Everyone is able to know where they are and

where other things are anytime, anyplace!

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

National Ocean Service

National Geodetic Survey

Positioning America for the Future

NATIONAL SPATIAL REFERENCE SYSTEM

The National Spatial Reference System (NSRS) is a consistent national coordinate system that specifies latitude, longitude, height, scale, gravity, and orientation throughout the Nation, as well as how these values change with time.

NATIONAL SPATIAL REFERENCE SYSTEM

ACCURATE -- cm accuracy on a global scale

MULTIPURPOSE -- Supports Geodesy, Geophysics, Land Surveying, Navigation, Mapping, Charting and GIS activities

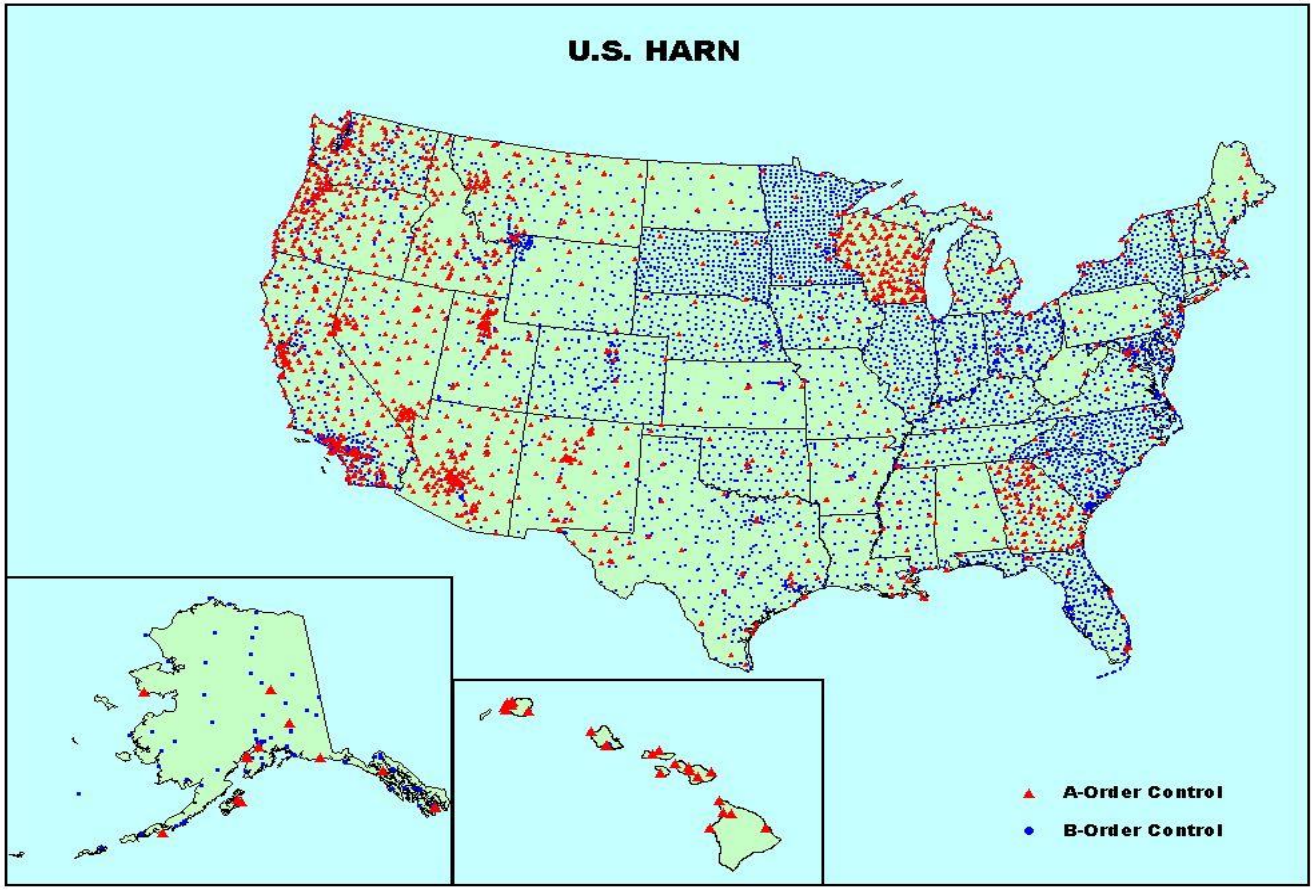
ACTIVE -- Accessible through Continuously Operating Reference Stations (CORS) and derived products

INTEGRATED -- Related to International services and standards (e.g. International Earth Rotation Service, International GPS Service etc.)

IMPROVING POSITIONAL ACCURACY

REFERENCE FRAME	TIME SPAN	NETWORK ACCURACY	LOCAL ACCURACY
NAD 27	**1927-1986**	**10 Meters**	**First-Order (1 part in 0.1 million)**
NAD 83(1986)	**1986-1990**	**1 Meter**	**First-Order (1 part in 0.1 million)**
NAD 83(HARN)	**1987-1997**	**0.1 Meter**	**B-Order (1 part in 1 million)** **A-Order (1 part in 10 million)**
NAD 83(CORS)	**1994 -**	**< 0.01 Meter - Horizontal** **< 0.02 Meter - Ellipsoid Height**	

HIGH ACCURACY REFERENCE NETWORKS (HARN)



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NAD 83 READJUSTMENT

FIRST SURVEYS OF HARN COMPLETED BETWEEN 1987 AND 1997

GPS HEIGHT MODERNIZATION SURVEYS OF HARN

(1997 - 2003)

3-D ADJUSTMENT OF ALL HARN SURVEYS AND
OTHER SELECTED GPS SURVEYS COMPLETED IN FEB 2007

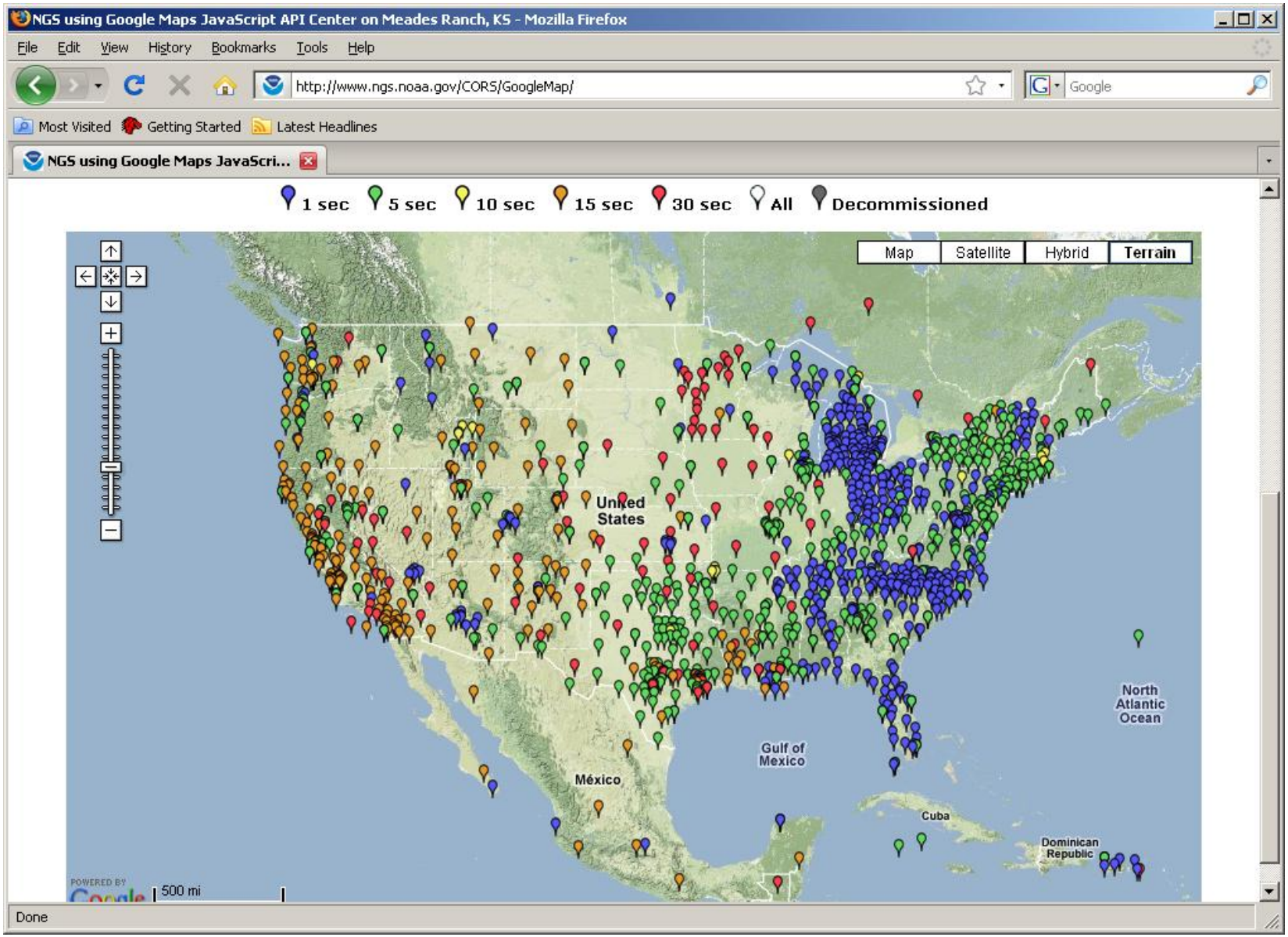
THIS ADJUSTMENT USED THE CORS NETWORK FOR CONTROL AND
IT REMOVED SMALL REGIONAL DISTORTIONS

(3 - 6 CM)

RESULTING REFERENCE FRAME IS CALLED

NAD 83 (NSRS2007)

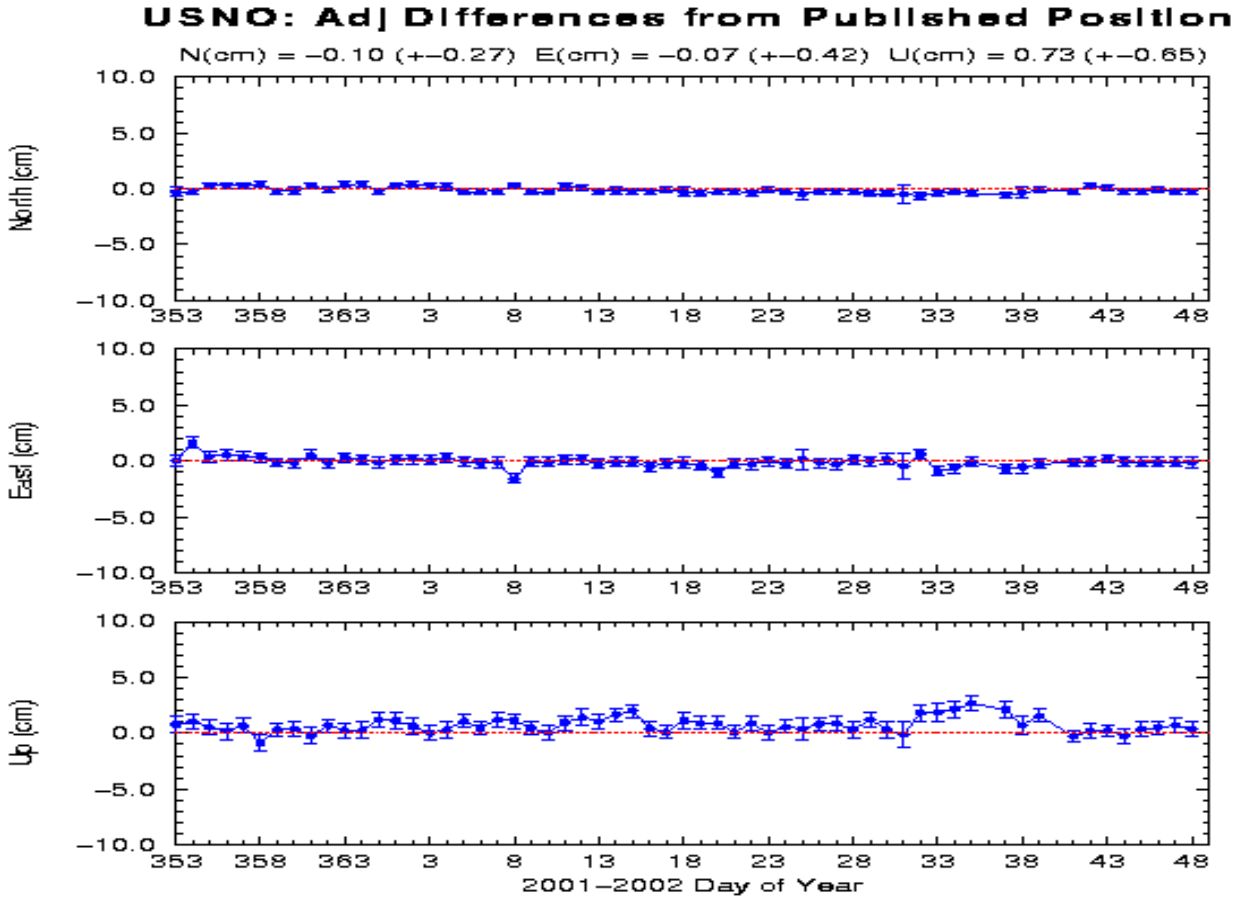
Continuously Operating Reference Stations



CORS ADVANTAGES

- 3-dimensional (Lat., Long., & Ellipsoid Ht. or X, Y, & Z)
- Eliminates control points reconnaissance (time and money).
- Eliminates needing people and equipment at a control points.
- Direct tie to National Spatial Reference System (NSRS).
- CORS positions and velocities are available in both NAD 83 and ITRF coordinate systems.
- CORS positions are of the highest accuracy.
- CORS positions are continuously monitored and will be updated if the site moves.

CORS DATA QUALITY



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Common Question

- CORS GPS hardware differs from our GPS hardware. Do we have to use only CORS with the same hardware?

GPS Data – Rinex Format

- Data file spans
  - hourly, daily, customized (UFCORS)
- Data collection rates
  - 1sec, 5sec, 10sec, 15sec, and 30sec
- Data file life-time
  - hourly: 2 days + today
  - daily: permanently
  - Data are decimated to a 30-second rate after 30 days

Common Question

- The closest CORS to our project area is 50 miles away. How can we use CORS at this distance?

TWO TESTS FOR POSITIONING PRECISION

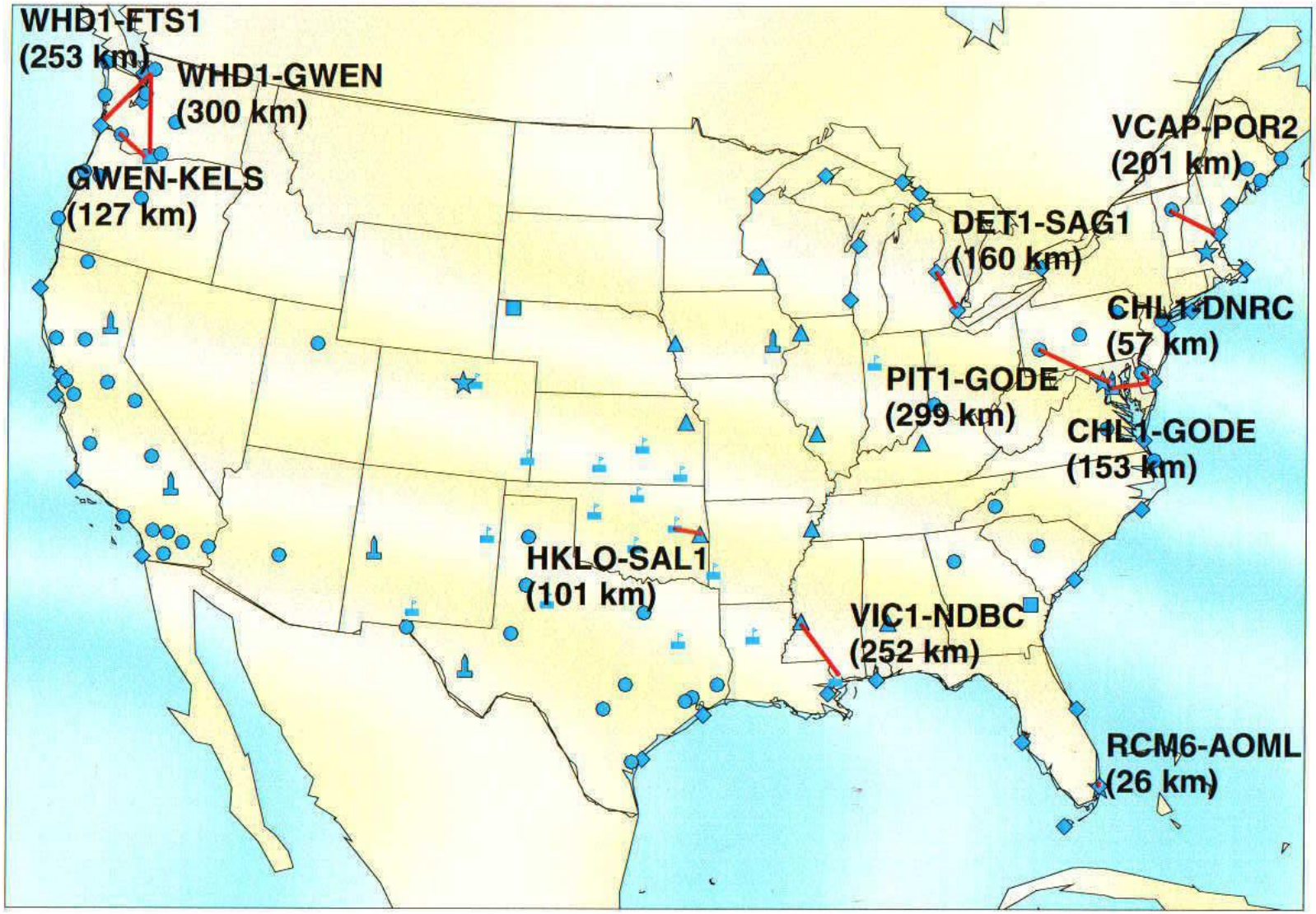
- Dual Frequency Carrier Phase
- Single Frequency Code

TEST DESIGN:
DUAL FREQUENCY CARRIER PHASE

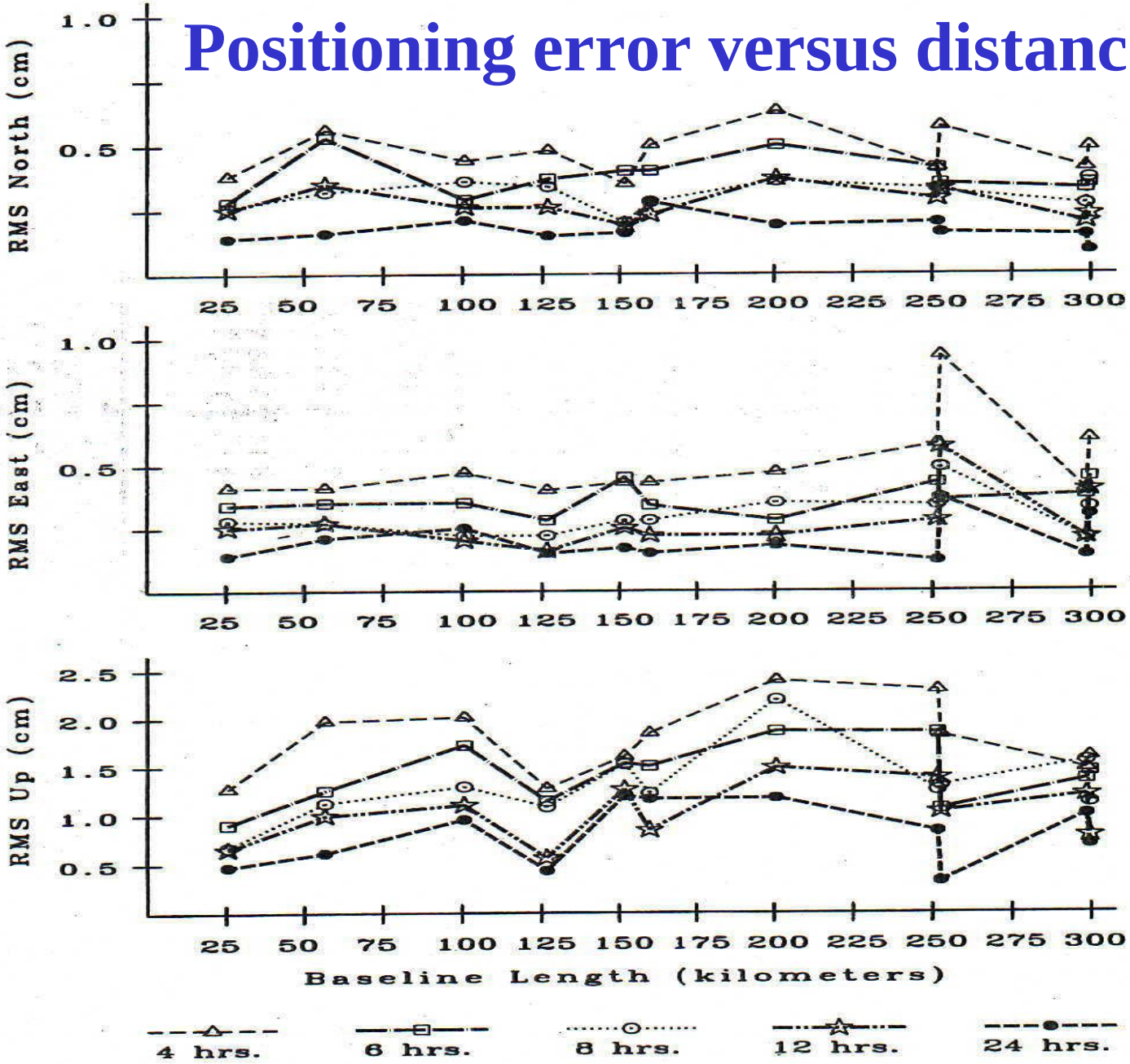
- Dual Frequency Geodetic Receivers
- Post-Processed with a Precise Orbits
- Pairs of CORS sites forming 11 Baselines
- Baseline lengths ranging from 26 to 300 km
- Various Observation Session Duration

(1, 2, 4, 6, 8, 12, and 24 hours)

BASELINES USED IN ACCURACY TESTS

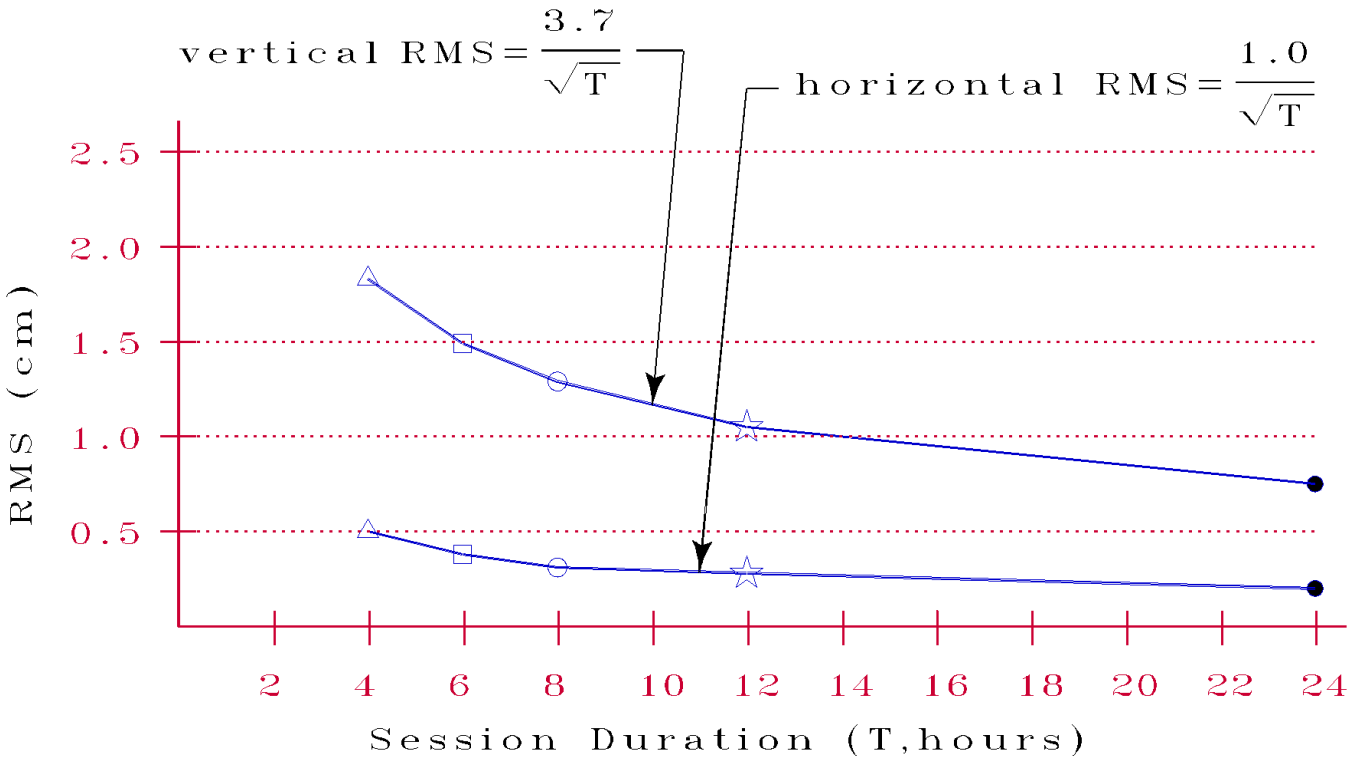


Positioning error versus distance



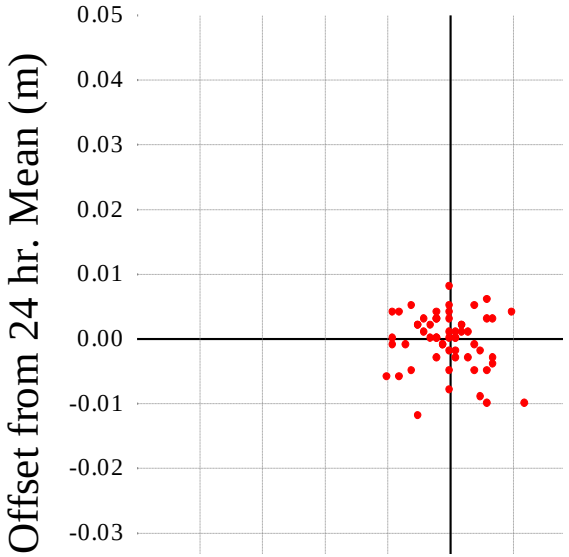
Positioning Error vs. Duration of the Observing Session

Dual-frequency GPS carrier-phase observations

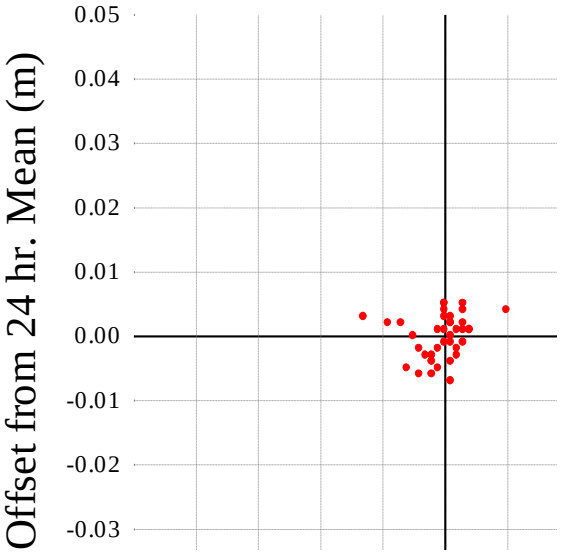


Time Scatter Plots (Horizontal)

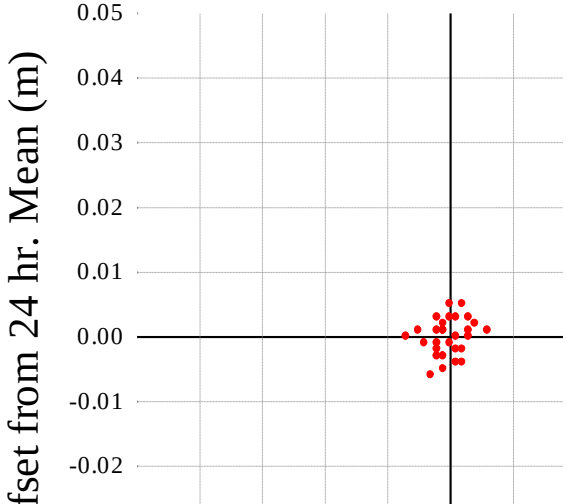
4 Hr/160



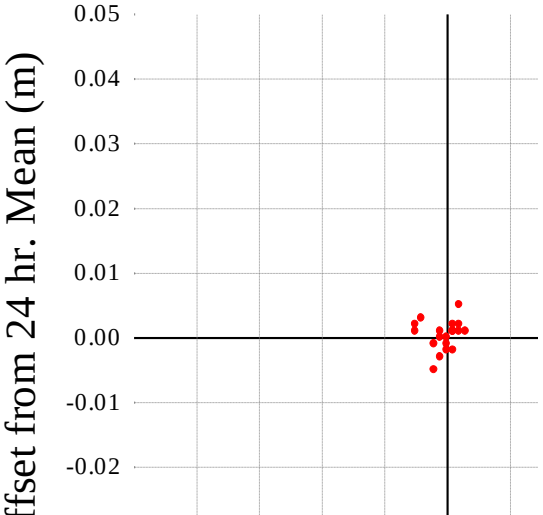
6 Hr/160



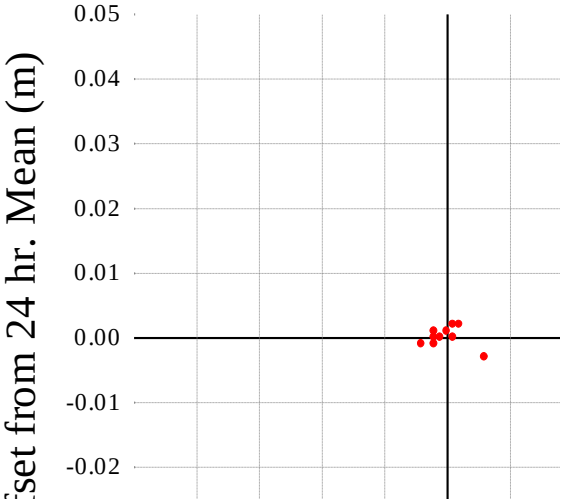
8 Hr/160



12 Hr/16



24 Hrs/16

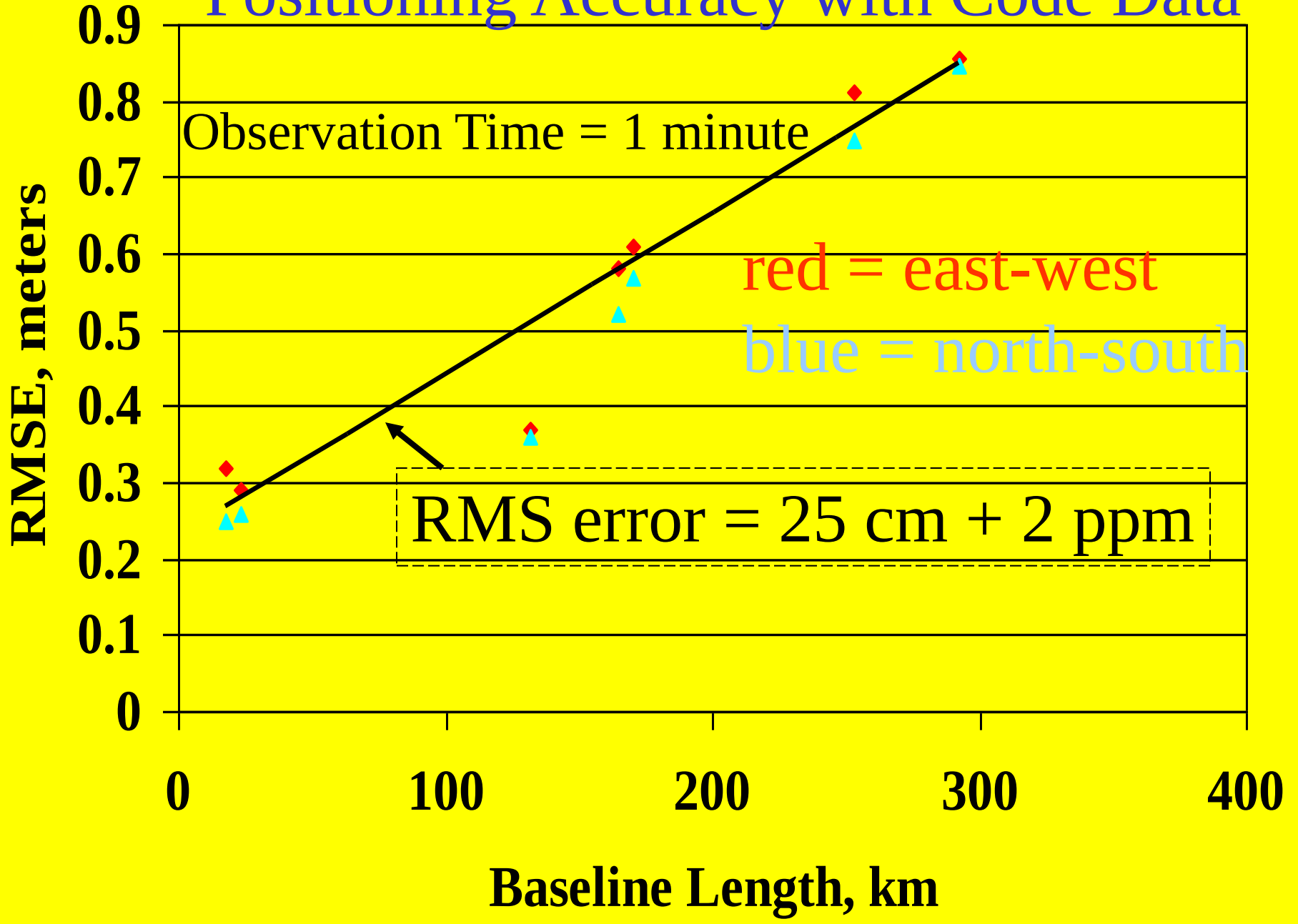


Vertical Precision Using Dual-Frequency GPS Carrier Phase Observations 95% Confidence Level

TEST DESIGN: SINGLE-FREQUENCY CODE

- Positioned 12 points relative to each of seven CORS sites
- Baseline lengths of 18, 23, 132, 165, 170, 253, and 292 kilometers
- Observed 1-minute sessions at a 5-second record rate (interpolated CORS data from 30 to 5 seconds)
- Repeated experiment 4 times over a 2-day period

Positioning Accuracy with Code Data



COMMENTS

- Sub-Meter precision is possible with baseline lengths up to 300 kilometers

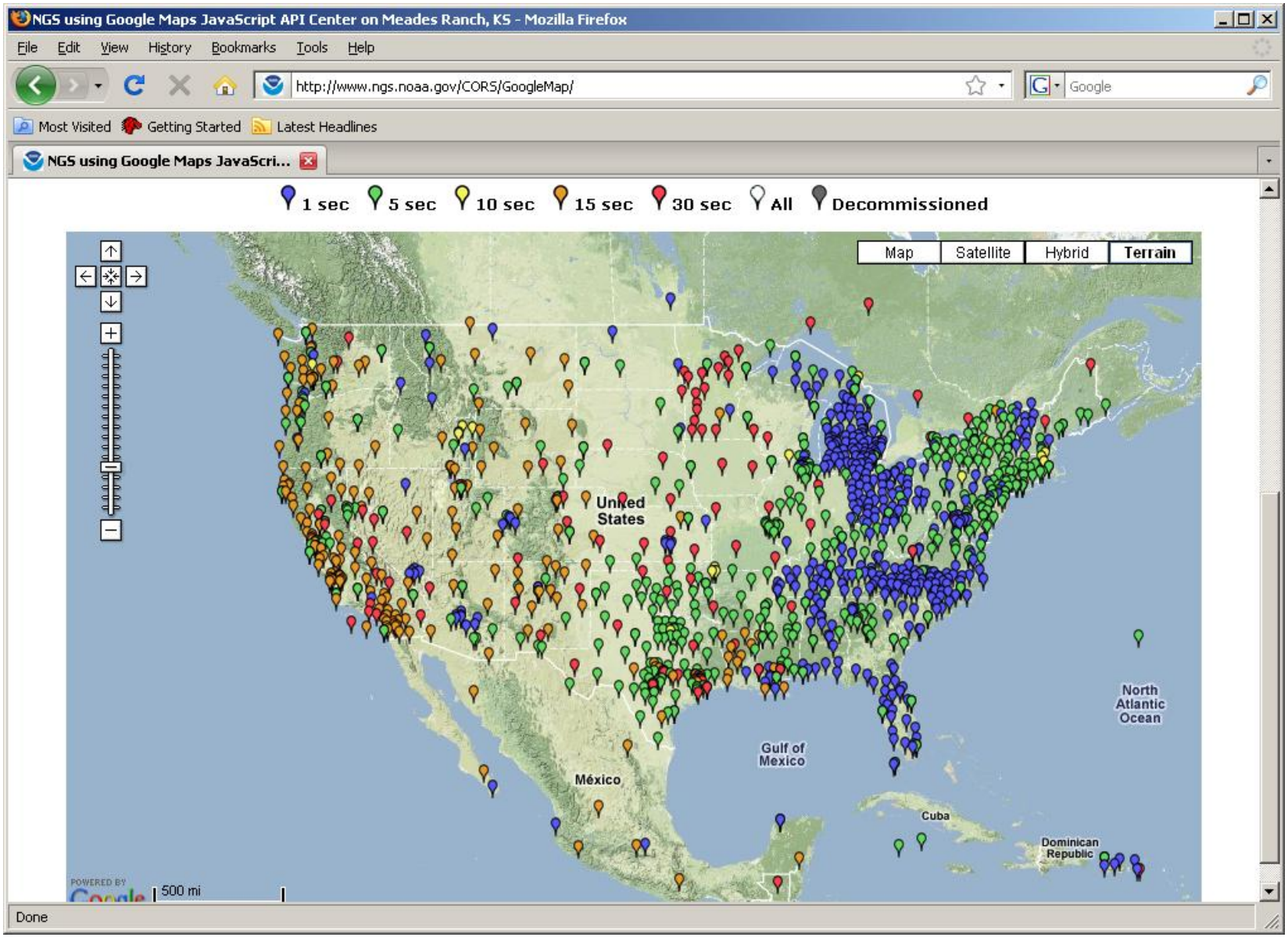
- This precision is possible using interpolated CORS data

- Most CORS data is available within 1-hour of the survey

ACCESSING CORS DATA & METADATA

- Web address = http://www.ngs.noaa.gov/CORS/
- Metadata = data about data
- CORSAGE = CORS Amiable Geographic Environment

Continuously Operating Reference Stations



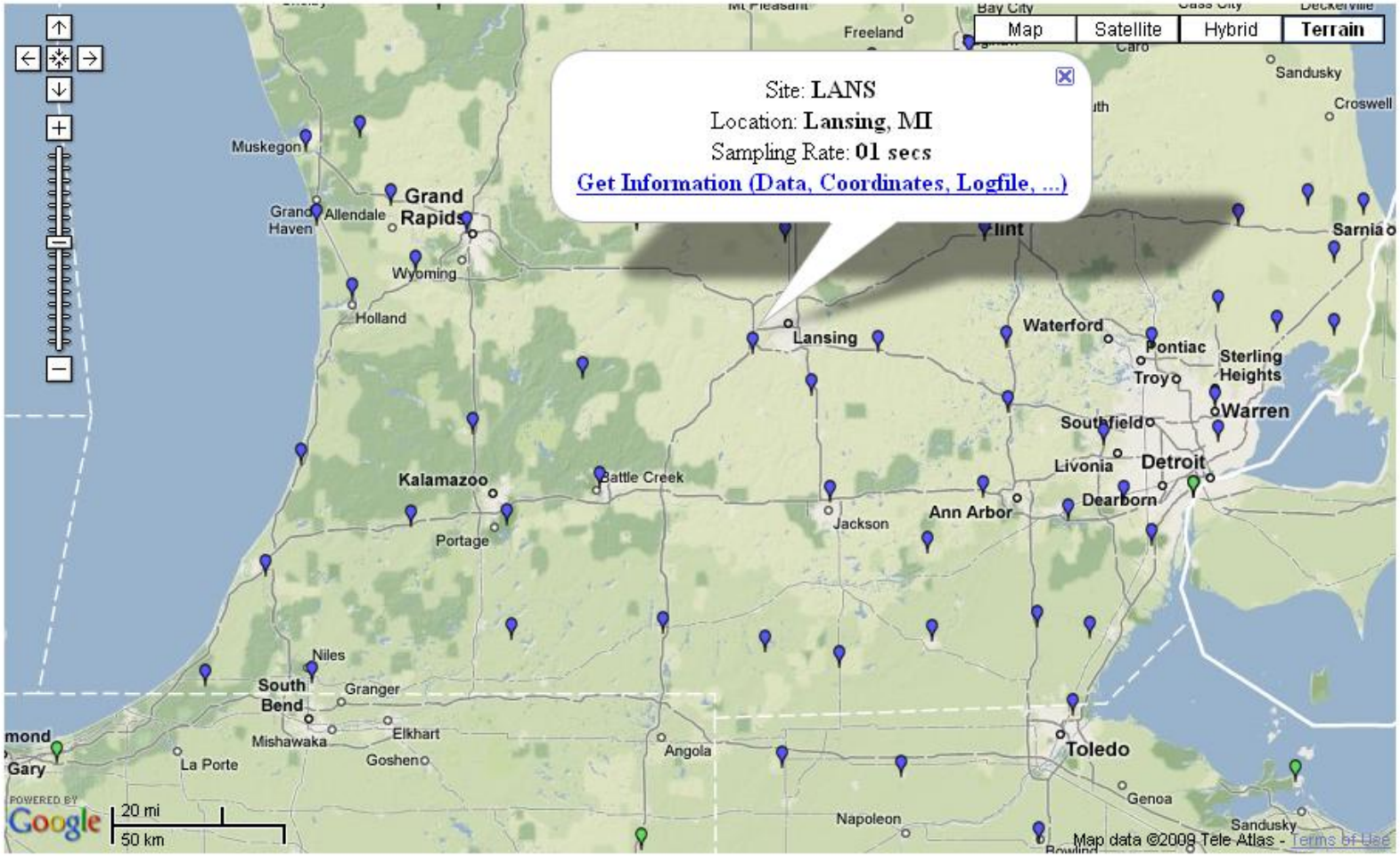
NGS using Google Maps JavaScript API Center on Meades Ranch, KS - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.ngs.noaa.gov/CORS/GoogleMap/

Most Visited Getting Started Latest Headlines

NGS using Google Maps JavaScri...



Done

lans map - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.ngs.noaa.gov/cgi-cors/corsage.prl?site=LANS

Most Visited Getting Started Latest Headlines

NGS using Google Maps JavaScript API ... | lans map

LANS
LANSING
Lansing, MI

Site operated by:
Michigan DOT

- Coordinates
- Data Sheet (ARP only)
- Data Sheets
- SiteLog
- Photographs
- Data Availability
- Standard Files
- Custom Files (UFCORS)

- Time Series (60-day)
- Time Series (longterm)

- Google Map lans only
- Google Map all CORS

Enter SiteID

CORS Home

National Geodetic Survey - CORS

Done

Start | Inbox for Richard.... | CORSWorkshop | OPUS HomePage -... | lans map - Mozill... | Microsoft PowerPoi... | Search Desktop | 2:50 PM

METADATA FOR A CORS SITE

- Coordinates (positions & velocities)
- Data availability profiles (charts showing times for which data has been collected)
- Data sheets (descriptive information)
- Log files (descriptive information)
- Site photos
- Time series of positional coordinates
- Google Maps

CORS POSITION & VELOCITY (NAD 83)

```
BILLINGS 1 (BIL1),  MONTANA

Retrieved from NGS DataBase on 01/10/01 at 09:45:16.

 ____________________________________________________________________________
|                                                                            |
| NAD_83 POSITION (EPOCH 1997.0)                                             |
| Transformed from ITRF97 (epoch 1997.0) position in Sep. 2000.              |
|     X =  -1372156.022 m     latitude    =  45 58 16.23742 N                |
|     Y =  -4223946.947 m     longitude   = 107 59 47.29949 W                |
|     Z =   4563650.156 m     ellipsoid height =  874.381   m                |
|                                                                            |
| NAD_83 VELOCITY                                                            |
| Transformed from ITRF97 velocity in Sep. 2000.                             |
|     VX =   0.0000 m/yr      northward =   0.0000 m/yr                      |
|     VY =   0.0000 m/yr      eastward  =   0.0000 m/yr                      |
|     VZ =   0.0000 m/yr      upward    =   0.0000 m/yr                      |
|____________________________________________________________________________|
```

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CORS POSITION & VELOCITY (ITRF)

```
 BILLINGS 1 (BIL1),  MONTANA

Retrieved from NGS DataBase on 09/25/00 at 12:27:27.
_____________________________________________________________________________
|                                                                           |
|         Antenna Reference Point(ARP): BILLINGS 1 CORS ARP                 |
|         ---------------------------------------------                     |
|                            PID = AI7658                                   |
|                                                                           |
|                                                                           |
| ITRF97 POSITION (EPOCH 1997.0)                                            |
| Computed in Sept., 2000 using 12 days of data.                            |
|     X =  -1372156.567 m     latitude    =  45 58 16.26213 N               |
|     Y =  -4223945.695 m     longitude   = 107 59 47.34150 W               |
|     Z =   4563650.195 m     ellipsoid height =  873.698   m               |
|                                                                           |
| ITRF97 VELOCITY                                                           |
| Predicted with HTDP_2.4 in Aug., 2000.                                    |
|     VX =  -0.0184 m/yr      northward =  -0.0106 m/yr                     |
|     VY =  -0.0020 m/yr      eastward  =  -0.0169 m/yr                     |
|     VZ =  -0.0074 m/yr      upward    =   0.0000 m/yr                     |
|                                                                           |
```

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Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Shop Stop

Bookmarks Location: http://www.ngs.noaa.gov/cgi-cors/support.prl?siteID=ashv What's Rela

Instant Message Internet Lookup New&Cool

DATA AVAILABILITY PROFILE

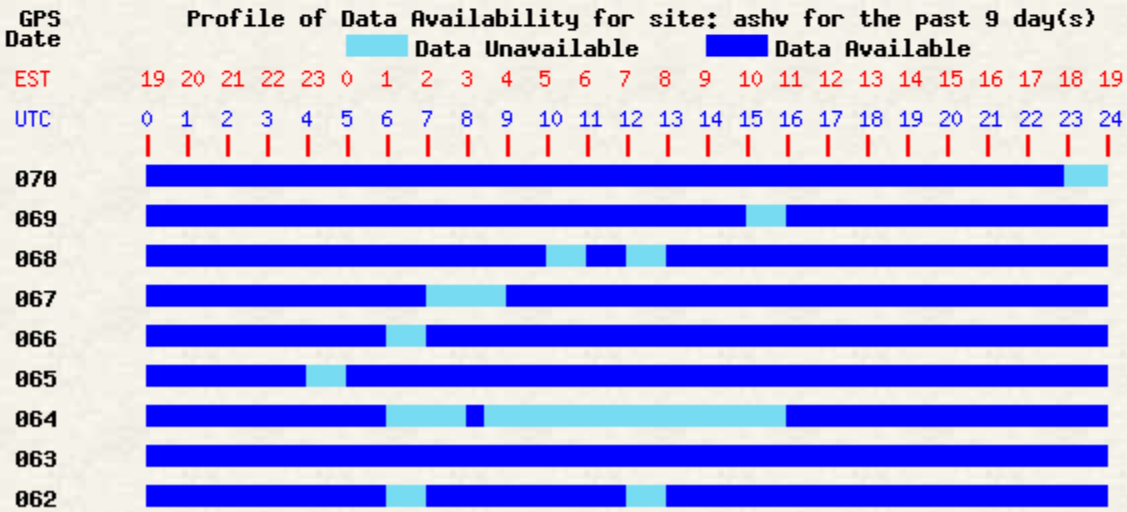
SiteID----------GPS Date----------Zone------Days

ashv | March 11, 2001 - day of year 070 | EST | 9

Submit

NOTE: Reset options and click 'Submit' to view data availability for another time period.

Get Customized Data | Get Uncustomized Data



BIL1 STATION LOG FILE

```
1.   Site Identification of the GPS Monument

     Site Name                  : Billings 1
     Four Character ID          : BIL1
     Monument Inscription       :
     IERS DOMES Number          : (XXXXXXXXX)
     CDP Number                 : (XXXX)
     Date Installed             : 25-AUG-2000 UT
     Geologic Characteristic    : (BEDROCK/CLAY/CONGLOMERATE/GRAVEL/SAND/etc)
       Bedrock Type             : (IGNEOUS/METAMORPHIC/SEDIMENTARY)
       Bedrock Condition        : (FRESH/JOINTED/WEATHERED)
       Fracture Spacing         : (1-10 cm/10-50 cm/50-200 cm/over 200 cm)
       Notes                    : (multiple lines)
     Additional Information     : (multiple lines)


2.   Site Location Information

     City or Town               : Billings
     State or Province          : Montana
     Country                    : U.S.A.
     Tectonic Plate             : North American
     Approximate Position
       X coordinate (m)         : -1372156.567
       Y coordinate (m)         : -4223945.695
       Z coordinate (m)         :  4563650.195
       Latitude (deg)           :  45.9712 N
       Longitude (deg)          : 107.9965 W
       Elevation (m)            : 873.698 (Ellip Ht)
     Additional Information     : ARP ITRF96 POSITION (EPOCH 1997.0) computed in
                                  Sept. 2000 using 12 days of data.
```

BIL1 STATION LOG FILE

```
4.    GPS Antenna Information

4.1   Antenna Type              : ASH700829.3     SNOW
      Serial Number             : 14295
      Antenna Height (m)        : (m)
      Antenna Reference Point   : (ARP/BCR/BPA)
      Degree Offset from North  :
      Antenna Radome Type       :
      Date Installed            : 25-AUG-2000 UT
      Date Removed              : (dd-MMM-yyyy hh:mm UT)
      Additional Information    : Serial # added 23-MAY-2001

4.x   Antenna Type              :
      Serial Number             :
      Antenna Height (m)        : (m)
      Antenna Reference Point   : (ARP/BCR/BPA)
      Degree Offset from North  :
      Antenna Radome Type       :
      Date Installed            : (dd-MMM-yyyy hh:mm UT)
      Date Removed              : (dd-MMM-yyyy hh:mm UT)
      Additional Information    : (multiple lines)
```

CORS SITES PHOTO

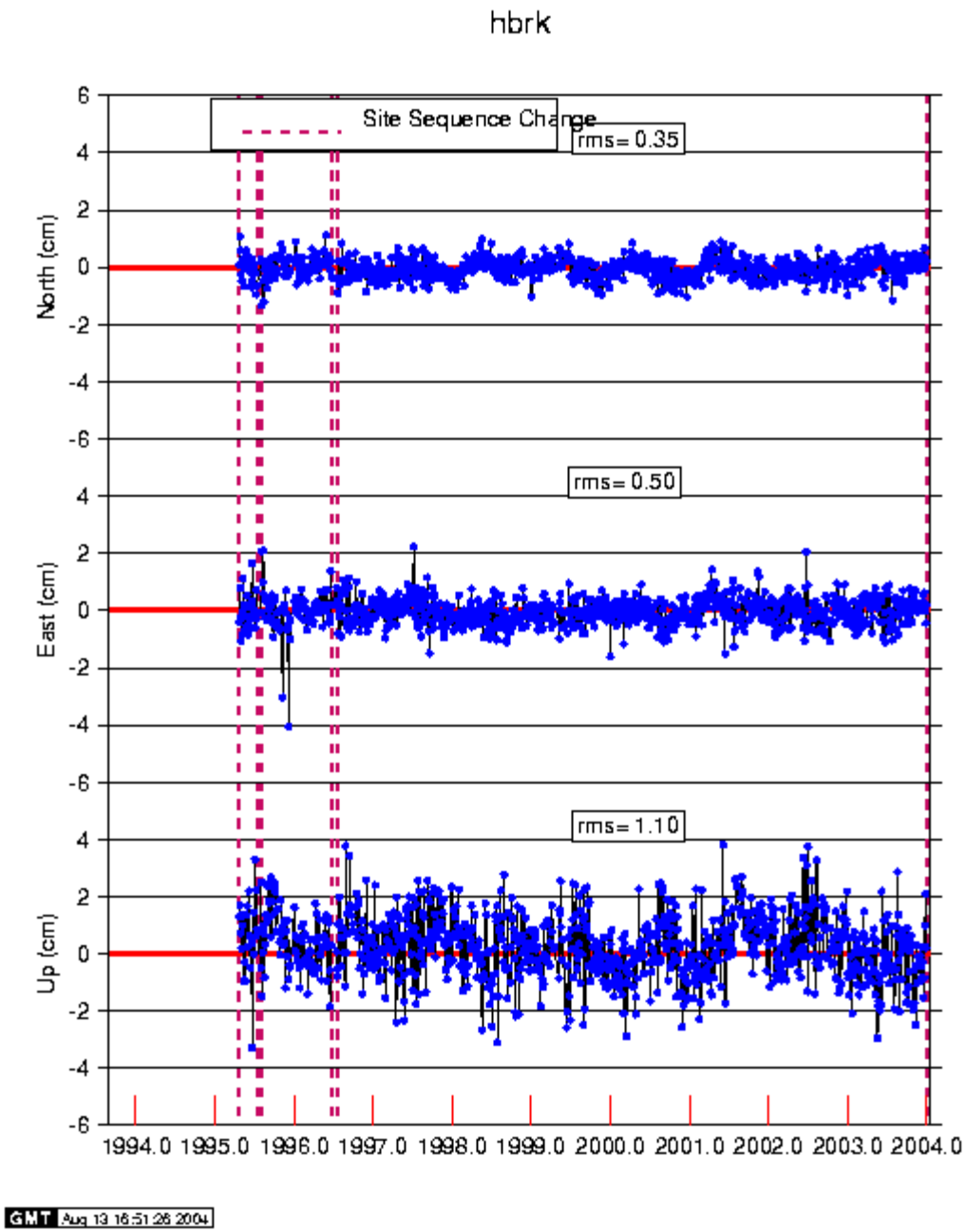
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

National Ocean Service

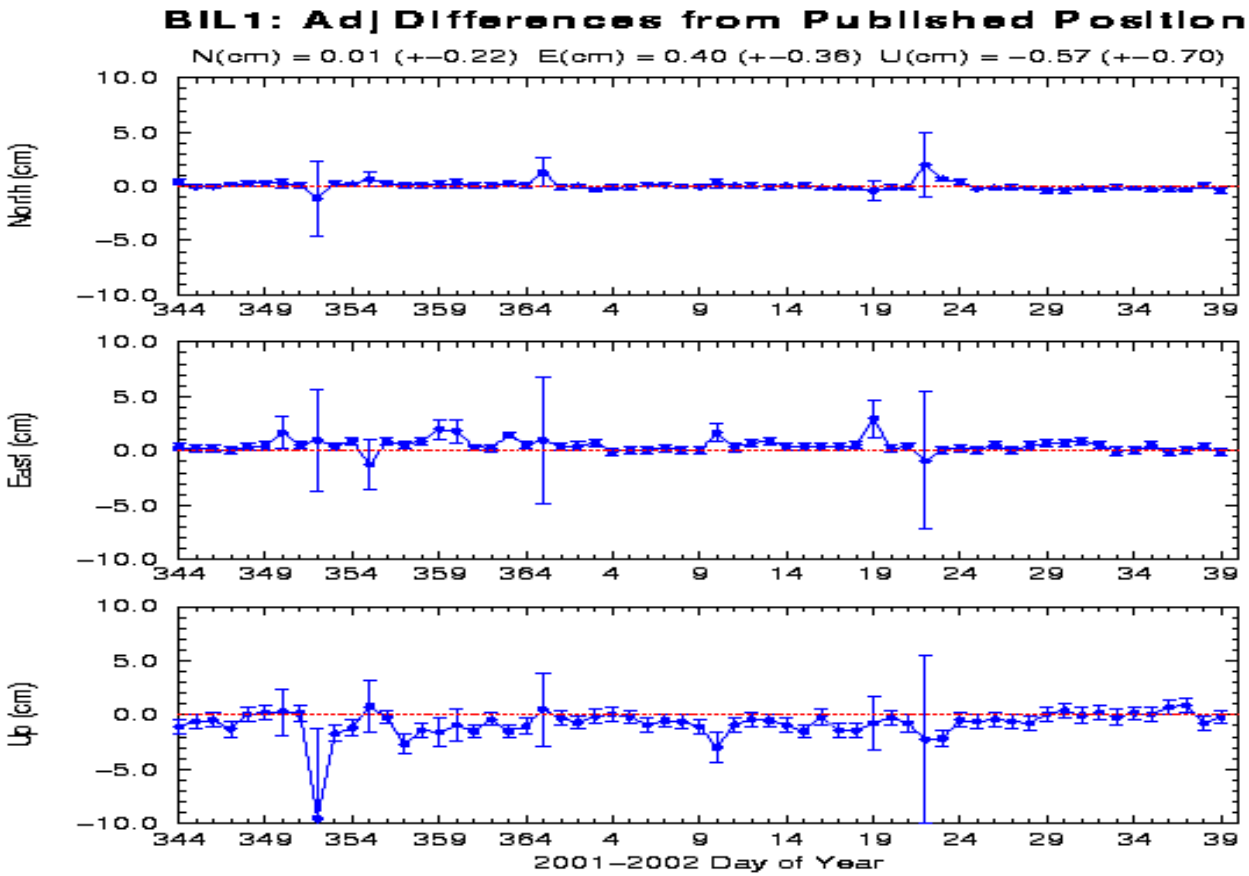
National Geodetic Survey

Positioning America for the Future

Position Time Series (long-term)



POSITION TIME SERIES (last 60 days)



NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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PRIMARY DATA FILES

- GPS observations at a CORS site
- Satellite orbits (ephemerides)

GPS Data – Rinex Format

- Data file spans
  - hourly, daily, customized (UFCORS)
- Data collection rates
  - 1sec, 5sec, 10sec, 15sec, and 30sec
- Data file life-time
  - hourly: 2 days + today
  - daily: permanently
  - Data are decimated to a 30-second rate after 30 days

FILE NAMING CONVENTION

The RINEX file naming convention is as follows:
{SSSS}{DDD}{H}.{YY}{T}

where	**SSSS**	**is the four character site identifier,**
	DDD	**is the day of year,**
	H	**is a letter which corresponds to an hour long UTC time block,**
	YY	**is the year,**
	T	**is the file type.**

For daily files, the format would be {SSSS}{DDD}0.{YY}{T}.
Hour long UTC time block identifier (H):

00	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**m**	**n**	**o**	**p**	**q**	**r**	**s**	**t**	**u**	**v**	**w**	**x**

File type	**Ending (T)**
Meteorological	**m**
Observation	**o**
Navigation	**n**
Summary	**s**

```
     2              OBSERVATION DATA    G (GPS)             RINEX VERSION / TYPE
GPS Data Logger     GRDL                21-Mar-2001 00:00   PGM / RUN BY / DATE
Jamaica Met Service                                         COMMENT
                                                            COMMENT
                                                            COMMENT
JAMA                                                        MARKER NAME
42601S001                                                   MARKER NUMBER
CR                  JamaicaMet                              OBSERVER / AGENCY
UZ01603             ASHTECH UZ-12       UG00                REC # / TYPE / VERS
114                 AOAD/M_TA_NGS   SNOW                   ANT # / TYPE
   1388123.458  -5909144.607   1951948.314                 APPROX POSITION XYZ
          0000          0000          0000                 ANTENNA: DELTA H/E/N
     1     1                                               WAVELENGTH FACT L1/2
     5    C1    L1    L2    P1    P2                       # / TYPES OF OBSERV
    30                                                      INTERVAL
  2001     3    21     0     0     0                       TIME OF FIRST OBS
  2001     3    21    23    59    30                       TIME OF LAST OBS
                                                            END OF HEADER
 01  3 21  0  0  0.0000000  0 11 24  6 30 23  9 26 17 10 18  5  4
  22525107.968   -12004584.60101  -9307794.83601  22525107.310    22525113.601
  21407074.677   -21302765.63901 -16590892.08801  21407074.328    21407080.397
  24273111.188    -6817866.50901  -5269844.90201  24273110.761    24273125.339
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  19829141.060   -28015349.71301 -21809187.84301  19829140.818    19829145.446
  24987202.822    -3519780.28501  -2735504.94601  24987202.593    24987213.187
  22285216.503   -15947032.36401 -11887374.74201  22285215.306    22285221.233
  24749918.403     -652695.17911   -473382.45901  24749918.770    24749934.463
  24264723.697    -3160535.55801  -2408534.86401  24264722.253    24264739.440
  25147913.811    -9528713.53001  -7369147.23701  25147913.155    25147921.207
```

NGS Satellite Ephemerides

http://www.ngs.noaa.gov/GPS/GPS.html

- NGS is one of the seven International GPS Service (IGS) Analysis Centers (AC) participating in the production of accurate GPS orbits:
  - Final Precise (~ 13 days latency)[accuracy < 4 cm]
  - Rapid (17 hours latency) [accuracy < 5 cm]
  - Ultra-Rapid (real-time) [accuracy < 10 cm]
- Satellite positions in SP3 format are given (once every 15 minutes) in current ITRFxx frame

Three ways to download CORS Information

- Web-based User-Friendly CORS (UFCORS)
- Web-based “Standard” download
- FTP (File Transfer Protocol)

UFCORS/STANDARD

CORS - Continuously Operating Reference Stations - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://www.ngs.noaa.gov/CORS/

Getting Started Latest Headlines

CORS - Continuously Operating Refer...

National Geodetic Survey

Newsletter
Downloads
Site Metadata
General Information
Cooperative CORS
California CORS
Instructions
GPS Links
Utilities

CORS Home

Contact Us

Products/Services

National and Cooperative CORS

Data Sheets Search

NGS NOAA

opus | coop cors | map | dynamic map | newsletter | standard download | ufcors | cors ftp | coordinates

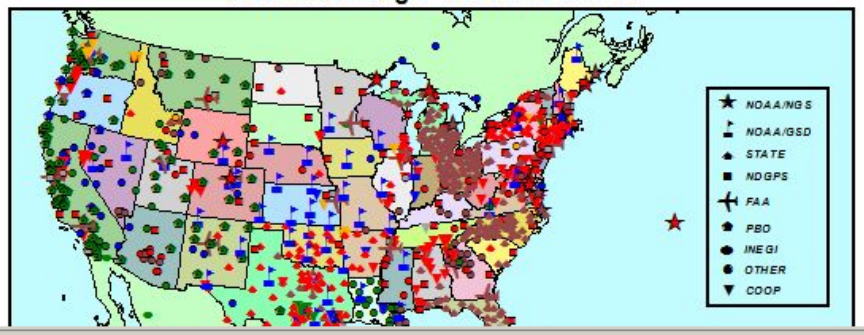
National Geodetic Survey - CORS

Continuously Operating Reference Stations

What is CORS? | Notices | CORS Site Guidelines | Future Sites | List Sites
OPUS | User Friendly CORS

Enter SiteID

CORS Coverage - November 2006



Done

Start | Inbox for Richard.Snay... | CORSWorkshop | Microsoft PowerPoint - [... | txpr map - Mozilla Firefox | CORS - Continuously ... | « 2:00 PM

UFCORS: a Web utility enabling users to

- Obtain CORS data for an exact time interval
- Choose a sampling rate for the requested data
- Specify how the data files should be compressed
- Receive all associated data & metadata (coordinates, descriptive information, orbits)
- Receive information as soon as it is posted (GPS data are usually posted within an hour of the time these data are received by NOAA)

UFCORS - page 1

User Friendly CORS Version 3.5.2 - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://www.ngs.noaa.gov/UFCORS/

Getting Started Latest Headlines

User Friendly CORS Version 3.5.2

User Friendly CORS

Version 3.5.2 - November 01, 2004

This utility allows you to obtain a specific block of Global Positioning System (GPS) data for a continuously operating reference station (CORS) contained in the network of GPS sites managed by the National Geodetic Survey.

The GPS data will be in "receiver independent exchange" (RINEX) format, version 2.10.

**** NOTE: Whenever possible, please use the new Problem/Comment form below or at the bottom of the following page to report problems.**

UFCORS Page Info | Trimble Products Configuration | UFCORS Problem/Comment Form

---

Starting Day: January 22, 2007 - Day of year 22 [Get Older Data]

Start Time of the field observation: 09:00 Day and Time Info

Time Zone relative to observation location: Central Standard (GMT - 6) Time Zone Info

Number of hours of data you wish to receive: 1 Please LIMIT requests for 1-second sampling rate data to 2 hours.

CONTINUE | CLEAR

National Geodetic Survey - CORS Team
Last modified: November 01, 2004
Question or Comments: michelle.ho@noaa.gov

Done

Start | Inbox for Richard.Snay... | CORSWorkshop | Microsoft PowerPoint - [... | User Friendly CORS V... | « 2:03 PM

UFCORS - page 2

User Friendly CORS Version 3.5.2 - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://www.ngs.noaa.gov/UFCORS/UFCORS2.jsp

Getting Started Latest Headlines

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User Friendly CORS

Version 3.5.2 - November 01, 2004

GPS data are available for the following sites for your specified time interval: txpr — Site Info, Site Map, Data Availability , Time Series

This utility will interpolate or decimate the GPS data.

How many seconds do you want between individual data points?: As Is — Please LIMIT requests for 1-second sampling rate data to 2 hours.

Would you like the corresponding files?

Coordinate File: no — Coordinate File Info

Met File: no — Met File Info

NGS data sheet: no

IGS Orbits in SP3 format: yes — Orbit File Info

Please choose the compression format.

Files can be compressed using pkzip — Compression Info

Processing will take place within a minute. A window will appear after processing that allows you to select where on your hard drive to save the transmitted files.

Also, a window displaying icons for several directories (folders) and files may appear. You may use this window to view the transmitted files. This feature is browser dependent and may not work on your browser.

SUBMIT CLEAR

To Report UFCORS Problem or Comment Form

National Geodetic Survey - CORS Team

Done

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SURVEYING METHODS

Kinematic GPS

Static Positioning (carrier phase)

Static Positioning (code)