ABOUT HONEYWELL AEROSPACE

Honeywell Aerospace innovates and integrates thousands of products, software, and services to advance and more easily deliver safe, efficient, productive, and comfortable transportation experiences worldwide. Our offerings are found on virtually every commercial, defense, and space aircraft.

We develop innovative solutions for more fuel-efficient and environmentally-friendly airplanes, more direct and on-time flights, safer flying and reduced runway and flight traffic plus engines, cockpit and cabin electronics, wireless connectivity equipment and services, and logistics.

In 2016, Honeywell launched a new business unit to bring a new range of class-leading IMUs and navigators to market. These are available with no export license (ECCN = 7A994), bringing our traditional aerospace quality and design standards to a new range of customers at industrial pricing.

To learn more about the Honeywell's HGuide IMUs and navigators, please visit: aerospace.honeywell.com/hguide.

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HOW TO SYNCHRONIZE

a Honeywell HGuide n580 navigator with a Velodyne HDL-32E or VLP-16 LiDAR unit

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EXECUTIVE SUMMARY

Honeywell has been producing high-performance inertial sensors for decades and has delivered more than 500,000 units to serve as navigation aids on just about every airplane and spacecraft flying today.

Our diverse suite of non-itar, commercial HGuide inertial measurement units (IMUs) and navigators provide the same technology and are available today for several industrial applications including but not limited to agriculture, AUVs, communications, industrial equipment, marine, oil and gas, robotics, survey and mapping, stabilized platforms, transportation, UAVs and UGVs.

The Honeywell HGuide n580 is a small, light-weight, self-contained, all-attitude inertial navigation system (INS)/global navigation satellite system (GNSS) navigator that provides position and orientation information, even when GPS/GNSS signals aren't available.

The HGuide n580 INS/GNSS contains Honeywell's leading edge HG4930 IMU and provides a powerful dual-antenna, multi-frequency, multi-constellation real-time kinematic (RTK) capability. Honeywell's integration expertise blends the IMU and GNSS data to provide accurate, robust navigation data.

Mobile Applications

Users needing to collect and process light detection and ranging (LiDAR) data from a static location need to know the location of the scanner to anchor the data logged and subsequent 3D image to a real latitude, longitude and height. It is usually assumed that the scanner has been set up so it is level.

If this scanning is performed from a moving platform like a car or aerial vehicle the location and attitude of the vehicle will constantly change over time. Thus, the user will need to understand a few key parameters about the host vehicle:

– Latitude, longitude and altitude at the precise time the LiDAR data is valid

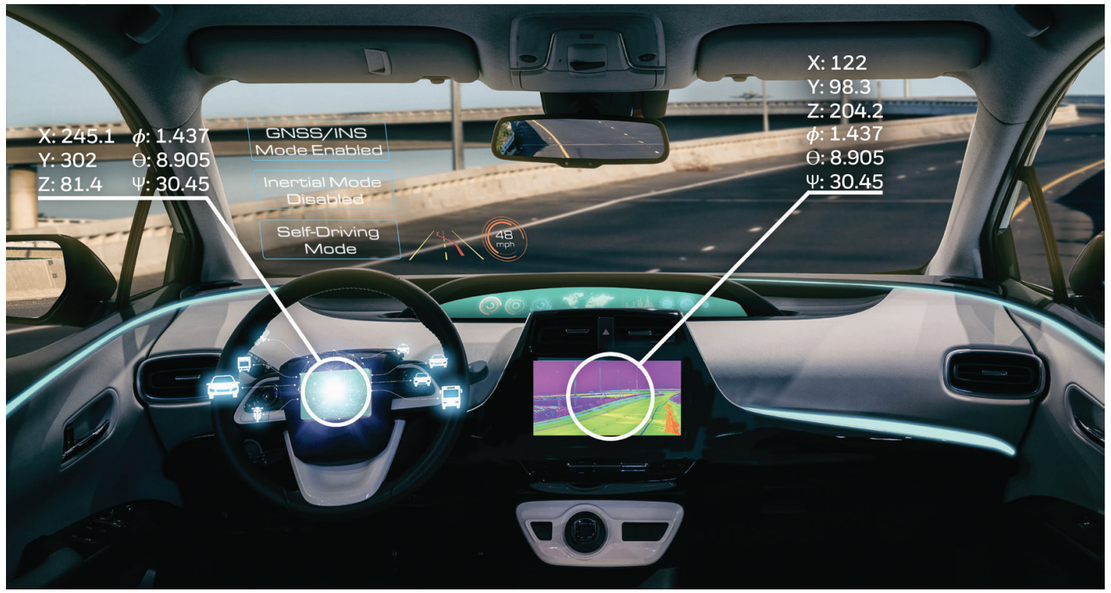
– Attitude at the precise time the LiDAR data is valid

– Time the LiDAR data is valid

These critical parameters are needed to use the point cloud data to build an accurate 3D map of the recorded environment.

HOW TO SYNCHRONIZE

a Honeywell HGuide n580 navigator with a Velodyne HDL-32E or VLP-16 LiDAR unit



An INS/GNSS is the key to understanding the vehicle dynamics during the data collection.

An INS/GNSS typically comprises a GNSS receiver, an IMU and data fusion software (e.g., Kalman Filter) to blend the GNSS and IMU data. Often this is supplemented with an odometer which provides vehicle speed to the data fusion software.

This navigation solution may be used in real-time. In other cases, raw data files from the INS/GNSS are logged for later processing. This paper will discuss the data-logging variant, however the LiDAR synchronization methodology is identical.

Using an INS/GNSS, the user will understand precise position, time and attitude at each point of the data collection run. Adding an odometer as a 3rd sensor improves this solution when the GNSS signal is not available, for example in tunnels or dense urban canyons.

The Honeywell HGuide n580 is ideal for applications with these requirements.

SYNCHRONIZATION CONCEPT

To merge the INS/GNSS and LiDAR data correctly, it is essential that the timestamps on the INS/GNSS and LiDAR data files are synchronized to a common reference clock. Typically, the synchronization between the data logged by the INS/GNSS and the LiDAR unit is achieved by using GPS time as the primary clock.

To effectively timestamp the Velodyne HDL-32E or VLP-16 LiDAR data file only requires two pieces of information from the INS/GNSS:

– A TTL level '1 pulse per second' (1PPS) signal. This is required to be sent precisely every second.

– NMEA $GPRMC message, which contains the actual time of the 1PPS.

The HGuide n580 output messages and relative timing of these signals has been designed and tested to be easily integrated with the Velodyne HDL-32E and VLP-16 as well as many other LiDAR scanners.

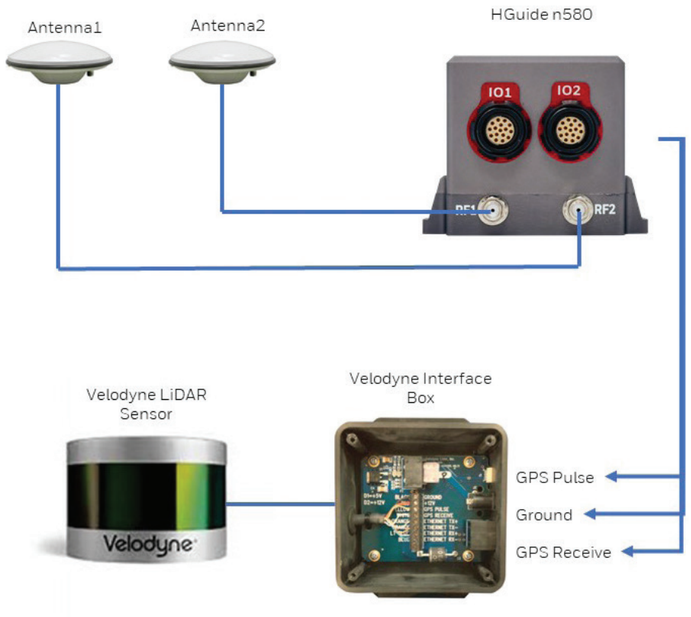


Figure 1: HGuide n580 -> LiDAR Interface Box -> LiDAR Diagram

This diagram shows how the major building blocks of the system are connected. The GNSS antennae provide an RF signal into the HGuide n580. The HGuide n580 provides both a 1PPS and real time GNSS data, including GPS time to the Velodyne unit.

PROCESS TO SET UP SYNC

The Honeywell HGuide n580 Navigator is set up to provide the $GPRMC and 1PPS signals needed through the IO2 port. IO1 typically carries the data to be logged.

The HGuide n580 allows for other connection methods too.

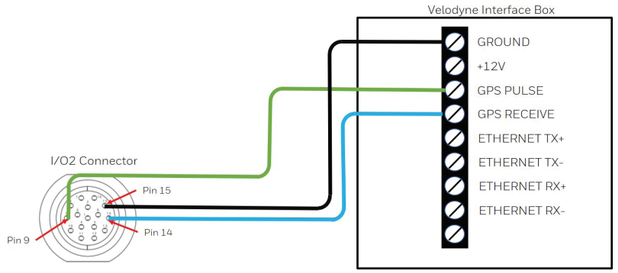
The 1PPS is always present and the $GPRMC message is on by default. However, the user may have disabled the $GPRMC message. Users have two options to enable the $GPRMC message if a customized configuration is already running on the HGuide n580.

– The easiest way to do this is to load in a config file, available from Honeywell.

– Alternatively, the user can issue a command to the HGuide n580 to re-enable the $GPRMC message.

– Full instructions on uploading config files and setting messages can be found in the HGuide n580 manual.

– The diagram and table below shows the connections that must be made from the HGuide n580 to the Velodyne interface box. It is possible to bypass the interface box and connect directly to the Velodyne LiDAR unit. More details are in the Velodyne manual.



SIGNAL	HGUIDE N580		VELODYNE INTERFACE BOX	
	IO Port	**Pin Number**	**Pin Label**	**Color**
Ground	102	Pin 15	Ground	Black
$GPRMC Message	102	Pin 14	GPS Receive	Blue
1PPS	102	Pin 9	GPS Pulse	Green

Figure 2. HGuide n580 to Velodyne Interface Box wiring table

– Once these connections have been made, power up the HGuide n580 and Velodyne LiDAR unit, ensuring the GNSS antennae connected to the HGuide n580 have a good view of the sky. This is needed to ensure it receives a satellite signal.

– Ensure the GNSS board in the HGuide n580 has acquired 'GNSS Lock,' by using the HGuide Data Reader program to verify status. The screen shot below shows latitude, longitude and altitude in the 'position' window. This indicates that the GNSS receiver has a GNSS position lock.

Figure 3 illustrates why our HGuide n580 navigator is vital to mobile applications that use LIDAR, like autonomous vehicles and unmanned aerial vehicles (UAVs). In this model, the autonomous car is passing under a bridge and loses GNSS for some time (travel line goes from blue to yellow). Fortunately, our HGuide n580 still produces real-time, accurate navigation data in GNSS-denied areas.

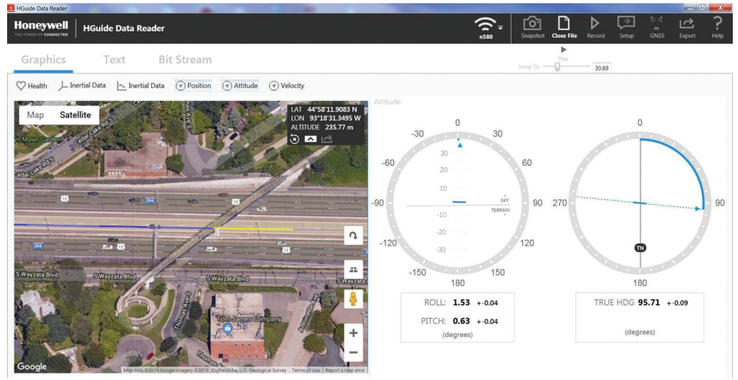


Figure 3: HGuide n580 Provides Accurate Navigation Data Driving Under an Overpass

To manually confirm the connection has been made, connect to the Velodyne hardware via Ethernet. The Webserver User Interface can be connected to by typing http://192.168.1.201 into the browser URL bar.

Once the user has confirmed that the PPS signal is 'Locked' and the GNSS position shown by the Velodyne software matches the position seen in the HGuide data reader, the user can begin to log both LiDAR and INS/GNSS data. The timestamping on both files will be concurrent and will support the offline data processing flow.

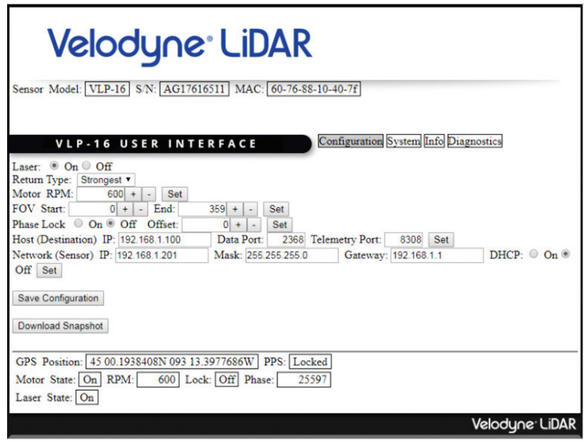


Figure 4: Velodyne LiDAR Software Showing GPS Position and PPS 'locked'

Conclusion

Synchronizing the Honeywell HGuide n580 and Velodyne VLP-16 or VLP-32E is a quick, simple task, enabling users to sync the files recorded by the LiDAR to those being logged from the HGuide n580.

The HGuide n580 output data includes time stamped position, velocity, angular rate, linear acceleration, roll, pitch and heading information. In dual-antenna mode, the device supports GNSS-based heading measurements and initialization and has been specifically designed with a broad range of inputs and outputs to quickly and easily interface with many other sensors.

Among these are the Velodyne VLP-16 and VLP-32E LiDAR units. The outputs required for this integration are available by default and users can quickly and easily connect the two hardware units and be ready to collect data.

More information on the Honeywell HGuide n580 can be found here.

Further information can be found in the Velodyne HDL-32E & VLP-16 Interface Box manual here.