Test Report iµVRU

(excerpt)

Commercial-in-Confidence

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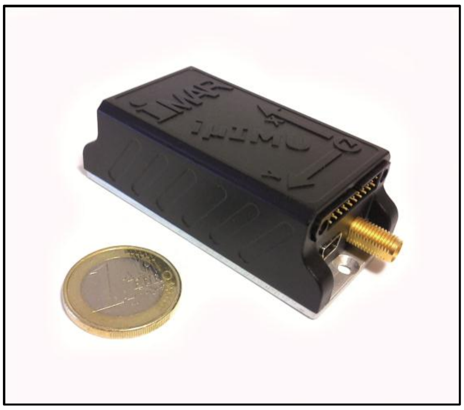

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CHANGE RECORD

Date	Issue	Paragraph	Comments
29.10.12	1.0	All	New Document
25.03.13	1.01	2.1	Pictures added (used ref. systems)
25.09.13	1.02	2.2	Comparison Baro Altitude vs. GPS Altitude added

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1 SCOPE

This report provides test results obtained from an iµVRU-01, compared with a high performance reference INS/GNSS system of type iTraceRT-F400. The iµVRU, based on the iµIMU hardware, with integrated iMAR's proprietary NoA² algorithm, is equipped with 3 gyroscopes, 3 accelerometers, 3 magnetometer axes, barometer (height), odometer interface and integrated GPS receiver and the weight is 50 grams only. To get an impression about the inertial sensor performance, in the following test the barometer height, the magnetometer heading aiding and the odometer aiding are disabled.

2 RESULTS

The iµVRU and the iTraceRT-F400 are mounted together in a car (Audi A4), both are supplied from the same GNSS antenna via an antenna splitter.

The following plots show the results of both units and the differences between them. The iTraceRT-F400 is based on an accurate fiber optical gyro and servo accelerometers and provides angular accuracy of roll/pitch of better 0.02 deg and heading better 0.03 deg. The data rate of the iTraceRT-F400 is 400 Hz, the iµVRU data rate was adjusted at 200 Hz.

The iµVRU performance is described in its datasheet. The test results show, that the performance in real environment is better than given in the datasheet.

The test track shown in the following was acquired in regular traffic.

2.1 Test Results with standard GPS condition

The GPS coverage was standard, i.e. no longer outages had been observed during this test.

Figure 1: Trajectory in © GoogleEarth, red = iµVRU, blue = iTraceRT-F400

The first figure shows the driven trajectory over a duration of 25 minutes. It can be well seen that the trajectory follows a street, which is located partially in rural area, partially in town and partially in dense forest.

The following figure shows a zoom of the trajectory in the forest area.

Figure 2: Zoom of trajectory; blue = iTraceRT-F400, red = iμVRU

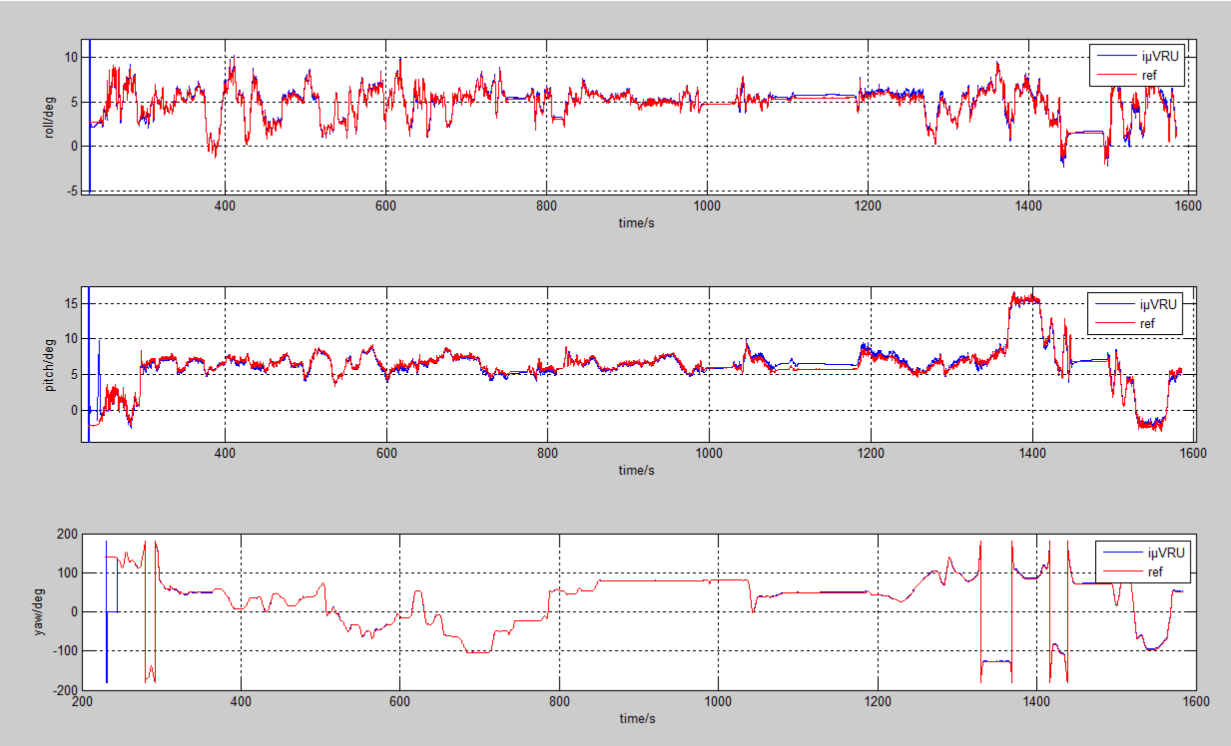

Figure 3: Roll and Pitch and Yaw Results of iµVRU, compared with iTraceRT-F400

Figure 5: iMAR's Reference INS/GNSS system iTraceRT-F400

Figure 4: iMAR's Reference INS/GNSS system iNAV-RQH (0.002°/h)

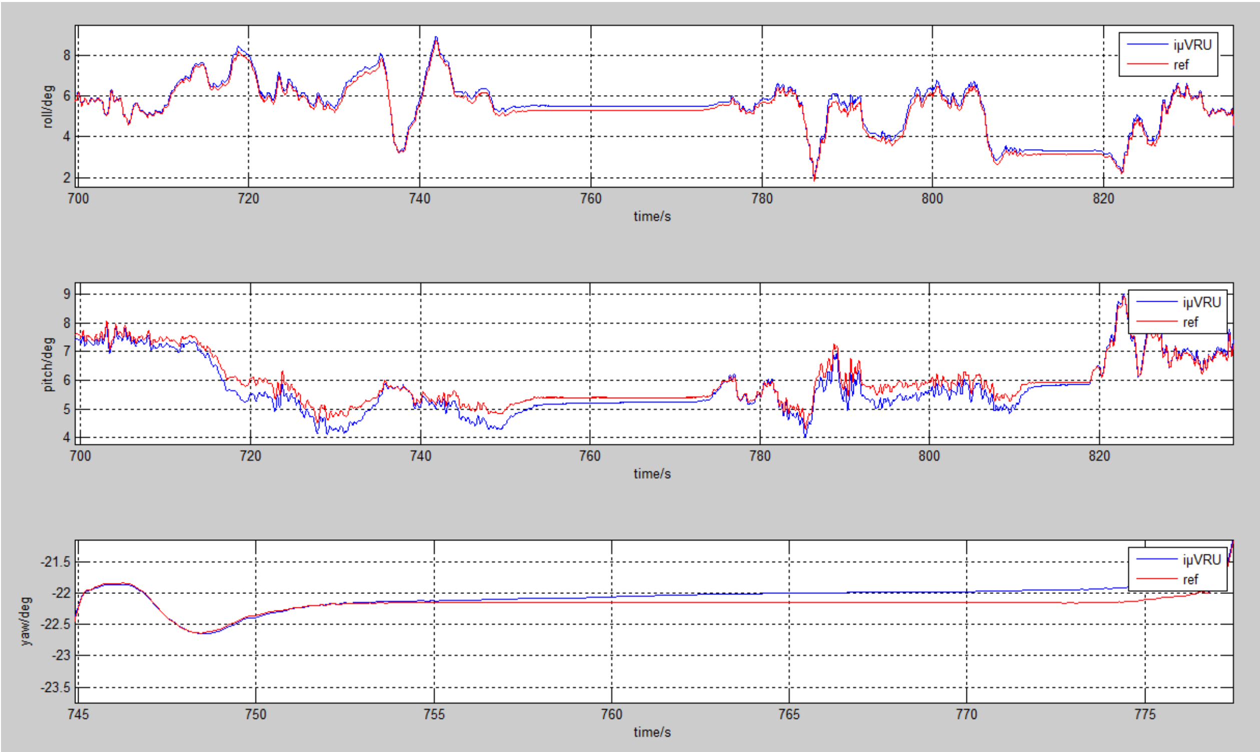

Figure 6: Roll, Pitch, Heading iµVRU against iTraceRT

The RPY figure demonstrates the high angular performance of the iµVRU. The dynamic roll/pitch accuracy is better than 1 deg and the heading drift at standstill (no heading aiding by GPS due to zero velocity) is only 0.2 deg over 30 sec, i.e. < 0.005 deg/s

The next figure shows the deviation between iµVRU and reference unit iTraceRT-F400 as well as the standard deviation and mean value of the deviation. It shows that the standard deviation is with 0.53 deg well below 1 deg under dynamic conditions.

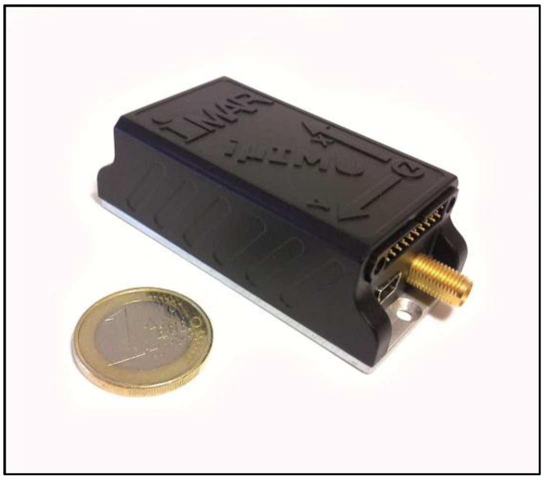

Figure 7: iMAR's iµVRU

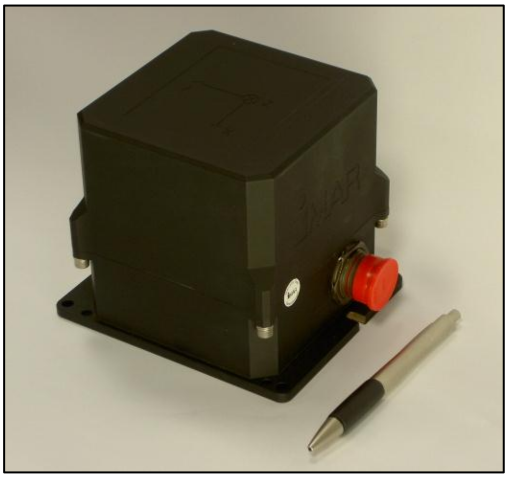

Figure 8: iMAR's iVRU-FC

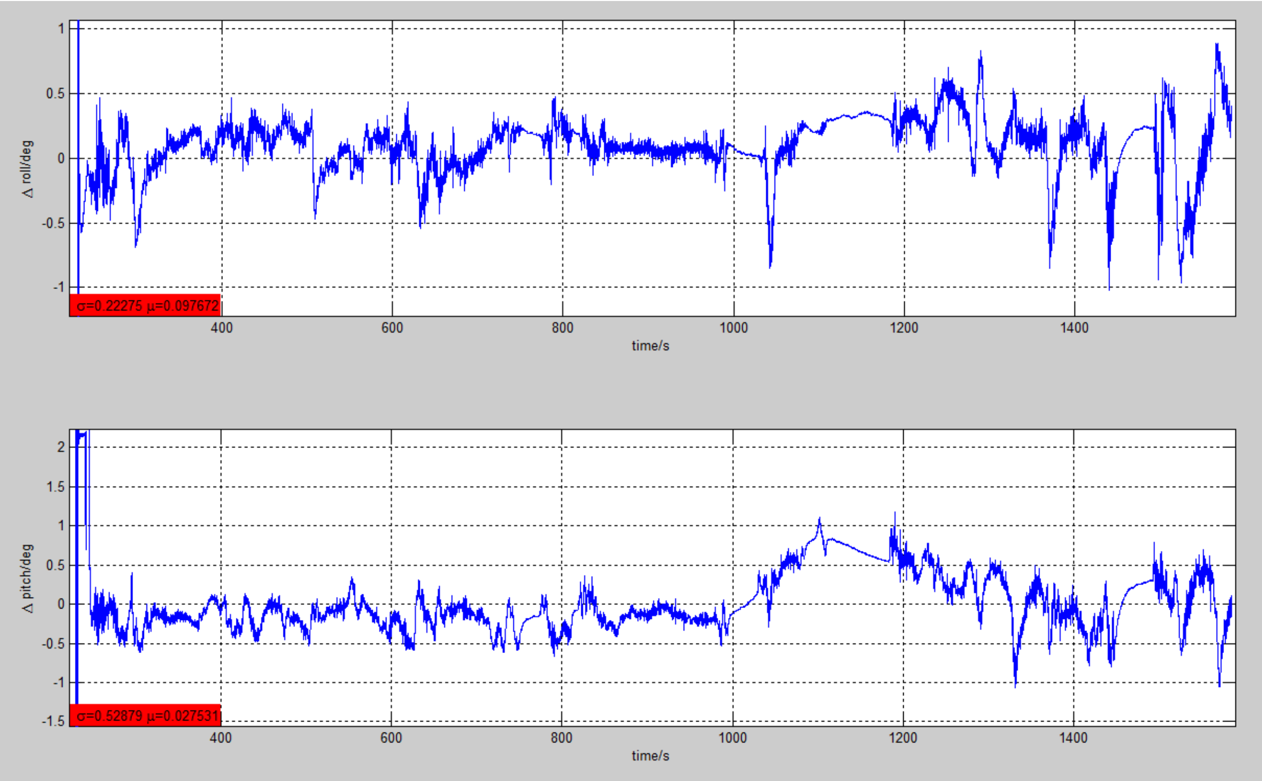

Figure 9: Deviation between iµVRU and iTraceRT-F400 in Roll and Pitch

The next figure shows the horizontal velocity provided by the iµVRU with 200 Hz data rate. The dots show the position update of the integrated GPS receiver, the red line shows the INS/GNSS navigation solution.

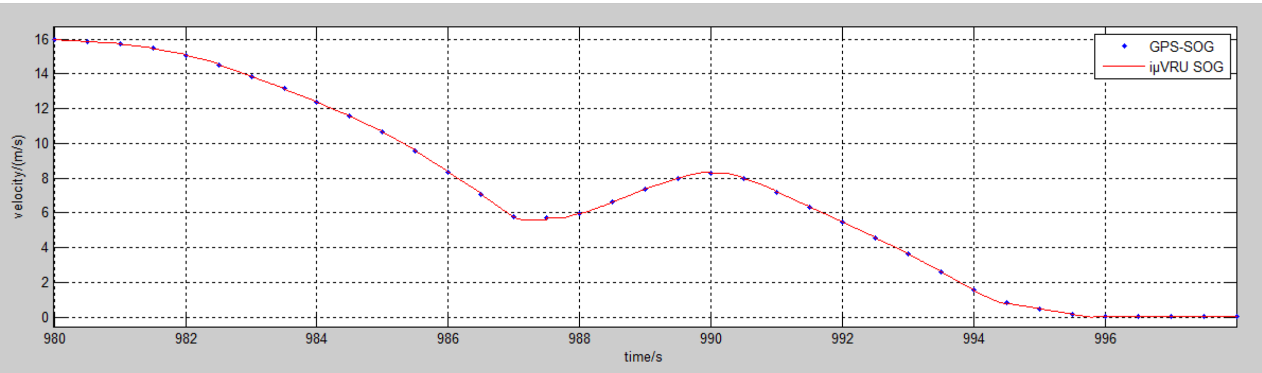

Figure 10: Velocity output of the INS/GNSS solution (speed over ground)

2.2 Altitude Test Results: Baro vs. GPS Height

The advantage of the iµVRU with its integrated NoA² algorithm is the availability of a quite excellent roll / pitch solution even if GPS is not available even for the entire (!) motion.

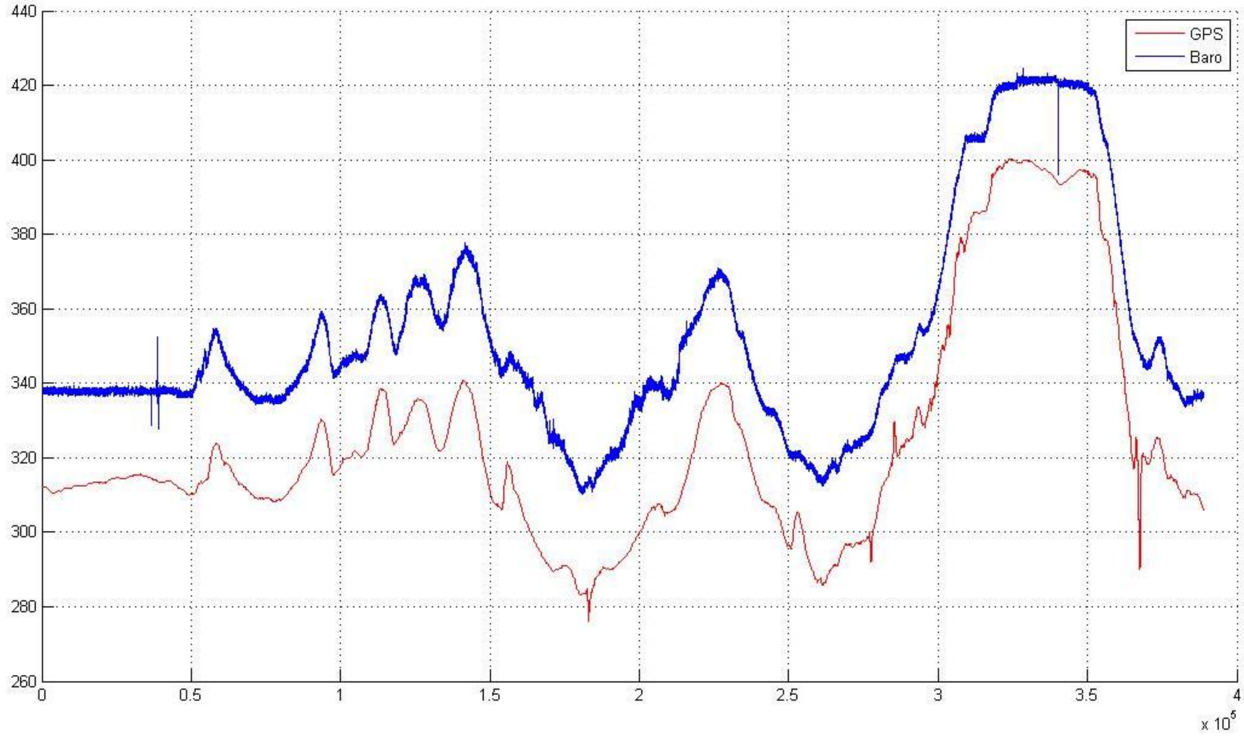

Figure 11: Comparison of Baro altitude against GPS altitude (both iµVRU)

In the figure above the axis of abscissa shows the time in samples (200 Hz), i.e. about 30 minutes) and the axis of ordinates shows the altitude in meters. The offset between both is result of the local barometric pressure. The tests had been performed in a car – the peaks at sample 40'000 and 340'000 are caused by opening / closing the car's door. For the test the data given in the figure are not smoothed using the available accelerometer data.

2.3 Test Results without GPS aiding

The advantage of the iµVRU with its integrated NoA² algorithm is the availability of a quite excellent roll / pitch solution even if GPS is not available even for the entire (!) motion.

For best comparison to the results of the test described above, the IMU data have been taken and fed into our HIL Simulation (hardware in the loop) of the iµVRU software. The results show, that – due to the implementation of iMAR's proprietary NoA² algorithm - the roll/pitch performance is quite comparable to those data obtained with GPS aiding.

The mean values are smaller than 0.5 deg and the standard deviation is smaller than 1 deg.

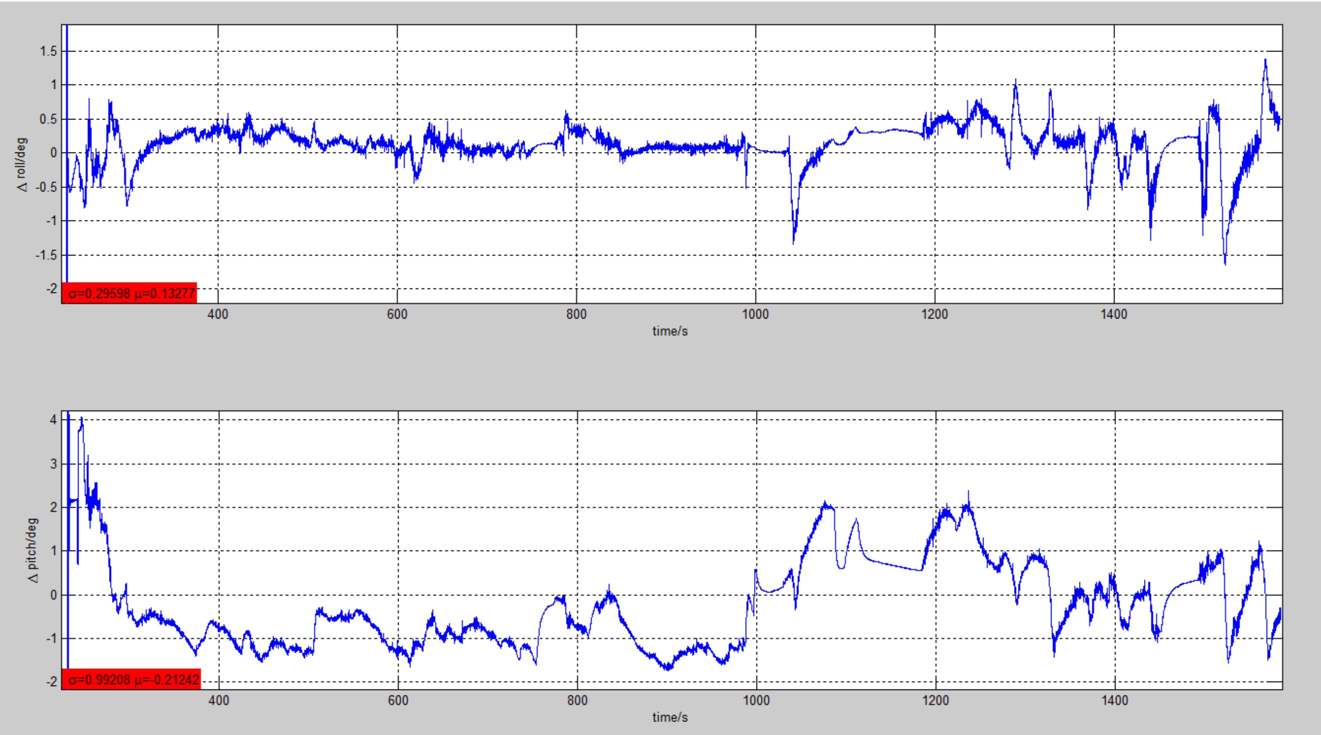

Figure 12: Roll and Pitch Deviation between iµVRU without GPS aiding and iTraceRT-F400

3 SUMMARY

The following table shows the results obtained from the above described tests with our iµVRU as well as from flight and automotive test data sets, obtained with our iVRU-FC. All measurements show a standard deviation which is below 1 deg under dynamic condition as well as under static condition. The mean value deviation is the result of a misalignment between the reference measurement system (iTraceRT-F400 [tactical grade, 0.75 deg/h, 1 mg] or iNAV-RQH-1003 [navigation grade, 0.002 deg/hr, 25 µg]) and the iVRU-FC and the iµVRU as well as of the specified accelerometer bias of the iVRU-FC and iµVRU.

		EC145 (Helicopter) iVRU-FC w/o aiding	**Audi A6 (car) iVRU-FC w/o aiding**	**C27J #6 (FixedWing) iVRU-FC w/o aiding**	**Audi A4 (car) iµVRU with GPS**	**Audi A4 (car) iµVRU w/o aiding**
Roll	µ [deg]	0.12	0.50	0.34	0.10	0.13
	σ [deg]	0.47	0.22	0.44	0.22	0.30
	min [deg]	-2.14	-0.37	-1.40	-1.01	-1.65
	max [deg]	1.51	1.01	2.46	0.89	1.41
Pitch	µ [deg]	0.42	-0.12	0.18	0.03	-0.21
	σ [deg]	0.60	0.31	0.63	0.53	0.99
	min [deg]	-1.22	-1.06	-2.03	-1.10	-1.76
	max [deg]	2.33	0.73	2.67	1.21	2.19

Table 1: Test Performance of iµVRU and iVRU-FC with and without aiding with GPS, compared with iTraceRT or iNAV-RQH