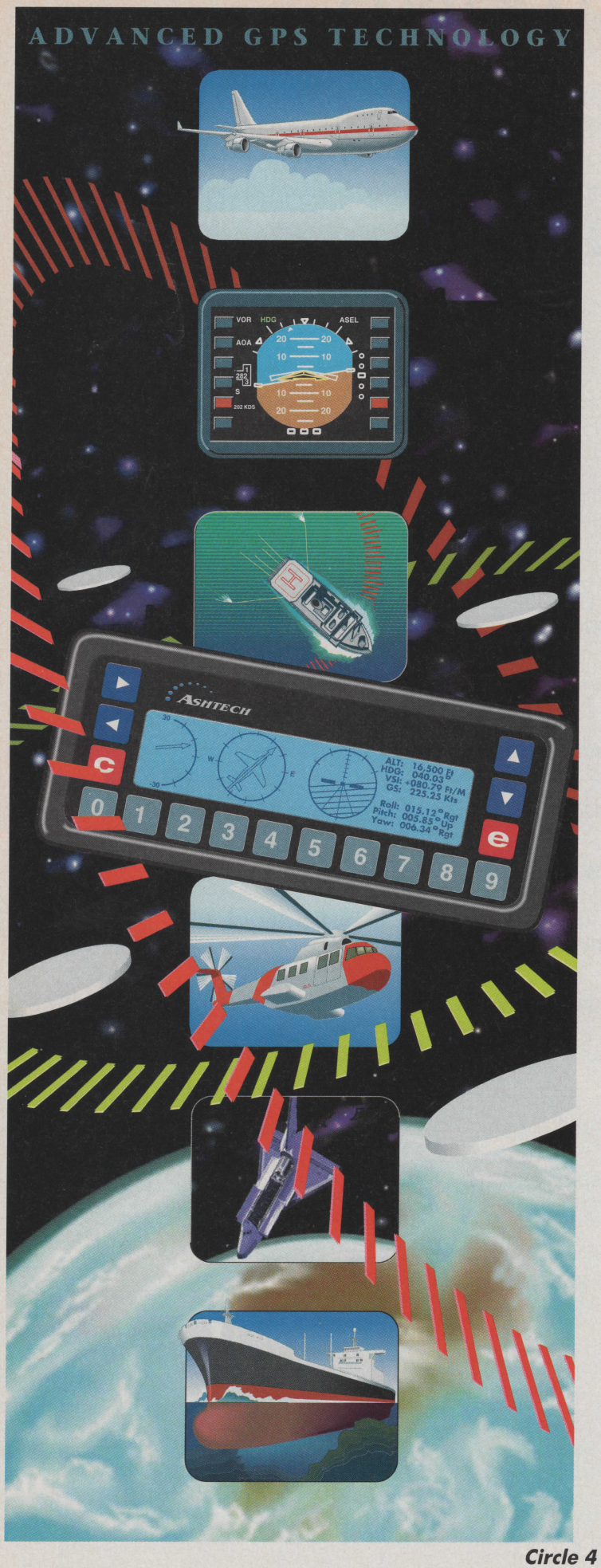



# Ashtech 3DF™ Dynamic Platform Attitude and Positioning...

*Attitude (heading, pitch, roll & yaw angles), position, velocity and time in a single, simple to use compact instrument.*

The Ashtech 3DF (Three-Dimensional Direction Finding) system determines platform attitude, position and velocity using GPS satellites. Combinations of azimuth, elevation, roll and yaw angles, or heading, pitch and roll angles are provided in real-time for static or dynamic platforms.

The 24 independent channels which are used for GPS satellite tracking are configured as four 6-channel banks with each bank receiving GPS L1 signals from a separate antenna. Small antenna size and flexible antenna array geometry permits easy installation on a variety of land, sea or air platforms.

The 3DF system displays platform attitude, position and velocity while storing these measurements internally at a one-second update rate. Two high-speed RS-232 serial ports are available to provide easy interface with other systems.

Useful as a real-time attitude and navigational aid, the Ashtech 3DF system is also ideally suited for many pointing applications. In an aerial photogrammetry application, where accurate aircraft heading and attitude are required, the 3DF system removes the need for an Inertial Navigation System (INS).

Unlike INS, the Ashtech 3DF system is not affected by magnetic fields or Schuler effects. It operates anywhere in the world, including the polar regions, with an accuracy of about one milliradian or 0.057 degrees.

The Ashtech 3DF system can be used either in a stand-alone or in an INS aiding role. In the latter, INS calibration and periodic gyro drift corrections can be performed continuously and automatically, dramatically reducing these labor-intensive tasks and effectively eliminating the associated platform down-time.

3D DIRECTION FINDING 3DF ASHTECH XII GPS

**ASHTECH**

*1170 Kifer Road, Sunnyvale, CA 94086*
*Phone (408)524-1400 • Fax (408)524-1500*

**Circle 4**

# 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 | STATION 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 o "hands-off" batch processin of 3 hour observations. A phase ambiguities were easil fixed and the effects of iono sphere were removed.)

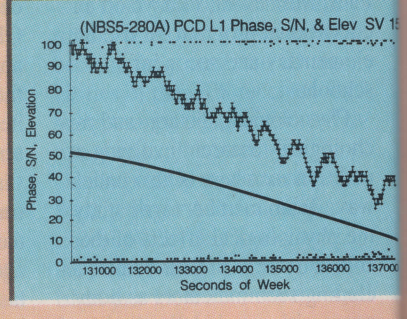
## P-12 Tracking Performance on L1 and L2

Typical of FGCC dat collected, Figures 1 and 2 sho signal strength vs. elevatio angle for P-Code tracking on L1 and L The closeness of the dots to the 0 and indicates high quality carrier-phas measurements at those epochs. The plots illustrate excellent tracking perfo mance down to 10° of elevation at bot GPS frequencies.

## "Rapid Static": Economy from Advanced Technology

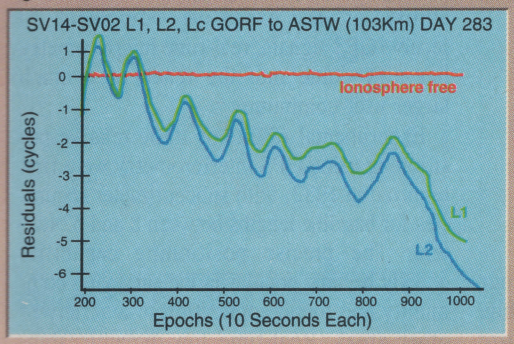
For the first time in FGCC histor Ashtech repeatedly demonstrated th observations of **5 to 10 minutes** c produce 1ppm survey accuracy. Th high level of field accuracy with sho observation times had been anticipate in the literature as the "rapid static"

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

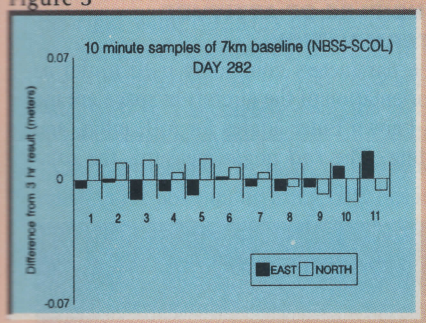



Figure 4

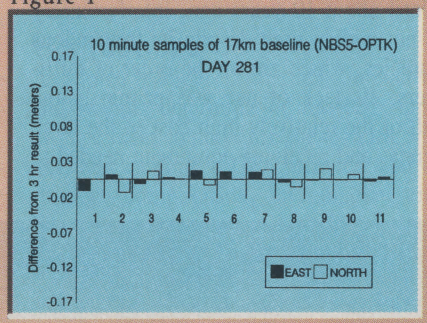
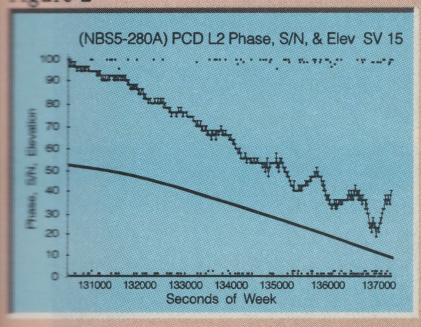



Figure 2




## 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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