APN-080:
SPAN Data Collection Recommendations

Table of Contents

Chapter 1 Overview

SPAN's deeply coupled Inertial Navigation System (INS) can provide accurate position, velocity and attitude of the IMU body in real-time. The accuracy of the solution depends on the IMU being used, quality of alignment (initialization) and kinematics experienced. This application note is intended to go through proper INS collection techniques as well as mention some common pitfalls that could hinder the quality of the SPAN output.

1.1 IMU Type

INS accuracy can only be as good as the IMU being used. IMUs contain a triad of accelerometers and gyroscopes that are used to measure the specific forces and rotation rates sensed by the IMU. See the SPAN brochure (www.novatel.com/assets/Documents/Papers/SPANBrochure.pdf) for information on accuracy specifications for each IMU supported by SPAN. For detailed information about the performance of each IMU, refer to the product sheet for the individual IMU (available at www.novatel.com). Note that proper INS initialization and initial convergence is required in order to meet the specifications stated in the product sheets.

Chapter 2 INS Alignment

The INS alignment (initialization) is a very important factor in performance throughout the lifetime of the INS filter. The alignment stage of the INS is where the initial position, velocity and attitude values used in the filter are defined. Position and velocity come from GNSS whereas attitude comes from one of the alignment methods available to users.

2.1 INS Alignment Environment

The following should be followed to have a good INS alignment:

- Ensure the antenna has clear visibility of the sky.
- Ensure the IMU and antenna (or antennas) are rigidly mounted to the vehicle. The GNSS signal is received at the antenna phase center whereas the IMU raw data and INS solution is computed at the IMU center of navigation. The separation between IMU and antenna must therefore be constant.
- If possible, start logging data as soon as possible so that complete information on INS alignment is saved.
- Mount the IMU as far as possible from external sources of vibration.
- If INS performance is being hindered by vehicle vibrations, consider using dampening mounts to minimize vibrations. Use dampening mounts with caution as there is always a risk of removing actual motion.
- If using a dual antenna setup, use the **ALIGNMENTMODE** command with either **AIDED_TRANSFER** or **AIDED_STATIC**. This guarantees the INS alignment uses the GNSS-derived heading. (See *INS Alignment Quality* below for further information on alignment modes).

> This is important as it is possible to have a scenario where the GNSS-derived HEADING messages are available, but are not being applied to the INS filter. Setting the alignment mode to one of the two AIDED modes ensures the INS will not align until a good GNSS-derived heading is available.

- If using a dual antenna setup, ensure both antennas are far from any obstructions. The GNSS-derived heading must be verified to RTK quality levels before it is fed into the INS. Being close to obstructions lengthens this process or in some cases even prevents the update from taking place.
- If using a dual-antenna setup, we recommend having both antennas at constant heights, especially in applications where large pitch/roll will be experienced.

2.2 INS Alignment Quality

2.2.1 INS Alignment Methods

Coarse:
Provided the IMU can sense the Earth's rotation rate, SPAN will average accelerometer and gyroscope measurements for approximately 45 seconds to come up with the initial pitch, roll and azimuth estimates. Note the system must stay stationary throughout this process.

The ADIS-16488, IMU-CPT, IMU-IGM-S1, IMU-IGM-A1, HG1930, EPSON EG320N and STIM300 IMUs cannot perform coarse alignments as they cannot sense the Earth's rotation accurately enough.

Kinematic:

GNSS course over ground for three consecutive seconds is averaged provided the speed is higher than 5 m/s or the user-specified value (through the **SETALIGNMENTVEL** command). Kinematic alignments are not suggested for marine or aerial environments with large crab angles between the course over ground and the Vehicle frame. This applies to any environment where the defined Vehicle frame and course over ground are not aligned during the kinematic alignment procedure.

UNAIDED:
SPAN will use either a coarse(static) or kinematic alignment, whichever is available first. This command is for dual antenna installations where users do not want to align the INS via the secondary antenna. In such cases, the secondary antenna is only used to provide heading updates to the SPAN filter.

AIDED_TRANSFER:
For dual antenna installations. Pitch and roll are computed from IMU observations whereas the INS heading is set to the first RTK-quality, GNSS-derived heading from the dual antenna installation.

AUTOMATIC (Default):
SPAN will use the first available alignment technique to complete INS alignment.

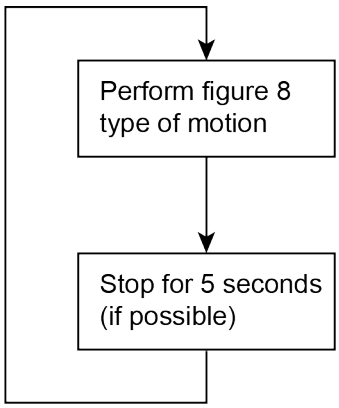
STATIC (OEM7 Only):
INS will only align through coarse alignment.

KINEMATIC (OEM7 only):
INS will only align through kinematic alignment.

User Injected Azimuth or Attitude:
It is also possible to align the INS manually by injecting an initial heading (**SETINITAZIMUTH** command) or attitude (**SETINITATTITUDE** command). Please note these commands are meant for bench test purposes OR advanced users. The initial value and its corresponding standard deviation are very important for a proper INS initialization. Using either of these commands with false standard deviations (e.g., actual value has a standard deviation of 30 degrees but user inputs a standard deviation of 1 degree) has grave repercussions on filter performance.

2.3 Kinematics Immediately after INS Alignment

As has been previously mentioned, it is very important to ensure INS alignment takes place in a relatively good GNSS environment. Right after initial INS alignment it is necessary to insert the appropriate type of kinematics into the system to converge the bias-drift states being modeled. It is suggested to perform the following iterative process for a total period of three minutes:



Furthermore, these types of kinematics need to be done under good sky coverage, as far as possible from obstructions. Initializing the INS and entering an urban canyon immediately after is not recommended. SPAN will not behave as per product sheet levels unless it has been properly initiated and this includes the initial kinematics. If possible, start logging data from the very beginning to ensure all information is captured should there be any issues.

INS filter confidence can be monitored through the INS standard deviations (e.g. **INSPVAX** log).

Chapter 3 Recommended Messages to be logged

Although every customer has a different application, and setup, it is important to always log as much information about the GNSS and INS filters and the environment in which the survey is taking place. The following are the suggested messages that should be logged for every survey. Note that the list includes all necessary messages for post-processing in Inertial Explorer.

For OEM7
INS logs will populate position, velocity, pitch and roll even before INS alignment has taken place. Position and velocity are reported from GNSS whereas pitch and roll are computed. The azimuth will always report zero until the INS alignment has completed.

Please note that even though position, velocity, pitch and roll estimates are available prior to alignment, they only reflect an inertial solution until after INS alignment has taken place.

3.1 Recommended SPAN Messages for OEM6

```
LOG RAWEPHEMB ONCHANGED
LOG GLOEPHEMERISB ONCHANGED → if tracking GLONASS
LOG GLOEPHEMERISB ONNEW → if tracking GLONASS
LOG BDSEPHEMERISB ONNEW → if tracking BeiDou
LOG GALEPHEMERISB ONNEW → if tracking Galileo
LOG QZSSEPHEMERISB ONNEW → if tracking QZSS
LOG HEADING2B ONNEW → if using dual antenna
LOG VERSIONB ONCE
LOG IMUTOANTOFFSETSB ONCHANGED
LOG RXSTATUSB ONCHANGED
LOG RXCONFIGB ONCE
LOG VEHICLEBODYROTATIONB ONCHANGED
LOG SETIMUORIENTATIONB ONCHANGED
LOG RANGECMPB ONTIME 1
LOG BESTPOSB ONTIME 1
LOG BESTGNSSPOSB ONTIME 1
LOG RAWIMUSXB ONNEW
LOG INSPVAXB ONTIME 1
LOG INSUPDATEB ONNEW
```

3.2 Recommended SPAN Messages for OEM7

```
LOG RAWEPHEMB ONCHANGED
```

```
LOG GLOEPHEMERISB ONCHANGED → if tracking GLONASS
LOG GLOEPHEMERISB ONNEW → if tracking GLONASS
LOG BDSEPHEMERISB ONNEW → if tracking BeiDou
LOG GALEPHEMERISB ONNEW → if tracking Galileo
LOG QZSSEPHEMERISB ONNEW → if tracking QZSS
LOG HEADING2B ONNEW → if using dual antenna
LOG VERSIONB ONCE
LOG RXSTATUSB ONCHANGED
LOG RXCONFIGB ONCE
LOG RANGECMPB ONTIME 1
LOG BESTPOSB ONTIME 1
LOG BESTGNSSPOSB ONTIME 1
LOG RAWIMUSXB ONNEW
LOG INSPVAXB ONTIME 1
LOG INSUPDATESTATUSB ONNEW
LOG INSCONFIGB ONCHANGED
```

Chapter 4 SPAN on OEM7 Setup Commands

4.1 Reference Frames

Users need to be aware of two coordinate frames on SPAN on OEM7: IMU Body Frame and Vehicle Frame. The IMU Body Frame defines the orientation (reference frame) of the IMU axes marked on the IMU/enclosure. This frame will then vary depending on the orientation in which the IMU is mounted.

The second frame, the Vehicle Frame is defined as follows:

+X axis → towards right of vehicle

+Y axis → towards forward direction of vehicle

+Z axis → upwards

Please refer to docs.novatel.com/OEM7/Content/SPAN_Operation/Definition_Reference_Frames.htm for further information.

4.2 Commands

There are two main commands that need to be sent in SPAN on OEM7: SETINSTRANSLATION and SETINSROTATION. Each command has multiple options but the most important ones are those used to:

- Specify the separation from the IMU center of navigation to the antenna phase centers.
  Use the ANT1 and ANT2 fields of the **SETINSTRANSLATION** command (docs.novatel.com/OEM7/Content/SPAN_Commands/SETINSTRANSLATION.htm).
- Specify the rotation from the IMU Body Frame to the Vehicle Frame (see *Reference Frames* above for frame definitions)
  Use the RBV field of the **SETINSROTATION** command (docs.novatel.com/OEM7/Content/SPAN_Commands/SETINSTRANSLATION.htm).

Chapter 5 Final Points

Should you have issues with your INS setup, email NovAtel Support at support@novatel.com and include the data from the messages shown in *Recommended Messages to be logged* on page 7.