ADVANCED NAVIGATION
POSITIONING EVERYWHERE

2nd November 2023

Boreas D90

Performance Evaluation

Revision History

VERSION	DATE	CHANGES
1.0	18th Aug 2022	Initial Release
1.1	2nd Nov 2023	Added car dead reckoning results

Table 1. Revision history

Table of Contents

Introduction

Boreas D90 combines Digital Fibre Optic Gyroscope (DFOG) and closed-loop accelerometer technologies, with a dual antenna RTK GNSS receiver. These are coupled in a sophisticated fusion algorithm to deliver accurate and reliable position, navigation and timing (PNT).

This performance evaluation report is designed to demonstrate a range of datasheet specifications as well as additional metrics useful for comparing IMU and INS products. This report aims to help facilitate decision making in the suitability and performance of Boreas D90 for a wide range of applications.

It is expected that additional application centric and performance metrics will be included in this report over time. If it does not contain key information needed to facilitate your needs then please contact your account manager or support@advancednavigation.com for more information. Advanced Navigation also offers loan units, if needed, to help determine product performance and suitability.

Allan Variance

PERFORMANCE GRADE	BIAS STABILITY
Consumer/Hobby	> 30 °/h
Industrial & Tactical	1 – 30 °/h
High-end Tactical	0.1 – 1 °/h
Navigation	0.01 – 0.1 °/h
Strategic	0.0001 – 0.01 °/h

The Allan Variance method is used to determine the Bias instability and Angular Random Walk (ARW) of the gyroscopes.

Bias Instability (sometimes referred to by others as Bias Stability, or In-run Bias Stability) is a comparative figure of merit for gyroscope drift. Lower numbers mean a lower error in orientation estimation when integrating the gyroscope output over time. It is often used to divide gyroscope performance into grades, for example; consumer, industrial, tactical, navigation or strategic. It is represented in the units of °/hr.

Angular Random Walk (ARW) is the angular error buildup with time due to white noise in the angular rate. It is represented in the units of °/√hr. It can also be represented as Noise Density, in the units of °/h/√Hz, by multiplying ARW by 60. More precisely, the conversation is as follows:

$$ARW\ (°/h) = \frac{1}{60} \cdot \text{FFT}\ (°/h/\sqrt{Hz})$$

Boreas D90 Published specification is:

- A gyroscope bias instability of < 0.001 °/hr
- A angular random walk (ARW) of <0.001 °/√hr

Method

In order to carry out an Allan Variance test, a Boreas unit is situated in a low noise/vibration environment with a relatively stable temperature. The unit is mounted in a stationary fashion. For the range of units tested below, these were situated in either an office environment overnight or in our dedicated calibration chamber. These environments are suitable to prove the performance of the units, however are imperfect, whereby artefacts can be seen on the Allan Variance plot. Tests are run for a duration of 5-12+ hours in order to collect sufficient data.

Results

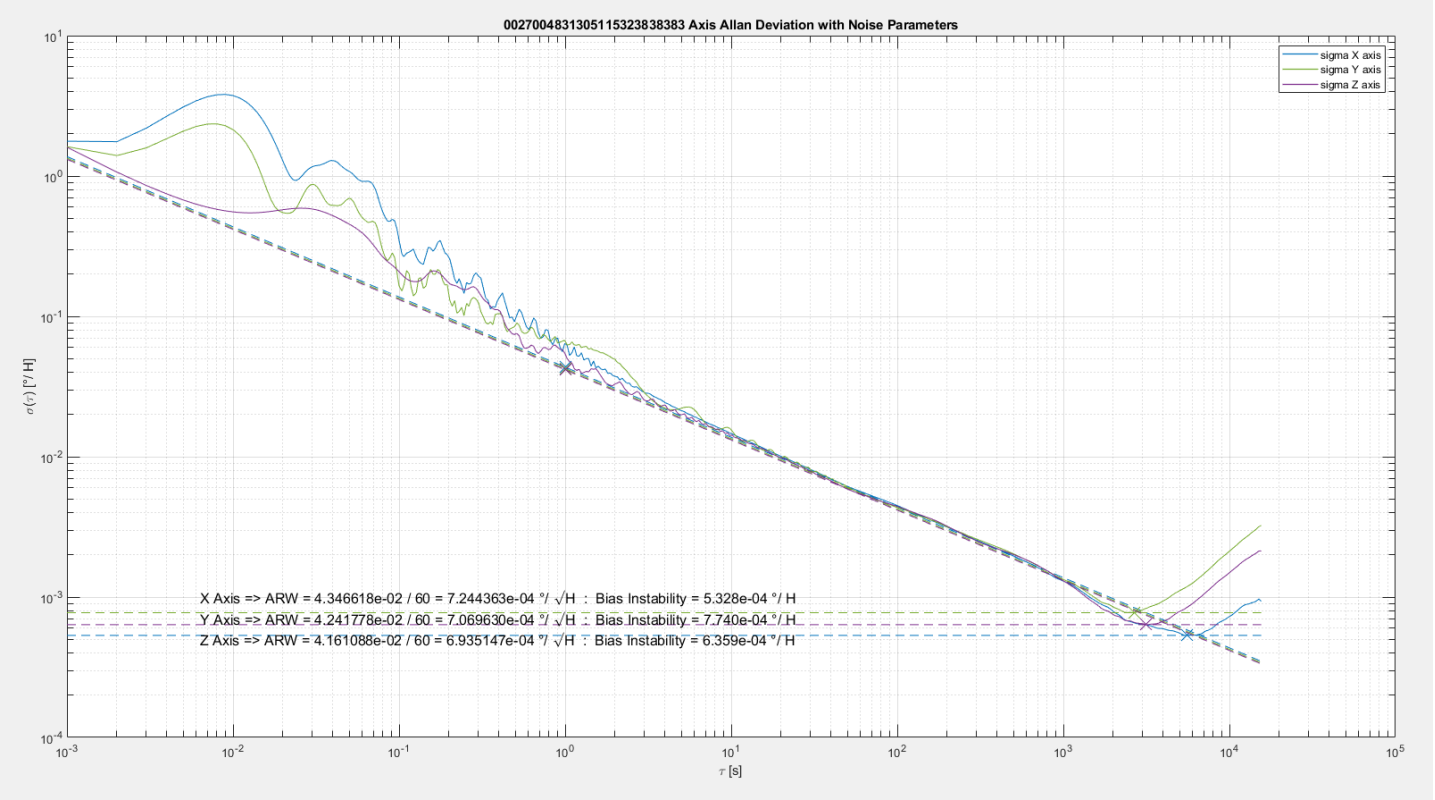
Overall

The average result across all axes of all units tested is:

- Gyro Bias Instability = 0.000574 °/hr (or 5.74 x 10^{-4})
- Angular Random Walk (ARW) = 0.000456 °/√hr (or 4.56 x 10^{-4})

For both bias instability and angular random walk, all Boreas D90 units exceeded the specification, and on average by a factor of 2x

The image below is representative of the Allan Variance test result of a Boreas D90 unit.



Allan Variance of unit 00270048313051153238383838

Individual Unit Test Results

#	Unit Serial Number	Hardware version	Gyro Bias Instability (°/hr) (x/y/z axis)	Angular Random Walk (°/√hr) (x/y/z axis)
1	0019003A3130511532383838	v1.0	0.000643 0.000631 0.000554	0.000739 0.000732 0.000737
2	004D00363130511532383838	v1.0	0.000896 0.000929 0.000826	0.000784 0.000776 0.000769
3	00170031313051153238383838	v1.0	0.000859 0.000501 0.000223	0.000752 0.000745 0.000710
4	00270048313051153238383838	v1.0	0.000457 0.000372 0.000567	0.000364 0.000379 0.000318
5	0048003E3130511832303437	v1.0	0.000690 0.000830 0.000591	0.000334 0.000372 0.000329
6	0048003B3130511832303437	v1.0	0.000678 0.000759 0.000726	0.000344 0.000357 0.000331
7	00470031313051183230343 7	v1.0	0.000397 0.000599 0.000512	0.000356 0.000400 0.000358
8	0048002D3130511832303437	v1.0	0.000468 0.000477 0.000605	0.000332 0.000386 0.000320
9	00480035313051183230343 7	v1.0	0.000875 0.000535 0.000894	0.000330 0.000320 0.000311
10	00470041313051183230343 7	v1.0	0.000423 0.000381 0.000259	0.000319 0.000349 0.000325
11	001A00273130511532383838	v1.0	0.000482 0.000380 0.000349	0.000386 0.000356 0.000347

#	Unit Serial Number	Hardware version	Gyro Bias Instability (°/hr) (x/y/z axis)	Angular Random Walk (°/√hr) (x/y/z axis)
12	00470045313051153238383 8	v1.0	0.000456 0.000657 0.000536	0.000405 0.000364 0.000362
13	00500034343051123139393 7	v1.1	0.000514 0.000513 0.000599	0.000465 0.000508 0.000467
14	00290046303851153931373 4	v1.1	0.000548 0.000542 0.000389	0.000582 0.000507 0.000441

Orientation Accuracy Test

The orientation accuracy test evaluates the absolute roll and pitch accuracy of Boreas D90.

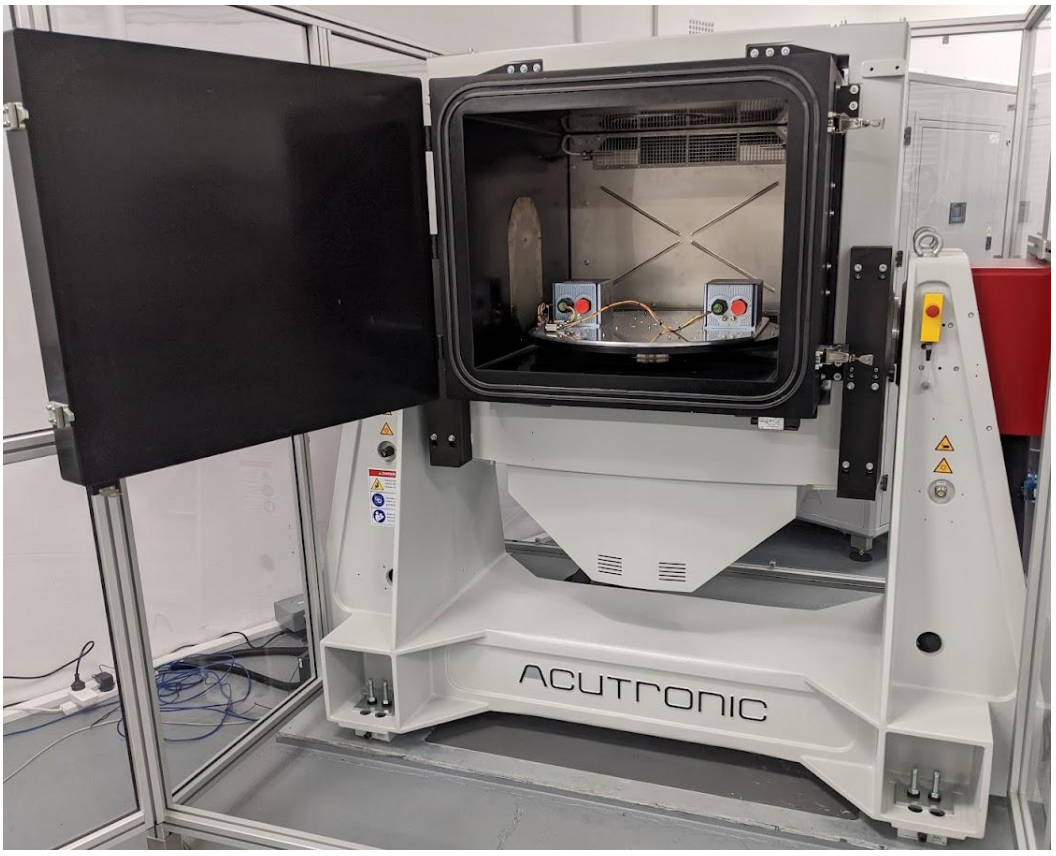
Boreas D90 Published specification is:

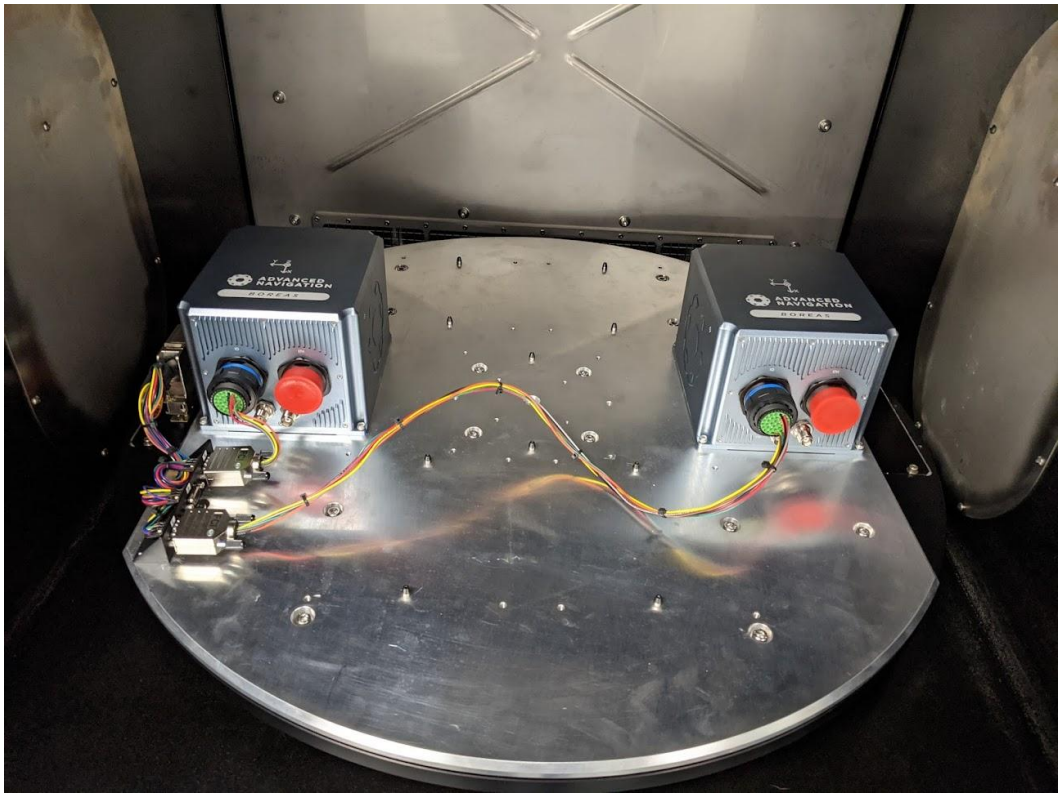
- A pitch accuracy of 0.005 degrees RMS
- A roll accuracy of 0.005 degrees RMS

Method

This orientation accuracy test was performed in an Acutronics iMPULSE GL2 in Sydney, Australia. This system allows orientation positioning accuracy to < 1 arc sec (0.00028 degrees). Two Boreas D90 units were rotated through all 3 axes and the orientation output error was measured against the Acutronic system.


ACUTRONIC
ACUTRONIC


ACUTRONIC

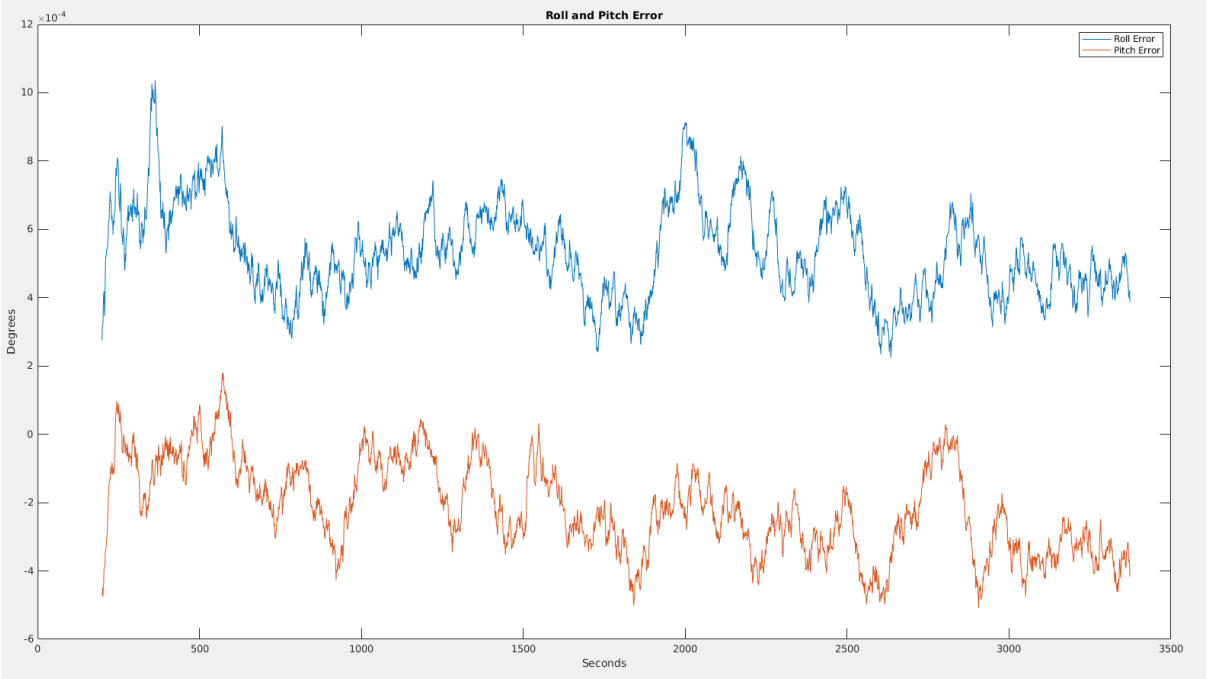


First a room temperature test was conducted, rotating the units through various orientations and measuring the INS filter orientation error against the Acutronic reference angles.

The second test carried out was a repeat of the first test but while the unit was cycled in temperature from -40C to 60C.

Results

The resultant figure below shows the difference between the Acutronic reference orientation and the Boreas D90 reported orientation.



The resultant normalised roll and pitch accuracy over the ~60 min duration of testing is:

- Roll = 0.00014 degrees RMS
- Pitch = 0.00013 degrees RMS

The resultant roll and pitch is an order of magnitude better than the published specification

Gyrocompassing Accuracy Test

Boreas D90 features fully automatic gyrocompassing capability, without the need for user intervention. Gyrocompass coarse alignment initialises as soon as the unit is powered up at a known latitude. Coarse alignment completes in 2 minutes under a range of stationary and low to moderate dynamic motion environments. Neither GNSS position nor heading is required for this operation to complete.

Once coarse alignment is complete, fine alignment commences and runs continuously during the operation of the unit.

Boreas D90 Published specification is:

- A gyrocompass heading accuracy of 0.01 degrees secant latitude RMS

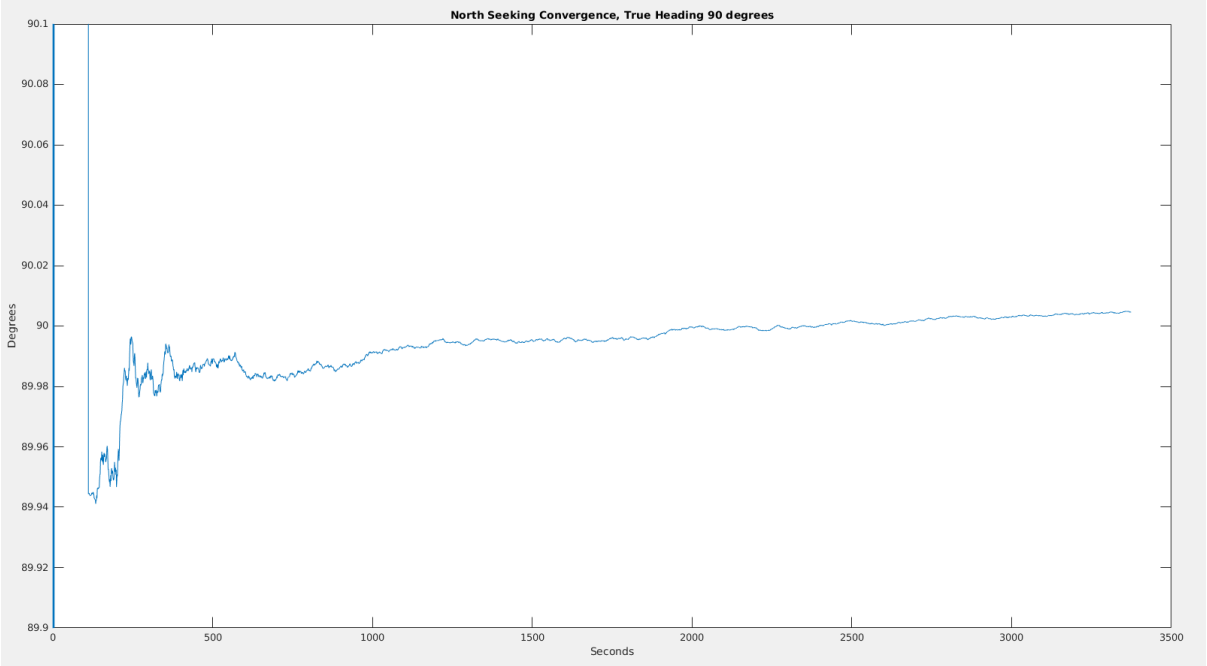
This gyrocompass heading accuracy equates to the equivalent absolute heading accuracy at defined latitudes as:

- 0.01° at 0° latitude (the equator)
- 0.012° at ±33° latitude (latitude of unit under test)
- 0.014° at ±45° latitude
- 0.020° at ±60° latitude
- 0.029° at ±70° latitude
- 0.058° at ±80° latitude

Method

A Boreas D90 unit was situated in the Acutronic chamber as detailed in the Orientation test described above. The unit was orientated to a known azimuth of 90 degrees. The unit was powered up from a cold start, initialised with a latitude of -33.911 degrees, and operated for 60 minutes.

Results



For the first 2 minutes, the unit is completing coarse alignment, for which no known good heading value is defined. After 2 minutes the unit completed coarse alignment and reported a heading of 89.94 degrees (-0.06 degrees from actual). Fine alignment is then in continuous operation.

Small fluctuations are observed whilst the filter resolves gyroscope biases. The system reached full accuracy within 6 minutes. As can be observed, the unit then maintained a heading accuracy better than specification for a period of 1 hour at which point the test was completed.

Dead Reckoning - Car with Aiding

Boreas D90 is a complete GNSS/INS, with exceptional GNSS denied navigation. When aided with an external velocity source, Boreas D90 can achieve long term dead reckoning performance of 0.01% of distance travelled.

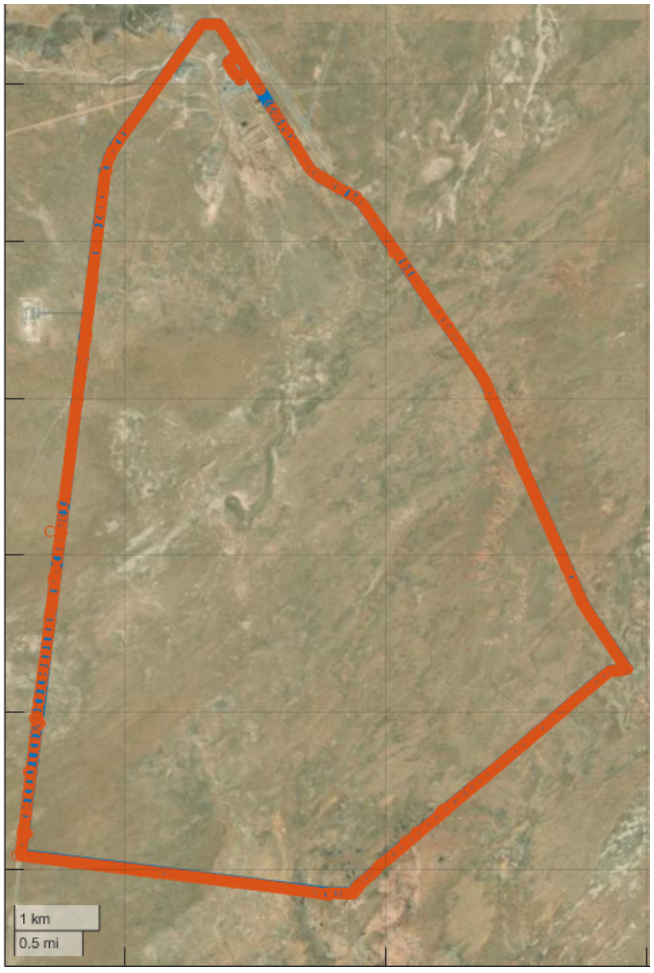
Method

Boreas D90 was installed in a passenger car and fitted with a high accuracy wheel encoder.

The test was to drive the car along a sealed secondary road and compare position data between the GNSS reference and the Boreas D90 DFOG INS at the end of the journey.

Results

A 28 km drive on a mix of sealed/unsealed roads was completed over a 47 minute duration. At the completion of the drive, an error of 4.72 m is measured from the Boreas D90 state output versus the GNSS position, representing an error of 0.017% of distance travelled.


1 km
0.5 mi


Ruler
Line
Path
Polygon
Circle
3D path
3D polygon
Measure the distance between two points on the ground
Map Length:
4.72
Meters
Ground Length:
4.72
Heading:
325.69 degrees
Mouse Navigation
Save
Clear

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