TRANSIT AND GPS — A REPORT ON
GEODETIC POSITIONING ACTIVITIES

Abstract

The Fourth International Geodetic Symposium on Satellite Positioning was held in Austin, Texas from 28 April to 2 May 1986. The symposium was organized as a forum for the discussion of recent geodetic activities related to precise positioning using observations from the Navy Navigation Satellite System (Transit) and the NAVSTAR Global Positioning System (GPS). In addition, the symposium promoted an exchange of ideas on the future direction of GPS geodetic activities and provided a summary of the status, policy, and plans for both the GPS and Transit systems. This report summarizes the proceedings of the meeting.

1. Introduction

The transition of geodetic surveying from Transit to GPS began recently with the development of portable receiver systems and the successful (for its accuracy and economy) determination of baselines. The results obtained from testing GPS for its geodetic utility have certainly met expectations from initial studies published by Fell (1980) and Remondi (1984). However, a full implementation of GPS into survey practice may be contingent upon the resolution of several issues and the completion of critical GPS program milestones. Among these are further deployment of satellites providing measurement availability and a final policy on the civilian use of GPS. The availability and distribution of precise ephemerides to support survey data reduction remain additional points. Yet despite these uncertainties remarkable progress has been achieved over a relatively short period. A contributing factor to this has been the development of commercial receiver systems, developed earlier for GPS than for Transit.

2. Transit and GPS — Status, Policy, and Plans

The first session of the symposium was dedicated to presenting the status of each satellite system, future plans, and, in the case of GPS, a statement on current policy for civilian use.

The Transit system, operational since 1968, currently consists of three OSCAR satellites, two on-orbit spares, and NOVA satellites I and III. In terms of continued Transit availability, Sentman stated that the Navy will continue to manage the system through 1994 when it will be phased out in favor of GPS. Until that time, the probability of an operational three-plane constellation will exceed 99 percent, as the launch of available spares maintains system performance.

The development of GPS is continuing with the program nearing the end of full scale engineering development designed to verify the operational effectiveness of the GPS concept for both military and civilian users. Currently there are seven research and development Block I navigational satellites in the constellation operating on stable atomic frequency standards and providing reliable information. These satellites are orbiting in two planes separated in longitude by 120 degrees with inclinations of 63 degrees. The operational Block II constellation of 18 satellites will be uniformly spaced in six orbital planes inclined at 55 degrees. Three on-orbit active spares will complement the system. All satellites will be routinely tracked by five Air Force monitor stations whose observations are processed at the Master Control Station in Colorado to support navigation.

The operational GPS will provide two distinct navigation services, the Precise Positioning Service (PPS) and the Standard Positioning Service (SPS). The SPS users will have access to only the C/A code on the L1 frequency of 1575.42 MHz. According to Stein, navigational accuracies from these positioning services are 15.0 and 76.3 meters respectively, spherical error probable.

Addressing policy on the civilian use of GPS, Baker stated that the SPS was designed for civil navigation and that no direct user charges would be assessed for that service. If possible, limited civil use of the PPS would be provided. A proposed approach toward making PPS available for civil applications has been formulated and will be circulated in the civil sector for review and comment prior to any implementation action.

3. Reference Frames

Decker and White provided summaries of the World Geodetic System 1984 (WGS 84), covering its development and evaluation. The WGS 84 is a general geodetic solution developed from various terrestrial and satellite data sets including Doppler and laser, geoid undulations from satellite altimetry, and mean free-air gravity anomalies. The gravity field is complete through degree and order 180 with satellite observations contributing to coefficients through degree and order 41. The reference frame differs from the Doppler 9Z-2 system by a Z-axis shift of 4.5 meters, a scale change of −0.6 ppm, and a longitude rotation of 0.814 seconds. The reference ellipsoid is consistent with the defining parameters of the International Geodetic Reference System 1980. The longitude rotation implies that WGS 84 and the North American Datum 1983 will have consistent orientation. In addition, approximately 80 datum transformations to WGS 84 have been developed using Doppler control. A question requiring further investigation is the consistency between point positions determined within WGS 84 with those obtained from 9Z-2 (or WGS 72) by direct transformation.

In other areas related to reference frames McCarthy discussed the prediction of polar motion and UT1–UTC, concluding that 30 centimeters and 7 centimeters per day to 40 days can be achieved. Bangert presented results on the same topic and Wooden summarized Doppler polar motion results obtained during the MERIT Campaign. Of interest is the apparent improvement in Nova satellite pole position agreement with BIH after the introduction of WGS 84. Finally, the paper by Welsch (in this issue) addressed the problem of combining terrestrial and satellite control networks.

4. Orbit Determination

Presentations on precision orbit determination for Transit and GPS concerned themselves with two approaches using terrestrial tracking data and a method for