NovAtel's SPAN® GNSS/INS with the Analog Devices ADIS16488 IMU

Performance Analysis–July 2012

ABSTRACT

NovAtel's GNSS/INS SPAN product is used to provide precise position, velocity and attitude across many applications. Increasingly, applications are requiring smaller and lighter components for use in compact vehicles or embedded within systems such as cameras or communication devices.

This paper gives the results of ground navigation tests of the Analog Devices ADIS16488 MEMS IMU within the SPAN system. Real-time position, velocity and attitude are shown to be comparable with systems using larger and heavier ring-laser and fibre optic gyro IMUs. Though the results are not as good as the larger IMUs, this must be weighed against the importance of the size, weight, and cost of these MEMS IMUs.

INTRODUCTION

NovAtel's SPAN GNSS/INS products are used in a range of applications requiring precise real-time position, velocity and attitude.

Traditionally, accurate navigation using inertial technology was only possible with high-end ring-laser or fiber optic gyroscope technology. New applications are increasingly requiring smaller, lighter and more cost effective solutions for use on smaller vehicles or within sensor assemblies. MEMS technology has improved dramatically over the last few years to answer this need. While the performance of some MEMS offerings from traditional IMU suppliers (for example, Honeywell HG1900 and HG1930) is approaching that of more traditional gyro technologies, they are still export controlled, heavier and expensive. Consumer MEMS IMUs such as the ADIS16488 are rapidly closing the performance gap. The results shown here demonstrate the possibility of using such an IMU with NovAtel's GNSS/INS engine, SPAN.

SYSTEM DESCRIPTION

SPAN (Synchronized Position, Attitude and Navigation) tightly couples NovAtel's industry-leading GNSS (Global Navigation Satellite System) precise-positioning technology with a robust INS (Inertial Navigation System) to provide high-rate, continuous, real-time position, velocity and attitude. A SPAN system comprises a NovAtel GNSS receiver, an IMU (Inertial Measurement Unit) and a dual-frequency GNSS antenna. A range of receiver and IMU options ensures customers obtain the accuracy and price/performance their applications require.

Combining GNSS and INS provides reliable, continuously available, position, velocity and attitude – even through short periods of time when satellite signals are blocked or unavailable. The real-time solution is available at up to 200 Hz and raw IMU and GNSS observation data can be stored for post-mission processing. GNSS signal tracking and RTK convergence times are also greatly improved due to the tightly-coupled architecture of SPAN.

For applications that require a post-processed solution, NovAtel's Inertial Explorer® software easily integrates raw data collected using a SPAN system to provide the best possible GNSS/INS accuracy.

The ADIS16488 is a Micro Electromechanical Systems (MEMS) gyro-based IMU suitable for various commercial and military guidance and navigation applications.

Test Equipment Overview

For testing, the IMU was operated using NovAtel's MEMS Interface Card (MIC) to provide the necessary regulated power inputs, decode the binary message stream and apply a precise time to each IMU measurement. The time stamped data were used along with the GNSS measurements to compute the integrated GNSS/INS solution onboard a NovAtel OEM6® GNSS receiver. The solution was available in real-time through the receiver peripheral devices.

Real-time data was compared to an Inertial Explorer® post processed solution from a navigation grade IMU running at the same time. See Table 3 for the navigation grade IMU specifications.

Analog Devices ADIS16488 IMU

Figure 1 and Table 1 show the Analog Devices ADIS16488, which is a rugged, lightweight, low power IMU. The ADIS16488 IMU is ideal for commerical or military applications that require high performance in a small form factor.

NovAtel OEM615 Receiver with MEMS Interface Card (MIC)

Figure 2 and Table 2 show the OEM615 and MIC, which is the lightest weight board combination available with SPAN. The test results are from this board combination, but SPAN performance for different OEM6 boards is equivalent.

Figure 1: ADIS16488 IMU

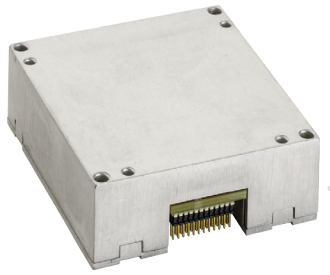


Figure 2: OEM615 with MIC

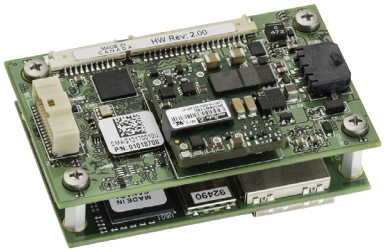


Table 1: ADIS16488 IMU Specifications

Dimensions	47 x 44 x 14 mm
Weight	<48 g
Power Consumption	<0.9 W
Gyro Rate Range	±450 deg/s
Gyro In-Run Bias	6.25 deg/hr
ARW	0.3 deg/√hr
Accel Range	±18 g
Accel In-Run Bias	0.1 mg
Data Rate	200 Hz

Table 2: OEM615 + MIC Specifications

Dimensions	75.1 x 45.7 x 19.5 mm
Weight	24 g (OEM615) + 31 g (MIC)
Power Consumption	2.5 W (board stack only) 3.5 W (with IMU)
Channels (when configured for SPAN operation)	120 channels • GPS L1/L2/L2C • GLO L1/L2 • SBAS
Time Accuracy	20 ns RMS
Peripherals	1x USB, 1x LVTTL, 1 x IMU port

Test Methodology

Testing was performed using the IMU in two different configurations. One test was conducted in single point mode with no GNSS aiding sources, such as Real-Time Kinematic (RTK). In the second test, RTK corrections were input to the system in real-time from a stationary NovAtel base station located within 10 km of the test site. Both tests were performed under conditions with relatively good view of the GNSS satellites. This scenario is similar to the expected satellite visibility in an airborne environment.

To provide a truth solution for testing, a navigation grade IMU was installed in the vehicle. The raw IMU and GNSS data from the navigation grade system was post processed to provide the control for the test. Due to the quality of the control system, relative to the MEMS device, differences between the two solutions are considered to be navigation errors in the MEMS system.

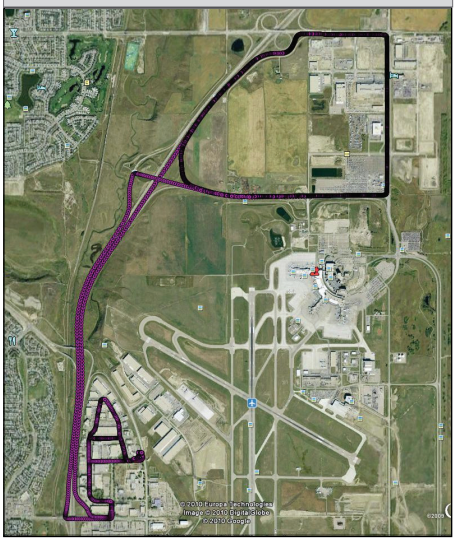
Table 3: Control IMU Performance Specifications

Gyro Bias	0.0035 deg/hr
Gyro Scale Factor	5 PPM
ARW	0.0025 deg/√hr
Accel Bias	0.03 mg
Accel Scale Factor	100 PPM

Test Area

The driving route of the test is shown in Figure 3.

Figure 3: Test Area-Calgary, AB



Test Results

The plots show the performance for the SPAN real-time navigation solution using the ADIS16488 IMU when operating in unaided single point mode and RTK mode. The physical misalignment between the control IMU and test IMU has been removed for these comparisons.

Figure 4: Single Point ADIS16488 SPAN Position Error

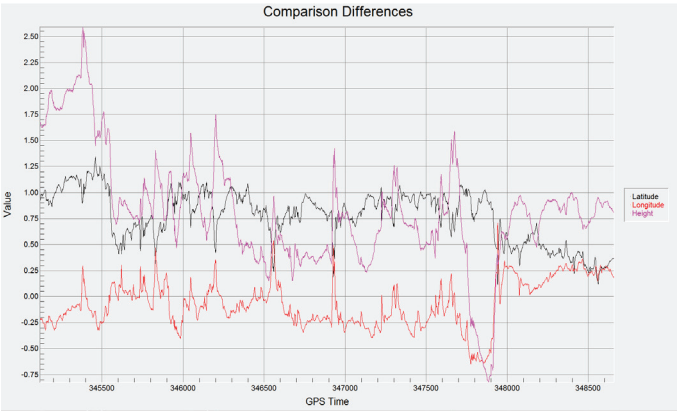


Figure 5: RTK ADIS16488 SPAN Position Error

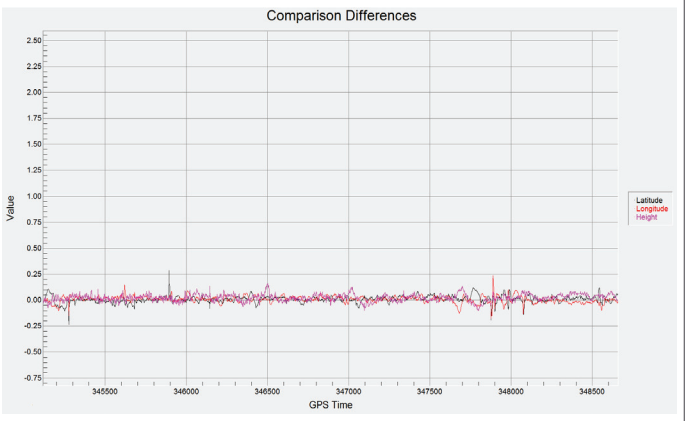


Figure 6: Single Point ADIS16488 SPAN Velocity Error

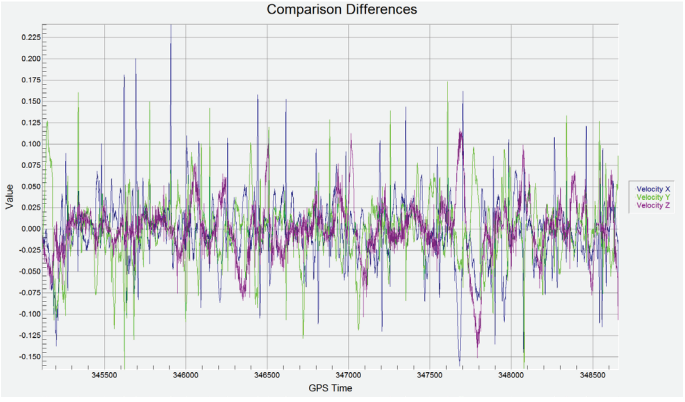


Figure 8: RTK ADIS16488 SPAN Velocity Error

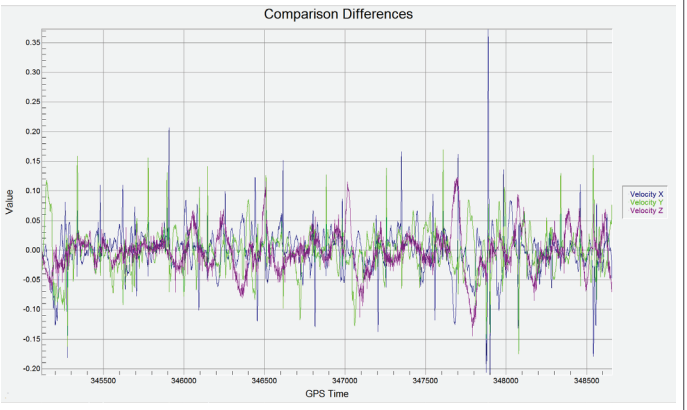


Figure 7: Single Point ADIS16488 SPAN Attitude Error

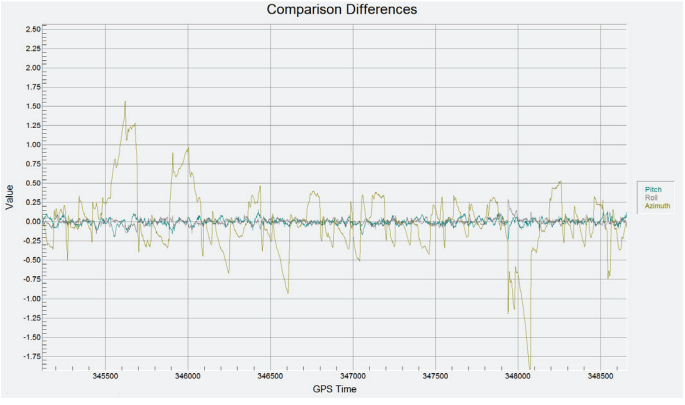
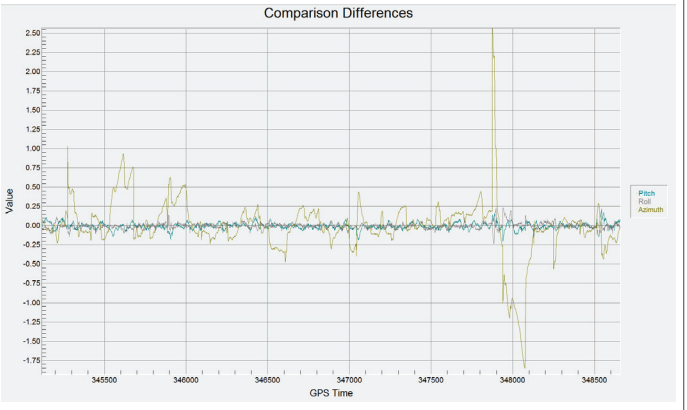


Figure 9: RTK ADIS16488 SPAN Attitude Error



Performance

The ADIS16488 IMU, when integrated with SPAN, provides accurate position, velocity and attitude information that is useful for many navigation and pointing applications. As expected, position accuracy is significantly improved by using RTK corrections, but the attitude performance is slightly noisier with RTK corrections. Velocity was essentially unaffected by operating in RTK mode versus single point.

The ADIS16488 offers a significant size and weight advantage over other comparable IMU technologies. For reference, the specifications available with the larger and heavier ring-laser HG1700 are given in Table 6. While it is clear that the performance of the ADIS16488 is still slightly below what can be achieved with a larger tactical IMU, the performance versus the size, weight, and price of these units is astonishing.

Table 4: ADIS16488 SPAN Performance Summary

Errors RMS	2D Pos. (m)	2D Vel. (m/s)	Roll (deg)	Pitch (deg)	Heading (deg)
SP	0.845	0.055	0.046	0.056	0.450
RTK	0.048	0.054	0.041	0.039	0.363
PP	0.020	0.020	0.060	0.060	0.250

Table 5: HG1700 SPAN Performance Summary

Errors RMS	2D Pos. (m)	2D Vel. (m/s)	Roll (deg)	Pitch (deg)	Heading (deg)
SP	0.731	0.020	0.010	0.010	0.023
RTK	0.020	0.020	0.010	0.010	0.021
PP	0.010	0.020	0.007	0.007	0.010

Table 6: HG1700 IMU Specifications

Dimension	168 x 195 x 146 mm with enclosure
Weight	4.5 kg with enclosure
Power Consumption	8 W typical
Gyro Rate Range	±1000 deg/s
Gyro Bias	1 deg/hr
Gyro Scale Factor	150 PPM
ARW	0.125 deg/√hr
Accel Range	±50 g
Accel Bias	1 mg
Data Rate	100 Hz

Conclusion

The ADIS16488 IMU offers huge size, weight, and price advantages over more traditional IMU technologies. While the performance of these units is not up to the level of the larger IMUs, it is still superb overall and well within the operating requirements of several applications. For any application where size, weight, and price are critical attributes these IMUs provide a very alluring option.

For more information on the NovAtel range of SPAN systems, including non-ITAR tactical grade IMU's, please visit:

http://www.novatel.com/products/span-gnss-inertial-systems/

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