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WHITE PAPER

Analysis of MIP vs NMEA Aiding Information with the MicroStrain 3DM-CV7-INS

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Introduction:

The 3DM-CV7-INS is MicroStrain by HBK's latest embeddable tactical grade inertial navigation system. The 3DM-CV7-INS processes data from an external GNSS receiver to produce a full position, velocity, and attitude (PVA) solution capable of withstanding periods of GNSS outage. Providing an external GNSS message to the 3DM-CV7-INS can be done in the following ways:

- Industry-standard NMEA format.
- MicroStrain's binary packet protocol (MIP) via the aiding command set.

Given that the 3DM-CV7-INS can accept GNSS data in two ways, one might ask - which method should I choose? Is one better than the other? This paper will provide a tutorial for implementing both methods and will compare their static position performance.

Experimental Setup:

A 3DM-CV7-INS was configured to receive NMEA input from a uBlox F9P, which had a continuous RTK-fix from a VT CORS (Vermont CORS network) base station. The uBlox module was connected to a roof-top Novatel VEXXIS 800-series antenna, wired to the 3DM-CV7-INS, and placed on a desktop. Data was collected for 60 minutes statically, minimizing any disturbances. The data was trimmed by 60 seconds at the beginning and end to remove any motion that may have occurred.

This test was repeated, replacing the uBlox F9P with a MicroStrain 3DM-GQ7-GNSS/INS fed from Sensor-CloudRTK, utilizing the same VT CORS reference station and roof-top antenna. The GNSS data was sourced from the GQ7's GNSS1 receiver in MIP format, which made conversion to the MIP aiding commands convenient.

3DM-CV7-INS with Standard NMEA input

Without any configuration, NMEA data can be input over the Main port by interleaving the NMEA sentences between any MIP packets. This requires the ability to stream NMEA to the device while simultaneously receiving the output in MIP format. Typically, this setup would require some programming on the user's part.

But, with some simple device configuration, NMEA data can be streamed over a GPIO pin, freeing up the primary communications port for MIP-only communications and requiring no programming. This is how NMEA data was provided to the 3DM-CV7-INS in this paper.

A picture of the setup can be seen in Figure 1.

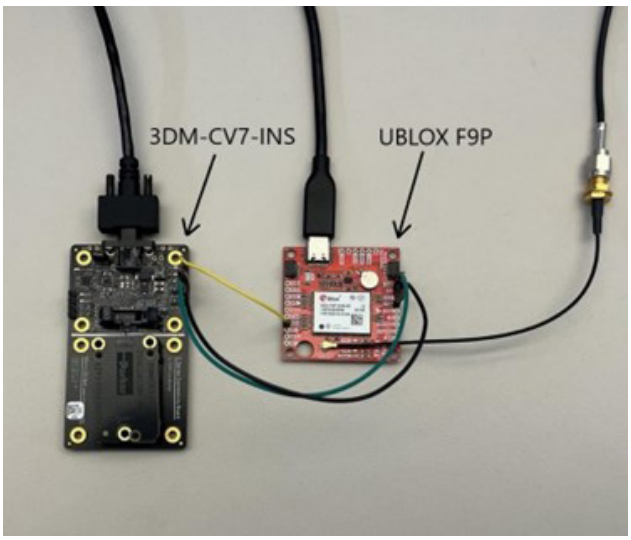


Figure 1: Setup for providing a NMEA input to the 3DM-CV7-INS

Materials Required:

- MicroStrain 3DM-CV7-INS development board, and USB interface cable.
- uBlox F9P, development board, USB cable, GNSS antenna, and associated RF cable.
- 3 jumper wires.
- A computer with the following:
  - SensorConnect.
  - uCenter by uBlox.
  - An internet connection for NTRIP RTK corrections.

Device Configurations:

The 3DM-CV7-INS can accept various NMEA sentences. For this test, we utilized uCenter to configure the uBlox module to output the following: GGA, GSV, VTG and ZDA. Additionally, RTK corrections were provided using uCenter's NTRIP client via the VT CORS network VTRI mountpoint (the closest base station to our location). All configuration files used in this paper can be downloaded *here* or by contacting our support team at *support.microstrain.com*.

The 3DM-CV7-INS was configured to receive a PPS input from the F9P on GPIO1 and NMEA input via GPIO3, which was configured as a UART input.

SensorConnect was used to interface to the 3DM-CV7-INS and record a binary file for analysis.

3DM-CV7-INS with MIP Aiding

The 3DM-CV7-INS can also accept a variety of aiding data, including position and velocity in either ECEF or LLH/NED format – common outputs from GNSS receivers. In this paper, LLH position, NED velocity, and GPS time from a GQ7-GNSS/INS was sent to a 3DM-CV7-INS using a Python script.

Experimental Setup:

This test was performed in the same manner as previously defined, except the GNSS data from a MicroStrain GQ7-GNSS/INS was shuffled to the 3DM-CV7-INS through MIP protocol via an internally-developed python script. The GQ7 was utilized for this test instead of the uBlox module because the GNSS data is in native MIP format and did not require the development of a uBlox parser. As in the previous test, the source-module's PPS output was connected to GPIO1 on the 3DM-CV7-INS.

Materials Required:

- A MicroStrain 3DM-CV7-INS with a development board.
- A Microstrain 3DM-GQ7-GNSS/INS, GNSS antenna, and associated RF cable.
- A MicroStrain 3DM-RTK dongle with micro DB9 to micro DB9 cable.
- A Micro DB9 cable with flying leads.
- An RS-232 USB converter.
- A 9 position D-sub Receptacle with female socket connectors.
- A Micro DB9 to USB cable.
- A computer with python script to shuffle GQ7 GNSS data over to the 3DM-CV7-INS.

A picture of the setup use for this test can be seen in Figure 2.

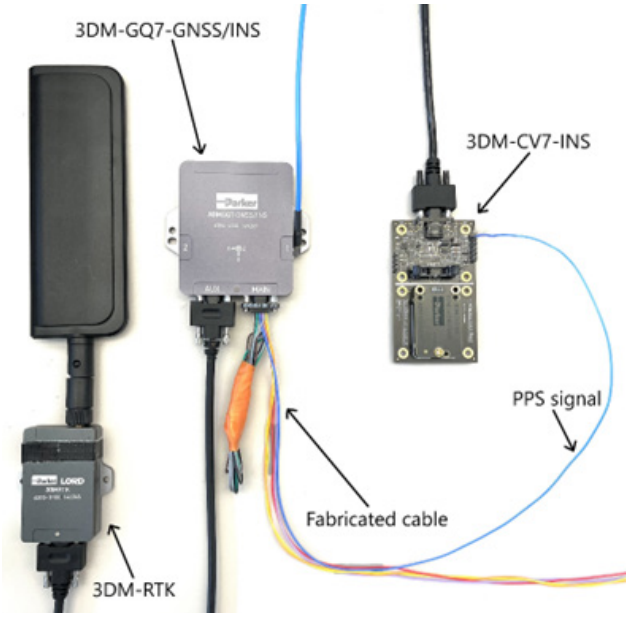


Figure 2: Setup for MIP aiding to the 3DM-CV7-INS.

Device Configurations:

The GQ7-GNSS/INS was configured to receive RTK corrections through the 3DM-RTK dongle. The 3DM-RTK dongle was configured using SensorCloudRTK to receive corrections from the VT CORS VTRI mountpoint to match the configuration in the previous test. The Micro DB9 flying leads cable was used to fabricate an appropriate wiring harness for this test. A wiring diagram for the fabricated cable can be seen in Figure 3. All configuration files used in this paper can be downloaded *here* or by contacting our support team at *support.microstrain.com*.

The 3DM-CV7-INS was connected to the computer using the Micro DB9 cable, and the fabricated cable was connected from the GQ7-GNSS/INS to the USB to RS-232 converter, and then to the computer. Subsequently, the python script was run, and data was collected in a binary file for analysis.

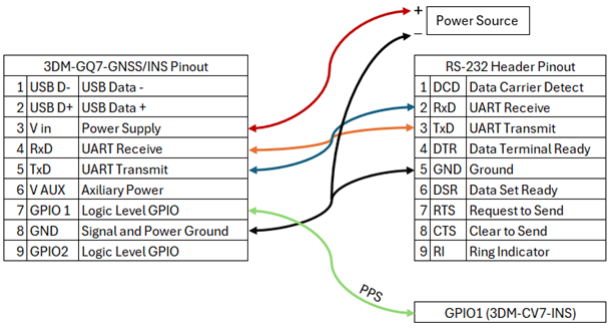


Figure 3: Wiring diagram for the custom cable used to extract a PPS signal from the GQ7-GNSS/INS.

Results and Discussion:

Results from the static position test for both GNSS aiding methods can be seen in Figure 4.

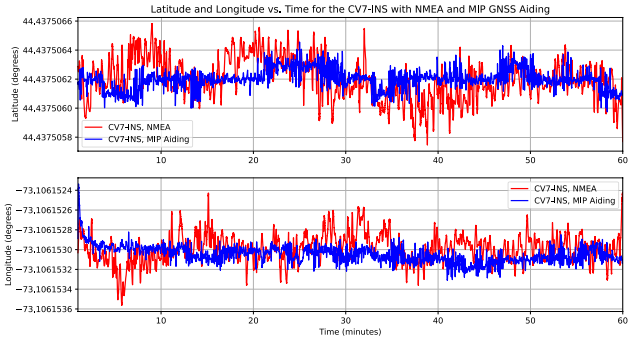


Figure 4: Latitude and longitude vs. time for the 3DM-CV7-INS with NMEA aiding and MIP aiding.

As can be seen from this data, the 3DM-CV7-INS has significantly less variation over the hour-long test when utilizing the MIP aiding command set. To help visualize the difference, the Latitude/Longitude data was converted to the Northing/Easting frame, and a 2D plot is provided on Figure 5, with the standard deviations provided in Table 1.

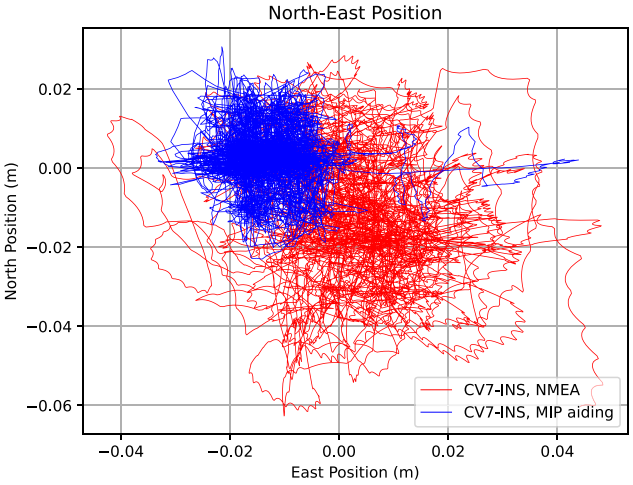


Figure 5: Northing/Easting for the 3DM-CV7-INS with NMEA aiding and MIP aiding.

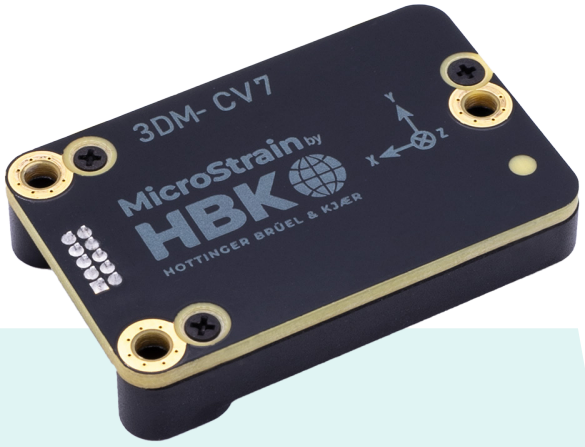
	North	East
3DM-CV7-INS, NMEA	0.0153 m	0.0112 m
3DM-CV7-INS, MIP	0.0075 m	0.0066 m

Table 1: Standard deviations (1σ) in the NED Frame.

The main reason for the difference between these aiding methods is that NMEA, while sufficient to form a full navigation solution, does not contain a complete description of the data needed by a GNSS/INS. For example, the NMEA velocity message (VTG), contains only ground speed and the direction of travel; there is no velocity data to describe the vertical motion of the vehicle. Additionally, standard NMEA messages output by legacy receivers do not typically provide position and velocity uncertainties, so the 3DM-CV7-INS uses conservative estimates based on the positioning mode reported by the receiver. These conservative estimates allow for slightly more position drift over time.

The key benefit of using the NMEA input is that it will reduce time to market and simplify integration into legacy systems. While the position solution may not be as precise as using MIP aiding, setup is quick and simple. Since the 3DM-CV7-INS can accept standard NMEA input over one of the GPIO ports, a full navigation solution can be achieved with no software development.

Using the MIP aiding command set is a great option for end users who are looking to improve performance and optimize their product. Some software development is required to format the GNSS data into MIP and interface with the 3DM-CV7-INS, but this interface is far more flexible and specific; thus, the position solution can be more accurate when compared to a standard NMEA input. To aid this integration, MicroStrain provides a full featured, publicly available SDK (*https://github.com/LORD-MicroStrain/mip_sdk*).



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