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ORIGINAL ARTICLE

# Influence of clock jump on the velocity and acceleration estimation with a single GPS receiver based on carrier-phase-derived Doppler

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**Abstract** Since the Selective Availability was turned off, the velocity and acceleration can be determined accurately with a single GPS receiver using raw Doppler measurements. The carrier-phase-derived Doppler measurements are normally used to determine velocity and acceleration when there is no direct output of the raw Doppler observations in GPS receivers. Due to GPS receiver clock drifts, however, a GPS receiver clock jump occurs when the GPS receiver clock resets itself (typically with 1 ms increment/decrement) to synchronize with the GPS time. The clock jump affects the corresponding relationship between measurements and their time tags, which results in non-equidistant measurement sampling in time or incorrect time tags. This in turn affects velocity and acceleration determined for a GPS receiver by the conventional method which needs equidistant carrier phases to construct the derived Doppler measurements. To overcome this problem, an improved method that takes into account, GPS receiver clock jumps are devised to generate non-equidistant-derived Doppler observations based on non-equidistant carrier phases. Test results for static and kinematic receivers, which are obtained by using the conventional method without reconstructing the equidistant continuous carrier phases, show that receiver velocity and acceleration suffered significantly from clock jumps. An airborne kinematic experiment shows that the greatest impact on velocity and acceleration reaches up to 0.2 m/s, 0.1 m/s$^2$ for the horizontal component and 0.5 m/s, 0.25 m/s$^2$ for the vertical component. Therefore, it can be demonstrated that velocity and acceleration measurements by using a standalone GPS receiver can be immune to the influence of GPS receiver clock jumps with the proposed method.

**Keywords** GPS receiver clock jump · Doppler measurement · Velocity and acceleration determination with a single GPS receiver

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## Introduction

Velocity and acceleration are important parameters to characterize the state of motion of a body. Three-dimensional velocity and acceleration information of a moving vehicle can be quickly, inexpensively, and accurately obtained using Global Positioning System (GPS) technology. In general, there are two main methods of velocity and acceleration determination for moving vehicles using GPS. One is the position derivation method, in which case the velocity is obtained by the first-order derivative of positions and the acceleration is calculated by the second derivative of positions. The other is the Doppler shift method, which obtains velocity/acceleration directly from the Doppler/Doppler rate measurements. The accuracy of the latter does not rely on the precision of the position, but on the accuracy of Doppler/Doppler rate measurements. Therefore, the Doppler shift method is a popular choice in practice. During the times of GPS Selective Availability (SA), errors imposed on the satellite ephemeris and clocks had an intolerable effect on the velocity/acceleration estimation with a single GPS receiver. Thus, in order to mitigate satellite orbit and satellite clock errors and improve the accuracy of velocity/acceleration estimation, the double-difference method for velocity/acceleration determination was usually adopted. However, this method is limited in practical operation due to the requirements of