

Application Note

ALIGN in Agriculture



HEXAGON AUTONOMY & POSITIONING DIVISION PROPRIETARY DATA

This document and the information contained herein are the exclusive properties of Antcom Corporation, Autonomous Stuff LLC, NovAtel Inc., Veripos Limited, and/or their affiliates within the Hexagon Autonomy & Positioning division ("Hexagon").

No part of this document may be reproduced, displayed, distributed, or used in any medium, in connection with any other materials, or for any purpose without prior written permission from Hexagon. Applications for permission may be directed to contact.ap@hexagon.com. Unauthorised reproduction, display, distribution or use may result in civil as well as criminal sanctions under the applicable laws. Hexagon aggressively protects and enforces its intellectual property rights to the fullest extent allowed by law.

This document and the information contained herein are provided AS IS and without any representation or warranty of any kind. Hexagon disclaims all warranties, express or implied, including but not limited to any warranties of merchantability, non-infringement, and fitness for a particular purpose. Nothing herein constitutes a binding obligation on Hexagon.

The information contained herein is subject to change without notice.

Hexagon, ALIGN, NovAtel, OEM7 and SPAN are trademarks of Hexagon AB and/or its subsidiaries and affiliates, and/or their licensors. All other trademarks are properties of their respective owners.

© Copyright 2024 Hexagon AB and/or its subsidiaries and affiliates. All rights reserved. A list of entities within the Hexagon Autonomy & Positioning division is available at <https://hexagon.com/company/divisions/autonomy-and-positioning>.

Contents

Introduction	4
How does ALIGN work and how accurate is it?	4
ALIGN models.....	4
ALIGN Heading Only ('Z' model).....	4
ALIGN Relative Positioning ('Y' model).....	5
ALIGN model comparison	5
Does the ALIGN Base need a specific ALIGN model?	5
Will external RTK or PPP corrections improve the Rover's ALIGN position accuracy?	6
Can the ALIGN output rate be changed?	6
ALIGN Base – ALIGN Rover communication options	6
SPAN with ALIGN	6
How does ALIGN help improve the inertial solution?	7
Agriculture use case examples	7
ALIGN Heading	7
ALIGN Relative Positioning – implement steer	8
ALIGN Relative Positioning – combine and grain cart	9
Support	10
Documentation	10

Introduction

NovAtel's ALIGN technology combines two or more NovAtel receivers to generate precise relative positioning and heading for dynamic applications. ALIGN can be used in two different applications: ALIGN Heading and ALIGN Relative Positioning. This guide describes the usage of each of these applications in agriculture.

An ALIGN solution typically utilises two receivers: a Base and Rover. The Base receiver sends correction information to the other receiver operating as the Rover (an ALIGN base can have multiple Rover receivers at a time). The Rover requires either the ALIGN Heading or ALIGN Relative Positioning model to use the ALIGN messages from the Base.

ALIGN can be utilised with any OEM7 receiver model tracking at least GPS L1&L2; however, it is recommended to implement a minimum tracking capability of GPS + GLONASS L1&L2.

How does ALIGN work and how accurate is it?

ALIGN uses a process completely independent of external corrections to compute a real-time relative positioning solution between two antennas. With the Base acting as the 'moving base station' sending corrections in NOVATELX format to the Rover, the Rover uses these corrections to carry out the ALIGN computation which results in the ALIGN Heading and ALIGN Relative Position¹ solution being available. The ALIGN solution computation uses satellite signals common to both antennas, regardless of any external corrections available to either receiver.

For every ALIGN setup, the quality of the ALIGN solution depends on the physical distance between the two antennas (baseline) and the number of common satellites between the Base and Rover. The ALIGN solution can generate the heading angle between two antennas to an accuracy of 0.20 degrees at a one-metre baseline. The antennas should be mounted where the view of the satellites is not obstructed by any part of the setup.

Table 1: ALIGN accuracy

	0.5 m Baseline	1 m Baseline	2 m Baseline
Dual Frequency – Fixed Heading Accuracy	0.40 degrees	0.20 degrees	0.10 degrees

ALIGN models

There are two ALIGN models available: Heading Only ('Z') and Relative Positioning ('Y'). These are generally applied to the ALIGN Rover only.

ALIGN Heading Only ('Z' model)

This model generates high precision angular heading and pitch measurements between two receivers for real-time navigation. Example: DDN-LZN-TMN.

¹ Available on the ALIGN Relative Positioning model only.

ALIGN Relative Positioning ('Y' model)

This model generates high accuracy angular heading and pitch measurements, precise relative positioning measurements and relative baseline information with centimetre level accuracy between two or more antennas for high precision monitoring and automation. Example: DDN-LYN-TMN.

ALIGN model comparison

Table 2: ALIGN model comparison

Feature / Receiver Output	Heading Only ('Z')	Relative Positioning ('Y')
Position of the ALIGN Base and Rover receivers	Available ²	Available
Centimetre accuracy position of ALIGN Rover relative to the ALIGN Base	Not Available	Available
Vector between ALIGN Base and ALIGN Rover relative to Earth's centre – 'XYZ Baseline distances'	Not Available	Available
Easting, Northing, Altitude vector between ALIGN Base and ALIGN Rover – 'ENU Baseline distances'	Not Available	Available
Heading and pitch angles with Rover ID (from Base receiver to Rover receiver)	Available	Available
NMEA-formatted heading angle	Available	Available
NMEA-formatted heading angle (synchronous output)	Available	Available
Heading information for dual-antenna receivers	Available	Available
DOP of ALIGN heading computation	Available	Available
Rate of change of the heading parameters	Available	Available
Overview of the numbers of the satellites being used in the heading solution	Available	Available

Does the ALIGN Base need a specific ALIGN model?

No, the ALIGN model only needs to be applied to the ALIGN Rover. The Base does not need a specific ALIGN model to function as the ALIGN Base, nor does it require a corrections output 'B' model (e.g. FFM-RNN-TBN) to send ALIGN measurements to the Rover. However, the ALIGN Base does require Char(4) model 'L' or greater to output a position and dual constellation and dual frequency tracking are a recommended minimum for the Base to ensure there are adequate satellites in common with the Rover.

² Available if Char(4) of Base software model is 'L' or greater.

Will external RTK or PPP corrections improve the Rover's ALIGN position accuracy?

The ALIGN Base can be configured to receive RTK/PPP corrections to improve the ALIGN *Base and Rover* receiver *absolute* position accuracy. However, this will not improve the Rover's ALIGN relative position accuracy. While an ALIGN Base with external corrections will have a more accurate *absolute* position, the Rover's *relative* position accuracy will remain the same – it is the ALIGN positioning accuracy of centimetre level relative to the Base. Therefore, the *relative accuracy* of the ALIGN Heading and Relative positioning solution will be unchanged by adding RTK or PPP corrections to the Base.

Can the ALIGN output rate be changed?

The heading information can be logged at various rates up to 20 Hz with options of 1, 2, 4, 5, 10 or 20 Hz. This can easily be done utilising plug and play commands such as [ALIGNAUTOMATION](#) and [INSALIGNCONFIG](#).

ALIGN Base – ALIGN Rover communication options

There are various options available for the ALIGN Base – Rover communication link. This can be wired (e.g. serial, ethernet) or wireless (e.g. Wi-Fi) depending on the application.

Table 3: ALIGN communication options

Wired	
Serial	- Requires a null modem cable link between receivers. - Can be configured both with manual commands and single command 'plug-and-play' feature.
Ethernet	- Can be favourable due to high-speed data transfer. - Requires manual configuration. - Can be configured over COM, USB, or additional ICOM port(s). - Possible to make wireless by utilising modems.
CAN	- Supports ALIGN with SPAN integration. - Supported ALIGN update rates vary based on CAN Bus speed. - Requires manual configuration.
Wireless	
Wi-Fi	- Can be configured both with manual commands and single command plug-and-play feature. - Range = ~30 m³.
Radio Link	- Configured via a serial COM port. - Only recommended for low rate ALIGN (<10Hz) due to possible radio transmission delays.

SPAN with ALIGN

ALIGN has proven to be valuable in improving the heading solution of the SPAN GNSS + INS fused solution. GNSS and INS are complementary technologies. While GNSS is absolute (and noisy), INS is relative and smooth.

In an agriculture application, low dynamic situations (slow velocities, few turns) are a challenge for inertial navigation systems. Lower dynamics reduce the ability of the navigation filter to estimate the errors in the system as there are fewer independent observations. Adding ALIGN to your system provides an additional, independent observation source for the most difficult-to-estimate parameter (heading of a GNSS + INS system).



How does ALIGN help improve the inertial solution?

The process to determine heading for an INS is difficult. In high grade systems, the gyroscopes are sensitive enough to detect the Earth³ rotation, allowing the system to determine true North. From the initial alignment, changes in heading are continually utilised in the solution to get the current heading. In lower grade systems, an external source is required to provide the initial alignment. In a SPAN system, if the IMU cannot detect Earth's rotation, initial alignment can be done through user input, kinematic alignment (requiring motion), or an ALIGN solution. When the lever arm (distance from the IMU to the antenna) is known to both ALIGN antennas, the difference of the ALIGN heading, compared to the heading axis of the INS, can be computed. This information allows the transfer of the ALIGN Heading to the INS, providing an initial alignment for the attitude solution while the vehicle remains stationary.

Agriculture use case examples

ALIGN Heading

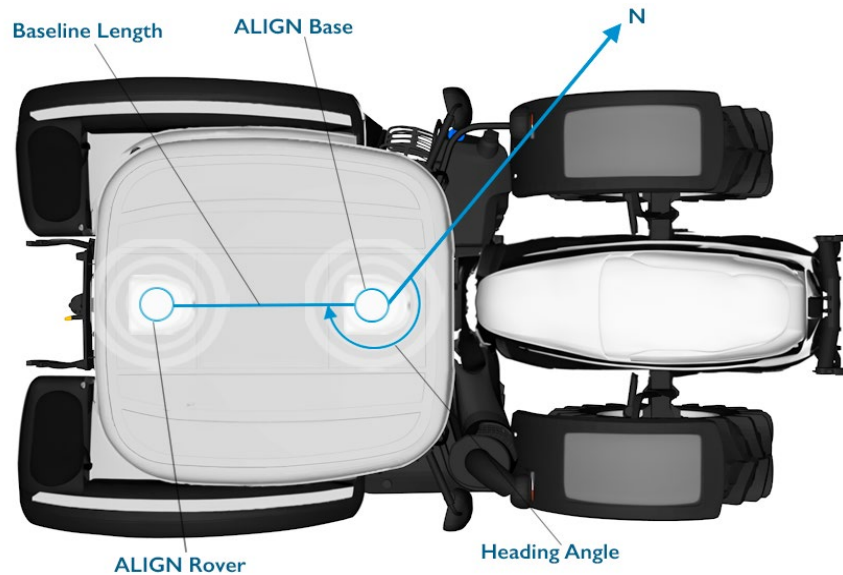


Figure 1: Heading angle represented by the vector from ALIGN Base to ALIGN Rover with respect to True North

A common use for the ALIGN Heading only 'Z' model in agriculture is for heading output in low speed or stationary applications where speeds below 0.5 m/s are required. In this case the heading angle from True North of the Base to Rover vector is available.

³ If the gyroscope has a drift and noise total that is significantly less than 15 degrees/hour, the rotation of the Earth can be detected, and the heading determined autonomously.



ALIGN Relative Positioning – implement steer

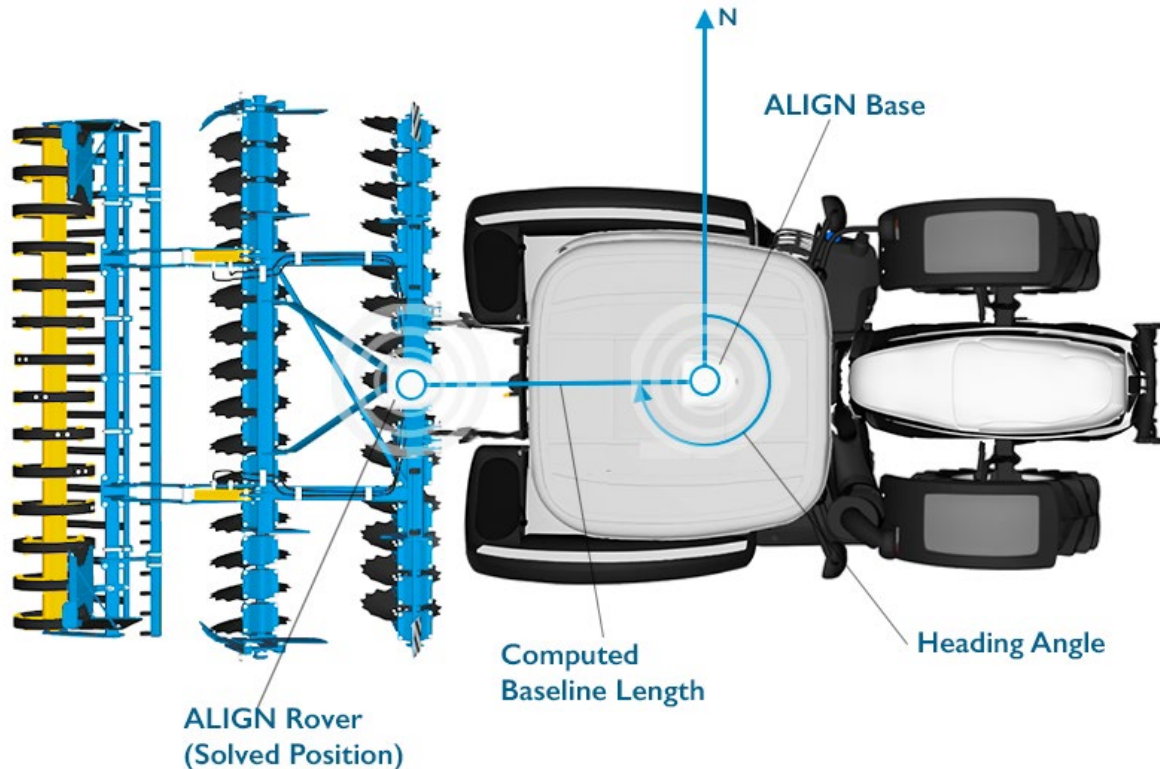


Figure 2: Full solution outputs in ALIGN Relative Positioning: ALIGN baseline length and Rover's relative position besides the Heading angle

ALIGN Relative Positioning can be very effective in implement steering applications such as high precision planting in steep terrain where the implement's accurate position is critical to the operation. With the ALIGN Base receiver installed on the tractor and ALIGN 'Z' model Rover on the implement, the relative heading and pitch angle can be output. Additionally, with a 'Y' model Rover the baseline length and Rover relative position can also be output. These outputs can allow either the tractor to compensate for the difference in heading to place the implement back on the wayline (passive steering) or the implement to steer itself back on the correct wayline (active steering).



ALIGN Relative Positioning – combine and grain cart

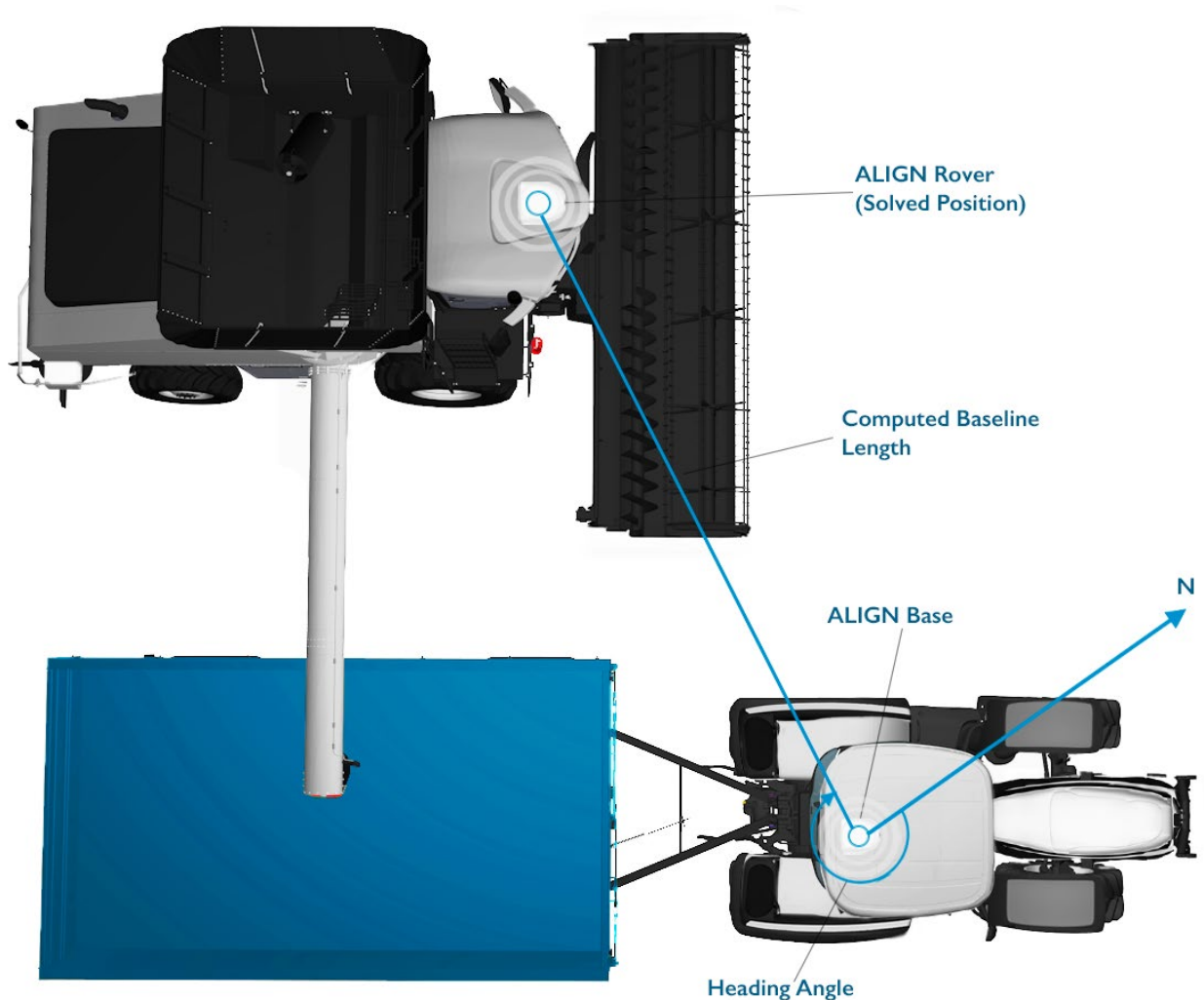


Figure 3: ALIGN Relative Positioning solution outputs utilised in a combine and grain cart setup

ALIGN Relative Positioning 'Y' model can be utilised on the Rover in operations requiring relative positioning between two different machines such as a combine (Rover) and tractor with grain cart (Base) in order to position the grain cart at an optimum offset distance from the combine during grain transfer. Wireless ALIGN communication between Base and Rover can be achieved using an ethernet, Wi-Fi or radio link.



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).

The data can also be collected using [NovAtel Application Suite](#).

Documentation

For any questions on logs and commands, please visit the [OEM7 Documentation Portal](#).

Please refer to [ALIGN Heading and GNSS Relative Positioning for OEM7](#) for additional ALIGN information or for more information on SPAN GNSS and INS Combined Solutions, please see our [SPAN brochure](#) and [SPAN Overview and Integration Guide](#).

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