz range. GPS receivers with antennas located in a position to clearly view the satellites pick up these signals and use the coded information to calculate a position in an earth coordinate system.

GPS is the navigation system of choice for today and many years to come. While GPS is clearly the most accurate worldwide all-weather navigation system yet developed, it still can exhibit significant errors. GPS receivers determine position by calculating the time it takes for the radio signals transmitted from each satellite to reach earth. It's that old "Distance = Rate x Time" equation. Radio waves travel at the speed of light (Rate). Time is determined using an ingenious code matching technique within the GPS receiver. With time determined, and the fact that the satellite's position is reported in each coded navigation message, by using a little trigonometry the receiver can determine its location on earth.

Position accuracy depends on the receiver's ability to accurately calculate the time it takes for each satellite signal to travel to earth. This is where the problem lies. There are primarily five sources of errors, which can affect the receiver's calculation. These errors consist of:

1. Ionosphere and troposphere delays on the radio signal.

2. Signal multi-path.

3. Receiver clock biases.

4. Orbital satellite (ephemeris) position errors.

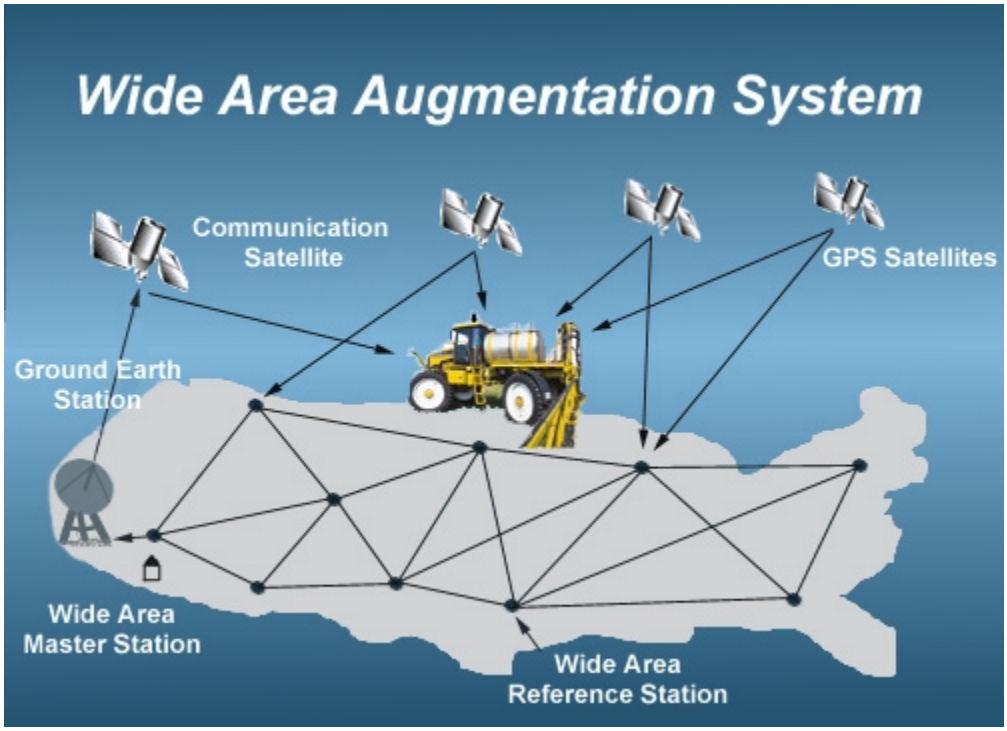
5. Intentional degradation of the satellite signal by the DOD (SA).

This intentional degradation of the signal is known as "Selective Availability" (SA) and is intended to prevent adversaries from exploiting highly accurate GPS signals and using them against the United States or its allies. SA accounts for the majority of the error budget. The combination of these errors in conjunction with poor satellite geometry can limit GPS accuracy to 100 meters 95% of the time and up to 300 meters 5% of the time. Fortunately, many of these errors can be reduced or eliminated through a technique known as "**Differential**."

DIFFERENTIAL GPS (DGPS) WAAS

DGPS works by placing a high-performance GPS receiver (reference station) at a known location. Since the receiver knows its exact location, it can determine the errors in the satellite signals. It does this by measuring the ranges to each satellite using the signals received and comparing these measured ranges to the actual ranges calculated from its known position. The difference between the measured and calculated range is the total error. The error data for each tracked satellite is formatted into a correction message and transmitted to GPS users. The correction message format follows the standard established by the Radio Technical Commission for Maritime Services, Special Committee 104 (RTCM-SC104). These differential corrections are then applied to the GPS calculations, thus removing most of the satellite signal error and improving accuracy. The level of accuracy obtained is a function of the GPS receiver. WAAS is based on a network of approximately 25 ground reference stations that cover a very large service area. Signals from GPS satellites are received by wide area ground reference stations and used to generate DGPS corrections.

Differential GPS Broadcast Site



NMEA MESSAGES

The RPR 110 receiver can be used to communicate with other electronic devices including Raven's RGL 500 Swath Guidance Light bar. A communication protocol (set of rules) known as the NMEA 0183 standard has been established by the National Marine Electronics Association. The NMEA 0183 standard contains numerous message formats such as the ones described below which the RPR 110 receiver uses to communicate with other devices.

RPR 110 NMEA Messages

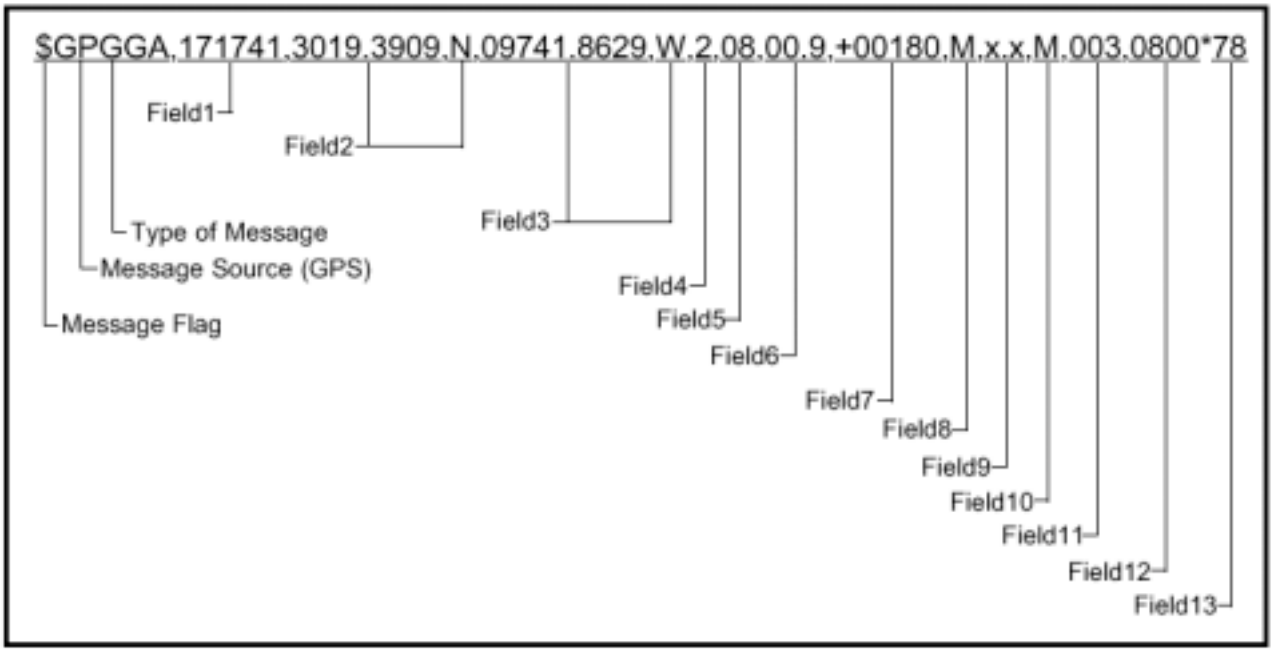
ALM	GPS Almanac Data
DTM	Datum Reference
GGA	Global Positioning System Fix Data
GLL	Geographic Position
GRS	GPS Range Residuals
GSA	GPS Dillution of Precision (DOP) and Active Satellites
GST	GPS Pseudorange Noise Statistics
GSV	GPS Satellites in View
MSK	MSK Receiver Interface
MSS	MSK Signal Status
RMC	Recommended Minimum specific GPS/Transit Data
VTG	Course Over Ground and Ground Speed
ZDA	Time and Date

PROPRIETARY NMEA MESSAGES

SLIB1S	Beacon Receiver Channel 1 Status
SLIB2S	Beacon Receiver Channel 2 Status
SLIDIF	DGPS Status Information
SLIE1S	External RTCM Channel 1 Status
SLIRTC	RTCM Message Data Received
SLISDA	Satellite Age of Data
SLISOL	Position Solution
SLIWRN	Receiver Warning Message

SAMPLE GGA MESSAGE STRUCTURE

The following example of the GGA message shows the format typical of NMEA messages.



Field	Description	Field	Description
$	Message Flag	6	Horizontal Dilution of Precision
GP	Message Source (GPS)	7	Antenna Altitude Ref: Mean Sea Level (geoid)
GGA	Type of Message	8	Units of Antenna Altitude, Meters
1	Universal Time Coordinate (UTC) of Position	9	Geoidal Separation
2	Latitude, North or South	10	Units of Geoidal Separation, Meters
3	Longitude, East or West	11	Age of Differential Data
4	GPS Quality Indicator	12	Reference Station ID
5	Number of Satellites in Use	13	Check Sum

RAVEN INDUSTRIES

LIMITED WARRANTY

WHAT IS COVERED?

This warranty covers all defects in workmanship or materials in your Raven Flow Control Product under normal use, maintenance, and service.

HOW LONG IS THE COVERAGE PERIOD?

This warranty coverage runs for 12 months from the purchase date of your Raven Flow Control Product. This warranty coverage applies only to the original owner and is not transferrable.

HOW CAN YOU GET SERVICE?

Bring the defective part, and proof of date of purchase, to your local dealer. If your dealer agrees with the warranty claim, he will send the part, and proof of purchase to his distributor or to Raven for final approval.

WHAT WILL RAVEN INDUSTRIES DO?

When our inspection proves the warranty claim, we will, at our option, repair or replace the defective part and pay for return freight.

WHAT DOES THIS WARRANTY NOT COVER?

Raven Industries will not assume any expense or liability for repairs made outside our plant without written consent. We are not responsible for damage to any associated equipment or product and will not be liable for loss of profit or other special damages. The obligation of this warranty is in lieu of all other warranties, expressed or implied, and no person is authorized to assume for us any liability. Damages caused by normal wear and tear, mis-use, abuse, neglect, accident, or improper installation and maintenance are not covered by this warranty.

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