Introducing NovAtel's *ALIGN™* Feature for Heading Applications

Precise thinking

Introducing NovAtel's *ALIGN* Feature for Heading Applications

NovAtel Inc.

Abstract

*This white paper introduces NovAtel's **ALIGN** technology, shows use cases, and discusses results from initial testing. **ALIGN** is a firmware feature for heading applications and is available in our OEMV 3.500 firmware.*

*Testing shows **ALIGN** offers precise directional orientation for applications where heading is important.*

Methodology

Resources for this paper were provided by NovAtel Inc. See also the test sections of this paper.

ALIGN Overview

The ***ALIGN*** firmware feature generates separation and bearing data between a master and one or multiple remotes. It is available with both single and dual frequency RTK models of firmware, and both GPS-only or GPS+GLONASS models. The ***ALIGN*** OEMV firmware product, is designed to be integrated into a custom end-product solution.

Use a heading feature, such as ***ALIGN*** in environments where you want to know the heading, either between two objects or of an object itself, for example, an implement on a controlled machine. Potential applications for the heading feature include machine control, collision avoidance, antenna pointing, see the photograph above, marine and unmanned vehicles.

Use Cases

This section describes the following heading use cases:

- Between a single master and remote(s) on different vehicles
- Between a single master and remote on the same vehicle
- Between two moving objects

Details on how to set up the first two use cases are also in the ***ALIGN*** application note, *APN-048*, available from our website. In the ***ALIGN*** application note you will also find the logs and commands related to the ***ALIGN*** feature.

Between a Single Master and Remote(s) on Different Vehicles

In this case, a user requires the separation and bearing between a single master station and one or more remote units. The master can be stationary or moving. The position of the master may be either an RTK or OmniSTAR HP solution. The example in *Figure 1* on *Page 3*, shows the type of slow moving vessel that can use HP to position itself. The remote requires a single point position of itself as well as corrections from the master/vessel to the remote. The remote is loaded with a heading model and uses this information from the master to calculate and output its single point position as well as the separation and bearing. The remote can then transmit its position, separation and bearing, typically by radio, to the master in NovAtel formatted logs.

The baseline between the master and remote may or may not be fixed. In this use case, it is not fixed and can be several kilometers long. However, the same use case can apply on a machine where the baseline is fixed, constant and <2 m. See the next use case.

Between a Single Master and Remote on the Same Vehicle

Another application is on a machine, see *Figure 2* on *Page 3*. In this case, fix two antennas at a short distance apart on a vehicle. The receiver calculates the separation and bearing between the master and remote, but the master and remote antennas are on the same machine and not on different vehicles. The receiver uses the heading solution to orient the vehicle or, in the case of a grader, the blade. The actual receivers for each antenna, with a data storage capability, can be integrated into the same physical box of hardware in the vehicle.

The box records and outputs position of the master, and separation/bearing between the master and remote. In this case, the two receivers (master and remote) are connected serially or, for DL-V3 only, Ethernet.

The master receiver can receive corrections from an external source. For example, it can receive RTK corrections, HP signals, or operate in SBAS mode. The 'optional' RTK base configuration, included in the first use case, could also apply to this use case.

Between Two Moving Objects

In this case, you want to determine the separation and bearing between two moving objects. Potential applications include anti-collision for mining or container terminals, see *Figure 3*. The gantry crane uses a combination of the existing ‘moving base’ option with an L1 RTK, WAAS, RT-2, or OmniSTAR HP option. Refer to the L1 RTK white paper available on our website for more details.

The master vehicle has a ‘swinging arm’, so that the GNSS antenna moves. The second and subsequent vehicles (remotes), within the area of influence of the swinging arm, compute the separation and bearing on their systems and in some cases are guided by this computation. The separation and bearing, as computed at each remote is sent back by telemetry to the master. The end user system displays the remote positions on a screen for the operator of the master vehicle so that the operator knows where all the remotes are relative to the swinging arm.

Figure 1: A static base antenna with one or more rover ships in port.

Figure 2: One antenna is the master and one antenna is the remote on this digger. They receive corrections from an external RTK base (not shown).

Figure 3: Gantry crane ‘arms’ and ‘rover’ containers

Dynamic Testing

A minivan was set up with 2 antennas; one at the front of the van and the other at the back of the van, see *Figure 4*. Each antenna was connected to a DL-V3 receiver in the van.

To test ***ALIGN*** we drove the van from Lancaster southeast 22 km to Abbeystead Lane in Lancashire, UK and back.

The purpose of the test, conducted with Forsberg Services Limited, was to compare their existing ‘moving base station’ solution, using NovAtel’s previous moving base feature, to NovAtel’s new ***ALIGN*** solution.

The results from NovAtel’s ***ALIGN*** heading solution provided a more convenient way of computing heading, rather than deriving heading from the XYZ components of a typical ‘moving base station’ solution.

Static Testing

We set up a static test at our NovAtel headquarters, see *Figure 5* on *Page 4*, where the antennas are in fixed positions on the roof.

The purpose of this test was to verify ***ALIGN*** software for accuracy and reacquisition times.

For static data, we fixed an OEMV-3 master receiver to a known position in a low multipath environment. It sent RTCAOBS2 corrections at 10 Hz and RTCAREF messages at 0.1 Hz (10 s). The rover receiver, also an OEMV-3, was on a different antenna with a baseline length of nearly 6 m. It collected heading data at 10 Hz for 3 hours.

For the reacquisition test, we used the same 6 m baseline. This time, we ran the test using an OEMV-2 receiver with L1-only heading models. This test shows the reacquisition times of the L1-RTK-based heading solution. To force a reacquisition, we blocked all signals to the receiver for 3 seconds. After the receiver achieved the expected heading type, the receiver waited another 120 s before moving to the next iteration of the test. The plot in *Figure 7,* on *Page 4,* is based on 330 test samples.

Figure 4: Antenna setup in a dynamic van test

Test Results

The dynamic testing in England yielded very good accuracy results but we found that we needed to improve our reacquisition times.

After our software team added enhancements to the ***ALIGN*** beta firmware, we started dynamic and static testing over again using the same methodology as the previous tests.

Figure 6 shows the heading accuracy error results for the ***ALIGN*** firmware. The errors are within the limits we expected to publish, that is less than 0.06 degrees for a 6 m baseline. *Figure 6a* shows the ***ALIGN*** heading accuracy specifications.

Figure 7 shows the fast reacquisition times that the ***ALIGN*** software allows. It shows that on a 6 m baseline, the heading firmware has a TTFF of less than 35 s, 80% of the time, and a TTFF of 45 s, 95% of the time.

Figure 5: Looking up to NovAtel's rooftop, which has a clear view of the sky.

Test Results with NovAtel's OEMV Receiver

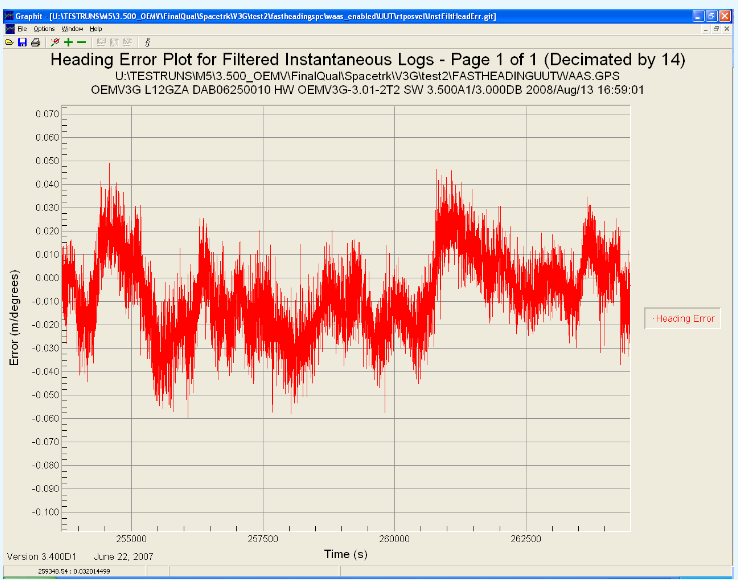

Figure 6: Heading error over a static data set

Figure 6a: *ALIGN* heading accuracy (RMS)

Baseline	0.5 m	1 m	2 m	10 m
Single Frequency	1.6°	0.8°	0.4°	0.08°
Dual Frequency	1.2°	0.6°	0.3°	0.06°

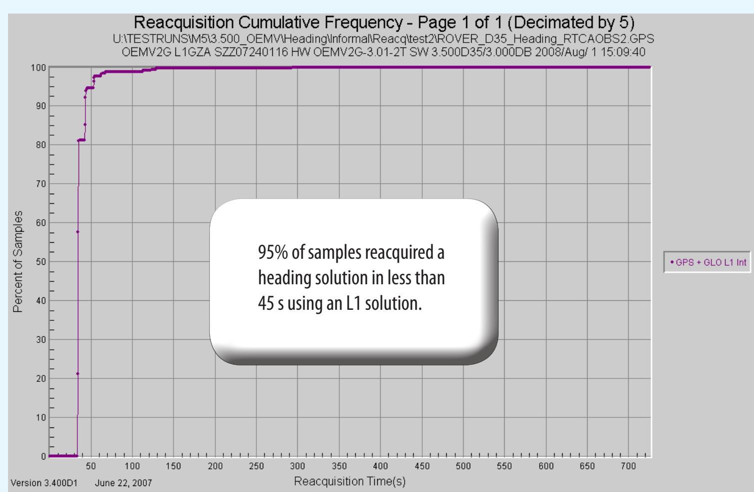

Figure 7: Cumulative reacquisition times using an L1-only *ALIGN* model

Conclusion

NovAtel's ***ALIGN*** feature provides distance and bearing information for customers looking for a robust and accurate heading solution. NovAtel offers ***ALIGN*** in single and dual frequency models for OEMV-1G, OEMV-2, and OEMV-3 products, as an upgrade to existing receivers or added as an option to new purchases.

The ***ALIGN*** feature is beneficial to customers that want to know the relative directional heading of an object, separation heading between two objects, or heading information with moving base and pointing applications. As such, heading applications can be applied over various applications, including machine control, unmanned vehicles, marine, antenna pointing and agriculture.

Our testing, highlighted in this paper, shows excellent accuracy results and fast reacquisition times.

For more information visit: http://www.novatel.com.

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Figure 2, Page 3:
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Figure 3, Page 3:
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Description: Gantry cranes at work

Figure 4, Page 3:
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Figure 8: The van setup, ready for its return journey from the Abbeystead region of Lancashire to Lancaster, to continue dynamic *ALIGN* testing

Figure 5, Page 4:
Photographer: NovAtel Inc.
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Date taken: 2008
Location: Calgary, Canada
Description: NovAtel building and clear view of the sky

Figure 8, Page 5:
Photographer: Adley Eng
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Date taken: 2008
Location: Lancashire, England
Description: ***ALIGN*** testing with Forsberg Services