SPAN® External PVA Feature

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Introduction

The External PVA feature enables the user to provide their own external position, and/or velocity, and/or attitude information to the SPAN® filter. These updates can help constrain the system to improve the performance when GNSS conditions are not optimal (e.g., long outages in the environment of urban canyon and tunnels, or GNSS jamming). With the rapid development of sensor technologies and decreasing prices, many customers have more than one sensor installed in their applications alongside the GNSS/INS system. The additional position, velocity or attitude information from already available sensors can assist in aiding the solution when needed.

This document describes the basic use and typical applications of the External PVA feature of the NovAtel GNSS/INS receiver. After outlining considerations in the setup, details are provided on how to use the External PVA feature along with special considerations and caveats.

Applicable Products

This application note is applicable to any Hexagon | NovAtel OEM7 receiver product, including enclosure products and OEM receivers, where SPAN® is enabled, with firmware newer than 7.08.00.

Configuration

Setup

The EXTERNALPVAS message provides a generic format that can be used with any external sensors. The EXTERNALPVAS message can be injected through serial ports, USB ports, Wi-Fi, Ethernet ports, or the CAN Bus. Users might have to manipulate the external sensor outputs to extract the relevant information to send to the receiver. For example, feature extraction and matching on the images from cameras or Iterative Closest Point (ICP) from a Lidar point cloud may be used to derive the relative position displacement between different time epochs. This document does not include external sensor operations nor data manipulations of the external sensor.

Sensor Offset

Position and velocity information supplied through External PVA messages should be valid for the IMU centre of navigation location. If there is an offset between the IMU centre of navigation and the external sensor location that has not been pre-accommodated, the SETINSTRANSLATION command should be used to configure the EXTERNAL offset with the lever arm from the IMU centre of navigation to the external position source location.

The EXTERNAL translation offset does not impact SPAN®'s output solution location and is only applicable for external updates via this command. Please note that only one EXTERNAL offset can be entered, and relative position updates assume the information is coming from a single source.

Attitude information supplied through External PVA messages should be valid for the configured attitude output reference frame. By default, this is the IMU body frame, but depending on user configuration (using the SETINSROTATION command) may also be either the User frame or Vehicle frame.

Accurate translation and rotational information are crucial to accurately apply External PVA information.

Time Synchronization

To achieve minimal latency, the external sensors should be synchronized with the receiver in use. The most common way of synchronization is using the PPS signal. Additionally, either a high-baud rate serial port connection or ethernet connection with reliable speed without loss of packets should be used to relay EXTERNALPVAS messages to the receiver without any delay. For supported baud rates over serial, refer to SERIALCONFIG and for ethernet connection example Ethernet Configuration.

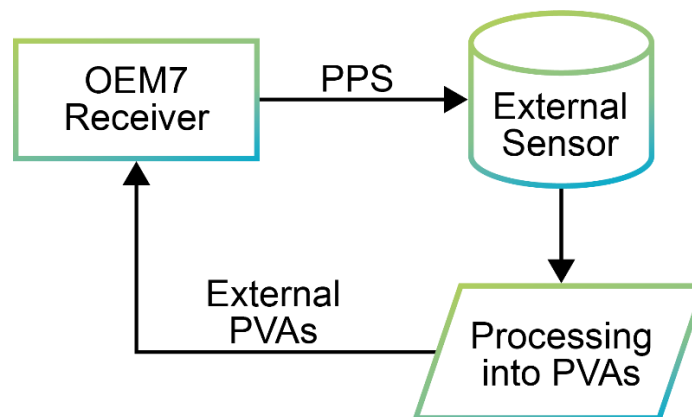> This document assumes that the provided external updates are time synchronized and calculated at IMU centre.

Figure 1: Simplified setup example

EXTERNALPVAS Command Usages

Command Formats

The user must format information from an external sensor into the EXTERNALPVAS command. The command can be sent either in Abbreviated ASCII, ASCII, or binary format. Abbreviated ASCII is the easiest to use for development, however due to the compactness of binary, binary is recommended to reduce the amount of data transmitted. When forming the command in binary, the user has to include a CRC for error checking and NovAtel header according to the binary structure.

The UpdateMask and OptionsMask fields of the EXTERNALPVAS message allow users to control the application of the provided External PVA information. The UpdateMask field specifies which information is valid; more than one update can be applied at a time (e.g., both position and attitude updates can be applied at the same time). The OptionsMask field indicates the input frame of the updates (ECEF, LLH, or vehicle) and whether the update values are absolute or relative.

For velocity updates, the user must set the OptionsMask properly depending on the velocity type derived from the external sensors. An absolute velocity measurement should be provided as a velocity update, whereas an average velocity measurement should be provided as a relative position update.

For local level position updates, ellipsoidal height must be provided rather than orthometric (aka. Mean Sea Level). To compute ellipsoidal height from orthometric, add the geoidal undulation available in many logs, including INSPVAX.

Please refer to the NovAtel manual for the detailed explanation of each field.

Examples

The following examples show different use cases of the EXTERNALPVAS command using Abbreviated ASCII formatting. The first two examples show how the command should be formed differently depending on whether an instantaneous velocity update or average velocity (relative position) update is intended. The third example shows a combined absolute Position, Velocity and Attitude update in the local level frame. The fourth example shows an absolute ECEF position update combined with an absolute attitude update.

Velocity - Local Level – Absolute

```
EXTERNALPVAS 0.0 0.0 0.0 0.450 10.54 -0.096 0.0 0.0 0.0 0.0 0.0 0.0 0.01 0.01 0.01
0.0 0.0 0.0 4000 10
```

Position - Local Level - Relative

```
EXTERNALPVAS 0.450 10.54 -0.096 0.0 0.0 0.0 0.0 0.0 0.0 0.01 0.01 0.01 0.0 0.0 0.0
0.0 0.0 0.0 20 44
```

Position, Velocity, Attitude - Local Level - Absolute

```
EXTERNALPVAS 51.150 -114.030 1095.395 0 0 0 0 0 90.0 0.3 0.3 0.3 0.3 0.3 0.3 0.2
0.2 0.2 C020 14
```

Position, Heading - ECEF - Absolute

```
EXTERNALPVAS -1632850.874 -3662162.239 4944897.284 0 0 0 0 0 90 0.1 0.1 0.1 0 0 0 0
0 1 10020 0
```

Update Time and Rate

When using ASCII or binary command input, the time in the header is used as the valid update time and the solution is propagated to the header time. Therefore, when providing valid time information, it is important to form the command with the time set to the update time of validity, without latency. If using Abbreviated ASCII (common for development purposes) the command may be issued without any time information, in which case the arrival time of the EXTERNALPVAS command handled by the receiver is used as the validity time for the update.

Firmware versions using 7.08.00[1] and newer apply External PVA updates in an asynchronous manner. There are no restrictions on the input times, and variable input rates of EXTERNALPVAS are supported for all the updates. High-rate updates are not recommended unless the updates are sent without any latency and known to be accurate; 1 Hz updates are expected to be sufficient for most applications.

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[1] Firmware versions older than 7.07.00 only support External PVA updates at 1 Hz, and these are applied as a synchronous update; if the updates are not issued on the even second, the updates won't be applied correctly. In addition, relative updates must be provided at a constant periodic rate. Unexpected behaviour may occur if relative updates are provided at an inconsistent rate, or if any EXTERNALPVAS messages providing relative updates are dropped or missed for any reason. Any customers who use External PVA feature are recommend upgrading the FW to 7.08.00 or newer.

Accuracy and Precision of Information

It is important to ensure that the external updates and its corresponding standard deviations are accurate and input accordingly. The standard deviations should represent its true errors in the update input frame. Entering an external update and its standard deviation inappropriately may have adverse effects on the SPAN® solution. Excessively large standard deviation values will prevent the External PVA information from improving the solution, while overly optimistic standard deviation values (when combined with inaccurate update values) may lead to error accumulation within the internal sensor error estimates and cause the INS solution to diverge.

EXTERNALPVAS for Alignment

If external absolute attitude is provided and a dual antenna ALIGN solution is not available, the provided azimuth will be used to perform an alignment as if it had been provided by command (see the SETINITAZIMUTH command). If a dual antenna ALIGN solution is available, it will be used instead, attitude from the ALIGN solution is preferred over external attitude updates for alignment. If external position and velocity information is provided without absolute attitude information, the velocity information will be used to estimate the Course Over Ground (CoG) to complete a kinematic alignment.

Status Reporting

The Extended Solution Status field (field 23) of the INSPVAX log will indicate whether External PVA updates have been applied to the solution. Alignment Indication bits (bit 28-26) will indicate whether External PVA information has been used for alignment. Refer to Table: Alignment Indication for details. Once the inertial filter has completed an alignment, individual status bits will report whether external position, velocity, attitude, heading, and height information have been applied to the filter as an update. Refer to Table: Extended Solution Status to check which updates are being applied.

The following examples show how to decode the status reported in INSPVAX to confirm what kind of External PVA updates are applied.

Examples

- Alignment with external attitude update when GNSS solution is available:

  #INSPVAXA,COM1,0,53.0,FINESTEERING,2217,158895.000,02000020,46eb,32768;**INS_AL IGNMENT_COMPLETE**,INS_PSRSP,51.15038536159,-114.03070785469,1098.4185,
  -17.0000,-0.0025,0.0016,0.0151,-0.793204161,1.450574110,90.008473840,
  1.0014,0.7619,1.6761,0.0449,0.0446,0.0389,0.2761,0.2915,3.7427,**13000005**,0*3e0
  75e49

  The binary representation of Hex 13000005 is:

  0001_{28} 0011_{24} 0000_{20} 0000_{16} 0000_{12} 0000_8 0000_4 0101_0

  The alignment indication bits of 100 show that a User Command alignment was performed, reflecting that External PVA information was used to complete the alignment.

- Alignment with external position and attitude update when GNSS solution is not available:

```
#INSPVAXA,COM1,0,74.0,UNKNOWN,0,45.000,024c4020,46eb,32768;INS_ALIGNMENT_COMP
LETE,EXT_CONSTRAINED,51.15043187306,-114.03068690928,1095.4034,0.0000,0.0031,
-0.0032,0.0140,-0.754442449,1.230576218,90.000692487,1.0111,1.0111,
1.0048,0.0483,0.0483,0.0392,0.4444,0.4444,3.7427,13000004,0*3917b7ad
```

The binary representation of Hex 13000004 is:

0001_{28} 0011_{24} 0000_{20} 0000_{16} 0000_{12} 0000_8 0000_4 0100_0

This example is similar to the first alignment example except that a GNSS antenna has not been connected and there was no GNSS solution available. The alignment bits indicate that the provided attitude information was used to perform the initial alignment, and the position type of EXT_CONSTRAINED reflects that a user provided position has been used without internal observations.

- External position and attitude updates applied in run:

```
#INSPVAXA,COM1,0,70.0,FINESTEERING,2215,489175.000,02000020,46eb,32768;INS_SO
LUTION_GOOD,INS_PSRSP,51.15039449324,-114.03070917294,1095.9102,-17.0000,
-0.0080,0.0076,0.0000,-0.662055141,1.546985538,90.284136543,1.0305,1.0309,
1.0457,0.0274,0.0274,0.0175,0.0921,0.0921,0.4640,13008025,0*160d9680
```

The binary representation of Hex 13008025 is:

0001_{28} 0011_{24} 0000_{20} 0000_{16} 1000_{12} 0000_8 0010_4 0101_0

Bits 5 and 15 show that external position and attitude updates were applied in this epoch.

Additional Resources

Commands

- EXTERNALPVAS
- SETINSROTATION
- SETINSTRANSLATION

Logs

- INSPVAX

References

- Binary Messages
- Ethernet Configuration

Support

To help answer questions and/or diagnose any technical issues that may occur, the NovAtel Support website is a first resource.

Remaining questions or issues, including requests for test subscriptions or activation resends, can be directed to NovAtel Support.

Before contacting Support, it is helpful to collect data from the receiver to help investigate and diagnose any performance-related issues. A list of appropriate troubleshooting logs can be found on the OEM7 Documentation Portal (the LOG command with the recommended trigger and data rate is included with each log).

For the External PVA feature, the following log should also be included:

```
LOG EXTERNALPVASB ONNEW
```

The data can also be collected using NovAtel Application Suite.

Documentation

For any questions on logs and commands, please visit the OEM7 Documentation Portal.

Contact Hexagon | NovAtel

support.novatel@hexagon.com 1-800-NOVATEL (U.S. and Canada) or 1-403-295-4900
For more contact information, please visit novatel.com/contact-us