ISSN 0747-9239, Seismic Instruments, 2019, Vol. 55, No. 6, pp. 720–726. © Allerton Press, Inc., 2019.
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Portable GNSS Signal Recording System with a High Sampling Rate: Field Tests and Application Forecasts

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Abstract—The article describes recording equipment for reception and preprocessing of global navigation satellite system (GNSS) signals. The base of the data logger is an industrial class receiver capable of a rather high sampling rate of 10 Hz for recording signals. An important option of the data logger is the possibility of transmitting the data in real time, including via wireless links. The technical characteristics of the equipment enabling its stable field operation, including when it is mounted on a moving object, are discussed. The device was tested under field conditions in different modes: as a reference station and on a moving carrier (a vehicle laboratory). In both modes, the recorded information was transmitted online to the data aggregation center of the Institute of Physics of the Earth, Russian Academy of Sciences. In the first case, broadband Internet wire access was used; in the second, via wireless links of cellular providers. Based on the test results, potential areas for the developing of this GNSS data recording system are determined, including improved navigation support of mobile geophysical observations.

Keywords: satellite navigation, satellite geodesy, GNSS, accurate positioning, data acquisition systems, GPS, Javad, geophysical monitoring systems, ARM-systems, mobile measurement and diagnostic laboratory, MMDL

DOI: 10.3103/S0747923919060069

INTRODUCTION

One of the most in-demand applied-research tasks today is highly accurate determination of the self-motion parameters of fast-moving objects. This is especially urgent in inertial measurements, the increased accuracy of which is determined by the improvement of measurement devices and development of methodological support.

The recording of global navigation satellite systems (GNSS) signals with a high sampling rate (≥10 Hz) is necessary to refine the motion trajectories of airborne laboratories (ALs) oriented toward geophysical and meteorological research, as well as of mobile measurement and diagnostic laboratories (MMDLs) (Bermishev et al., 2016) on vehicles employed for evaluating navigation conditions using GNSS and for solving a number of metrological tasks (Information..., 2018).

For standard receiving equipment and observation schemes, data are logged to the internal, relatively small memory of the receiver. The high sampling rate hampers data transmission from the GNSS receiver through communication channels. Therefore, autonomously operating data loggers on a nonfixed carrier and stationary observation points, reference stations, are often used.

The Institute of Physics of the Earth, Russian Academy of Sciences (IPE RAS), has been actively developing technologies and methods for airborne gravimetric research (Drobyshev et al., 2009; Koneshov et al., 2014, 2016). To ensure a survey scale of 1 : 200 000–1 : 1 000 000, a GNSS sampling rate of at least 10 Hz is used to correct inertial GNSS gravimetric systems and to position with the required accuracy gravimetric measurements executed aboard ALs. A differential mode using the system of terrestrial reference stations (RS) in real time is hardly possible, since it requires on-line calculation and transmission of a differential correction at a high rate from RS to a nonfixed GNSS receiver linked with the gravimetric systems. This is rather complicated even when satellite communication channels are used; therefore, currently, navigation information of mobile receivers is often corrected based on RS data during postprocessing.

In Russian airborne gravimetric research, to correct AL navigation solutions, temporary terrestrial RS are usually deployed, which are located in the immediate vicinity of the survey area and record measurements at the same sampling rate as on the mobile carrier (Bolotin et al., 2006; Drobyshev et al., 2009). As a

Clearly, the positive experimental use of the GNSS data acquisition system with a high sampling rate and its software implementation presuppose further studies. A feature of such trajectory measurements is studying the possibilities of high-precision satellite navigation as applied to problems on providing geophysical measurement data, primarily, airborne gravimetric measurements.

A number of methodological proposals on improving the accuracy and reliability of navigation support requires practical testing and accumulation of a certain volume of information for subsequent analysis. It is not financially feasible to perform such experimental measurements from an aerial or marine carrier, and it is not always possible to include them in scheduled operations. Consequently, the optimal and most promising solution may be the creation of a special mobile measurement laboratory (MML) mounted on a vehicle with the mobile recording GNSS system described in this work. In view of the specific task, including study of techniques further oriented toward airborne geophysical measurements, we can suggest some ways to update an existing vehicle:

(1) improve the satellite equipment capable of operating in GPS+GLONASS systems, with verification valid for the period of experimental works;

(2) introduce an independent inertial system for determining (refining) motion parameters;

(3) develop software for converting the current position of an object to the inertial system.

As some promising areas of study for an MML-vehicle configured as discussed above, we mention the following:

(1) determination of possibilities for the PPP mode (Precise Point Positioning) as applied to airborne gravimetry;

(2) comparative assessment of the pros and cons of DGNSS (differential) and PPP modes, development of a procedure for their use depending on the conditions, as well as perhaps their joint use;

(3) general comparative GPS and GLONASS assessment for problems of positioning at a high sampling rate, including vertical positioning at different latitudes.

FUNDING

This study was carried out under the state task of the Schmidt Institute of Physics of the Earth, RAS (topics AAAA-A17-117060110059-7 and AAAA-A17-117051110256-8) and the Federal Center for Integrated Arctic Research, RAS (topic AAAA-A18-118012490072-7).

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