FGCS **Federal Geodetic Control Subcommittee**

Test and Demonstration of the Trimble 4000 SSE Geodetic System GPS Surveyor: October 1992

FGCS Report: FGCS-IG-94-2

December 1994

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Test and Demonstration of the Trimble 4000 SSE Geodetic System GPS Surveyor: October 1992

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Report on the Test and Demonstration of the
TRIMBLE 4000 SSE GEODETIC SYSTEM
GPS SURVEYOR: October 1992

Instrument Working Group
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ABSTRACT

The Federal Geodetic Control Subcommittee ran a test for evaluation of the Trimble 4000 SSE Geodetic Surveyor™ and associated data processing software in October, 1992. The dual frequency receivers were tested in static and rapid static operational modes. The post-processing software, GPSurvey,™ was employed to process data in the field using the predicted (broadcast) ephemerides. Measured vectors ranged in length from 0.2 kilometers (km) to 104 km. Both static and rapid static modes yielded centimeter-level results. Selective Availability (SA) was on continuously during the test period. Anti-Spoofing (A-S) was activated during the first two days of the 4-day test. Neither SA or A-S had any significant impact on the results. Overall, the results from the use of the predicted (broadcast) ephemeris in the solutions indicate that the Trimble 4000 SSE Geodetic System Surveyor and the GPSurvey™ Software System will yield accuracies that meet or exceed the vendor's stated specifications.

INTRODUCTION

In October, 1992, the Federal Geodetic Control Subcommittee (FGCS) conducted a test and demonstration of the Trimble 4000 SSE Geodetic System GPS Surveyor, a dual band (L1 and L2) receiver developed by Trimble Navigation, Limited. This was the seventeenth in a series of tests by FGCS to evaluate the capability and performance of Global Positioning System (GPS) geodetic satellite survey systems.

TEST DESCRIPTION

The goal of the October, 1992 FGCS campaign was to test the performance of the 4000 SSE Geodetic Surveyor receiver in conjunction with the GPSurvey™ baseline reduction package. Static and rapid static (FastStatic™) positioning techniques were the focus of the test. The test and demonstration were conducted over a 6-day period beginning Sunday, October 4, and ending Friday, October 9, 1992. The test was run using stations of the FGCS test network located in the vicinity of Washington, D.C. (Hothem and Fronczek, 1983). Figure 1 is a sketch of the general layout of the FGCS test network. Many of the closely spaced stations are located within the grounds of the National Institute of Standards and Technology (NIST) in Gaithersburg, Maryland (Figure 2).

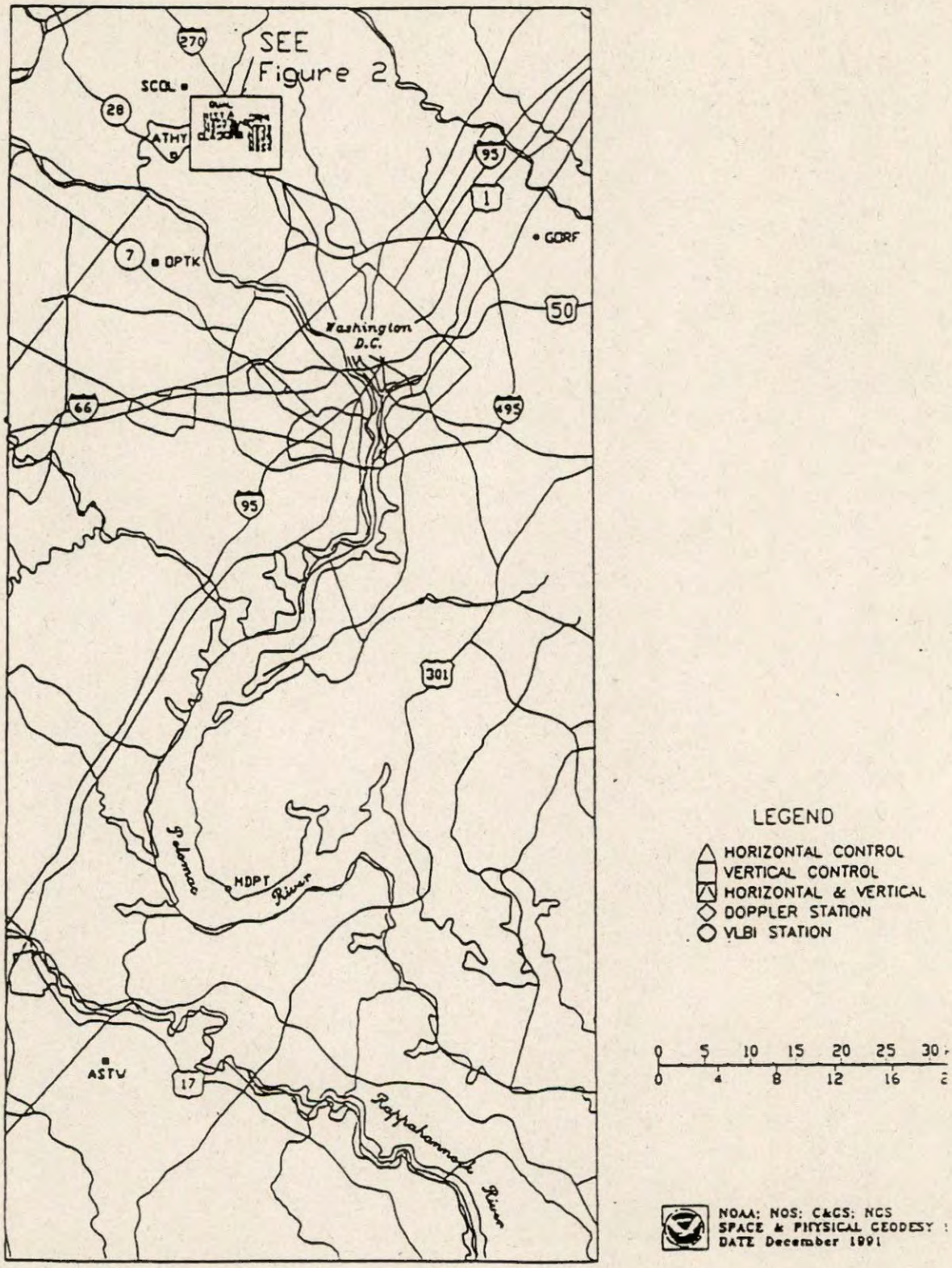

Figure 1. FGCS test network located in the vicinity of Washington, D.C.

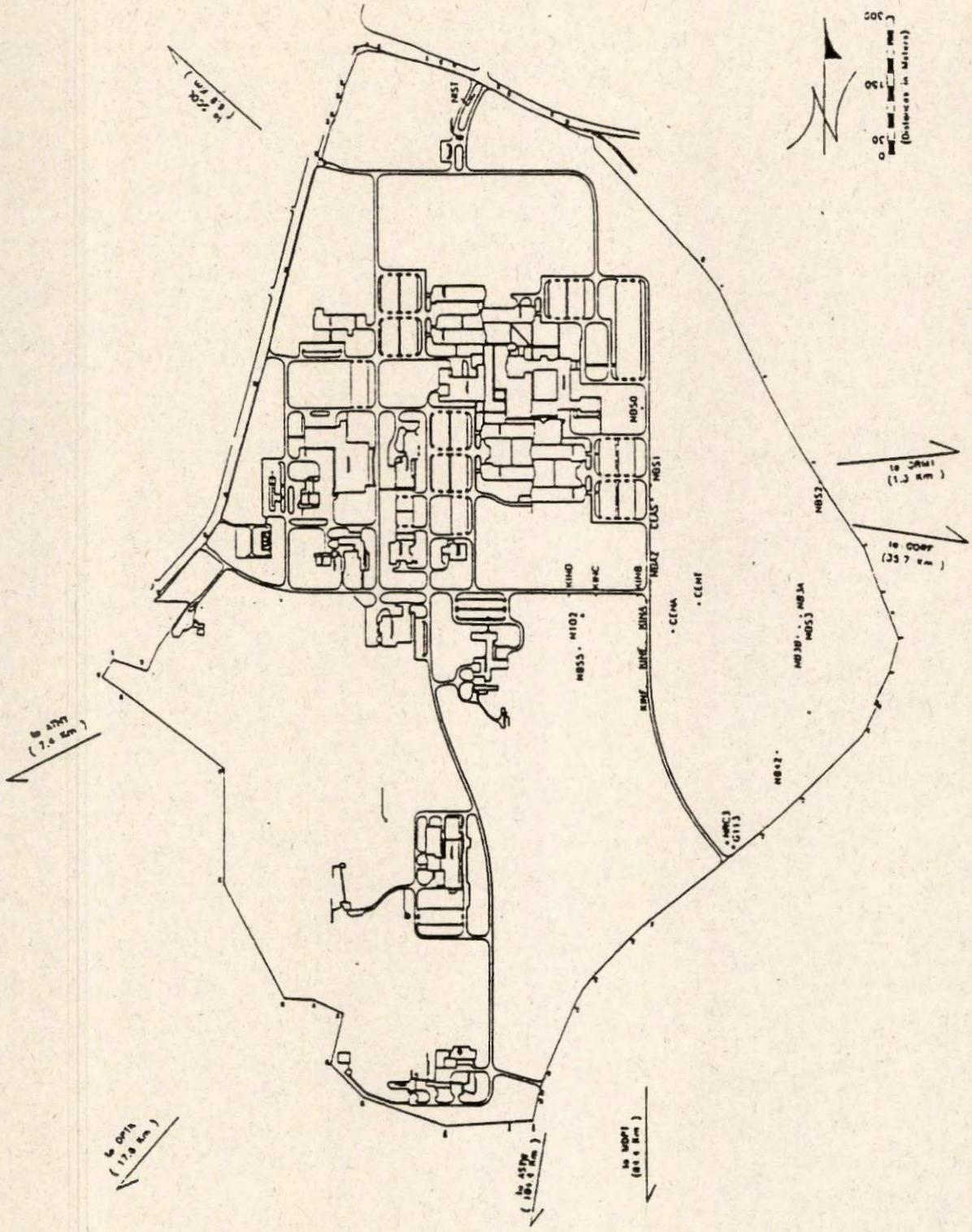

Figure 2. Portion of the FGCS test network near Gaithersburg, Maryland.

The 4000 SSE Geodetic Surveyor receiver provides L1 and L2 signal tracking of up to nine GPS satellites using parallel channels. One of the distinct features of the Geodetic Surveyor unit is the method it uses to overcome P-code encryption. The 4000 SSE tracks the P-code signal and full-cycle L1 and L2 carrier phase measurements when the P-code is available. During periods of A-S, the receiver maintains full-cycle L1 and L2 carrier tracking, and automatically switches from dual-frequency P-code tracking to precise C/A-code and cross-correlated Y-code operation. The 4000 SSE receiver can track and store dual-frequency code and full-cycle carrier phase measurements with P-code, or with the precise C/A-code and cross-correlated Y-code.

The GPSurvey™ processing software utilizes the precise code and carrier phase measurements collected with the Geodetic Surveyor unit for rapid static (FastStatic™) surveys and high-accuracy long baseline estimation. The GPSurvey™ software suite runs under the Microsoft Windows operating system, version 3.1 or higher.

The status of the GPS satellite constellation, was obtained from information available from the Bulletin Board Service (BBS) of the United States Coast Guard (USCG) Navigation Information Center, formerly known as the GPS Information Center (GPSIC). This information is summarized in Table 1. The accuracy for the predicted (broadcast) satellite orbital coordinate data used in the baseline solutions was estimated to be about 1 mm/km (1 ppm) at the 1 sigma (σ) level.

Table 1. GPS satellite constellation status.

PARAMETER	SATELLITES	
	BLOCK I	BLOCK II
PRN	3 11 12 13	2 14 15 16 17 18 19 20 21 23 24 25 26 27 28
PLANE SLOT	C4 C3 A1 C1	B3 E1 D2 E3 D3 F3 A4 B2 E2 E4 D1 A2 F2 A3 C2
CLOCK	RB RB RB CS	CS CS CS CS CS CS CS CS CS CS CS RB CS CS CS

Plane: Six planes, A through F; Slot: Four slots in each plane; CS=Cesium; RB=Rubidium

The FGCS test was conducted over four days: from Sunday, October 4, to Wednesday, October 7, 1992. Five Trimble 4000 SSE Geodetic Surveyor systems were deployed during the test. Observations were divided into two sections: static surveying, which was performed on Sunday, Monday, and Wednesday, (4-5, and 7 October), and rapid static surveying, which was conducted on Tuesday (6 October). Table 2 summarizes the static surveying observation schedule.

Today, the full GPS constellation is in orbit and observation times are readily available. During the GPS constellation build up, however, tighter planning was necessary to determine the appropriate observational windows that would provide a sufficient number of GPS satellites in view that provided reasonable satellite geometry relative to the observer. The observation times for the tests were in the afternoon (2 pm to 6 pm local time). Although there were brief periods when only 4 GPS satellites were available, there were several observation windows with at least 5 satellites that were 15° above the horizon. Table 2 summarizes the satellite availability during the test. Table 3 presents the week's events at a glance.

Table 2. Satellite availability during the FGCS Test.

SESSION	START/END TIMES (UTC[1])	NUMBER OF STATIONS OCCUPIED	PRN NUMBER OF BLOCK I SATELLITES OBSERVED	PRN NUMBER OF THE BLOCK II SATELLITES OBSERVED	NO. OF SVS START/MAX/ MIN/END
278A	18:00-20:00	5	3,13	16 17 18 20 24 26	5/6/5/5
278B	20:00-22:00	5	3,12	16 17 21 23 24 26 28	5/7/4/7
279	19:00-22:00	5	3	16 17 21 23 24 26 28	5/7/4/7
280	18:00-22:00	5	3	16 17 21 23 24 26 28	5/7/4/7
281	19:00-22:00	5	3	16 17 21 23 24 26 28	5/7/4/7

[1] Subtract 4 hours to convert UTC to local time used during the test.

Table 3. Test and demonstration calendar.

Day of Week	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
Date	4 October	5 October	6 October	7 October	8 October	9 October
DAY	DAY 278	DAY 279	DAY 280	DAY 281	DAY 282	DAY 283
SURVEY MODE	Static	Static	Rapid Static	Static	---	---
REMARKS	SA in effect; A-S activated for certain SVs	SA in effect; A-S activated for certain SVs	SA in effect	SA in effect	Completion of data processing	Public Meeting at NIST on results

Initial Operational Capability (IOC) had not yet been declared for GPS when this test was run. Before IOC was declared, sporadic testing of A-S would occur. A-S was activated during this test on two days, 4 and 5 October. As mentioned, the 4000 SSEs employ the cross-correlation technique during periods of A-S, and the fact that A-S was implemented during the test allowed the receivers to be tested in that mode.

FIELD OBSERVATIONS

STATIC SURVEY FIELD OBSERVATIONS. For all static baseline sessions, the receivers were set to a 15 second recording rate with a 15 degree masking angle. To minimize user interaction with the receivers in the field, all sessions were pre-planned and the information entered before the receivers were deployed to the field. After a receiver and antenna were pre-programmed in this manner, the operator set up the receiver in the field and then activated the pre-defined session. Survey data with accompanying surface meteorological data were collected during the 25 independent station occupations.

Short baselines were observed on Sunday (DAY 278), using two 2-hour observation sessions. The P-code was encrypted on five Block II satellites (PRNs 16, 17, 20, 23 & 26) throughout the DAY 278. All receivers automatically switched to C/A-code and cross-correlated Y-code tracking on the encrypted satellites. A mix of P-code, C/A-code and cross-correlated data was stored for later processing and analysis.

Medium length baselines, varying from 7 km to 42 km, were observed on Monday, DAY 279, using a single three hour session.

Long baselines of up to 104 km were observed on Wednesday, Day 281, during another single three hour session. Table 4 summarizes the stations occupied and the observations attempted and achieved.

Table 4: Static survey observations.

STATION 4-char Identification	DAY 278 SESSION A	DAY 278 SESSION B	DAY 279	DAY 281
NBS0	X	X		
NBS1	X	X		
NBS3	X	X		
NBS5	X	X	X	X
ORM1	X	X		
ATHY			X	
SCOL			X	X
OPTK			X	
GORF			X	X
MDPT				X
ASTW				X

RAPID STATIC (FastStatic™) SURVEY FIELD OBSERVATIONS. Rapid static surveys were conducted on DAY 281. The rapid static surveying method improves productivity compared to static surveying techniques by reducing site occupation time without significantly compromising solution quality. The field occupations followed the schedule as planned. Again, as was done for the static surveying, receivers were pre-programmed and operators simply switched the equipment on and started the predefined session. Rapid static survey test operations utilized 2 rovers and 3 reference sites. The rovers occupied one permanent control site for 5 separate occasions and 2 other control sites on 4 separate occasions, for a total of 13 site occupations and a total of 39 separate baselines. The reference sites were approximately 0.5, 7 and 17 km away, respectively, from the roving units. The range of baseline lengths provided some breadth for the analysis of Trimble's FastStatic™ technique.

An afternoon observing window from 2 pm until 6 pm local time provided reasonable satellite geometry for the receiver rapid static tests. Although there were brief periods where only 4 satellites were available, most of the time the observations were made during periods when only 5 satellites above 15 degrees were available. Rapid static survey occupation times varied from only a few minutes when 7 satellites were in view, to approximately 20 minutes when only 4 satellites were available. The 4000 SSE receiver has a screen that provides guidance to the receiver operator on how long a station must be occupied. This indicator uses the number of satellites available and other information to determine the suggested occupation time. Site occupation times that were used for the test were rather conservative, to insure that successful results would be obtained for the longest baseline of 17 km.

DATA PROCESSING

All processing and adjustment had been completed by Trimble personnel on site by the end of the day, on Thursday, 8 October, using the Trimble GPSurvey™ Data Processing System. This processing includes: 1] data download, 2] baseline reduction, 3] graphical viewing, and 4] network adjustment. The software has a structured, graphical interface to guide the operator through these steps. The results of this analysis were presented at a public meeting held on Friday afternoon, 9 October, 1992. The GPSurvey™ software is a suite of software packages allowing the user to download the GPS data, process baselines, view a graphical representation of the processed data and adjust a GPS network through use of a graphical user interface. The specific software packages used from the GPSurvey™ suite of programs were: Trimble's TrimVEC™ for static baseline processing, TrimKIN™ for kinematic processing, and TrimNET™ for the data adjustment. Icons, pull-down and pop-up menus and mouse support provide a user friendly environment. One hundred thirty-five rapid static and static baselines were processed and adjusted within a day of leaving the field.

RESULTS

STATIC SURVEY RESULTS. All possible combinations of baselines were successfully processed within the GPSurvey™ package. Given that 5 receivers were operated simultaneously, 10 baselines were generated for each common occupation. Table 5 shows the comparison of the results of 3 repeated vector measurements for the traditional static surveys. The unadjusted baseline solutions, using the predicted satellite ephemerides, close to less than 5 mm $\pm$ 0.5 ppm of the baseline length in all examples.

Table 5. Results of three repeated vector measurements for the static surveys.

FROM TO	DAY SPAN (Min)	Δx (m)	Δy (m)	Δz (m)	Length (m)	Remarks
NBS5 SCOL	278A 178	-5812.4614	1562.2182	3473.0720	6948.9181	(1)
	278B 178	-5812.4579	1562.2176	3473.0750	6948.9165	(1)
	281 238	-5812.4548	1582.2169	3473.0722	6948.9124	(1)
	Range	0.0066	0.0013	0.0030	0.0057	
NBS5 OPTK	279 178	-6182.4333	-11004.2057	-11585.4541	17132.9440	(1)
	280 238	-6182.4230	-11004.2091	-11585.4443	17132.9359	(1)
			0.0034	0.0098	0.0081	
	Range	0.0103				
NBS5 GORF	279 178	34380.1687	152.9915	-9461.5107	35658.6538	(2)
	280 178	34380.1929	152.9795	-9461.4992	35658.6741	(1)
	Range	0.0242	0.0120	0.0115	0.0203	

Remarks: Solution method:(1) Ionospheric Free Fixed(2) Wide Lane Fixed

Table 6 summarizes three loop misclosure computations based on static survey results. The loops were formed using independently determined vectors, which were selected to provide uniform sampling in time and a mixture of baseline lengths. Only double difference solution were used, which were computed using the predicted satellite positions. The first closure included data from the mixed C/A code, cross-correlated Y-code, and P-code observations collected on DAY 278. This again supports the claim that the Trimble 4000 SSE can successfully operate under Y-code conditions, using the cross-correlation method. The resultant misclosure for all the solutions randomly examined by the FGCS ranged from 0.9 cm to 4.1 cm. Table 7 gives summaries for the static baseline closures for short, medium and long baselines.

Table 6. Summary of loop misclosure computations.

NUMBER OF LINES		LENGTH OF LOOP (km)	MISCLOSURE				Remarks
Independent	Total		North (cm)	East (cm)	Up (cm)	Resultant	
3	4	14.7	0.4	0.2	0.8	0.9	(1)
4	5	114.6	0.0	2.6	2.8	3.8	
6	7	243.0	0.8	0.1	4.0	4.1	

(1) One independent line, SCOL --> NBS3 (7.3 km), was a rapid static baseline.

Table 7A. Static Baseline Solution Closure Summaries: Baselines ≤ 8 km.

BASELINE		SESSION		SLOPE LENGTH (meters)	
NBS5	SCOL	279		6,948.92	
SCOL	NBS3	280		7,299.77	
NBS3	NBS5	278A		519.16	
		Total		14,767.9	
Closure (m)	+0.004 N	-0.002 E	+0.008 U	0.009 R	0.62 ppm

Table 7B. Static Baseline Solution Closure Summaries: Baselines ≤43 km.

BASELINE		SESSION		SLOPE LENGTH (meters)	
NBS5	OPTK	279		17,132.9	
OPTK	SCOL	280		19,616.6	
SCOL	GORF	279		42,246.2	
GORF	NBS5	281		35,658.7	
		Total		114,654	
Closure (m)	0.000 N	-0.026 E	-0.028 U	0.038 R	0.33 ppm

Table 7C. Static Baseline Solution Closure Summaries: Baselines ≤ 84 km.

BASELINE		SESSION		SLOPE LENGTH (meters)	
NBS5	OPTK	280		17,132.9	
OPTK	ATHY	279		12,083.1	
ATHY	SCOL	279		7,534.7	
SCOL	GORF	279		42,246.2	
GORF	MDPT	281		80,017.2	
MDPT	NBS5	281		84,015.7	
		Total		243,030	
Closure (m)	+0.008 N	+0.001 E	+0.040 U	0.041 R	0.17 ppm

RAPID STATIC RESULTS. The repeatability of the rapid static surveying method was investigated using the baselines derived from reference stations NBS3, NBS5, OPTK and SCOL. The repeatability figures shown in Tables 8A and 8B represent the deviations from the mean of all baseline solutions between the respective reference site and NBS5. Accuracies attainable using rapid static methods are limited in part by baseline length, since they rely on high correlation in the ionospheric error between the reference and roving sites. Results from the 17 km baseline from OPTK to NBS5 are only marginally worse than the repeatability figures obtained from the 7.3 km baseline from SCOL and NBS3. The GPSurvey™ package processes precise dual frequency code and carrier phase observations so that the reliability of FastStatic™ is not limited to short baselines.

Table 8. Repeatability of the rapid static (FastStatic™) baselines :

Table 8A. Over a 7.3 km baseline.

BASELINE		δN (mm)	δE (mm)	δU (mm)	OCCUPATION TIME (minutes)
SCOL	NBS3	+4.6	+1.8	-1.5	20
		+1.9	-5.8	+14.3	15
		+4.0	-0.3	-3.1	14
		-10.4	+4.3	-9.7	16
StdDev	(mm)	6.1	3.8	8.8	
Range	(mm)	15.0	10.1	24.0	

Table 8B. Over a 17 km baseline.

OPTK	NBS5	+13.1	-1.9	+1.8	15
		-19.3	+1.3	-10.9	16
		-2.5	-3.2	+7.2	14
		+8.7	+3.9	+1.8	20
StdDev	(mm)	12.5	2.8	6.7	
Range	(mm)	32.4	7.1	18.1	

Each occupation was processed independently to obtain a vector solution. Table 9 compares the results for repeated baselines. The resultant of the horizontal position standard deviation did not exceed 1.5 cm, while the vertical component was less than 2.0 cm. Given adequate satellite coverage and vectors shorter than 17 km, the user should generally be able to achieve similar results with the rapid static technique with these receivers, the GPSurvey™ software and at least 15 minutes of occupation time. To determine whether acceptable results can be attained reliably for baselines longer than 20 km, additional testing is required.

Table 9. Comparison of repeat rapid static vector measurements.

BASELINE	DAY/No. of Measurements	Observation span (minutes)	Dist. (km)	Range (cm)			Standard Deviation (cm)		
				North	East	Up	North	East	Up
NBS5 N102	280/4	12/15/20/15	0.11	1.3	1.3	1.3	0.5	0.5	0.5
NBS5 G113	280/4	11/12/15/20	0.47	0.7	1.2	2.5	0.3	0.5	0.9
NBS5 NBS3	280/5	14/13/15/16/20	0.52	2.1	1.0	2.0	0.8	0.3	0.8
SCOL N102	280/4	20/15/15/12	6.9	1.9	2.0	2.1	0.8	0.7	0.8
SCOL G113	280/4	20/11/12/15	7.4	1.0	1.5	1.4	0.4	0.6	0.5
SCOL NBS3	280/5	20/15/14/13/16	7.3	1.5	1.0	2.4	0.6	0.3	0.8
OPTK N102	280/4	20/15/15/12	17.5	1.3	1.4	1.4	0.5	0.6	0.6
OPTK G113	280/4	20/11/12/15	16.9	1.6	1.5	3.6	0.6	0.6	1.3
OPTK NBS3	280/5	20/15/14/13/16	17.5	3.2	0.7	1.8	1.1	0.7	1.8

COMPARISON WITH FGCS ACCURACY STANDARDS

Table 10 summarizes the published criteria for FGCS Orders III through AA. The capability of the Trimble 4000 SSE System Surveyor and the GPSurvey™ Software System to achieve the various orders are indicated. This is based on the analysis of the results of the FGCS test survey and assuming the accuracies for the broadcast and precise ephemerides of approximately 1 ppm and 0.1 ppm, respectively. The 4000 SSE was capable of tracking and storing dual frequency code and full cycle carrier phase measurements with P-code or with precise C/A code and cross-correlated Y code. The use of the cross-correlated Y-code technique offers a significant advantage in overcoming the effects of A-S. The remarks in Table 10 qualify the conditions upon which the standards are based. To achieve orders A and AA, it is assumed that the GPSurvey™ Software System is capable of producing results from fixed orbital

coordinate data solutions that are limited only by the accuracy of the precise orbit data. It may be necessary to adjust the orbital elements of satellites in processing vectors to attain the highest classes of accuracy.

CONCLUSION

Overall, the results from the use of the predicted (broadcast) ephemeris in the solutions indicate that the Trimble 4000 SSE Geodetic System Surveyor and the GPSurveyTM Software System will yield accuracies that meet or exceed the vendor's stated specifications. Specifically, the test data were acquired with four or more satellites in an acceptable geometrical configuration, and with A-S implemented and with it not activated. The results support that the Trimble 4000 SSE System Surveyor can obtain FGCS Order B with the predicted (broadcast) ephemerides and Order A or possibly better with precise ephemeris information and careful reduction and analysis.

Table 10. Summary of FGCS Orders III through AA.

FGCS ACCURACY STANDARDS (2-sigma or 95% confidence level) (Reference: Version 5.0, May 11, 1988, reprinted with corrections August 1, 1989)		
ORDER	**DEFINITION**	**TRIMBLE 4000SSE CAPABILITY OF MEETING FGCS STANDARDS**
3I 2II 2I	$\pm\{[(50mm)2 + (d \times 100mm/km)2]\}^{½}$ $\pm\{(30mm)^2 + (d \times 50mm/km)^2]\}^{½}$ $\pm\{[(20mm)^2 + (d \times 20mm/km)^2]\}^{½}$	Can meet with predicted (broadcast) ephemerides
1	$\pm\{[(10mm)^2 + (d \times 10mm/km)^2]\}^{½}$	Can meet with predicted (broadcast) ephemerides
B	$\pm\{[(8mm)^2 + (d \times 1mm/km)^2]\}^{½}$	Can meet with predicted (broadcast) ephemerides, but use of precise ephemeris recommended
A	$\pm\{[(5mm)^2 + (d \times 0.1mm/km)^2]\}^{½}$	Can possibly meet using predicted (broadcast) ephemerides, but use of precise ephemeris strongly recommended
AA	$\pm\{[(3mm)^2 + (d \times 0.01mm/km)^2]\}^{½}$	Can possibly meet with use of precise ephemeris.

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APPENDIX A:

The Trimble 4000 SSE Geodetic Surveyor

Geodetic Surveyor™ Series 4000

Precision surveying system with 6th Observable™ technology

The ultimate in survey accuracy, with or without P-code.

The most capable GPS survey system in the world now has the *6th Observable* technology. The Geodetic Surveyor GPS survey system includes all the system hardware you need to make the highest quality measurements for reliable FastStatic™ surveys and improved accuracy over long baselines.

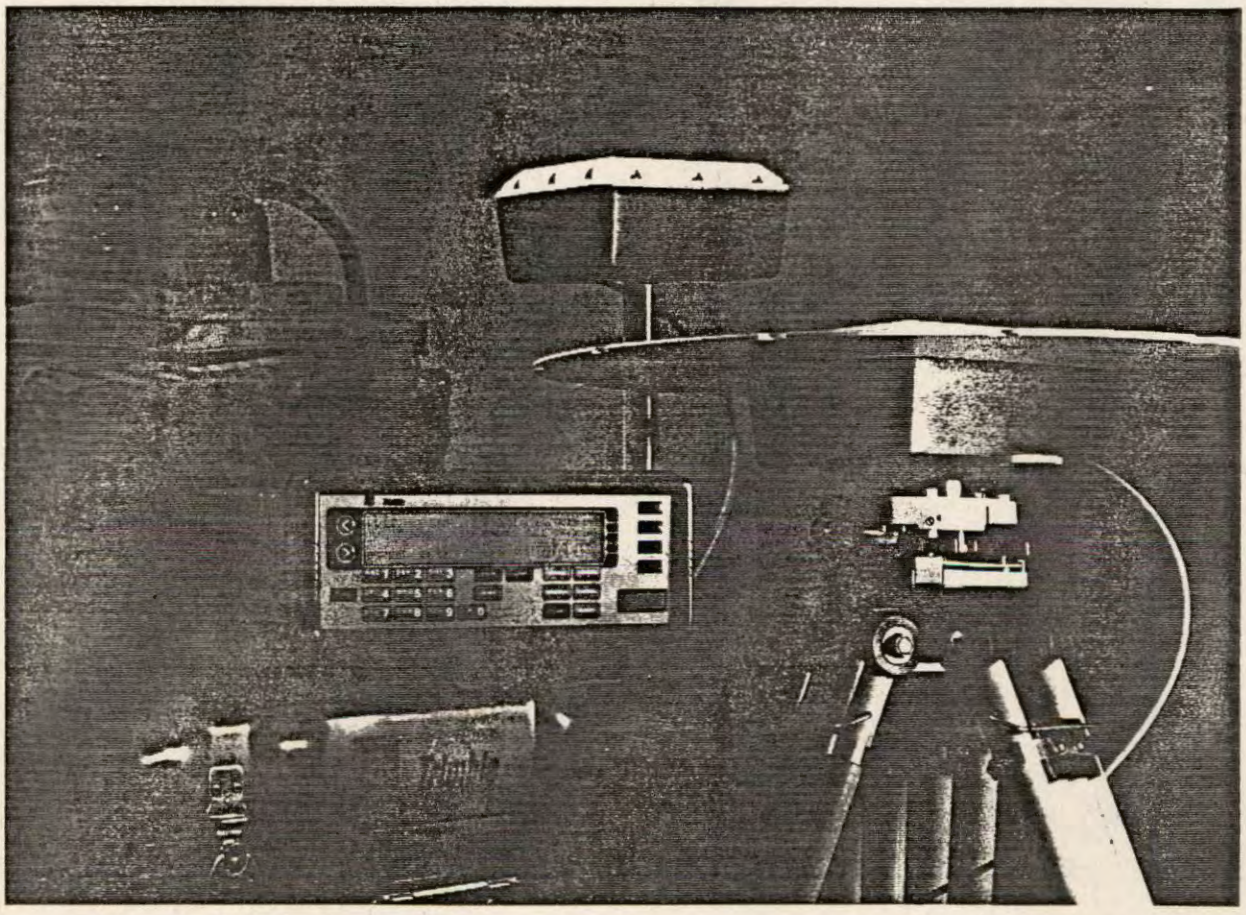
GPS provides five direct observables: C/A-code on the L1 frequency, P-code on L1 and L2 frequencies, and full cycle carrier phase on L1 and L2 frequencies. The Geodetic Surveyor records the best four of these observables to provide the redundancy and ionosphere-free measurements necessary to achieve the highest quality results. In the presence of P-code encryption, the system continues to offer the greatest possible accuracy through the use of the *6th Observable*, which is a measurement of the cross-correlation of the encrypted P-code on the L1 and L2 frequencies. It is tracked in conjunction with C/A-code and carrier phase on L1 and L2.

Using full cycle L1 and L2 carrier phase, C/A-code and the *6th Observable*, the Geodetic Surveyor system continues to offer reliable and accurate FastStatic surveying during periods of P-code encryption. This combination of observables provides faster ambiguity resolution than with other techniques such as enhanced squaring. It ensures that you continue to get economic performance as well as accuracy from the Geodetic Surveyor system regardless of the availability of P-code.

The system is available in two standard configurations for first order control and rapid control densification, or mobile airborne and marine applications and geodetic research surveys.

With support for the full range of GPS surveying techniques, from static and Pseudo Static, through to kinematic and FastStatic, the Geodetic Surveyor receivers provide the versatile operation needed to respond to the differing situations encountered in practical field operations.

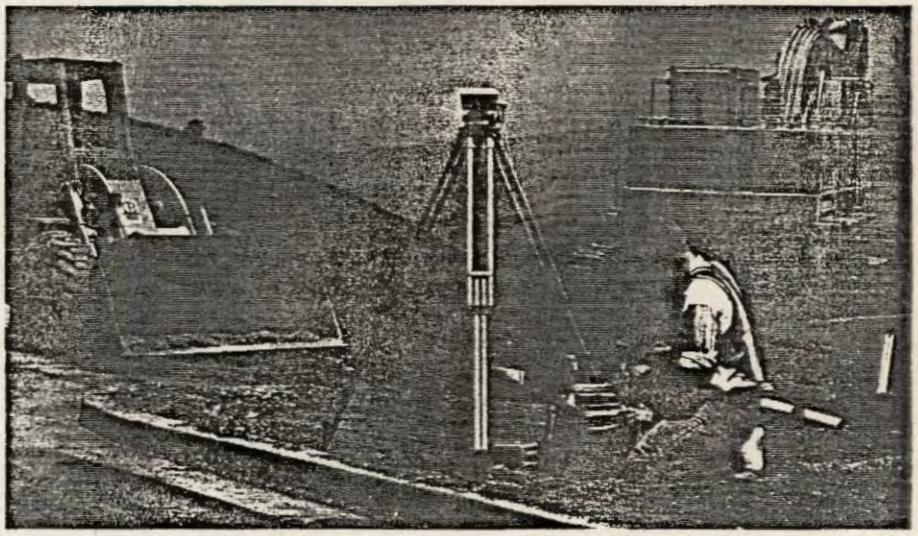
The system utilizes the GPSurvey software operating in the Windows™ environment. This software provides for multi-site planning, reduction, management, and adjustment of the survey data including the new FastStatic baseline processor.

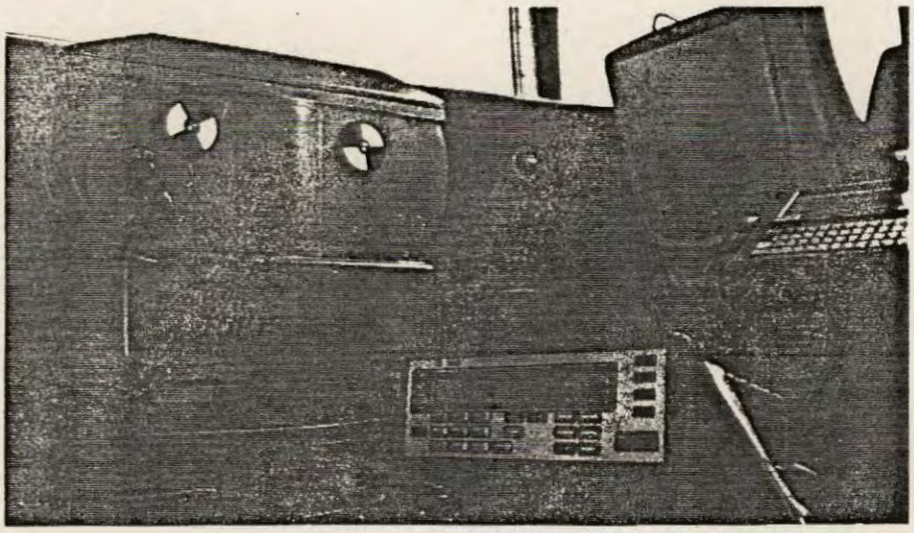


Applications:
Versatile and Cost Effective

Geodetic control The Geodetic Surveyor system is the ideal tool for Geodetic control. Its full cycle dual-frequency capability with dual-frequency P-code provides ionosphere-free measurements for accurate measurement of long baselines, and FastStatic measurement of short baselines. During periods of P-code encryption, the *6th Observable* provides for continued high performance. Our field proven multi-path resistant Geodetic antenna ensures that you achieve the highest quality results.

Site control When used with GPSurvey's FastStatic processor, the Geodetic Surveyor system is a more effective tool for survey control, even on lines you would normally traverse. With the short occupation times available using FastStatic processing, the system will reduce the labor costs for placing local site control. A single operator can now provide the complete control for a site. After you complete the site control, the system can be used for topographic surveying in conjunction with the optional software TRIMMAP,™ Trimble's topographic mapping system.

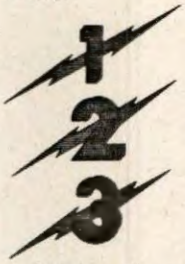




System applications The Geodetic System Surveyor is designed to support a range of real-time applications as well as performing geodetic control surveys. With the RTCM input, the Geodetic Surveyor receiver provides positioning using differential survey techniques. This can be used for applications such as hydrographic surveys for volume channels, and stake out of land seismic survey lines. When mounted in aircraft, the event marker can be used to precisely record events such as the time of a camera shutter opening.

Hardware features

Power

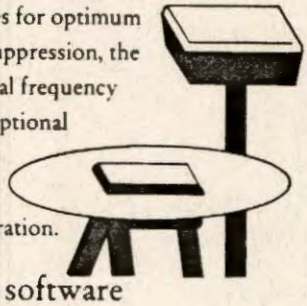


The standard configuration connects with up to three power sources. With its automatic switching system, it provides fail-safe operation, and ensures that your batteries are cycled correctly for maximum life. The "fuel tank" display allows you to check the battery status and voltage. Batteries can be replaced independently during operation, allowing uninterrupted battery operation over extended periods.

With low power consumption of only 9 watts, the Geodetic Surveyor operates longer per battery, which minimizes the number and weight of batteries required.

Flexible antenna system

The external antenna connection gives an operator a versatile selection of antenna configurations for customized applications. These include the high precision dual frequency antenna with ground planes for optimum multi-path suppression, the kinematic dual frequency antenna, or optional third party antenna for airborne operation.



Optional software

GPS software

The optional GPSurvey software provides multi-tasking capabilities through its Windows environment. This software is designed for two level operation with an automated production mode and an interactive processing mode for data analysis. Its comprehensive multi-site planning option is essential for productive field operations. Automated processing, interactive database management, loop closures and a powerful network adjustment module for both GPS and total station observations completes your GPS system needs.

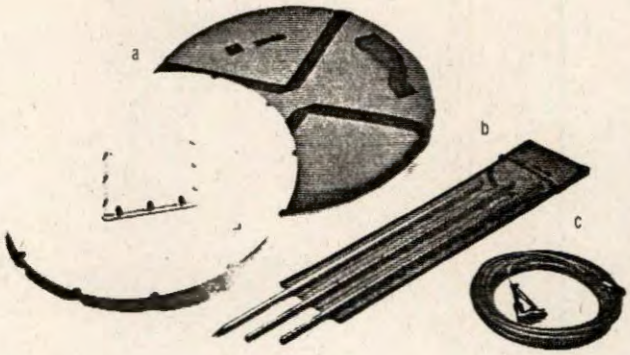
Geodetic Surveyor

a 4000 SSE receiver
b Power cord
c International AC adapter
d Transport case
e Four camcorder batteries
f Operating manual
g Lemo to dual BNC cable*
h DB9 to DB9 cable and OSM battery charging cable
i Dual camcorder battery tripod mount
j Office support module
k Lemo (5 pin and 7 pin)* to DB9 cables

* *Only on Geodetic System Surveyor*

Geodetic Option

a Dual-frequency geodetic antenna and soft case
b Height rod and soft case
c 10 meter antenna cable

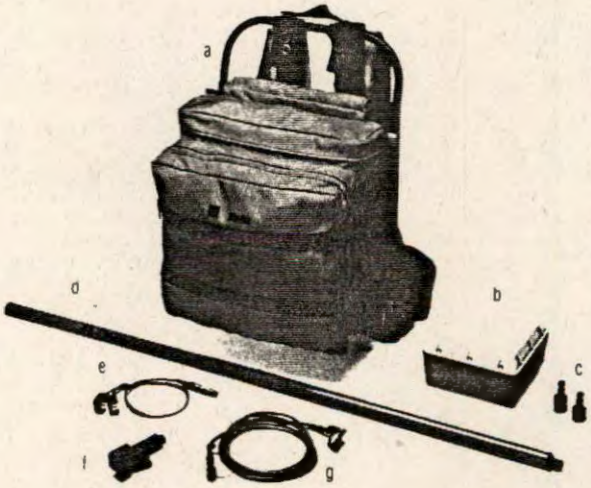


TDC 1 Option

a TDC 1 handheld computer

Traverse Option

a Rigid frame backpack
b Dual-frequency kinematic antenna
c Two bayonet fittings
d Backpack antenna mount
e Dual camcorder battery power cable
f Quick release adapter
g 3 meter antenna cable



Geodetic Surveyor™ Series 4000

Made in U.S.A.

Physical Characteristics

Receiver/Datalogger:

Size:	9.8" (24.8cm) x 11" (28cm)D x 4" (10.2cm)H
Weight:	6.8 lbs (3.1kg) receiver/datalogger 12 lbs (5.5kg) receiver/datalogger, battery; cables and backpack
Memory:	Geodetic Surveyor 1.0 Mb, Geodetic System Surveyor 2.5 Mb
Power:	Nominal 10.5-35 VDC, 9 watts Office Support Module for AC operations
Operating temp:	-20° to +55°C
Storage temp:	-30° to +75°C
Humidity:	100%, Fully sealed buoyant

Geodetic antenna:

Size:	19" (48cm) diameter (ground plane), 3.5"(9cm) height
Weight:	6 lbs (3.2kg)
Operating temp:	-40° to +65°C
Storage temp:	-55° to +75°C
Humidity:	100%, Fully sealed

Kinematic antenna:

Size:	6.3" (16cm)W x 6.3"(16cm)D x 3.5" (9cm)H
Weight:	3.5 lbs (1.6kg)
Operating temp:	-40° to +65°C
Storage temp:	-55° to +75°C
Humidity:	100%, Fully sealed

Pre-configured options

Traverse option:	Includes backpack, dual frequency kinematic antenna with carry bag, 3m antenna cable, dual power cable, and quick release clamp with bayonets.
Geodetic option:	Dual frequency Geodetic antenna complete with 10m cable, height rod and carry bag.

Options

Antenna options:	Geodetic antenna; Kinematic antenna
Datalogging options:	TDC1 Survey controller Memory upgrades
Tracking:	12-channel upgrade
Input/Output:	RTCM SC-104 output Version 1.0 or 2.0 RTCM SC-104 input Version 1.0 or 2.0* 1PPS ouput* Event marker input* NMEA navigation interface* * *Standard on Geodetic System Surveyor*
Reference:	External frequency input
Support:	Extended hardware warranty Firmware update service Software update service Site training

Accessories

Batteries:	9.5 hour battery Spare camcorder batteries
Cables:	30m antenna cable 10m antenna cable 3m antenna cable

Technical Specifications

Static Survey:	L1/L2 P-code and full cycle carrier or L1 C/A code, L1/L2 full cycle carrier, cross-correlation of encrypted P-code
Modes:	Quick start Planned survey Auto-timed survey
Accuracy:	
Horizontal:	5mm + 1ppm (times baseline length)
Vertical:	10mm + 1ppm (times baseline length)
Azimuth:	1 arc second + 5/baseline length in kilometers
	Assumes five satellites (min) tracked continuously with the geodetic antenna using the recommended static surveying procedures utilizing the L1 and L2 signals at all sites, precise ephemerides and meteorological data may be required.
Kinematic Survey:	L1/L2 P-code and full cycle carrier, or L1 C/A code, L1/L2 full cycle carrier, and cross-correlation of the encrypted P-code
Modes:	Continuous Stop & go Pseudo static (pseudokinematic) survey FastStatic survey
Accuracy:	2cm + 1ppm times baseline length (typical with kinematic antenna)
Occupation:	Continuous: 1 second measurement time Stop & go: 2 second (min) with 5 satellites
General:	
Start-up:	<2 minutes from power on to start survey
Tracking:	9 channels L1/L2 P-code and full cycle carrier phase or 9 channels L1 C/A code, L1/L2 full cycle carrier phase and cross correlation of the encrypted P-code.
Datalogging:	Kinematic or static: 0.5 second to 15 minutes
Geodetic Surveyor:	26 hours of 5-satellite L1/L2 data, at a 15 second measurement time (typ) or 1.8 hours at 1.0 second (minimum). Optional memory expansion available.
Geodetic System Surveyor:	65 hours of 5-satellite L1/L2 data, at a 15 second measurement time (typ) or 4.5 hours at 1.0 second (minimum). Optional memory expansion available.
Battery:	8 hours operation provided by the four camcorder batteries; Auto-timer (sleep mode) for extended battery life; 90 day battery warranty. Optional 9.5 hour battery.
Downloading:	Less than 1 minute to download one hour of 5-satellite L1/L2 data, logged at 15 sec measurement time: 38,400 baud.
Display:	Backlighted LCD, four lines of 40 large, easy-to-read alphanumeric characters.
Keyboard:	Alphanumeric, function and softkey entry
Connectors:	Dual RS232, triple power inputs, 1PPS/event marker, antenna. External reference (optional)
Software:	GPSurvey, everything from planning to adjustment.

ADVISORY NOTICE: This receiver uses the GPS P-code signal, which by U. S. policy may be switched off without notice.

Specifications subject to change without notice

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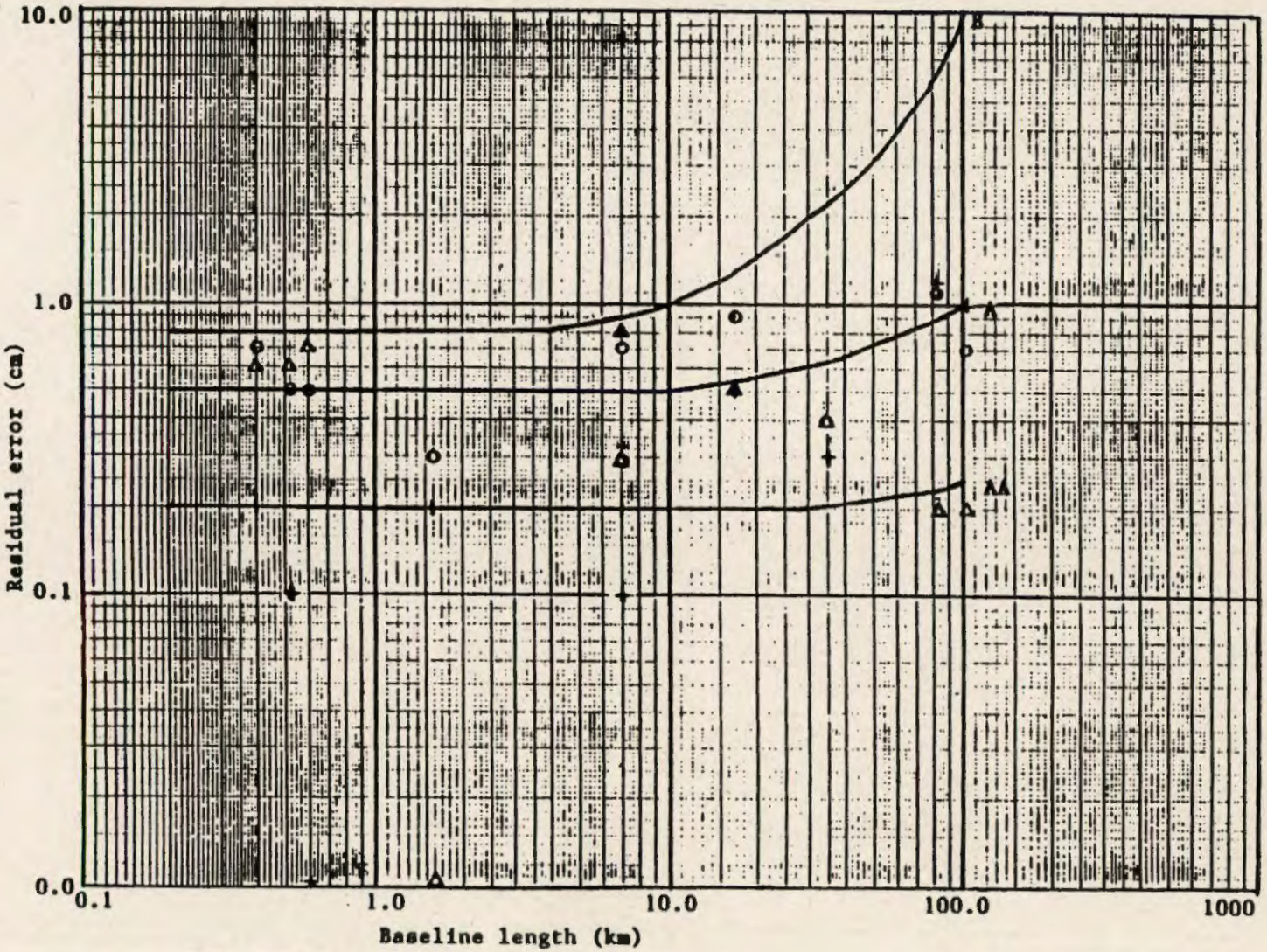
APPENDIX B:

FGCS Geometric Accuracy Standards vs. Trimble 4000 SSE

Figure 3 Standard deviations of vector components and FGCS 2-SIGMA geometric accuracy standards



KEY: Δ - dx ; + - dy ; O - dz

APPENDIX C:
CHRONOLOGY OF EVENTS DURING FIELD OPERATIONS

FGCS observers and Trimble field personnel occupied 5 stations during the static surveys (4-5 and 7 October, 1992) and 3 reference and 2 rovers during the rapid static survey (6 October, 1992).

DAY 278

The 5 stations observed were NBS0, NBS1, NBS3, NBS5 and ORM1 for 2 sessions. The first session was from 1800 - 2000 UTC (1400 - 1600 Local time). The second session was from 2000 - 2200 UTC (1600 - 1800 Local time). The second session was scheduled to obtain redundant measurements for short baselines measured during the first session. The quality of the data for both sessions were acceptable for processing.

DAY 279

The 5 stations observed were NBS5, SCOL, ATHY, OPTK, and GORF. One session from 1900-2200 UTC (1500 - 1800 Local time) was conducted. All 5 stations were observed with no problems noted.

DAY 280

Rapid static surveys were performed from 1800 - 2200 UTC (1400 - 1800 Local time). Reference receivers were set over NBS5, SCOL, and KINN. Two rovers were used. From 1800 - 2130 UTC (1400 - 1730 Local time), the first rover visited NBS2, NBS3, NB42, G113, and N102, without any problems. From 1800 - 2200 UTC (1400 - 1800 Local time), the second rover visited NBS2, NBS3, NB42, G113, N102, NBS2, NBS3, NB42, and G113. The first rover went on to occupy KIND, KINB, KINA, KINE, KINF, and KIND from 2130 - 2200 UTC (1730 - 1800 Local time).

DAY 281

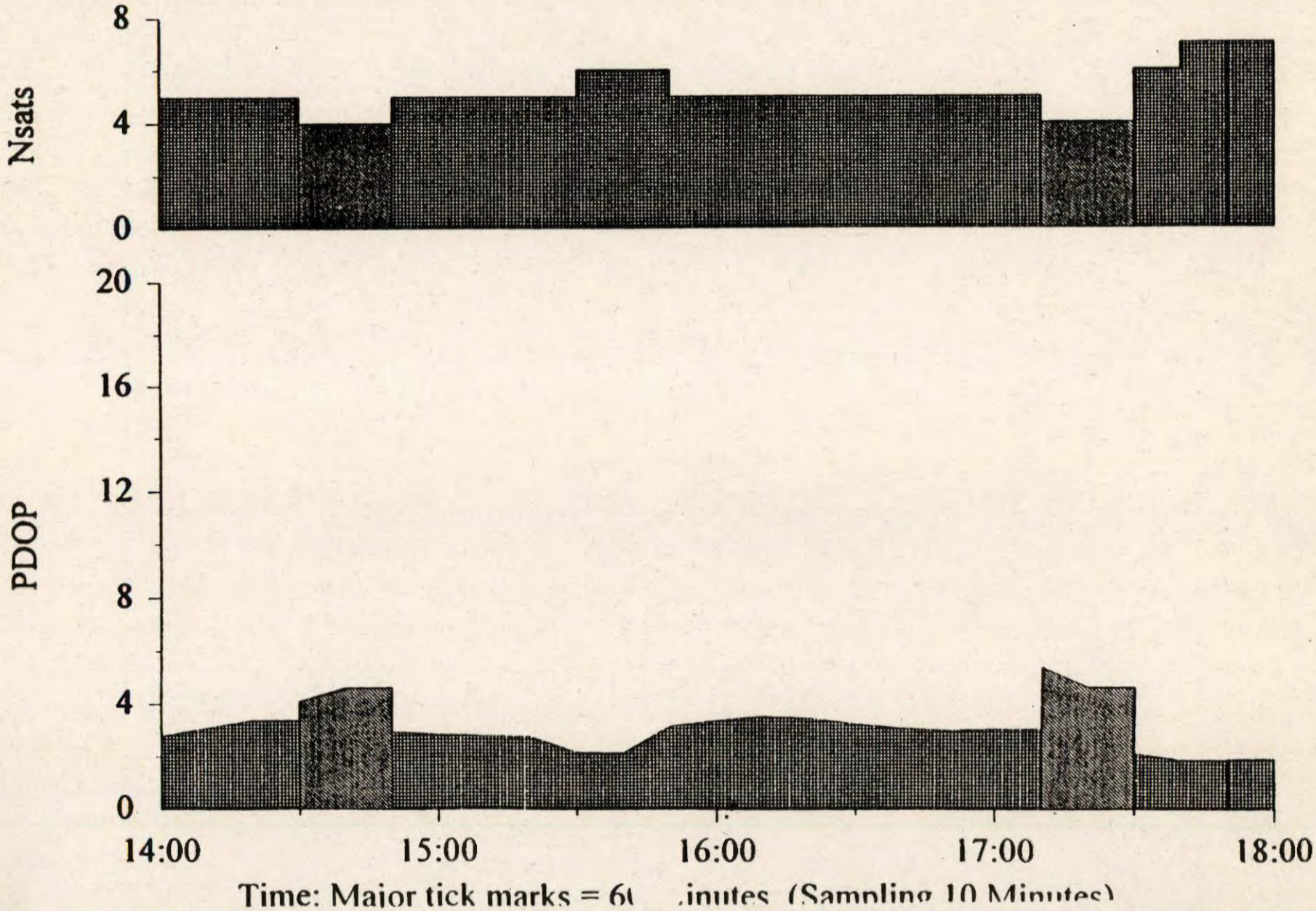
The 5 stations were occupied for a single 3 hour session from 1900 - 2200 UTC (1500 - 1800 Local time). The stations were NBS5, GORF, MDPT, SCOL, and ASTW.

APPENDIX D:

Number of GPS Satellites and PDOP

Number SVs and PDOP

Point: NBS5 Lat 39:07:48.3653 N Lon 77:12:54.1136 W Ephemeris: CURRENT.EPH 10/7/92

Date: Tuesday, October 06, 1992 Threshold Elevation 15 (deg) Time Zone 'Eastern Day USA' -4

19 Satellites considered : 2 3 11 12 13 14 15 16 17 18 19 20 21 23 24 25 26 27 28