Geosci. Instrum. Method. Data Syst. Discuss., 5, C251–C256, 2016
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5, C251–C256, 2016

Interactive Comment

Interactive comment on "A new high-precision and low-power GNSS receiver for long-term installations in remote areas" *by* D. H. Jones et al.

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Received and published: 7 March 2016

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Interactive Discussion

Discussion Paper

Modifications to “A new high-precision and low-power GNSS receiver for long-term installations in remote areas”

David H. Jones, Carl Robinson, G. H. Gudmundsson

7 March 2016

1 Modifications 02/03/16, in response to feedback from M. King

We thank the reviewers for their very helpful and constructive thoughts and suggestions. In the following we give a point-by-point list of all comments made by the reviewers and how we have responded to them. Our responses are in italic.

- The key weakness of the developed hardware is that firmware upgrades cannot be done remotely. *This is not considered a weakness in the intended applications — Wherever low-power consumption is a requirement, we can also assume that there is not an available Ethernet socket or high-bandwidth data link. When GPS receivers are installed by BAS they are powered by wind turbines and solar panels, and do not have the power or infrastructure necessary for communicating the raw data back to BAS, or for BAS to re-configure the firmware by sending it updates. Having said which, the firmware can be updated remotely if someone*

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*on-site changes a switch setting and connects the **Ubi** to a networked serial port. I have added the sentence "It is simple to load the **Ubi** with new firmware via a serial port interface"*.

- Likewise, I don't think the MB100 can take, for example, a meteorological data feed. *This is not something BAS typically does, but we do recognise that the ability to take a meterological data feed is of value, for example, for estimating the inverse bariometric effect. We have added the sentence "The **Ubi** receiver has one external serial port interface, and has connections for another. It also has connections for general purpose digital and analogue, inputs and outputs. As such it can be easily adapted to log external data feeds or control power lines based on commands triggered by a timer or the Iridium link."*

- The receiver power consumption comparison is based on manufacturer specifications. *In table 2 I compare measured power consumptions for different GNSS receivers and the **Ubi** , all using the same antenna*.

- The positioning tests are, to me, problematic. Comparing baseline time series between identical receivers vs non-identical is the key here. The authors note this, but I think the tests are sufficiently suspect to not add anything but confusion. Differencing data treated identically (by identical receivers) will produce smaller baseline noise.

  I have included the following paragraph at the top of the accuracy assessment section

  "The comprehensive assessment of the accuracy and precision of a GPS receiver is difficult, expensive (Jackson et al., 2000; UNAVCO, 2012; Penna et al., 2012) and subjective — different conclusions can be drawn depending on the form of the experiment and the type of post-processing performed. These assessments normally consist of several different measurement types, performed on data from one or more of the receivers under evaluation. Here we use three

separate types of metrics to evaluate the accuracy of GPS positions calculated from data recorded by ***Ubi*** *. By themselves, none of these metrics are a conclusive measure of the absolute performance of* ***Ubi*** *but, taken as a whole, their results can be considered indicative of the relative performance of* ***Ubi****".*

We assume there are no systematic sources of error in either receiver design. Such error sources would introduce a static bias or a trend in the position which would prejudice this analysis. However such trends or bias would be evident in figures 7 and 11, and they're not. Nor will the data be identical by the time it is differenced — they do not share a common antenna, thermal noise introduced by the receiver amplifiers and sampling noise from the receiver ADCs — will all cause the data to differ between receiver processors. What we are trying to do is evaluate the ability of each receiver to track satellites, the amount of noise added by the receivers, and the ability of the receivers to filter out noise sources prior to recording it. Both of these factors are captured in any variations between the receivers recorded separation. We have been very careful in the conclusions we are drawing from these tests, but the results from 3 separate testing methodologies all have similar results.

- The positioning tests are not actually a test of the Ubi, but of the GPS receiver in the Ubi. *This is indeed a good point, and something that we initally believed true. However, during early trials we found that other electronics within the Ubi can adversely affect the accuracy of the recorded data via : EMI interferance and power supply instability, as well as there being difficulties logging the raw data using a low-power, slow, microprocessor. All of these problems we have now fixed, but this is why we did positioning tests on the* ***Ubi*** *as opposed to directly on the MB100.*

- As such, positioning solutions will generate different residuals depending on how this smoothing was done and how the relative weighting of range and phase are done in the PPP solutions. This makes comparison of residuals between

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receivers quite challenging. *We included this analysis because it is a common method of comparing GPS receivers (e.g. UNAVCO GNSS Receiver Evaluations 2012). Even so, we are including this result alongside another analysis (Scatter position plot, Fig 11) and are conservative in the conclusions we draw from them*.

- *I have made all of the minor corrections you list except for*
  - your concerns about a sample rate of 300s. Here I'm just passing on a configuration option Ashtech think you may use. However others have used this sample rate (e.g. "Testing real time gps orbit and clock products" J. Dousa 2007, Precise orbit determination of GPS satellite using regional tracking network SPIE 2007 Min Li et. al.
  - Precision - Accuracy, *We are not trying to quantify the resolution at which Ubi can measure position, this is not a measure of precision. Ideally accuracy would be measured against an absolute truth, but in the absence of this we measure the consistency of our position measurements with position measurements from other receivers, and we measure the noise in these measurements as well. I have added the sentence "Due to the unobstructed view of the sky available to the antenna and the long duration of this experiment, we are confident assuming that there is no bias in the calculated positions; that we can use the mean calculated position as a reference point."*.

Again, we thank the reviewers for their time and efforts. The reviews have indeed been very helpful tous and we feel they have significantly contributed to the quality of the paper.

Jackson, M., Meertens, C., Andreatta, V., and Hove, T. V.: GPS Receiver and Antenna Testing Report for SumoiNet, UNAVCO Knowledgebase, 2000. Penna, N., Clarke, P., Edwards, S., and King, M.: Further testing of commer- cial Network RTK GNSS

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services in Great Britain (NetRTK-2), The Survey Association presentation, 2012. UNAVCO: GPS Receiver Evaluations, UNAVCO Knowledgebase, 2012.

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