

**HOW TO
ENHANCE
POINT
CLOUDS
USING
HONEYWELL'S
HGUIDE N580**

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EXECUTIVE SUMMARY

For companies in surveying and mapping, generating accurate point clouds is critical when creating mapping systems. Creating them real-time reduces the overhead needed in post-processing and opens new possibilities for the final application.

From collision avoidance in areas surrounded by rugged terrain, to mapping urban areas where GNSS/GPS signals aren't available, knowing where you are in relation to detected obstacles and locating the point clouds and photographs correctly is important.

In this study, we identify how customers can easily create accurate point clouds in real-time using our HGuide n580 inertial navigation system (INS/GNSS) in combination with one or more sensors on a computer running the robotic operating system (ROS).

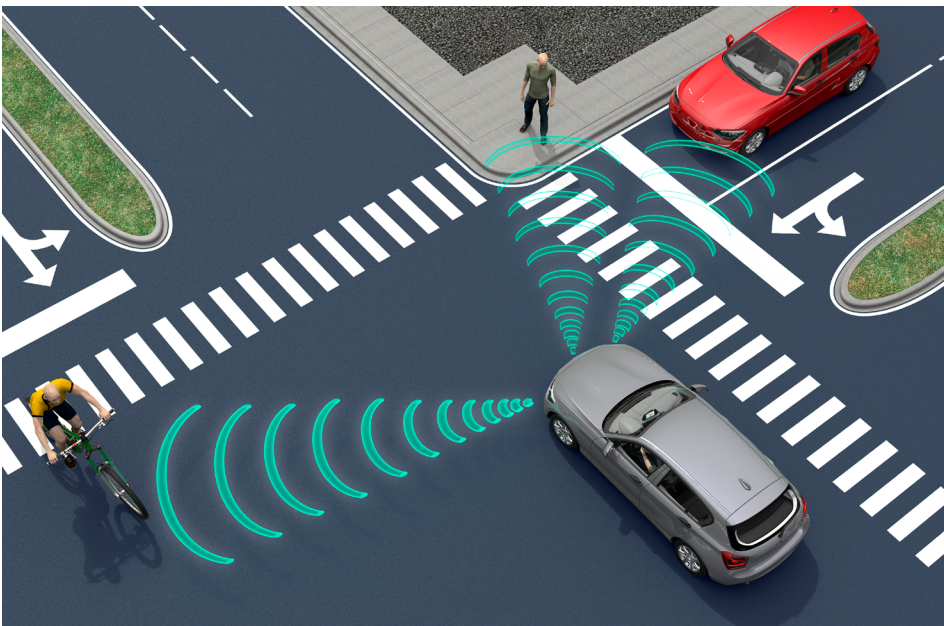
PROBLEM STATEMENT

Surveying and mapping companies rely on post-processing software, requiring all sensors to be synchronized by a pulse per second (PPS) signal achieved by using light detection and ranging (LiDAR) systems and navigation data. The navigation data is usually derived from an inertial navigation system which uses inertial sensors, a GNSS receiver and sensor fusion software.

For applications like mobile mapping, companies may require real-time point clouds to develop mapping systems for urban areas. Similarly, unmanned aerial vehicles (UAVs) may need real-time point cloud information to avoid terrain in their flight path. Having position and attitude information from the INS/GNSS simplifies the integration into complex systems and greatly reduces the computation power requirements.

In addition, developing or buying the software required to achieve real-time point clouds can be expensive and time-consuming.

It's important to note that our study identifies a quick and easy way to enhance real-time point clouds in a prototyping instance and that customers may need to consider alternative approaches for production use cases.



HARDWARE SYSTEMS ARCHITECTURE

To conduct this study and create real-time point clouds, we used our HGuide n580 INS/GNSS, a Velodyne VLP-16 LiDAR system, a computer and the robotic operating system (ROS) nodes which are available for both units to position point clouds.

To achieve the same results, it's important that you use a computer with the ROS installed. For this study, we used an NVIDIA Jetson AGX Xavier with Ubuntu 18.08 with ROS melodic distribution. Please refer to Diagram A to see how we connected everything to our HGuide n580 INS/GNSS.

The ROS is supported on a wide scale of architectures including Ubuntu, Windows 10 and experimental implementations like on OS X.

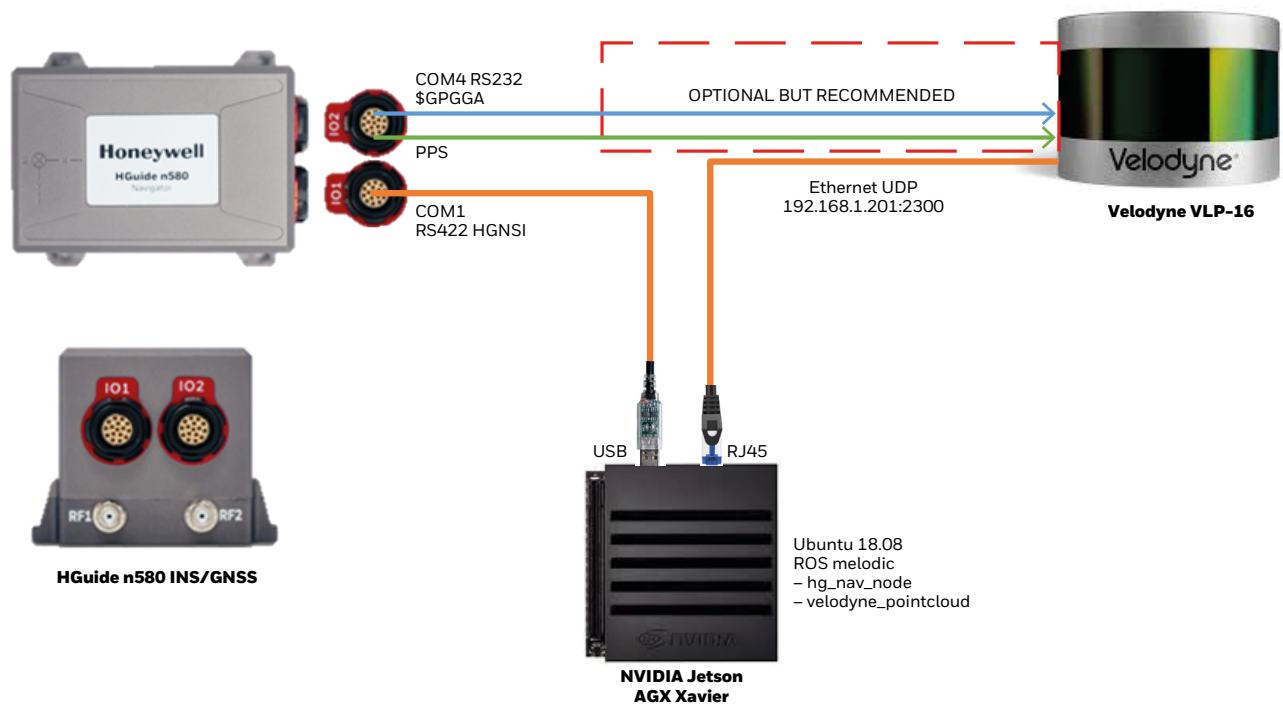
You can find the ROS installation procedure here:

<http://wiki.ros.org/melodic/Installation>

For more information on how to synchronize a Honeywell HGuide n580 INS/GNSS with a Velodyne VLP-16 or HDL-32E LiDAR unit, [you can download our related study here](#).

The HGuide n580 INS/GNSS can provide pulse per second (PPS) and GPGGA string (global positioning system fix data NMEA sentence) to the Velodyne VLP-16 LiDAR system. Although this is optional, it's highly recommended to achieve the most accurate results.

Diagram A: Hardware connection diagram with Honeywell HGuide n580 INS/GNSS

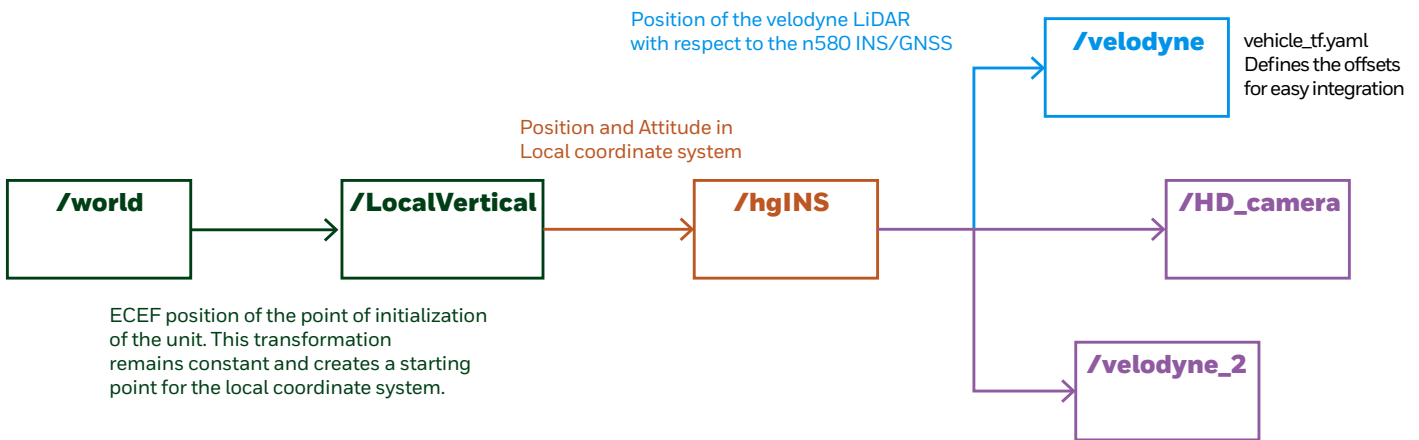


SOFTWARE SYSTEMS ARCHITECTURE

The hg_nav_node is an ROS driver for the HGuide navigation portfolio and it handles the conversion of binary data coming out of the HGuide n580 INS/GNSS to human readable numbers, such as geodetic position (latitude, longitude, altitude) and attitude information.

This data is used to generate transformation functions from the unit itself (/hgINS frame) to the user defined frames, which could be the positions of various sensors such as LiDAR, cameras, ultra sounds, etc. The user can define the frames via a simple .yaml configuration (vehicle_tf.yaml). In order to better understand the transformation tree, please see the Diagram B which describes the transformations made.

Diagram B: Real-time robotic operating system transformation tree



Frame Name	Frame Description
/world	ECEF (Earth-Centered, Earth-Fixed) coordinates zero point
/LocalVertical	Position and attitude of the n580 INS/GNSS in ECEF coordinates upon initialization
/hgINS	n580 INS/GNSS in the local coordinates during run
/velodyne	Frame of Velodyne VLP-16 LiDAR where the point cloud data points are referenced
/HD_camera	Another sensor
/velodyne_2	Another sensor

The hg_nav_node and Velodyne's ROS driver called velodyne_pointcloud will position the LiDAR scans (/velodyne frame) precisely and enables real-time maps as well as greatly simplifying simultaneous localization and mapping (SLAM) applications. This principle can be applied on any sensor with an ROS driver accelerating the integration and reducing risk when upgrading systems with new sensors.

Honeywell ROS drivers and the Velodyne ROS drivers used to conduct this study, can be downloaded here:

Honeywell HGuide:

<https://gitlab.com/HoneywellIMU/RosDriver>

ros.wiki page of the hg_nav_node (http://wiki.ros.org/hg_nav_node)

Velodyne:

<http://wiki.ros.org/velodyne>

INSTRUCTIONS FOR INTEGRATING SOFTWARE

This section describes the necessary steps to run the HGuide ROS driver with Velodyne's VLP-16 LiDAR. It assumes the default configuration of ROS environment and Velodyne LiDAR.

Prerequisites:

- Jetson AGX Xavier with Jetpack and ROS installed
 - ~ Jetpack installation instructions:
<https://developer.NVIDIA.com/embedded/jetpack>
 - ~ ROS Installation instructions:
<http://wiki.ros.org/melodic/Installation>
- Hardware is connected according to Diagram A
- You're using a Honeywell HGuide n580 INS/GNSS with an available GNSS signal
- Ensure the IP address configured in Velodyne VLP-16 LiDAR is reachable from the Jetson environment
 - ~ **\$ ping 192.168.1.201**

QUICK START:

1. Configure the lever arm from HGuide n580 INS/GNSS to Velodyne LiDAR

```
$ cd ~/catkin_ws/  
$ source ./devel/setup.bash  
$ cd /src/hg_nav_node/launch  
$ gedit vehicle_tf.yaml
```
2. Input the translation and rotation of the Velodyne frame

```
X, Y, Z Translation [m] -----> - frameName: velodyne  
                                pos: [1,0,0.1] # [m]  
Roll, Pitch, Yaw Rotation [deg] -----> rpy: [0,0,3] # [deg]
```
3. Launch the Velodyne VLP-16 driver [velodyne_pointcloud]

```
$ cd ~/catkin_ws/  
$ roslaunch velodyne_pointcloud VLP-16.launch
```
4. Open new terminal
5. Switch to super user to access the USB COM port correctly.

```
$ sudo su
```
6. Launch the HGuide n580 INS/GNSS driver [hg_nav_node]

```
$ cd ~/catkin_ws/  
$ source ./devel/setup.bash  
$ roslaunch hg_nav_node n580_start.launch
```

NOTE

When using custom IP and/or port number, those changes must be present in the velodyne_pointcloud driver also. Otherwise, the Velodyne driver won't work properly.

NOTE

Each new frame is separated by '-' and must contain at least 'frameName'.

VISUALIZATION:

7. Open new terminal
8. Start RVIZ with prepared configuration

```
$ cd ~/catkin_ws/  
$ source ./devel/setup.bash  
$ rviz rviz -f LocalVertical -d src/hg_nav_node/launch/RvizDemo.rviz
```

RECORDING:

9. Open new terminal
10. Record all topics via Rosbag application

```
$ cd ~/catkin_ws/  
$ source ./devel/setup.bash  
$ rosbag record -a
```

RE-PLAYING RECORDED DATA:

11. Open new terminal
12. Run ROS Core

```
$ cd ~/catkin_ws/  
$ source ./devel/setup.bash  
$ roscore
```
13. Open new terminal
14. Enable simulated time

```
$ cd ~/catkin_ws/  
$ source ./devel/setup.bash  
$ rosparam set /use_sim_time true
```
15. Play the bagged recording

```
$ rosbag play --clock [path to your bag file]
```

NOTE

Using the simulated time rectifies the possible timing conflicts in the ROS environment.

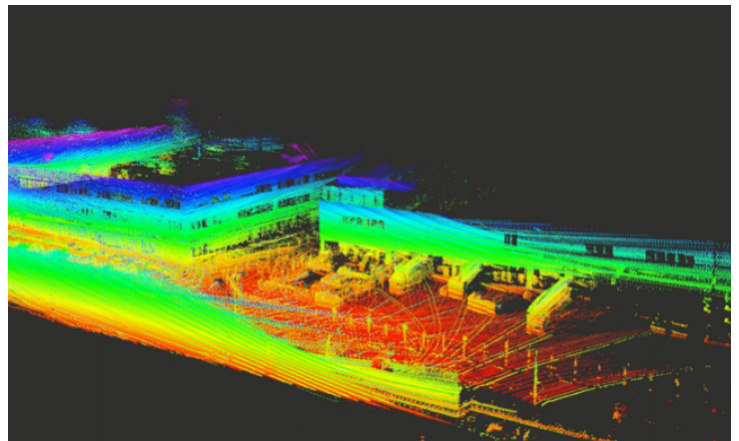
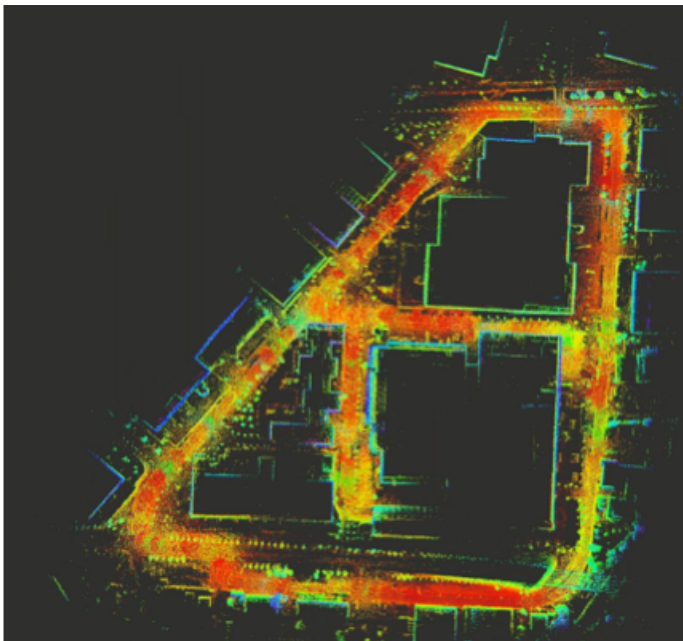
CONCLUSION

Using an inertial navigation system (INS) over a pure GNSS navigation system in applications utilizing position and attitude sensitive devices (e.g., LiDAR, Camera) brings great value in the form of much higher data rate and attitude accuracy coupled with high reliability and robustness.

The ROS driver for Honeywell's HGuide navigation portfolio, enabled the Velodyne point clouds to be more accurate by applying the position and attitude from the HGuide n580 INS/GNSS in real-time. Because the HGuide n580 INS/GNSS is using a high-grade micro-electro-mechanical systems (MEMS) IMU (HG4930CA51), the attitude performance and stability figures are superb. When coupled with RTK position precision of up to 1 cm, it enables the user to create more complex applications like mapping, collision avoidance, SLAM and multiple sensor fusion faster without the need for post-processing.

In this instance, it was used to create a map of a business park within minutes without the need for any programming, saving time and money which would be spent on processing the data from LiDAR and INS/GNSS separately.

Diagram C: Map created using integration model



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 IMUs and inertial navigation systems 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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