ADVANCED NAVIGATION
POSITIONING EVERYWHERE

5th Apr 2024

Orientus, Spatial & Certus Allan Variance

Revision History

VERSION	DATE	CHANGES
1.1	5th April 2024	Added Accelerometer Allan Variance
1.0	4th April 2024	Initial Release

Table 1. Revision history

Introduction

Orientus, Spatial and Certus are micro-electromechanical systems (MEMS) inertial measurement and/or inertial navigation units (IMU/INS). Each of these units contains the same MEMS gyroscopes and accelerometers.

This report uses the Allan Variance method to demonstrate bias instability and random walk values for both the gyroscopes and accelerometers. This is useful for comparing the raw sensor performance of an AHRS or INS product. This report facilitates decision making in the suitability and performance of Orientus, Spatial & Certus for a wide range of applications.

For further application, performance, or reference needs, please contact your account manager or support@advancednavigation.com for more information.

Allan Variance

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

PERFORMANCE GRADE	GYRO BIAS INSTABILITY
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

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

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:

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

Velocity Random Walk (VRW) is the velocity error buildup with time due to white noise in acceleration expressed in *m/s/√hr*, or *mm/s/√hr*. It can also be represented as Noise Density, in the units of *ug/√Hz*

Orientus, Spatial and Certus published specifications are:

- A gyroscope bias instability of 3 °/hr
- A angular random walk (ARW) of 0.24 °/√hr
- An accelerometer bias instability of 20 ug
- An accelerometer noise density of 100 *ug/√Hz, or* velocity random walk (VRW) of 58 mm/s/√hr

Method

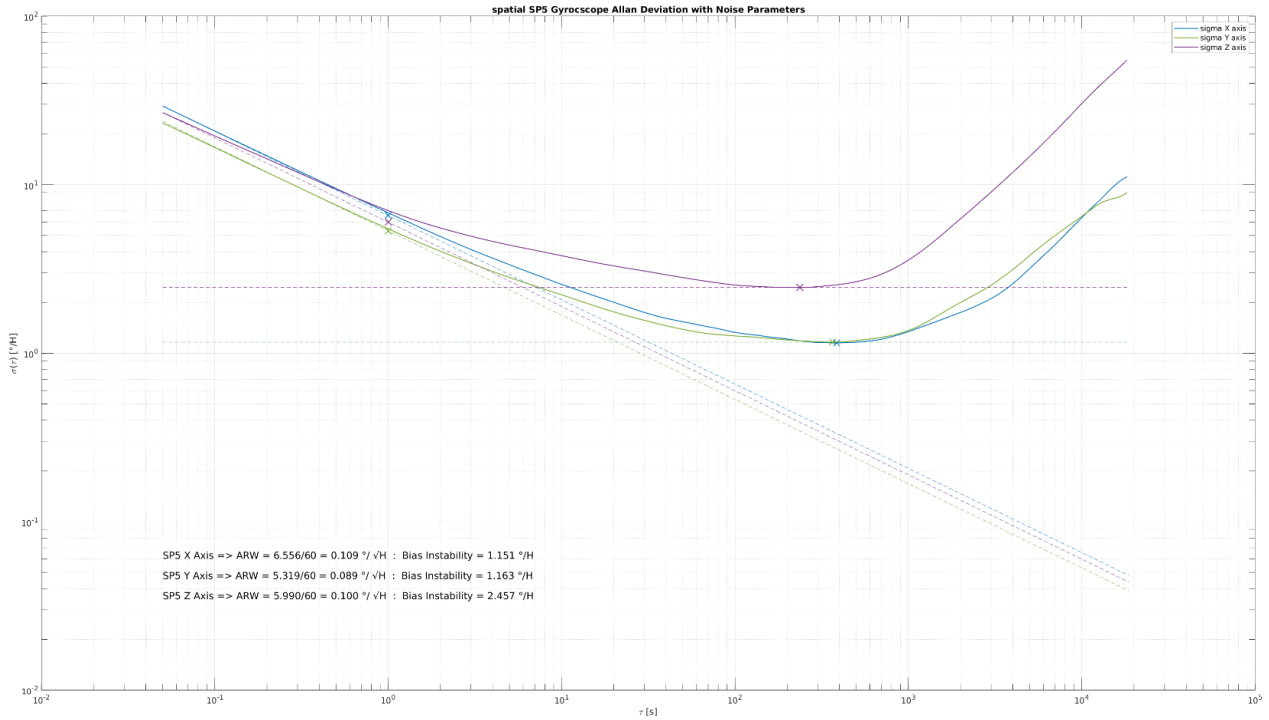
In order to carry out an Allan Variance test, a Spatial unit is situated in a low noise/vibration environment with a relatively stable temperature. The unit is mounted in a stationary fashion in an office environment overnight on an optical table. This environment is suitable to prove the performance of the units, however some artefacts may be seen on the Allan Variance plot. Tests are run for a duration of 5+ hours in order to collect sufficient data.

Gyroscope Results

The average gyroscope result across multiple axes is:

- **Gyro Bias Instability = 1.59 °/hr**
- **Angular Random Walk (ARW) = 0.099 °/√hr**

The image below is representative of the Gyroscope Allan Variance test result of a Spatial unit.



Gyroscope Allan Variance of unit of 0460046374E500C2036374B

Representative Unit Gyroscope Test Results

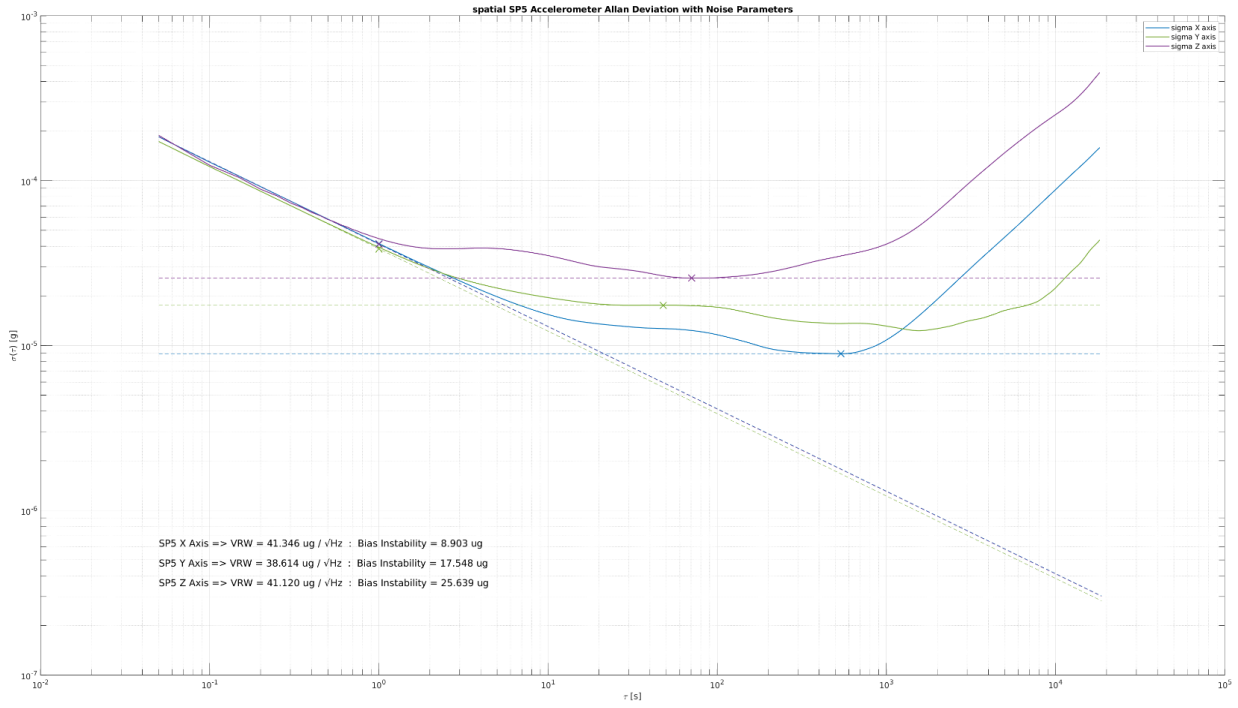
#	Unit Serial Number	Hardware version	Gyro Bias Instability (°/hr) (x/y/z axis)	Angular Random Walk (°/√hr) (x/y/z axis)
1	0460046374E500C2036374B	v8.0	1.15 1.16 2.46	0.109 0.089 0.100

Accelerometer Results

The average accelerometer result across multiple axes is:

- **Accelerometer Bias Instability = 17.3 ug**
- **Velocity Random Walk (VRW) = 23.7 mm/s/√hr**

The image below is representative of the Accelerometer Allan Variance test result of a Spatial unit.



Accelerometer Allan Variance of unit of 0460046374E500C2036374B

Representative Unit Accelerometer Test Results

#	Unit Serial Number	Hardware version	Accelerometer Bias Instability (ug) (x/y/z axis)	Accelerometer Noise Density (ug/√Hz) (x/y/z axis)	Velocity Random Walk (mm/s/√hr) (x/y/z axis)
1	0460046374E500C 2036374B	v8.0	8.9 17.5 25.6	41.3 38.6 41.1	24.3 22.7 24.2

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