ASHTECH

GPS

NEWS FOR PRECISION GEODESY & GLOBAL NAVIGATION

Expanded GPS Survey Seminars Set for Ashtech Training Center

Ashtech's newly expanded 4-day training program is a practical introduction to the use of GPS for precision geodetic surveying and differential navigation. The course is divided into three main sections. Day 1 is devoted to a general introduction to the uses of the Global Positioning System.

- System Components
- System Observables
- Processing Methods
- GPS Receivers
- Applications
- Planning

Day 2 covers differential navigation with particular emphasis on GIS applications.

- GIS Field Survey
- Filtering & Averaging
- GIS/LIS Interface
- Differential Navigation
- Real-Time Differential

Days 3 and 4 focus on precision surveying methods and applications.

- Static, Kinematic & Pseudo-kinematic Surveys
- Governmental Control
- Field Survey Session
- Post Processing
- Network Adjustment

Students may sign up for individual sections in addition to the complete course. Advanced training courses are also available to Ashtech users.

This expanded format permits greater "hands on" experience with GPS receivers and processing software. The Ashtech Training Center is fully equipped with GPS receiver systems and 386-based computers so that all participants can process data collected during both the field survey and differential navigation sections. Participants receive a greater understanding of GPS and its practical applications to their specific areas of interest by attending this comprehensive training seminar. For more information regarding Ashtech GPS Training Seminars or to enroll in upcoming classes, call the Director of Training or Ashtech Customer Service: 1 (800) 229-2400.

Moving Up...Again!

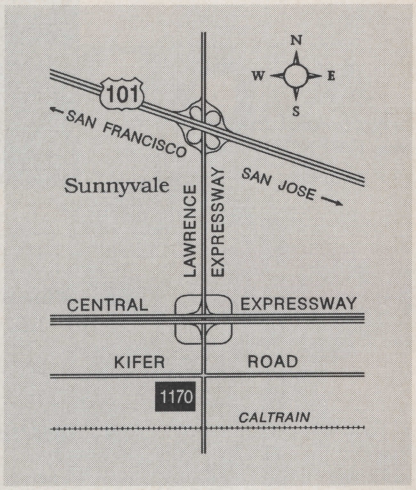
GPS Expansion Prompts Ashtech Move to New World Headquarters

Sunnyvale, CA - Ashtech Inc., the leading manufacturer of high precision GPS receiver systems, is moving to expanded headquarters in the heart of California's Silicon Valley. The new building provides 60,000 square feet for an expanded engineering and manufacturing facility as well as a fully equipped GPS Training Center.

Worldwide interest in GPS applications continues to grow in both the precision surveying and navigation communities according to Ashtech president, Javad Ashjaee, Ph.D. "Our commitment to GPS is very strong," says Ashjaee. "We are totally committed to continue to develop the best GPS hardware and software for a variety of applications. This move, which triples our working space, will help us remain the world's most expert GPS company."

The first Ashtech XII 12-channel "All-In-View" GPS receiver was delivered in 1988 after completing all FGCC test procedures. Recently, the Ashtech P-12 Dual P-Code system successfully completed the FGCC test network and demonstrated the "rapid static" survey methodology; a 1ppm level of accuracy after an observation time of only 5 to 10 minutes.

The new Ashtech headquarters is located at 1170 Kifer Road, on the corner of Kifer Road and Lawrence Expressway. Convenient to Highway 101 as well as the Central Expressway, Ashtech is 10 minutes from the San Jose International Airport (SJC) and 30 minutes South from San Francisco International Airport (SFO).



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Ashtech P-12 Dual P-Code GPS "Ra

Higher Accuracy Carrier & Code-Phase Measurements

To obtain carrier phase observations, either the pseudo-random code component of the GPS signal needs to be decomposed by mixing the signal with itself (the "squaring" or codeless technique) or by mixing it with a receiver-generated replica of the code (code-correlating).

Ashtech's non-compromising "true" P-Code technology, based on code correlation, uses non-sequenced parallel physical channels. This provides several advantages: 1) significantly improved signal strength and tracking capability over multiplexed or squaring systems; 2) full-wavelength carrier-phase measurement at L2; and 3) parallel tracking of P-Code phases (full-range measurements) on both L1 and L2 frequencies.

True P-Code correlation yields greater than 25db improvement in SNR over codeless techniques, allowing accurate measurements even at low elevation angles. P-Code tracking on L2 also results in a full wavelength carrier phase observable. There is a fundamental advantage in having full wavelengths on both L1 and L2 carriers. The most "fixable" integer ambiguity parameter is the "wide-lane" phase ambiguity for the quantity:

$$\frac{1}{\frac{1}{\lambda_1} - \frac{1}{\lambda_2}} = \frac{\lambda_1 \lambda_2}{\lambda_2 - \lambda_1}$$

The effective widelane wavelength is 86cm, which is significantly easier to fix than the widelane wavelength of 34cm on codeless systems. Once the widelane ambiguity is fixed, the L1 ambiguities become much easier to solve.

Most dual-frequency carrier phase algorithms assume that the ionosphere may be ignored while fixing the widelane integer ambiguities. Given enough differential ionosphere between observation stations, this assumption becomes invalid. Ashtech uses high-resolution P-12 code phase measurements on both frequencies to precisely determine the differential ionosphere. This provides robust phase-ambiguity resolution for high-ionosphere data sets as well as for very long baselines.

Another advantage of dual P-code phase measurement is the ability to fix cycle slips immediately in the widelane observable. Identification and automatic correction of cycle slips in batch processing is critical for rapid-production surveying.

In the final analysis, the ability to solve phase ambiguity parameters is the most powerful technique for high-precision, rapid-production GPS surveying. Widelaning is the essential ingredient for "rapid static" surveys. Reliable and accurate "rapid static" is possible only when P-Code tracking is available on **both** L1 and L2 frequencies.

Table 1

Network Adjustment of Selected FGCC Baselines > 5 km.
2-D & 1-D Relative Station 95% Confidence Regions (Meters)

STATION TO	FROM	MAJ. SEMI AXIS	MIN. SEMI AXIS	VERT.	APPROX. DISTANCE	PRECISION
NBS5	ATHY	0.007	0.006	0.015	7089	0.96 PPM
NBS5	GORF	0.005	0.004	0.009	35659	0.13 PPM
NBS5	ASTW	0.006	0.004	0.011	103940	0.05 PPM
NBS5	SCOL	0.005	0.004	0.009	6949	0.65 PPM
NBS5	OPTK	0.004	0.003	0.008	17133	0.23 PPM
ATHY	ORM1	0.007	0.006	0.016	8683	0.83 PPM
ATHY	SCOL	0.007	0.006	0.016	7535	0.95 PPM
ATHY	OPTK	0.007	0.006	0.015	12083	0.57 PPM
OPTK	ORM1	0.005	0.004	0.010	18481	0.27 PPM
OPTK	MDPT	0.006	0.005	0.013	69463	0.09 PPM
OPTK	NBS3	0.005	0.004	0.010	17462	0.29 PPM
OPTK	ASTW	0.005	0.004	0.011	88280	0.06 PPM
OPTK	GORF	0.005	0.003	0.009	42123	0.11 PPM
OPTK	SCOL	0.004	0.003	0.008	19617	0.20 PPM
ORM1	SCOL	0.005	0.004	0.011	7719	0.70 PPM
SCOL	MDPT	0.007	0.005	0.014	88556	0.07 PPM
SCOL	GORF	0.005	0.004	0.010	42246	0.12 PPM
SCOL	ASTW	0.006	0.005	0.012	107817	0.05 PPM
ASTW	MDPT	0.006	0.005	0.013	22713	0.28 PPM
ASTW	NBS3	0.006	0.005	0.012	104090	0.06 PPM
ASTW	GORF	0.005	0.004	0.010	102588	0.05 PPM
GORF	MDPT	0.006	0.005	0.013	80017	0.08 PPM
GORF	NBS3	0.005	0.004	0.011	35205	0.15 PPM

Ashtech P-12 Precision P-Code GPS Receiver

From October 7 to 11, 1991, five Ashtech P-12 precision GPS receivers were committed to the Federal Geodetic Control Committee (FGCC) test network, surveying governmental control points at the National Institute of Standards and Technology (NIST) in the Washington, D.C. area. Ashtech P-12 GPS Receivers repeatedly demonstrated that measuring P-Code on both L1 and L2 frequencies provides the highest accuracy possible for geodetic survey.

The combination of precise code (pseudo-range) and carrier-phase data from 12 channels of C/A Code on L1, 12 channels of P-Code on L1 and 12 channels of P-Code on L2, processed with Ashtech's GPPS survey software, provided better than 1ppm results... consistently! In fact, measurement accuracy of most baselines surveyed was limited only by the accuracy of the broadcast ephemeris.

Table 1 shows results of a network adjustment for FGCC baselines between 5 and 110km in length. The consistency and precision of these results is due to the P-12 system's high-accuracy observations at both L1 and L2 frequencies.

(All baselines were the result of "hands-off" batch processing of 3 hour observations. All phase ambiguities were easily fixed and the effects of ionosphere were removed.)

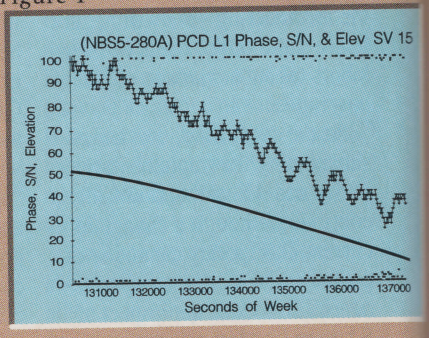
P-12 Tracking Performance on L1 and L2

Typical of FGCC data collected, Figures 1 and 2 show signal strength vs. elevation angle for P-Code tracking on L1 and L2. The closeness of the dots to the 0 and 1 indicates high quality carrier-phase measurements at those epochs. These plots illustrate excellent tracking performance down to 10° of elevation at both GPS frequencies.

"Rapid Static": Economy from Advanced Technology

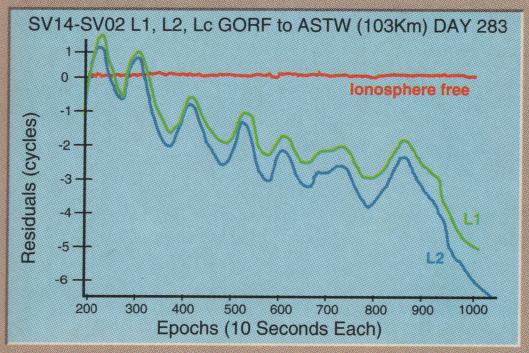
For the first time in FGCC history, Ashtech repeatedly demonstrated that observations of **5 to 10 minutes** can produce 1ppm survey accuracy. This high level of field accuracy with short observation times had been anticipated in the literature as the "rapid static" or

Figure 1



"Rapid Static" Precision Surveying

Figure 5



"fast static" technique. The rapid static method requires a GPS receiver of advanced design which provides high-precision measurements of both code and carrier on both L1 and L2 frequencies. The Ashtech P-12 is the only GPS receiver field-proven and FGCC-tested to meet these demanding performance requirements.

Figures 3 and 4 display rapid static results for a 7km baseline observed on Day 282 and a 17km baseline observed on Day 281. The differences in Northing and Easting between each individually processed 10-minute data segment and the 3-hour solution for each baseline are displayed. These figures clearly show the centimeter-level agreement between the 3-hour and the 10-minute observation results.

P-12 "Terminates" Ionosphere Effects

Figure 5 shows the double-differenced carrier-phase residuals for P-Code tracking on L1 and L2 and the ionosphere free linear combination (LC) for the FGCC baseline observed between stations GORF and ASTW on Day 283 (103km). This figure is an excellent example of the highly-correlated effect of ionospheric refraction on both L1 and L2. It also demonstrates the power of the ionosphere-free combination observable (LC). The differential ionosphere effect shown accounts for over 1.5 meters of systematic bias in the phase residuals. In comparison, the RMS of the LC observable is about 10mm.

Figure 3

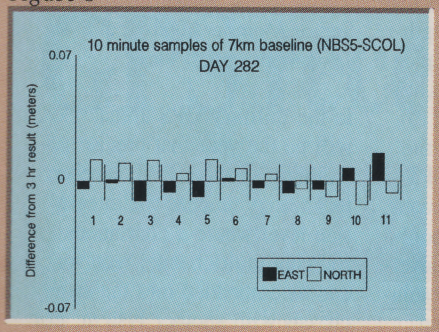


Figure 4

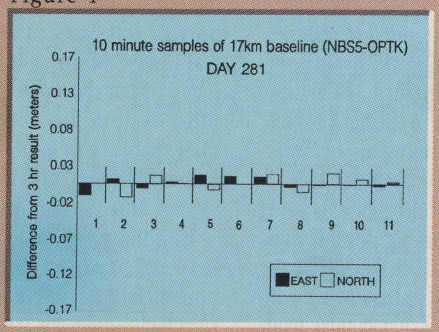
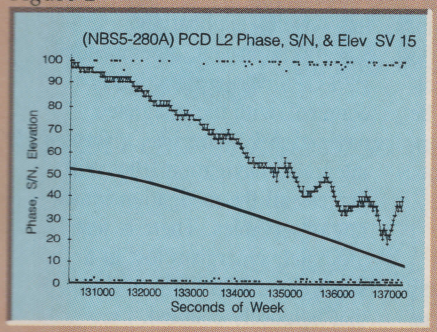


Figure 2



Cost Effective Precision and Productivity

The Ashtech P-12 illustrates the relationship of advanced electronics and basic economics; the most sophisticated GPS technology is actually the most cost-effective. The "rapid static" technique significantly increases survey productivity by reducing the site occupation time by a factor of approximately 10, thereby allowing more points per hour. In conducting precision geodetic surveys, the true business costs involve crew time not capital equipment.

For the practicing professional, the P-12 GPS surveying system represents a new level in productivity and provides the best cost benefit.

All Ashtech's GPS geodetic receiver systems are FGCC tested... the 12 channel single-frequency M-XII, the 24 channel dual-frequency codeless MD-XII, and now the "true" P-Code Ashtech P-12. It is Ashtech's philosophy to protect the customers investment in GPS. Users can upgrade any Ashtech geodetic receiver from single to dual frequency, and now to dual-P-Code P-12 technology.

Ashtech continues to bring all of the expanded capabilities of the Global Positioning System and the latest in technology to the art and science of precision geodetic surveying and global navigation.

ASHTECH XII TECHNOLOGY true P CODE GPS

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Circle 15

Ashtech Dual P-Code GPS brings "Rapid Static" performance to precision geodetic surveying.

FGCC TESTED Intensive FGCC testing of five Ashtech P-12 GPS Receivers, surveying governmental control points at the National Institute of Standards and Technology (NIST), repeatedly demonstrated that an observation time of **5 to 10 minutes** produced a **1ppm level of survey accuracy**. Long theorized in the literature as the "rapid static" technique, this high level of accuracy is now achievable with the Ashtech Dual P-Code P-12, a GPS receiver of advanced design which provides simultaneous high-precision measurements of both code and carrier at both L1 and L2 frequencies. The Ashtech P-12 is the **only GPS receiver** field-proven and FGCC-tested which meets these demanding performance requirements.

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