

INITIALIZATION AND OCCUPATION TIME FOR KINEMATIC SURVEYS USING ONLINE PRECISE POINT POSITIONING

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1. Introduction

GPS (Global Positioning System) and GLONASS (Global Orbiting Navigation Satellite System) were developed by the early 1970s, and with the inception of GALILEO (Europe's upcoming Global Navigation Satellite System) and BEDIUO (China's Satellite Navigation System), a new name to encompass all these systems has been born, that is, GNSS (Global Navigation Satellite System). Using GNSS, positions on the surface of the earth can be determined utilizing point positioning or relative positioning [Wells *et al.* 1999]. One of the relative positioning techniques is kinematic method.

In many areas of surveying, speed and productivity are essential elements to success. In satellite surveying, the most productive form of surveying is kinematic method [Wolf and Ghilani 2006]. Kinematic surveying provides positioning while the receiver is in motion. Kinematic method is done either using Real Time Kinematic mode in the field or in the office using the Postprocessed Kinematic mode.

Construction surveys provide line, grade, control elevations, horizontal positions, dimensions and configurations for construction operations. They also secure needed data for computing construction pay quantities [Wolf and Ghilani 2006]. Kinematic GNSS technique can provide answers for all these applications quickly and economically.

Nowadays, kinematic GNSS data processing can also be completed using online services. It means that data

collected in kinematic mode can be submitted to online data processing services, and within a short period of time, the coordinates of the points surveyed are returned to the user. Thus, these services significantly reduce the equipment and personnel costs, pre-planning and logistics compared to conventional approaches [Ebner and Featherstone 2008].

As of now, no studies have determined the optimal length of time that the individual locations should be occupied, or the optimal length of time that the GNSS receiver should be initialized, to achieve coordinates with sub-decimetre accuracy. Thus, in this study, kinematic measurements are collected at five points in CSUF (California State University, Fresno) campus and these measurements are processed using three online services (see Section 2) to determine initialization and occupation time for kinematic surveys.

2. Methods

To our knowledge, among online GNSS data processing services currently, only APPS (Automatic Precise Positioning Service), CSRS-PPP (Canadian Spatial Reference System Precise Point Positioning Service) and GAPS (GPS Analysis and Positioning Software) provide free kinematic data processing options.

APPS (<http://apps.gdgps.net/>) is currently using GIPSY (GNSS-Inferred Positioning System and Orbit Analysis Simulation Software) version 6.4. A PPP

(Precise Point Positioning) technique [Zumberge *et al.* 1997] is implemented within GIPSY to process GPS phase and pseudorange measurement in RINEX (Receiver Independent Exchange) format. By default, the most accurate orbit and clock products are used if available. APPS users may specify the elevation angle cutoff, and, for kinematic positioning, the output data rate. By default, the 7.5° elevation angle cutoff is applied, and for kinematic positioning the positions are output at the same rate as the measurement data. The reference frame for APPS is ITRF (International Terrestrial Reference Frame) 2008.

CSRS-PPP (<http://webapp.geod.nrcan.gc.ca/geod/tools-outils/ppp.php>) is an online application for GNSS data post-processing that allows users to compute high accuracy positions from raw observation data. CSRS-PPP uses the precise GNSS satellite orbit ephemerides to produce coordinates across the globe, regardless of proximity to known base stations. Users can submit RINEX observation data from single or dual-frequency receivers operating in static or kinematic mode over the Internet and receive positioning in the CSRS (Canadian Spatial Reference System) and ITRF. By default, the 10° elevation angle cutoff is applied by CSRS-PPP.

GAPS (<http://gaps.gge.unb.ca/>) provides users accurate satellite positioning using a single GNSS receiver both in static and kinematic mode. Through the use of precise orbit and clock products provided by sources such as IGS (International GNSS Service), it is possible to achieve centimetre-level