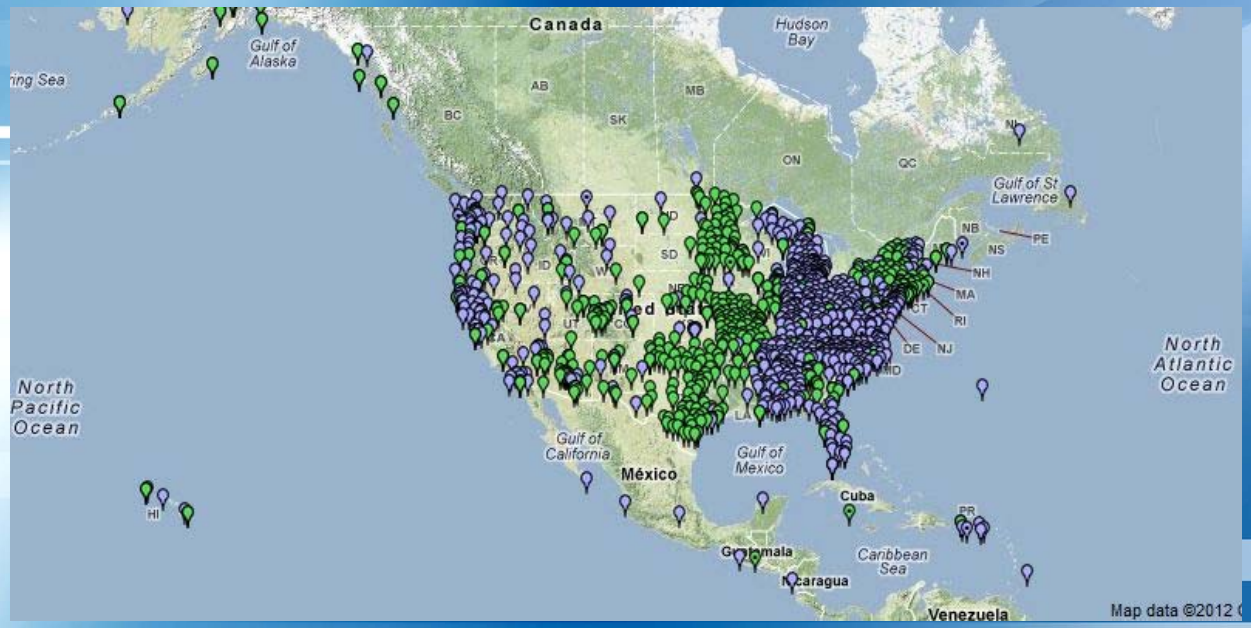
National Geodetic Survey

NERRS
GEODETIC TRAINING
CORBIN, VA

CORS & OPUS



NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM

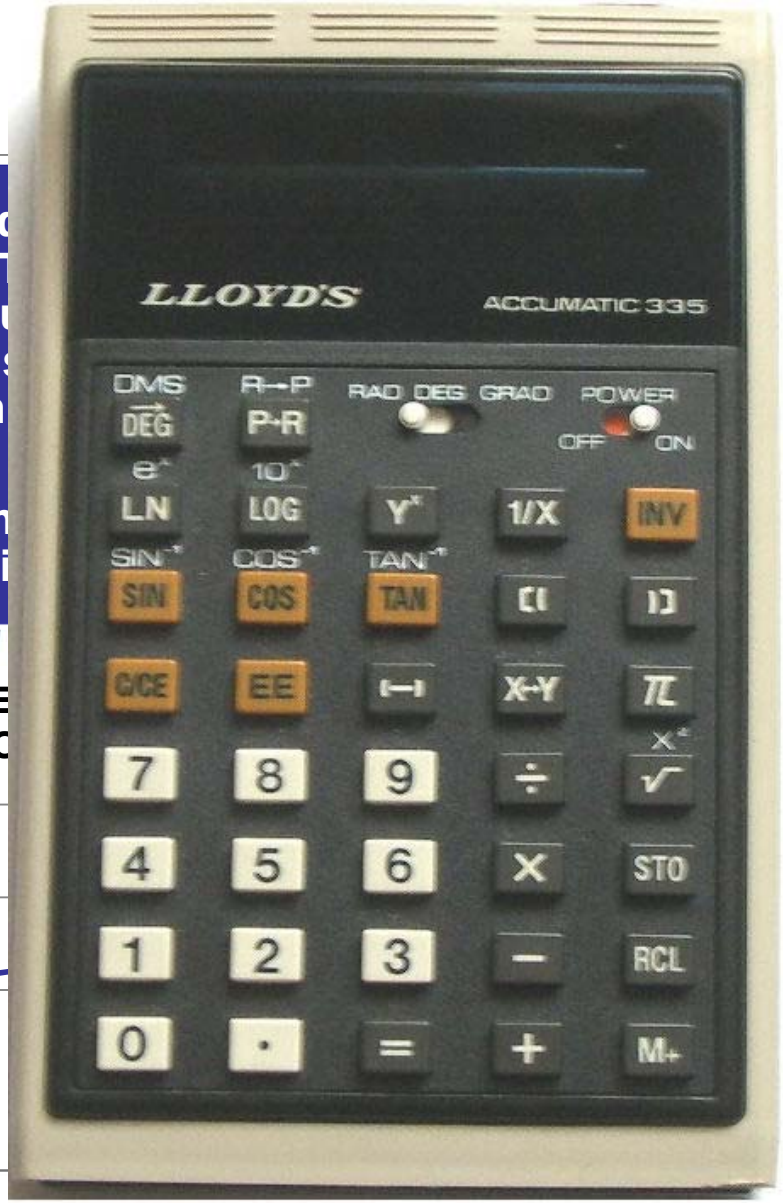
National Oceanic and Atmospheric Administration

BILL HENNING
GEODESIST, PROF. LS.

POSITIONING TECHNOLOGY-

"Human knowled
every 10 years. T
knowledge produ
1987 and 1997 is
that produced in
history".

Michio Kaku- ren
theoretical physi



THE CHANGE
INTENSIVE TO

STICKS AND
STRINGS-
W.HENNING BORN

-2700 -2500 -1500 -1000 -500 0

ONASS,
ALILEO,
EIDOU,

TN

RTK

PS

AL STATION

0.5' SAT IMAGERY,
TERR. LASER
SCANNING, 0.10'
AERIAL MAPPING,
INTERNATIONAL
NETWORKS, INDOOR
POSITIONING, 3-D GIS

TECHNOLOGY

2000 2010 2017 2030

YEAR

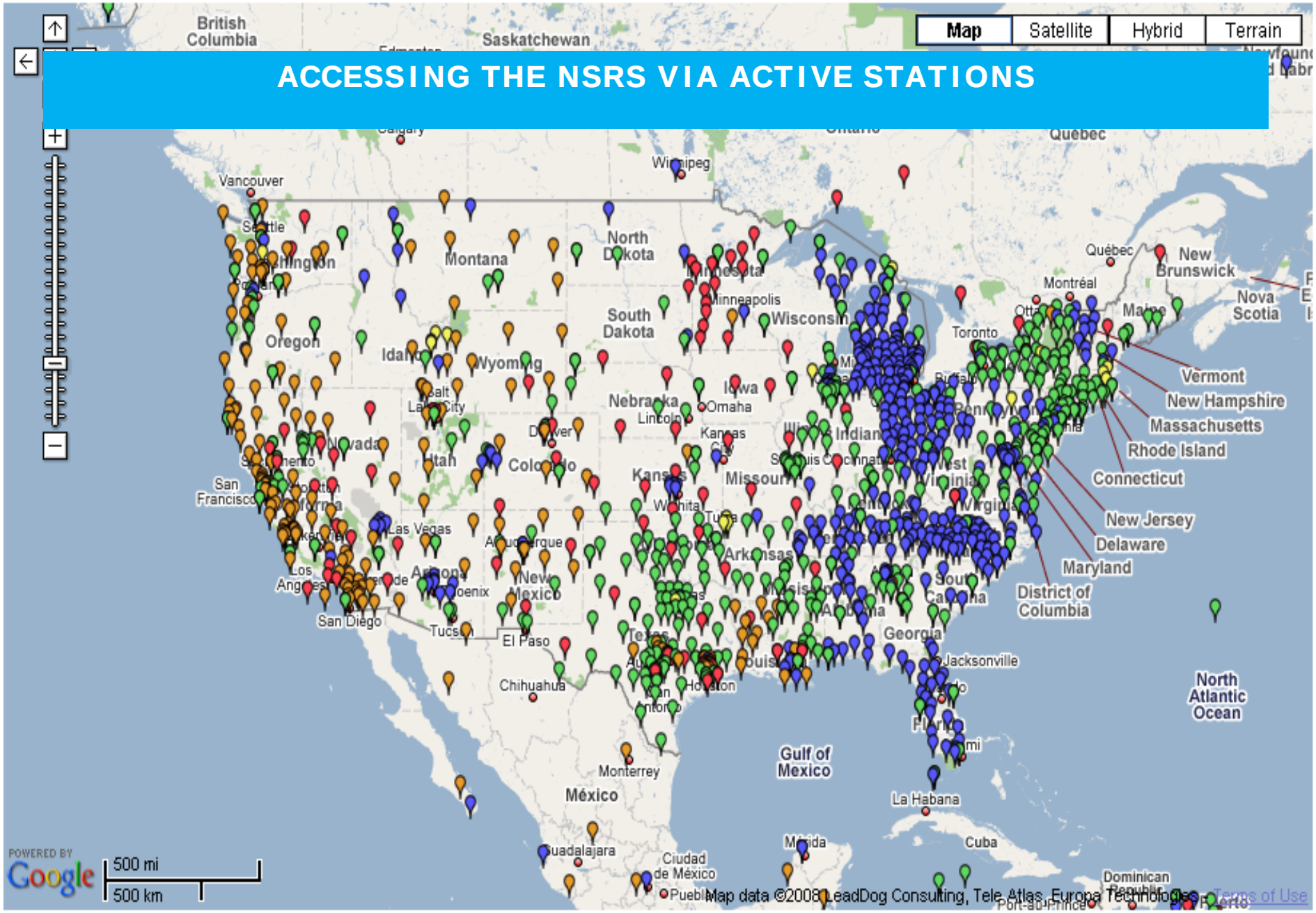
GPS GROWTH

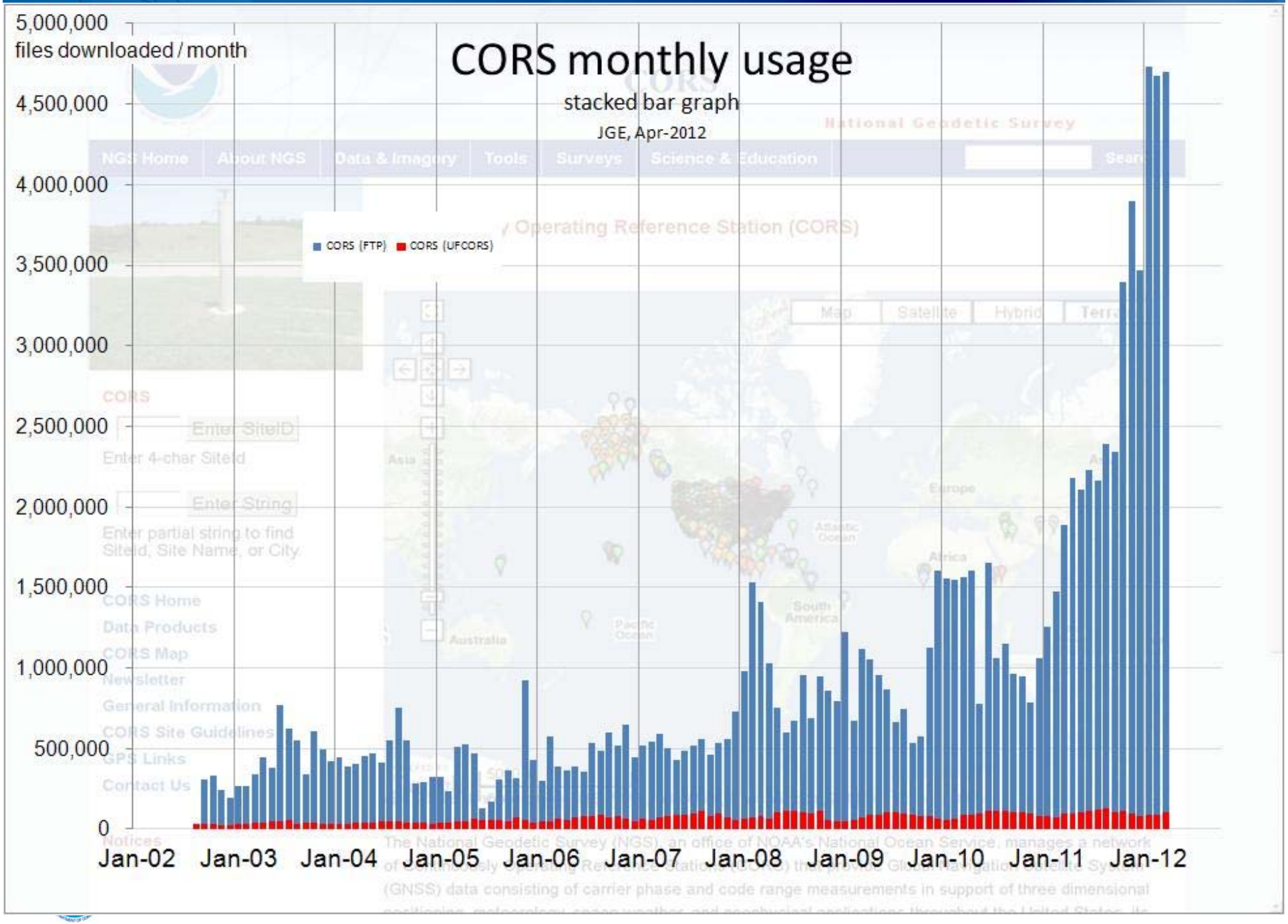
2000
1.5 MILLION USERS
ECONOMIC IMPACT = $6.2 BILLION

2010
1 BILLION USERS
1 BILLION RECEIVERS
ECONOMIC IMPACT = $50 BILLION

(Source: University of Washington Olympic Natural Resources Center.)

ACCESSING THE NSRS VIA ACTIVE STATIONS




CORS monthly usage
stacked bar graph
JGE, Apr-2012
files downloaded / month
5,000,000
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
CORS (FTP)
CORS (UFCORS)
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12

Antenna Reference

IGS08 POSITION (EPOCH 2005
Computed in Aug 2011 using
X = 1097041.320 m
Y = -4897238.428 m
Z = 3923126.259 m

IGS08 VELOCITY
Computed in Aug 2011 using
VX = -0.0146 m/yr
VY = -0.0001 m/yr
VZ = 0.0023 m/yr

NAD_83 (2011) POSITION (EP
Transformed from IGS08 (ep
X = 1097041.999 m
Y = -4897239.891 m
Z = 3923126.362 m

NAD_83 (2011) VELOCITY
Transformed from IGS08 vel
VX = 0.0017 m/yr
VY = 0.0013 m/yr
VZ = -0.0019 m/yr

Antenna Reference Point(ARP): CORBIN CORS ARP

PID = AJ2122

ITRF00 POSITION (EPOCH 1997.0)
Transformed from ITRF97 position in Nov. 2001.

X =	1097041.441 m	latitude	= 38 12 07.85567 N
Y =	-4897238.428 m	longitude	= 077 22 24.57954 W
Z =	3923126.231 m	ellipsoid height	= 35.938 m

ITRF00 VELOCITY
Transformed from ITRF97 velocity in Nov. 2001.

VX =	-0.0161 m/yr	northward	= 0.0032 m/yr
VY =	-0.0018 m/yr	eastward	= -0.0161 m/yr
VZ =	0.0027 m/yr	upward	= 0.0003 m/yr

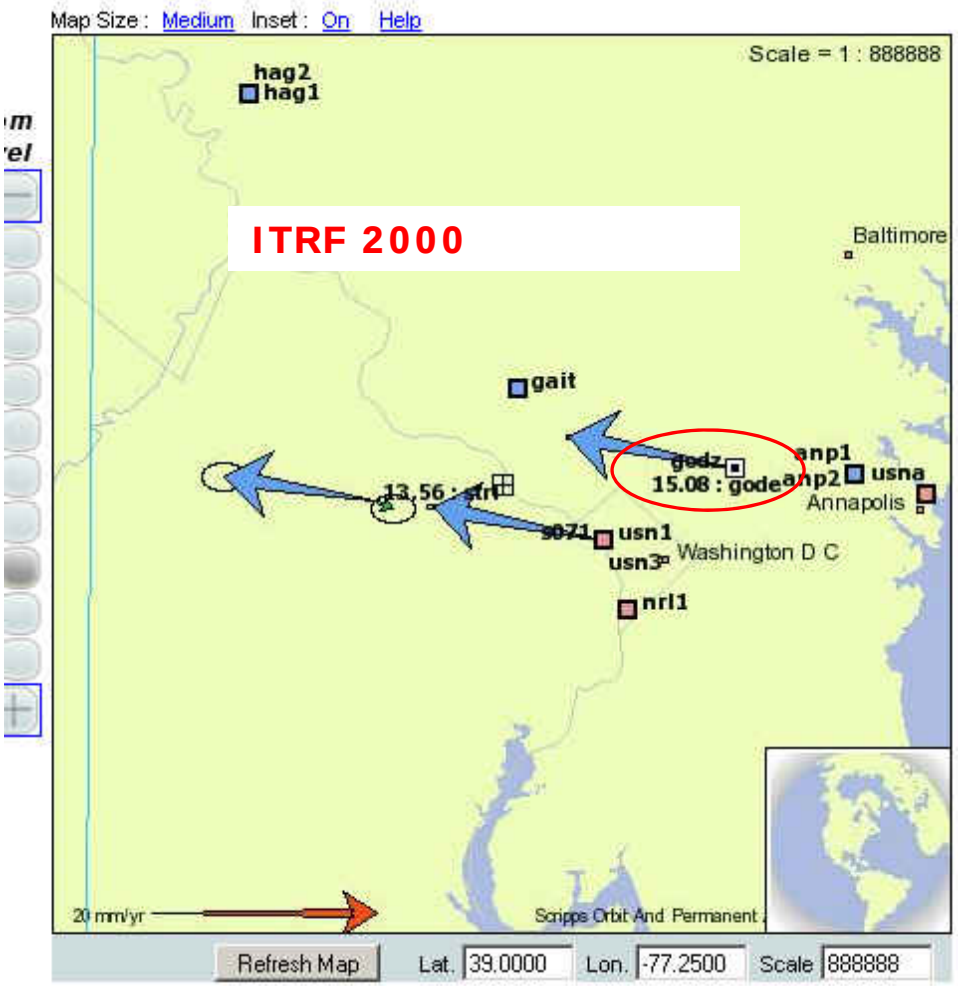
NAD_83 (CORS96) POSITION (EPOCH 2002.0)
Transformed from ITRF00 (epoch 1997.0) position in Mar. 2002.

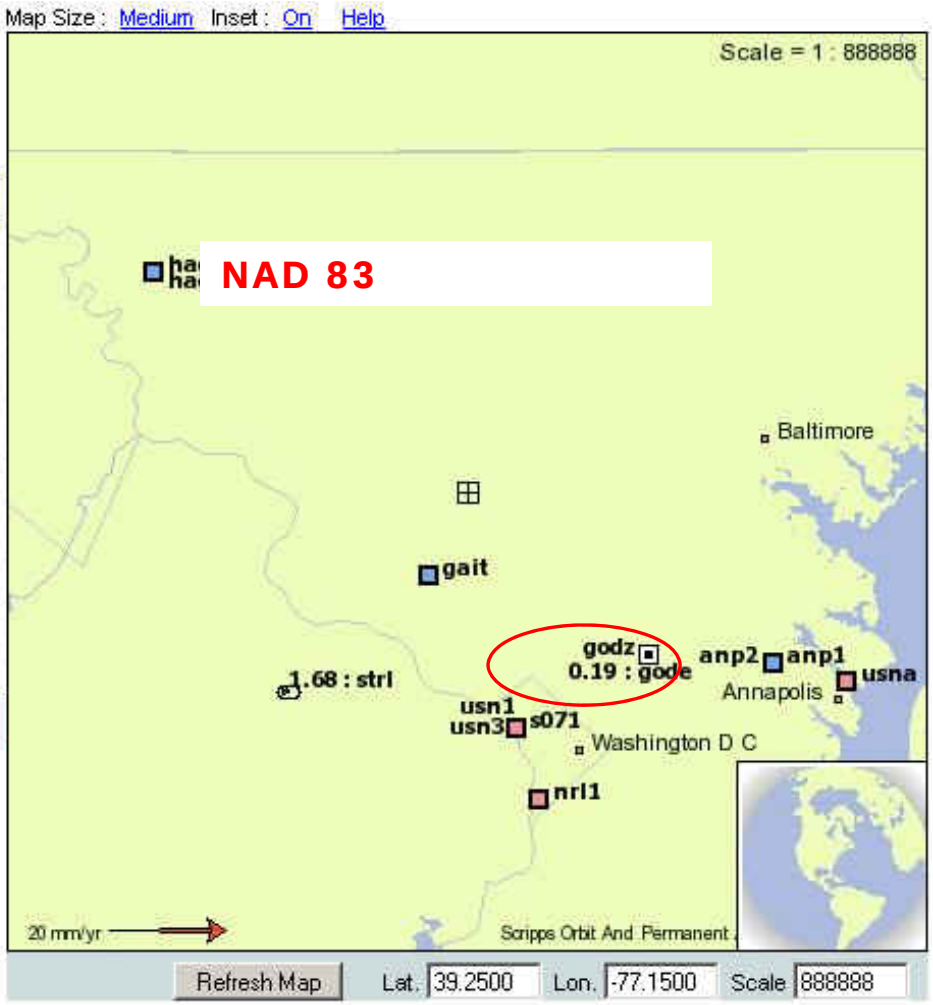
X =	1097041.982 m	latitude	= 38 12 07.82819 N
Y =	-4897239.901 m	longitude	= 077 22 24.57106 W
Z =	3923126.377 m	ellipsoid height	= 37.252 m

NAD_83 (CORS96) VELOCITY
Transformed from ITRF00 velocity in Mar. 2002.

VX =	0.0000 m/yr	northward	= -0.0001 m/yr
VY =	-0.0001 m/yr	eastward	= -0.0000 m/yr
VZ =	0.0000 m/yr	upward	= 0.0001 m/yr

SILVER SPRING, MD

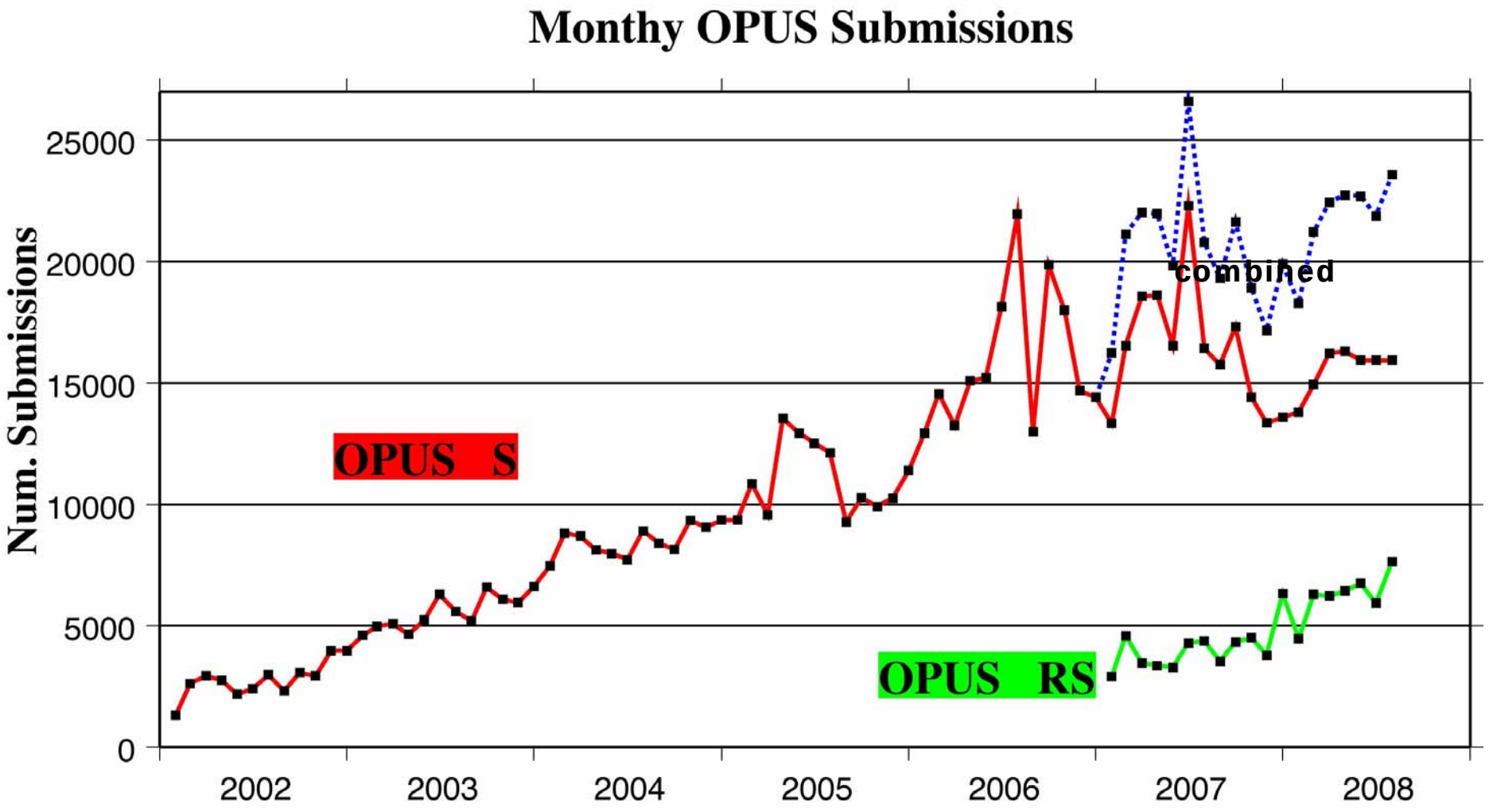




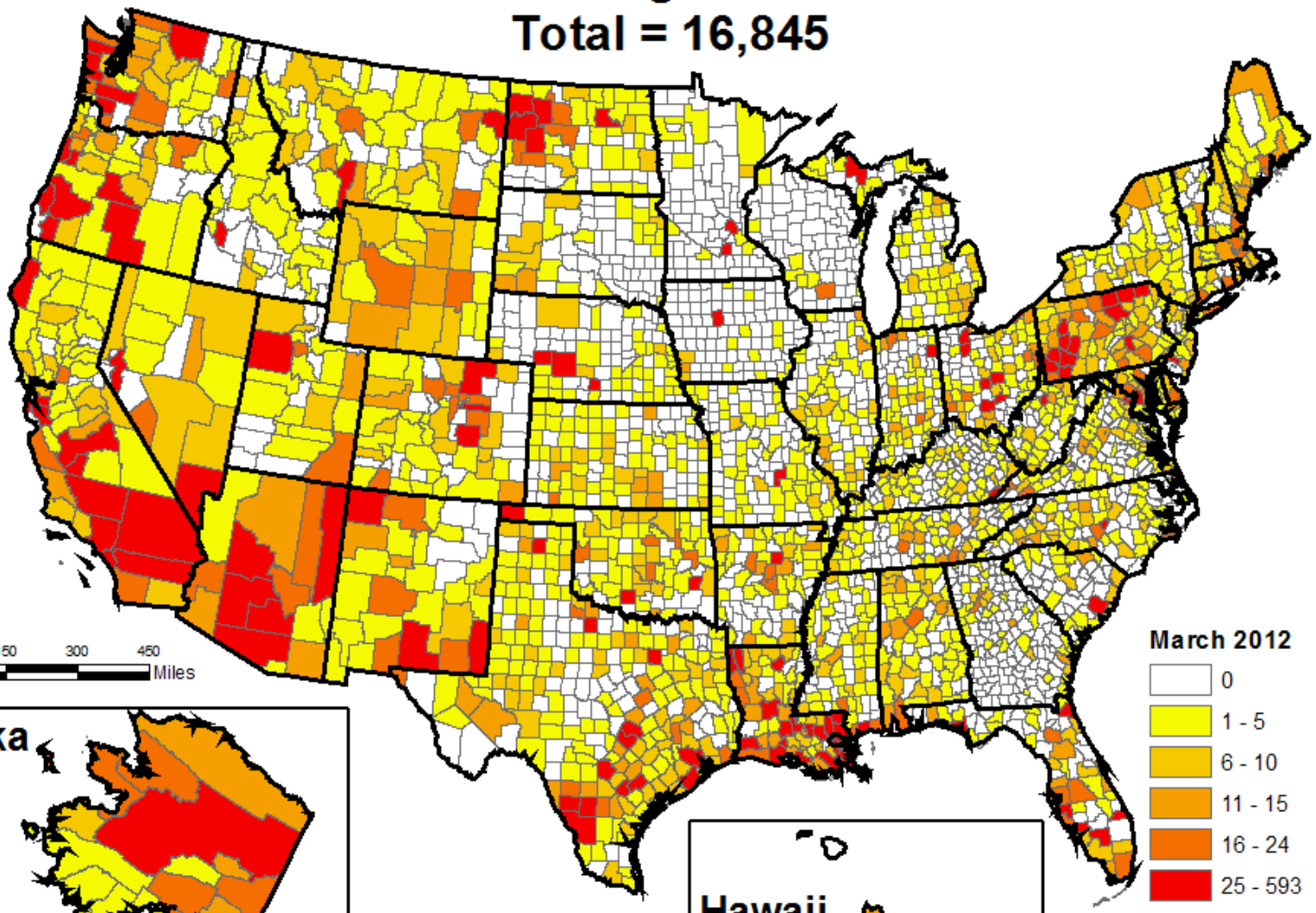
SANTA CRUZ, CA

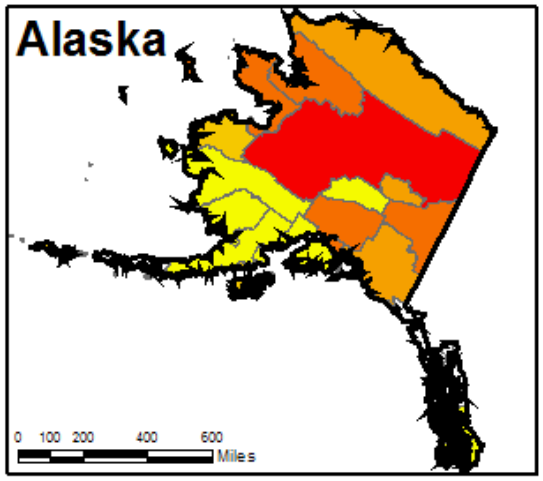
NAD 83 VELOCITIES (GOLD)

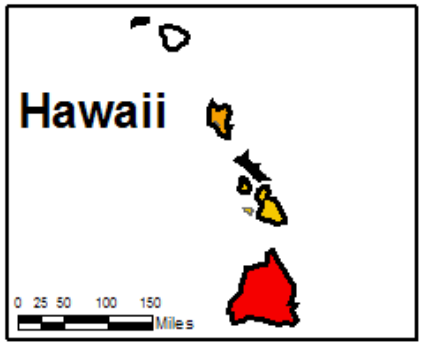
ITRF 2000 VELOCITIES (BLUE)


Monthy OPUS Submissions
Num. Submissions
25000
20000
15000
10000
5000
0
2002
2003
2004
2005
2006
2007
2008
combined
OPUS S
OPUS RS

OPUS-S Usage March 2012
Total = 16,845



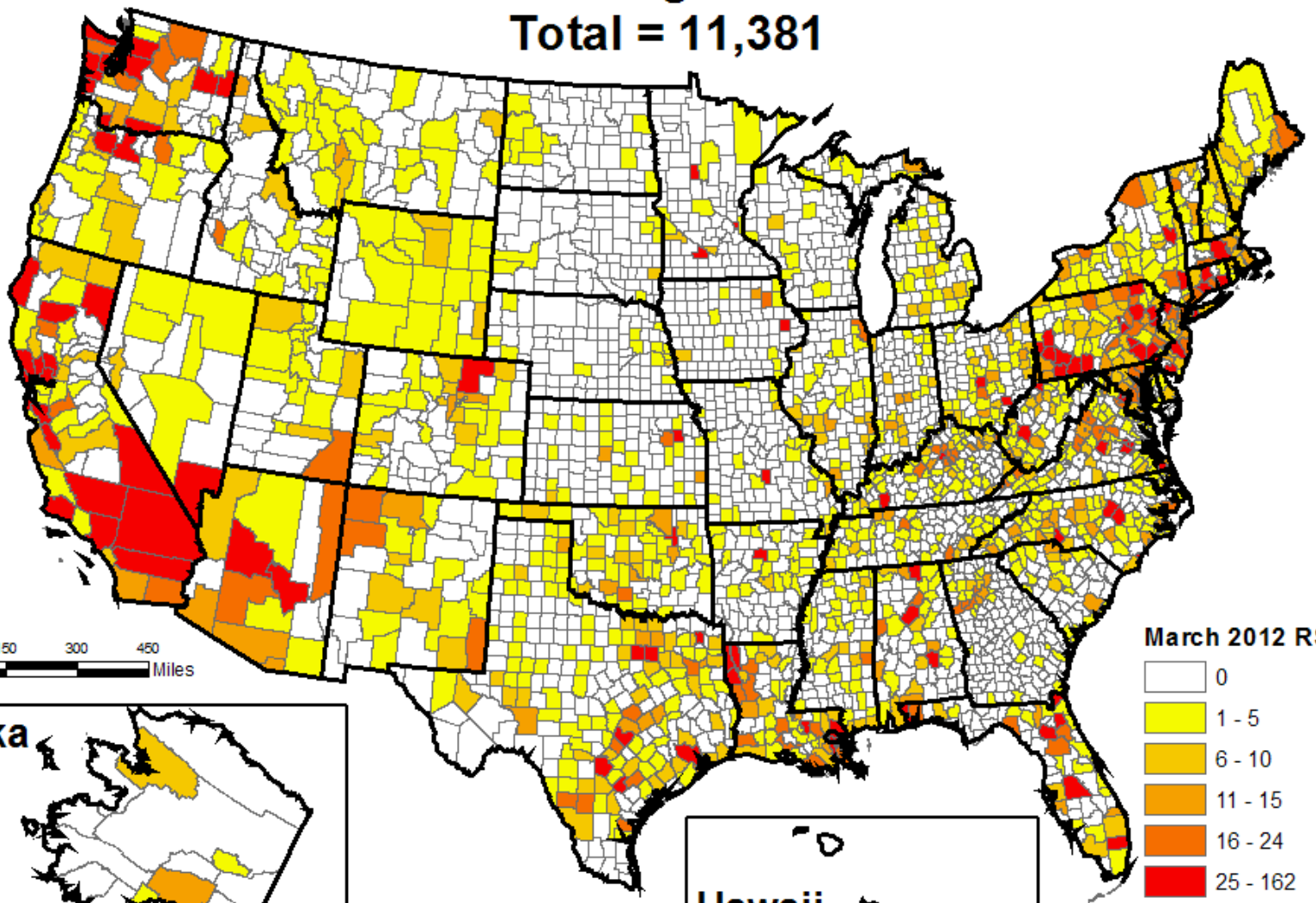


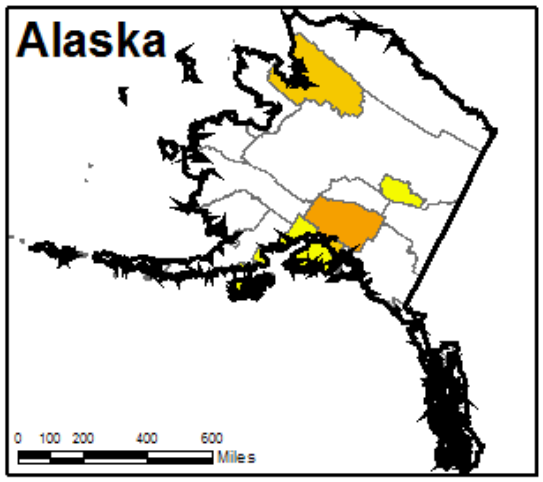


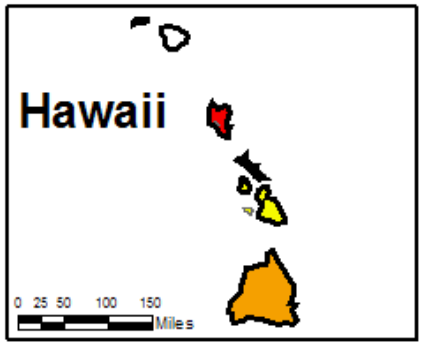
Note: NOAA usage excluded.

Whitsitt 04/02/12

OPUS-RS Usage March 2012
Total = 11,381



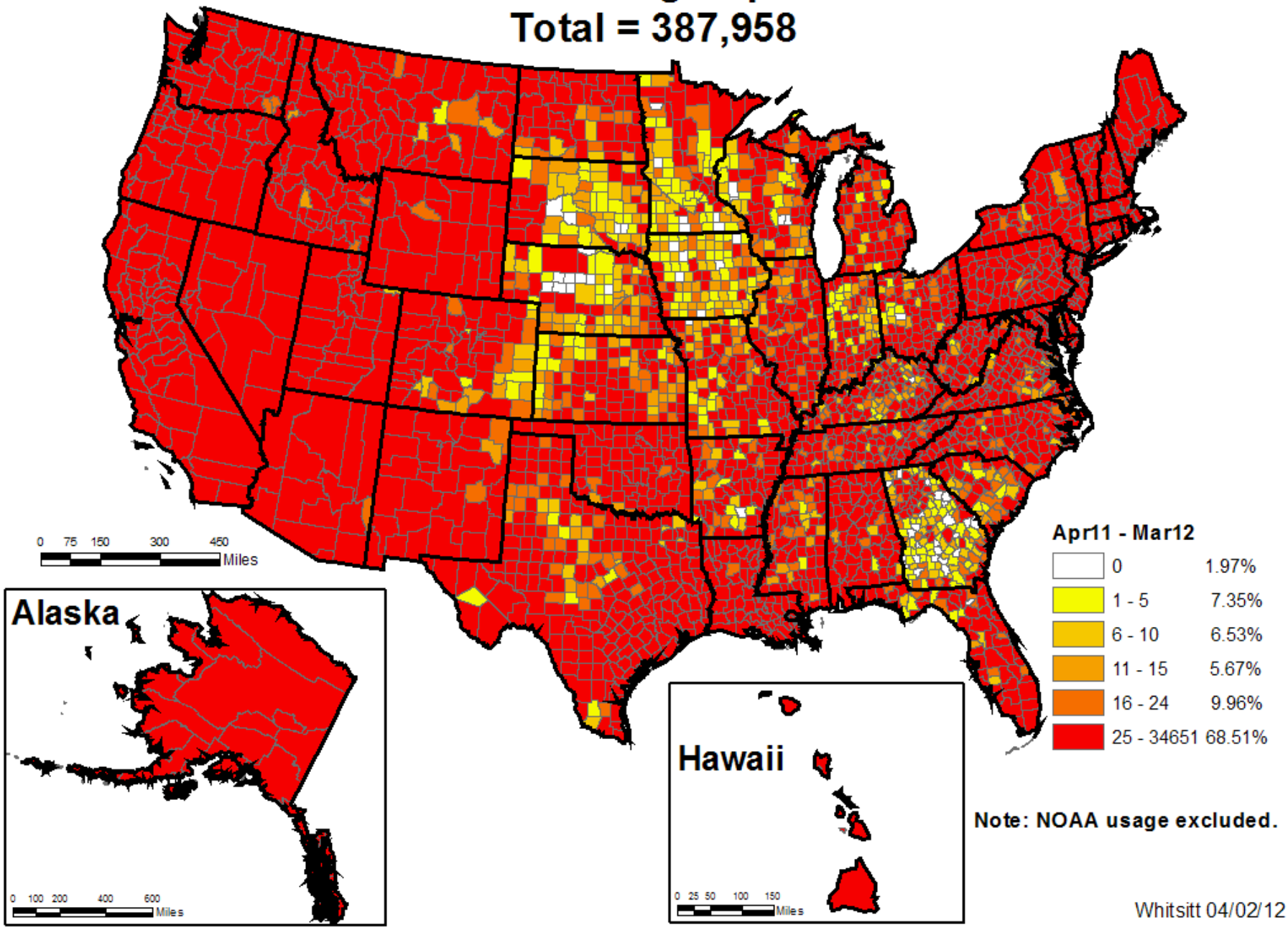




Note: NOAA usage excluded.

Whitsitt 04/02/12

OPUS-S and OPUS-RS Usage April 2011 - March 2012
Total = 387,958

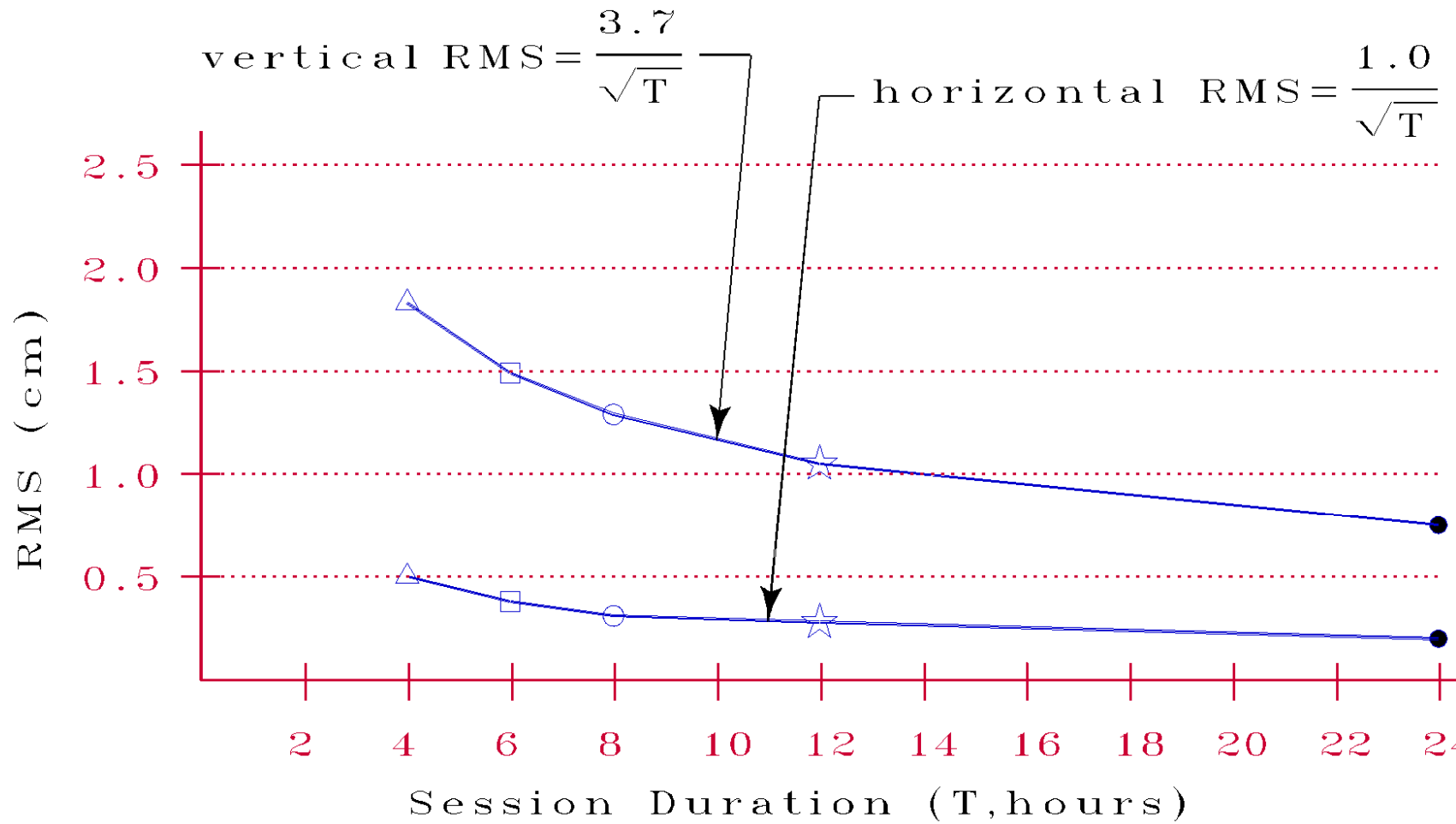


Note: NOAA usage excluded.

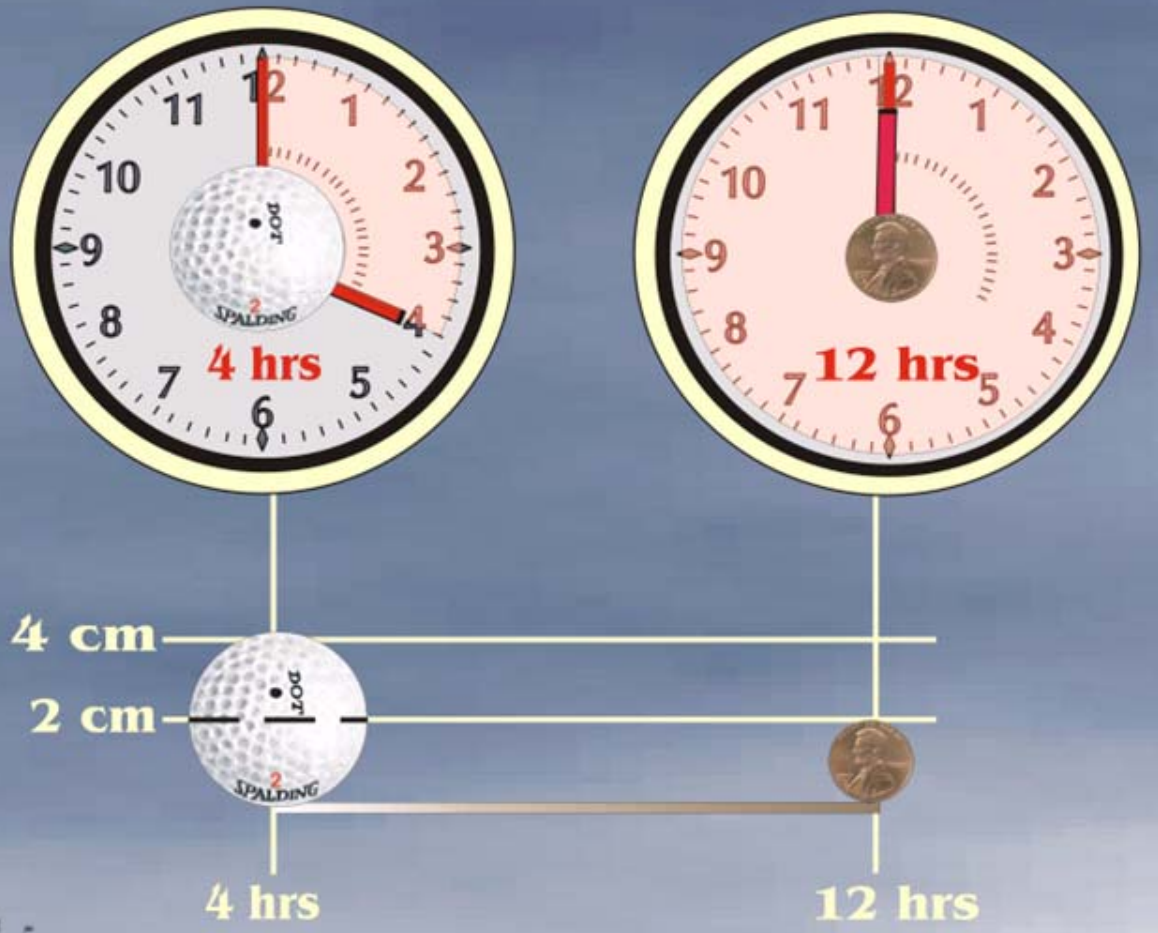
Whitsitt 04/02/12

How to get better results...

collect more data...



National CORS Accuracy



COMMENTS ABOUT RESULTS WITH CORS DATA

- **MAJORITY OF TIME YOU ARE LESS THAN 300 KM FROM CORS (CONTINENTAL U.S.)**
- **BASELINE LENGTH HAS LITTLE EFFECT ON POSITIONAL ACCURACY**
  - NO SETUP ERROR OR ANTENNA MEASUREMENT BLUNDERS
  - < 300 KILOMETERS
  - USING NGS' PAGES SOFTWARE
  - PRECISE EPHEMERIS, TROPO MODELS, AND ANTENNA PATTERNS
- **HORIZONTAL AND VERTICAL SPECIFICATIONS CAN BE MET IN ONE 4-HOUR SESSION**

PASSIVE MARKS VS. ACTIVE STATIONS CONUNDRUM

1,500,000 MARKS IN THE NGSIDB
1850 NATIONAL CORS
107 RTN
OPUS/CORS POINT (SOON PROJECT) PROCESSING

PASSIVE MARKS GET DISTURBED, DESTROYED, AND CAN BE HARD TO RECOVER
EVERYTHING MOVES, BUT WE KNOW WHERE THE ANTENNAS ARE 24/7/365.25
GNSS POSITIONING IS GETTING MORE AND MORE PRECISE
GNSS POSITIONING CAN EASILY USE OUR NATIONAL DATUMS, MAKING GIS FIT TOGETHER AND YIELDING HOMOGENEOUS DATA

National Geodetic Survey

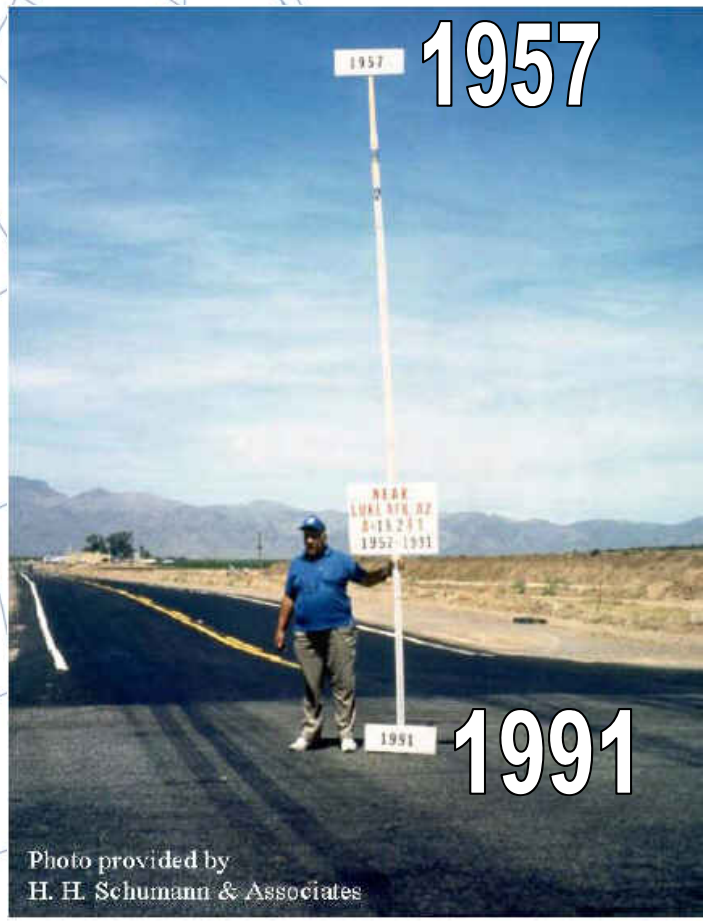
Monumented Points Deterioration

Disturbed Geodetic Control
Coordinates/Elevations Questionable!

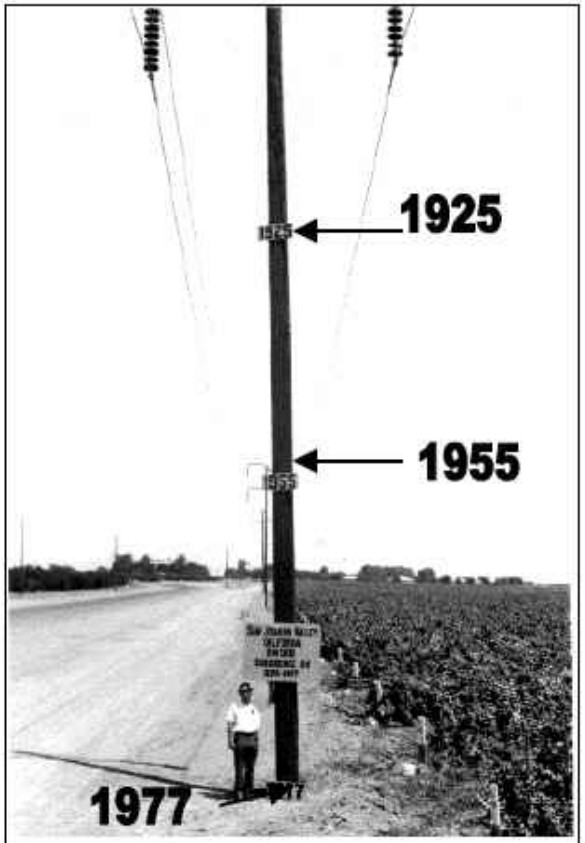
MISSING MARKS- TYPICAL EXAMPLE

Control
ation

WHEN WAS THE PASSIVE MARK ACCESSED?



Due to land subsidence, the elevation of this spot near Luke Air Force Base in Maricopa County has dropped by more than 18 feet over a 34-year period. Knowledge of subsidence areas is a fundamental requirement for planning infrastructure such as pipelines, canals, and power plants.



Approximate levels of subsidence. The signs show the position of land surface in 1925, 1955, and 1977. Although the rate of subsidence has decreased, the continued pumping of ground water has resulted in additional subsidence in the past 20 years.

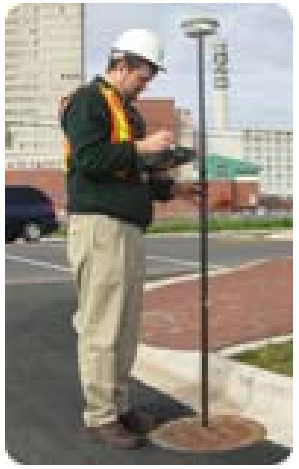
Figure 6 Subsidence in California's Central Valley

EXPANDING GPS MARKETS

MACHINE GUIDANCE

MOBILE MAPPING SYSTEMS

Advanced Farming Systems



GIS INFRASTRUCTURE

MULTI-YEAR CORS SOLUTION (MYCS) = NAD 83 (2011):

- BETTER ORBITS http://www.ngs.noaa.gov/web/surveys/NA2011/
- MORE TRUE VELOCITIES KNOWN (1200 STATIONS +/- WITH >2.5 YEARS OF DATA-OTHERS MODELED WITH HTDP)
- ABSOLUTE ANTENNA CALIBRATIONS
- BROUGHT TO A MORE CURRENT EPOCH (2002 to 2010)
- IMPLEMENTED JULY 2011

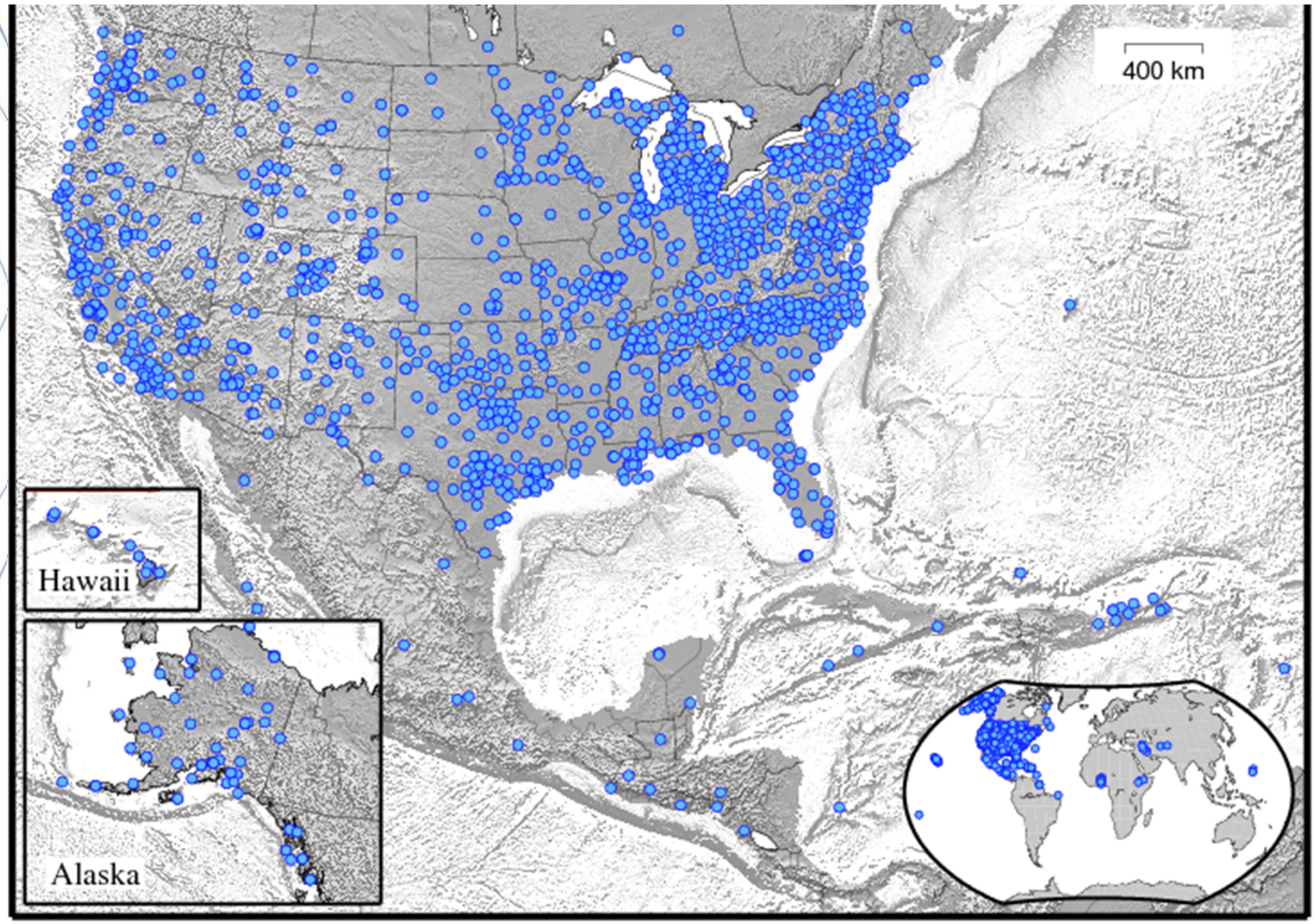
PASSIVE CONTROL ADJUSTMENT TO MYCS:

- ORIGINAL OBSERVATIONS!!
- NO VELOCITIES KNOWN (MODELED ONLY)
- NO RIGOROUS ADJUSTMENT
- 5000 GPS PROJECTS SIMULTANEOUSLY VIA "NETSTAT" TO 95% CONFIDENCE
- IMPLEMENTED SPRING 2012
- WILL HAVE NETWORK & LOCAL ACCURACIES

RTN AND NGS "FOUNDATION CORS" WILL BE THE PRIMARY ACCESS TO THE NSRS

CORS Network continued growth

- Active sites 1850+
- 1250 used in NAD 83(2011)



NEW NATIONAL VERTICAL DATUM

•A PURELY GRAVIMETRIC SURFACE
•BASED ON A HIGH RESOLUTION, 1 CM GEOID FROM GRAV-D PROGRAM

• OBTAINABLE PROJECT ACCURACY TO 2 CM (ALLOWING FOR GNSS ERROR)

• ACCESSABILITY: BROUGHT TO A PROJECT SITE VIA ***ACTIVE*** REFERENCE STATIONS (NATIONAL CORS), DENSIFIED TO PROJECT ACCURACY NEEDS. (ALTERNATIVE: USE BMs PREVIOUSLY TIED TO THE DATUM-CAVEAT EMPTOR)

• ETD: 2022?

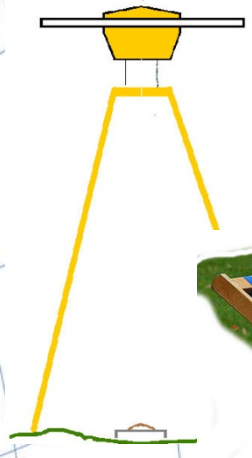
IN TEN YEARS…….

- 115+ SATELLITES
- 1.5 DM AUTONOMOUS POSITIONING
- NEW GEOMETRIC DATUM – ITRF ALIGNED GEOCENTER BUT PROBABLY FIXED ON NORTH AMERICAN PLATE. NSRS ENTIRELY REALIZED BY ACTIVE STATIONS OF THE FOUNDATION CORS
- NEW NATIONAL GEOPOTENTIAL DATUM – 1 CM GRAVIMETRIC GEOID, ORTHOMETRIC HEIGHT SITE CONTROL TO 2 CM RELATIVE TO THE NATIONAL DATUM.
- MORE REMOTE SENSING: 2 - 3 DM SATELLITE IMAGERY/MAPPING , MMS
- INDOOR AND UNDERGROUND POSITIONING

Planned GNSS

- Global Constellations
  - GPS (24+) USA
  - GLONASS (24) Russia
  - Galileo (27) EU
  - Compass (35) China
- Regional Constellations
  - QZSS (3) Japan
  - IRNSS (7) India
- Satellite-Based Augmentations
  - WAAS (3) USA
  - MSAS (2) Japan
  - EGNOS (3) EU
  - GAGAN (3) India
  - SDCM (2?) Russia

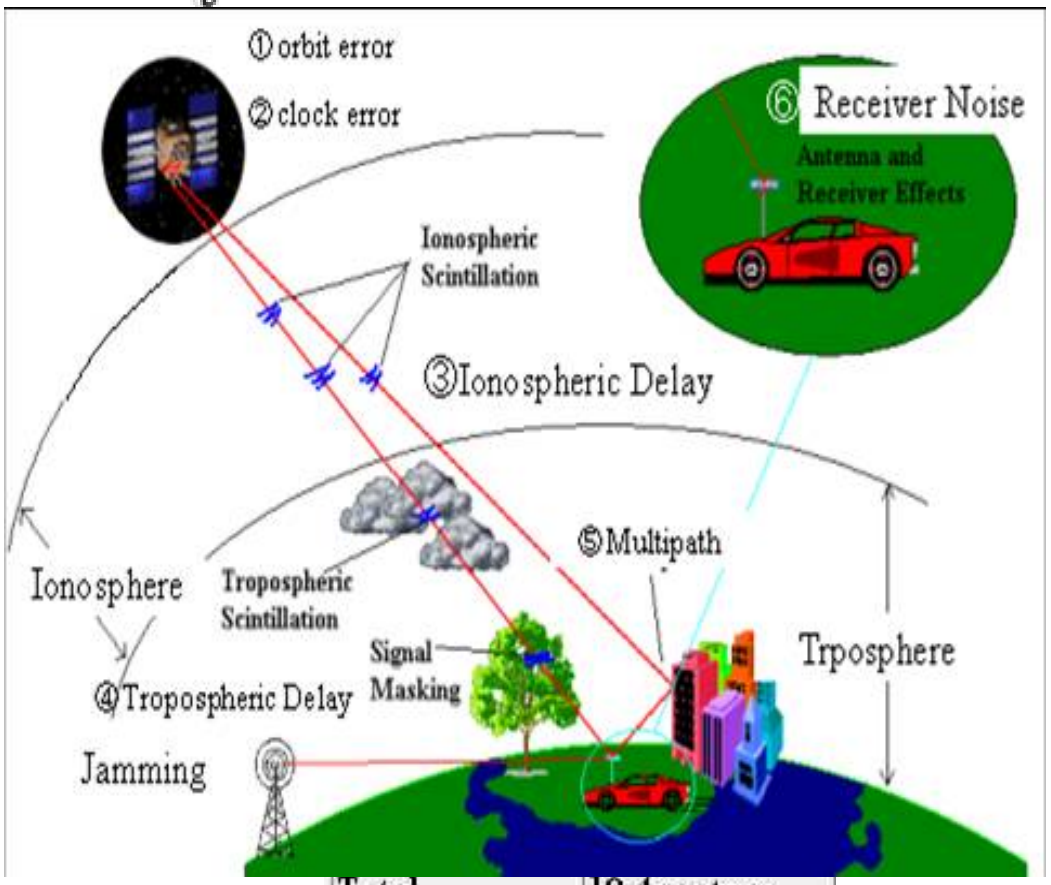
WHAT CAN AFFECT THE GPS SIGNAL? WHAT SHOULD I BE CONCERNED ABOUT WHEN COLLECTING DATA?

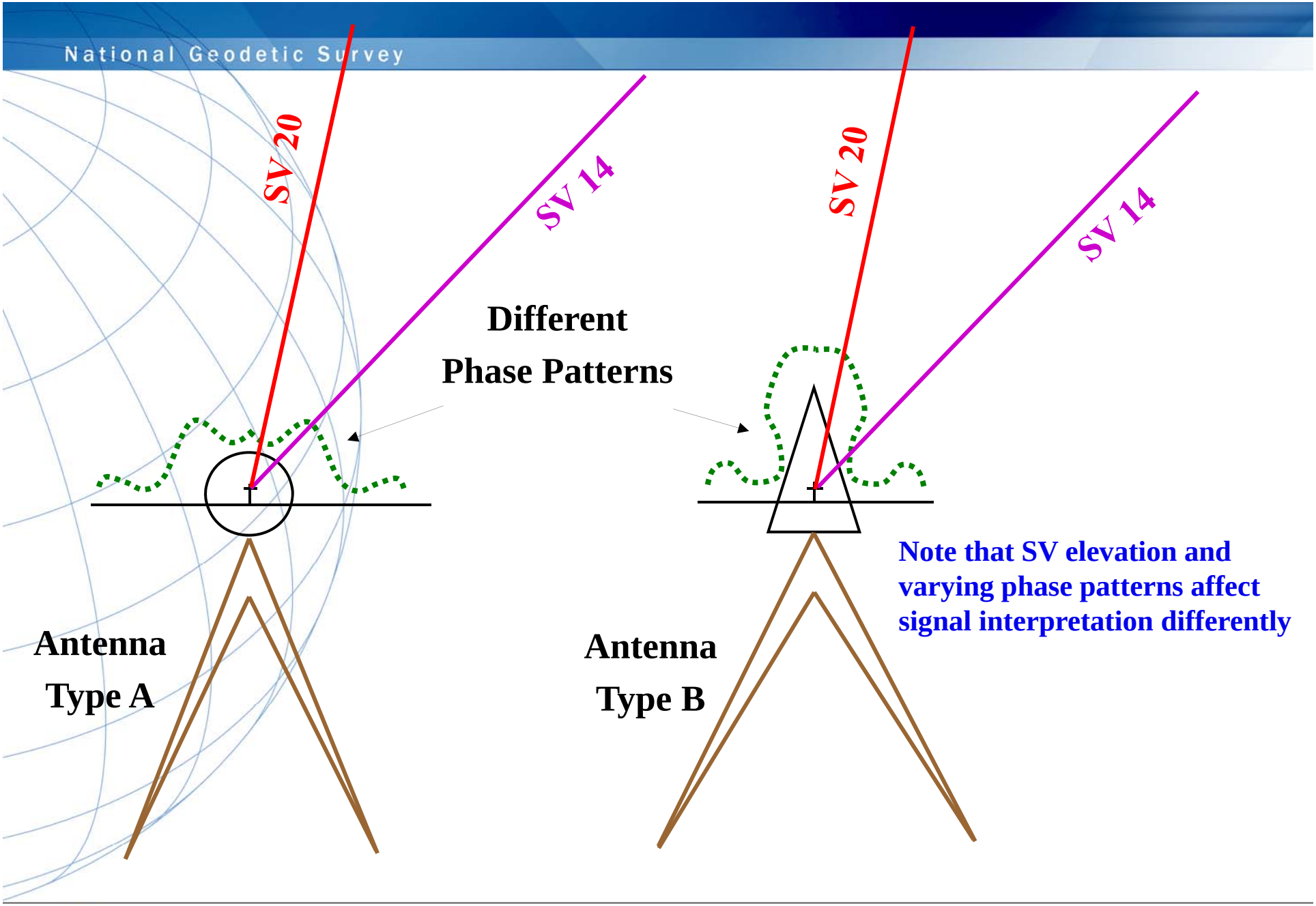


UNDIFFERENCED PHASE OBSERVABLE (CYCLES)

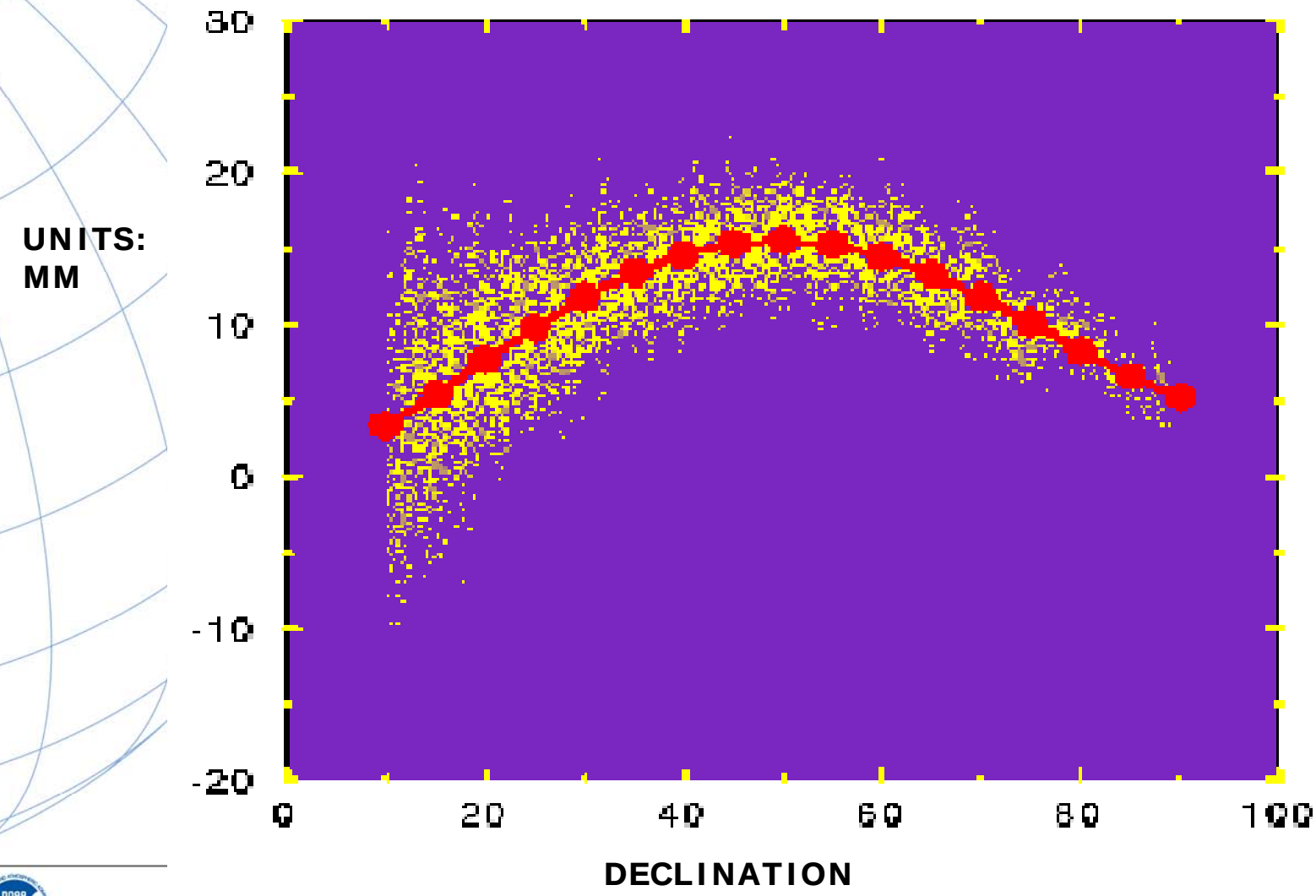
$$\varphi_k^p(t) = \frac{f}{c}\rho_k^p(t) - f dt_k(t) + f dt^p(t) + N_k^p - I_{k,\varphi}^p(t) + \frac{f}{c}T_k^p(t) + d_{k,\varphi}(t) + d_{k,\varphi}^p(t) + d_\varphi^p(t) + \varepsilon_\varphi$$

ERROR	VALUE
Ionosphere	4.0 METERS
Ephemeris	2.1 METERS
Clock	2.1 METERS
Troposphere	0.7 METERS
Receiver	0.5 METERS
Multipath	1.0 METERS
TOTAL	10.4 METERS
UNCORRELATEDERROR	5.15 m (square root of sum of errors squared)

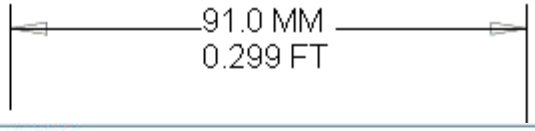



SV 20
SV 14
Different
Phase Patterns
SV 20
SV 14
Antenna
Type A
Antenna
Type B
Note that SV elevation and
varying phase patterns affect
signal interpretation differently

VARIATION IN THE ELECTRICAL PHASE CENTER

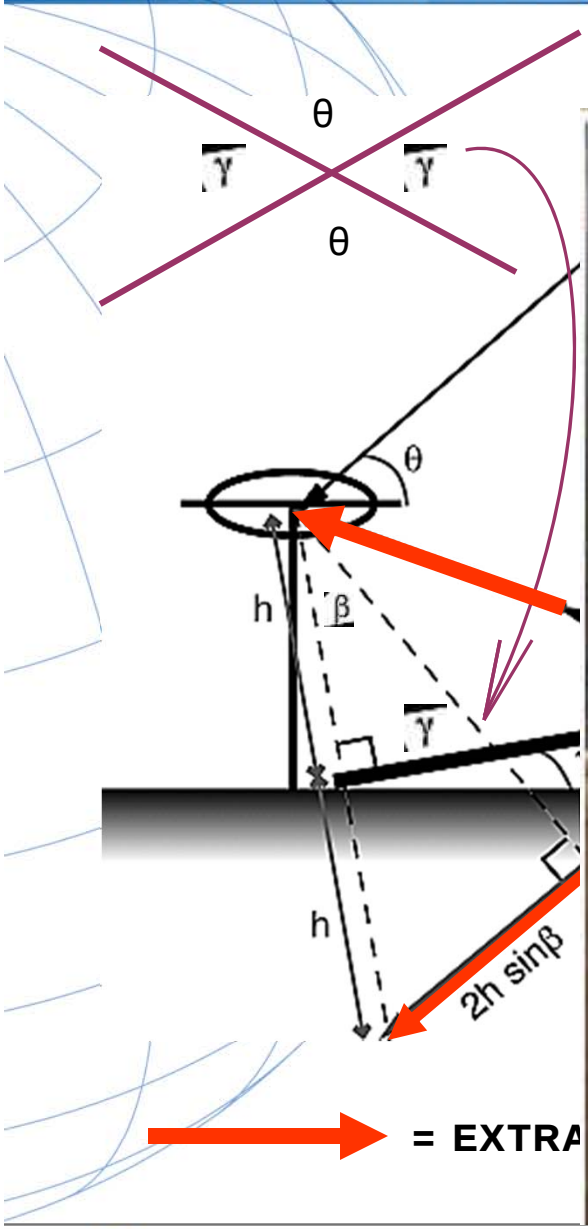


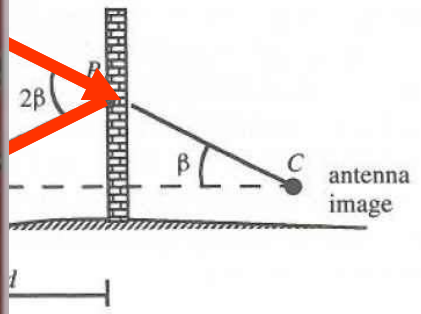
RELATIVE & ABSOLUTE ANTENNA CALIBRATIONS



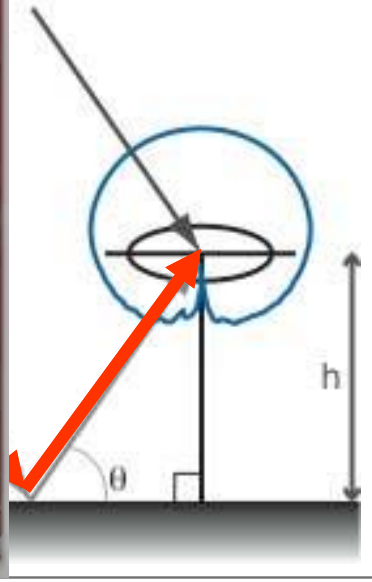

```
    1.4           G                                     ANTEX VERSION / SYST
A                                                       PCV TYPE / REFANT
This calibration extracted from composite ngs08.atx.  See  COMMENT
the composite file ngs08.atx for more information.      COMMENT
                                                        END OF HEADER
                                                        START OF ANTENNA
TRM_R8          NONE                                    TYPE / SERIAL NO
FIELD               NGS                     3    05-DEC-02 METH / BY / # / DATE
     0.0                                                DAZI
     0.0  80.0   5.0                                    ZEN1 / ZEN2 / DZEN
     2                                                  # OF FREQUENCIES
NGSRA_1683                                              SINEX CODE
CONVERTED FROM RELATIVE NGS ANTENNA CALIBRATIONS        COMMENT
   G01                                                  START OF FREQUENCY
      0.78      1.13     74.85                         NORTH / EAST / UP
   NOAZI    0.00    1.37    2.50    3.07    3.28    3.28  3.14    2.91    2.73    2.69    2.74    2.91    3.17    3.65    4.22    5.19    6.57
   G01                                                  END OF FREQUENCY
   G02                                                  START OF FREQUENCY
      0.12     -2.19     77.25                         NORTH / EAST / UP
   NOAZI    0.00   -1.03   -1.11   -0.68    0.01    0.82  1.41    1.93    2.19    2.09    1.95    1.74    1.37    0.97    0.67    0.49    0.85
   G02                                                  END OF FREQUENCY
   G01                                                  START OF FREQ RMS
        .5        .4        .2                        NORTH / EAST / UP
   NOAZI      .0      .2      .3      .4      .4      .4    .4      .4      .4      .3      .3      .4      .4      .4      .4      .3      .2      .0
.0
   G01                                                  END OF FREQ RMS
   G02                                                  START OF FREQ RMS
        .4        .4        .6                        NORTH / EAST / UP
   NOAZI      .0      .1      .2      .3      .4      .4    .4      .4      .5      .4      .4      .4      .4      .4      .5      .5      .7      .0
.0
   G02                                                  END OF FREQ RMS
                                                        END OF ANTENNA
```

MULTIPATH





on on a vertical planar plane.



ON-LINE DATA RETRIEVAL/SUBMISSION: UFCORS & OPUS


CORS
National Geodetic Survey
NGS Home
About NGS
Data & Imagery
Tools
Surveys
Science & Education
Search
CORS Data - Standard Download
User Friendly CORS
Version 3.6.1
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.
UFCORS Page Info
Trimble Products Configuration
UFCORS Problem/Comment Form
Starting Day: Mar 20, 2012 - 080
Get Older Data
Start Time of the field observation: 00:00
Day and Time Info
Time Zone relative to observation location: UTC (GMT)
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
CORS Map
Newsletter
General Information
CORS Site Guidelines
GPS Links
Contact Us
Notices
AK Akhiok , AC13
AK Anchorage , ANC2
AK Anchorage , TBON
AK Anchorage , TSEA
AK Anchorage , UAAG
AK Anchorage WAAS 1 , ZAN1
AK Annette Island , AIS5
AK Annette Island , AIS6
AK Barrow , BRW1
AK Barrow , SG27
AK Bethel , BET1
AK Biorka Island , BIS5
AK Biorka Island , BIS6
AK Buckland , AC07
AK Cape Hinchinbrook , CHI5
AK Cape Hinchinbrook , CHI6
AK Cape Sarichef , AC10
AK Cape Spencer , AB43
AK Central , CENA
Photo
Time Series (60-day)
Time Series (longterm)
_____Non Site Specific_____
Global Navigation
IGS Ephemeris (precise,rapid or ultra-rapid)
Find Files
January
Day*
1
or
Enter Day of Year (e.g. 2, 93, 365)*
This will override the Month and Day boxes if selected!

RECEIVER INDEPENDENT EXCHANGE FORMAT: "RINEX" – A TEXT FILE THAT YOU CAN EDIT

ALL MAJOR GNSS MANUFACTURERS SUPPLY A CONVERSION UTILITY TO CONVERT FROM THEIR PROPRIETARY FORMATS TO RINEX

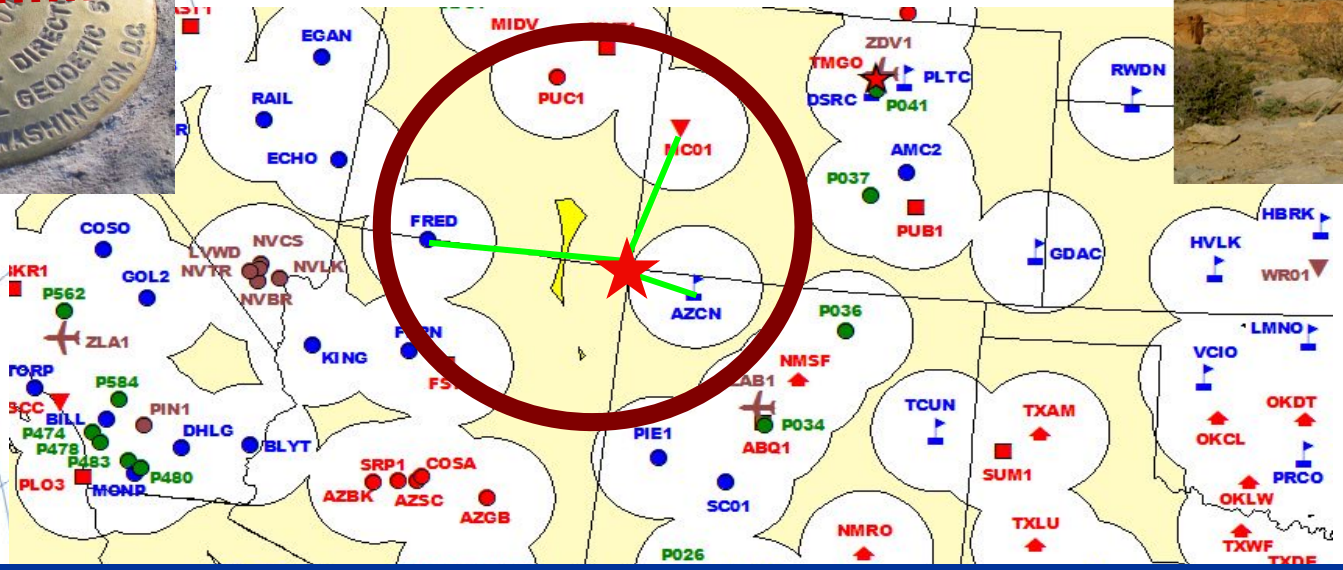

Convert to RINEX.lnk

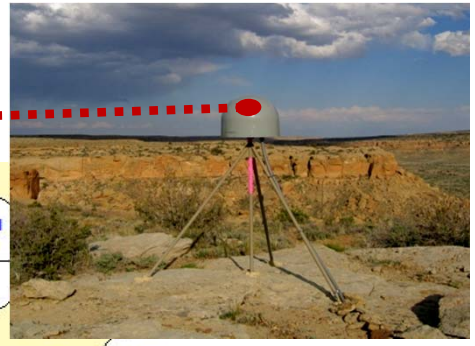

C:\Presentations\
FINAL REPORT FI


Package

Adobe Acrobat Document

Online Positioning User Service (OPUS)





- Submit GPS data to OPUS – www.ngs.noaa.gov/OPUS
- Processed automatically on NGS computers
  - OPUS-S (2-48 hours): ties to 3 CORS **or**
  - OPUS-RS (15 minutes–2 hours): ties to <= 9 CORS
- Solution via email - in minutes
- Fast, easy, consistent access to NSRS

From: opus@ngs.noaa.gov
Sent: Friday, August 24, 2007 8:58 AM
To: Curt.Smith@noaa.gov
Subject: OPUS solution : L1222340.07o 000200294

Attachments: l122234r.07o.xml

FILE: L1222340.07o 000200294

NGS OPUS SOLUTION REPORT
==========

USER: Curt.Smith@noaa.gov
RINEX FILE: l122234r.07o

DATE: August 24, 2007
TIME: 14:57:41 UTC

SOFTWARE: page5 0612.06 master12.pl
EPHEMERIS: igr14413.eph [rapid]
NAV FILE: brdc2340.07n
ANT NAME: TRM4800 NONE
ARP HEIGHT: 2.000

START: 2007/08/22 17:25:00
STOP: 2007/08/22 22:26:00
OBS USED: 11651 / 11783 : 99%
FIXED AMB: 42 / 43 : 98%
OVERALL RMS: 0.017(m)

	REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2007.6406)	
X:	-1872566.694(m)	0.016(m)	-1872567.435(m)	0.016(m)
Y:	-4326352.439(m)	0.031(m)	-4326351.192(m)	0.031(m)
Z:	4283701.741(m)	0.007(m)	4283701.717(m)	0.007(m)
LAT:	42 27 8.21603	0.013(m)	42 27 8.23405	0.013(m)
E LON:	246 35 44.46740	0.027(m)	246 35 44.41598	0.027(m)
W LON:	113 24 15.53260	0.027(m)	113 24 15.58402	0.027(m)
EL HGT:	1328.228(m)	0.019(m)	1327.585(m)	0.019(m)

ORTHO H

t.

ER 19, 2007
****

(W)	SCALED
(feet)	ADJUSTED
	GEOID03
(feet)	COMP
	NAVD 88

aphic map and have

Northing
Easting
Converge
Point Sc
Combined

US NATIC

THE VALUE OF OPUS SAVED THIS SURVEYOR'S LICENSE AND BUSINESS! OPUS ON BENCH MARKS IS ALSO VALUABLE TO PLACE ACCURATE POSITIONS ON LOCATIONS THAT COULD BE JUST SCALED FROM TOPO MAPS. THIS AIDS IN THE MONUMENT'S RECOVERY (AND LOCATES THE BENCH MARK ACCURATELY FOR INPUT INTO THE GEOID MODELING DONE BY NGS)

e

PID					
AI5649	GTRG	GTRG_EBRY_ID1998 CORS ARP	N431438.711	W1131428.314	88985.7
DG9771	P121	HNSLVALLY_UT2004 CORS ARP	N414812.179	W1124153.795	92771.9
DG6570	IDPO	POCATELLO CORS ARP	N425155.995	W1122554.287	92030.4

ravity values.

OPUS: Online Positioning User Service

National Geodetic Survey

NGS Home | About NGS | Data & Imagery | Tools | Surveys | Science & Education

OPUS Menu

- Upload
- About OPUS
- Published Solutions
- Contact OPUS

Upload your data file.

Tie your GPS observation to the National Spatial Reference System.

What is OPUS? **FAQs**

You selected 2011 frame for processing your observation.

* **Email address** - your solution will be sent here.

Browse...

* **Data file** of dual-frequency GPS observations. **sample**

NONE no antenna selected

Antenna type - choosing wrong may degrade your accuracy.

0.0 meters above your mark.

Antenna height of your antenna's reference point.

Options to **customize** your solution.

Upload to Rapid-Static | Upload to Static

for data > 15 min. < 2 hrs. for data > 2 hrs. < 48 hrs.

* required fields

ONLINE EXAMPLE?

Is Your OPUS-S Solution Good?

NGS OPUS SOLUTION REPORT
==========

USER: william.stone@noaa.gov
RINEX FILE: satt142p.03o

- check ephemeris

EPHEMERIS: igs[illegible].eph [precise]
NAV FILE: brdc1420.03n
ANT NAME: ASH701975.01B NONE
ARP HEIGHT: 2.0

- check antenna info

- > 90 % observations used
- > 50 % ambiguities fixed
- < 3 cm overall RMS

OBS USED: 5443 / 5491 : 99%
FIXED AMB: 27 / 27 : 100%
OVERALL RMS: 0.011(m)

REF FRAME:	NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2003.3882)	
X:	-1483421.741(m)	0.011(m)	-1483422.387(m)	0.011(m)
Y:	-5020822.786(m)	0.018(m)	-5020821.428(m)	0.018(m)
Z:	3633944.541(m)	0.011(m)		
LAT:	34 56 43.60684	0.005(m)	34 56 43.62530	0.005(m)
E LON:	253 32 24.06657	0.005(m)	253 32 24.02700	0.005(m)
W LON:	106 27 35.93343	0.005(m)	106 27 35.97300	0.005(m)
EL HGT:	1810.320(m)	0.023(m)	1809.352(m)	0.023(m)
ORTHO HGT:	1830.434(m)	0.034(m)	[Geoid03 NAVD88]	

- < 5 cm peak-to-peak

...and which CORS were used? ...
resubmit later for better CORS scenario & ephemeris

SOFTWARE: page5 1108.09 master31.pl 082511 START: 2012/03/05 21:00:00
EPHEMERIS: igu16781.eph [ultra-rapid] STOP: 2012/03/05 23:00:00
NAV FILE: brdc0650.12n OBS USED: 5596 / 6003 : 93%
ANT NAME: MPL_WAAS_2225NW NONE # FIXED AMB: 41 / 42 : 98%
ARP HEIGHT: 0.0 OVERALL RMS: 0.014(m)

REF FRAME: NAD_83(2011)(EPOCH:2010.0000)		IGS08 (EPOCH:2012.1774)	
X:	-1488630.619(m) 0.027(m)	-1488631.393(m)	0.027(m)
Y:	-5003949.257(m) 0.029(m)	-5003947.897(m)	0.029(m)
Z:	3654557.565(m) 0.020(m)	3654557.443(m)	0.020(m)
LAT:	35 10 24.85211 0.006(m)	35 10 24.86911	0.006(m)
E LON:	253 25 57.80711 0.018(m)	253 25 57.76247	0.018(m)
W LON:	106 34 2.19289 0.018(m)	106 34 2.23753	0.018(m)
EL HGT:	1620.721(m) 0.040(m)	1619.766(m)	0.040(m)

ORTHO HGT: [Geoid Model Not Yet Available w/ NAD83 (2011).]

UTM COORDINATES	UTM (Zone 13)	STATE PLANE COORDINATES SPC (3002 NM C)
Northing (Y) [meters]	3893416.216	462874.619
Easting (X) [meters]	357280.108	471100.606
Convergence [degrees]	-0.90299007	-0.18276968
Point Scale	0.99985103	0.99991029
Combined Factor	0.99959674	0.99965598

US NATIONAL GRID DESIGNATOR: 13SCU5728093416(NAD 83)

SOFTWARE: page5 1108.09 master81.pl 060711 START: 2012/03/05 21:00:00
EPHEMERIS: igu16781.eph [ultra-rapid] STOP: 2012/03/05 23:00:00
NAV FILE: brdc0650.12n OBS USED: 5514 / 5995 : 92%
ANT NAME: MPL_WAAS_2225NW NONE # FIXED AMB: 38 / 41 : 93%
ARP HEIGHT: 0.0 OVERALL RMS: 0.013(m)

REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2012.1774)	
X:	-1488630.625(m) 0.021(m)	-1488631.385(m)	0.021(m)
Y:	-5003949.252(m) 0.024(m)	-5003947.898(m)	0.024(m)
Z:	3654557.554(m) 0.006(m)	3654557.409(m)	0.006(m)
LAT:	35 10 24.85188 0.012(m)	35 10 24.86824	0.012(m)
E LON:	253 25 57.80682 0.013(m)	253 25 57.76279	0.013(m)
W LON:	106 34 2.19318 0.013(m)	106 34 2.23721	0.013(m)
EL HGT:	1620.713(m) 0.027(m)	1619.745(m)	0.027(m)

ORTHO HGT: 1641.542(m) 0.048(m) [NAVD88 (Computed using GEOID09)]

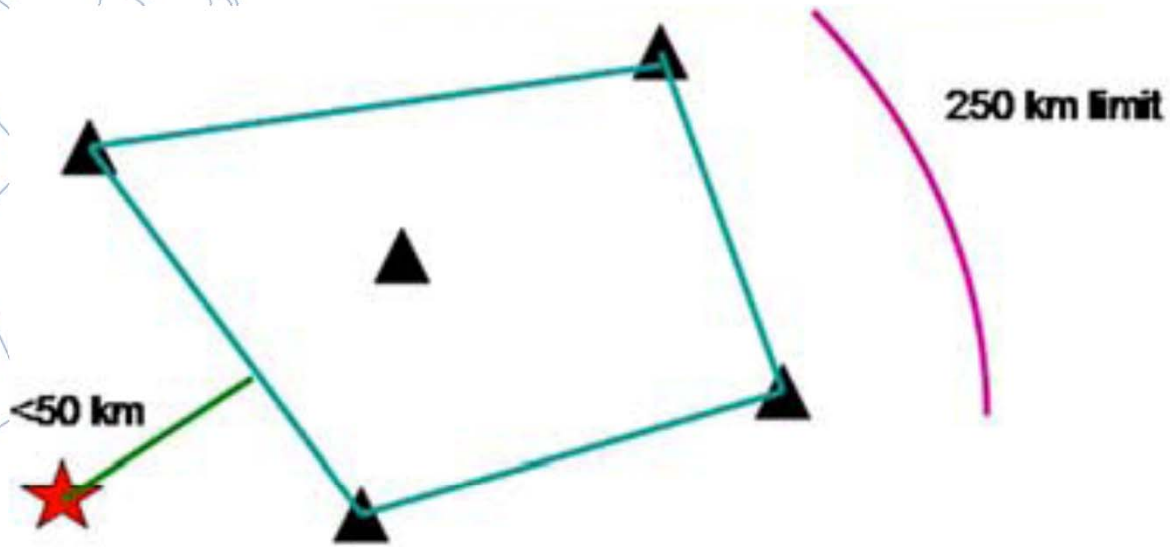
UTM COORDINATES	UTM (Zone 13)	STATE PLANE COORDINATES SPC (3002 NM C)
Northing (Y) [meters]	3893416.209	462874.612
Easting (X) [meters]	357280.101	471100.599
Convergence [degrees]	-0.90299012	-0.18276972
Point Scale	0.99985103	0.99991029
Combined Factor	0.99959674	0.99965598

US NATIONAL GRID DESIGNATOR: 13SCU5728093416(NAD 83)

OPUS-Rapid Static (OPUS-RS)

- 15-minute to 2-hour sessions
- ties to 3 – 9 CORS (< 250km)
- uses RSGPS vs. PAGES software
- P1/P2 code & L1/L2 phase observations
- resolves all ambiguities with LAMBDA
- similar to Real-Time Network computations
- RSGPS solution modes:
  - network: solves ambiguities, tropo, iono
  - rover: tropo and ion interpolated to rover
- ~10,000 lines of code

OPUS-RS REFERENCE STATION SEARCH ALGORITHM



- Sort stations in CORS network by distance from rover. Select up to nine CORS that are less than 250 km from rover, with suitable data.
- No solution is attempted if fewer than three CORS selected.
- No solution attempted if distance from rover to polygon enclosing selected CORS is greater than 50 km.

THE 28 NERRS, BEING ALONG COASTAL REGIONS, MIGHT HAVE PROBLEMS USING OPUS-RS!

OPUS-RS Output

NGS OPUS-RS SOLUTION REPORT

USER:	william.stone@noaa.gov	DATE:	October 29, 2007
RINEX FILE:	1207287x.07o	TIME:	14:39:04 UTC
SOFTWARE:	rsgps 1.09 RS11.prl 1.12	START:	2007/10/14 23:27:15
EPHEMERIS:	igr14490.eph [rapid]	STOP:	2007/10/15 00:00:15
NAV FILE:	brdc2870.07n	OBS USED:	1962 / 2082 : 94%
ANT NAME:	ASH701975.01A	QUALITY IND.	34.21/ 37.91 *
ARP HEIGHT:	0.0	NORMALIZED RMS:	0.307

REF FRAME:	NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2007.78627)	
LAT:	36 2 52.79767	0.008(m)	36 2 52.81498	0.008(m)
E LON:	252 2 18.45532	0.013(m)	252 2 18.41156	0.013(m)
W LON:	107 57 41.54468	0.013(m)	107 57 41.58844	0.013(m)
EL HGT:	1974.304(m)	0.005(m)	1973.396(m)	0.005(m)
ORTHO HGT:	1995.280(m)	0.026(m)	[Geoid03 NAVD88]	

"#Fixed Ambiguities" replaced by "Quality Indicator"

- average of W-ratio (separation between candidate sets of ambiguities) of last 3 epochs
- reported as network mode / rover mode
- look for values > 3 for confidence in solution

OPUS-RS Output

NGS OPUS-RS SOLUTION REPORT

USER:	william.stone@noaa.gov	DATE:	October 29, 2007
RINEX FILE:	1207287x.07o	TIME:	14:39:04 UTC
SOFTWARE:	rsgps 1.09 RS11.prl 1.12	START:	2007/10/14 23:27:15
EPHEMERIS:	igr14490.eph [rapid]	STOP:	2007/10/15 00:00:15
NAV FILE:	brdc2870.07n	OBS USED:	1962 / 2082 : 94%
ANT NAME:	ASH701975.01A	QUALITY IND.	34.21/ 37.91
ARP HEIGHT:	0.0	NORMALIZED RMS:	0.307 *

REF FRAME:	NAD_83(CORS96)(EPOCH:2002.0000)		ITRF00 (EPOCH:2007.78627)	
LAT:	36 2 52.79767	0.008(m)	36 2 52.81498	0.008(m)
E LON:	252 2 18.45532	0.013(m)	252 2 18.41156	0.013(m)
W LON:	107 57 41.54468	0.013(m)	107 57 41.58844	0.013(m)
EL HGT:	1974.304(m)	0.005(m)	1973.396(m)	0.005(m)
ORTHO HGT:	1995.280(m)	0.026(m)	[Geoid03 NAVD88]	

"Overall RMS" replaced by "Normalized RMS"

- unitless quantity, "expected" = 1
- aka standard deviation of unit weight
- if > 1, noisy data somewhere
- typically <1, meaning noise less than expected

OPUS-RS Output

NGS OPUS-RS SOLUTION REPORT

USER:	william.stone@noaa.gov	DATE:	October 29, 2007
RINEX FILE:	1207287x.07o	TIME:	14:39:04 UTC
SOFTWARE:	rsgps 1.09 RS11.prl 1.12	START:	2007/10/14 23:27:15
EPHEMERIS:	igr14490.eph [rapid]	STOP:	2007/10/15 00:00:15
NAV FILE:	brdc2870.07n	OBS USED:	1962 / 2082 : 94%
ANT NAME:	ASH701975.01A	QUALITY IND.	34.21/ 37.91
ARP HEIGHT:	0.0	NORMALIZED RMS:	0.307

REF FRAME:	NAD_83(CORS96)(EPOCH:2002.0000)			ITRF00 (EPOCH:2007.78627)		
LAT:	36 2 52.79767	0.008(m)		36 2 52.81498	0.008(m)	
E LON:	252 2 18.45532	0.013(m)		252 2 18.41156	0.013(m)	
W LON:	107 57 41.54468	0.013(m)	*	107 57 41.58844	0.013(m)	*
EL HGT:	1974.304(m)	0.005(m)		1973.396(m)	0.005(m)	
ORTHO HGT:	1995.280(m)	0.026(m)		[Geoid03 NAVD88]		

Peak-to-Peak replaced by Est. Standard Deviations

- **approximately 95% confidence**
- **derived from scatter of single baseline solutions**
- **formal standard deviations (optimistic) available in Extended Output**

SOFTWARE: rsgps 1.37 RS4.prl 1.78 START: 2012/03/05 21:00:00
EPHEMERIS: igu16781.eph [ultra-rapid] STOP: 2012/03/05 23:00:00
NAV FILE: brdc0650.12n OBS USED: 15102 / 15381 : 98%
ANT NAME: MPL_WAAS_2225NW NONE QUALITY IND. 28.20/ 17.13
ARP HEIGHT: 0.0 NORMALIZED RMS: 0.266

REF FRAME: NAD_83(2011)(EPOCH:2010.0000)		IGS08 (EPOCH:2012.1	
X:	-1488630.607(m) 0.005(m)	-1488631.381(m)	0.005(m)
Y:	-5003949.246(m) 0.010(m)	-5003947.886(m)	0.010(m)
Z:	3654557.568(m) 0.007(m)	3654557.446(m)	0.007(m)
LAT:	35 10 24.85245 0.003(m)	35 10 24.86945	0.003(m)
E LON:	253 25 57.80744 0.004(m)	253 25 57.76281	0.004(m)
W LON:	106 34 2.19256 0.004(m)	106 34 2.23719	0.004(m)
EL HGT:	1620.712(m) 0.012(m)	1619.756(m)	0.012(m)

ORTHO HGT: [Geoid Model Not Yet Available w/ NAD83 (2011).]

	UTM COORDINATES UTM (Zone 13)	STATE PLANE COORDINATES SPC (3002 NM C)
Northing (Y) [meters]	3893416.226	462874.630
Easting (X) [meters]	357280.117	471100.615
Convergence [degrees]	-0.90299002	-0.18276963
Point Scale	0.99985103	0.99991029
Combined Factor	0.99959674	0.99965598

US NATIONAL GRID DESIGNATOR: 13SCU5728093416(NAD 83)

SOFTWARE: rsgps 1.37 RS84.prl 1.78 START: 2012/03/05 21:00:00
EPHEMERIS: igu16781.eph [ultra-rapid] STOP: 2012/03/05 21:14:59
NAV FILE: brdc0650.12n OBS USED: 1200 / 1272 : 94%
ANT NAME: MPL_WAAS_2225NW NONE QUALITY IND. 18.18/ 22.01
ARP HEIGHT: 0.0 NORMALIZED RMS: 0.230

REF FRAME: NAD_83(2011)(EPOCH:2010.0000)		IGS08 (EPOCH:2012.17727) 1)	
X:	-1488630.610(m) 0.005(m)	-1488631.384(m)	0.005(m)
Y:	-5003949.276(m) 0.015(m)	-5003947.916(m)	0.015(m)
Z:	3654557.596(m) 0.013(m)	3654557.474(m)	0.013(m)
LAT:	35 10 24.85264 0.003(m)	35 10 24.86964	0.003(m)
E LON:	253 25 57.80766 0.004(m)	253 25 57.76303	0.004(m)
W LON:	106 34 2.19234 0.004(m)	106 34 2.23697	0.004(m)
EL HGT:	1620.752(m) 0.019(m)	1619.797(m)	0.019(m)

ORTHO HGT: [Geoid Model Not Yet Available w/ NAD83 (2011).]

	UTM COORDINATES UTM (Zone 13)	STATE PLANE COORDINATES SPC (3002 NM C)
Northing (Y) [meters]	3893416.232	462874.635
Easting (X) [meters]	357280.122	471100.620
Convergence [degrees]	-0.90298999	-0.18276959
Point Scale	0.99985103	0.99991029
Combined Factor	0.99959673	0.99965598

US NATIONAL GRID DESIGNATOR: 13SCU5728093416(NAD 83)

VARIOUS OPUS SOLUTIONS USING "CORB"

Adobe Acrobat Document

4/1/12.15M

Adobe Acrobat Document

12/1/11.15M

Adobe Acrobat Document

12/1/11.1 H

Adobe Acrobat Document

3/09/12. 1 H

Adobe Acrobat Document

4/1/12. 1st4 H

Adobe Acrobat Document

4/1/12. 2nd4 H

Adobe Acrobat Document

4/1/12. 2last RS

Adobe Acrobat Document

4/1/12. 2last S

Adobe Acrobat Document

4/1/12.1last RS

Adobe Acrobat Document

4/1/12. 1first RS

	N	E	h	H
CORB: PUBLISHED (OLD)	2060045.533	3598666.726	37.252	"CORB" REFLECTS A PERFECT SCENARIO FOR A
CORB: 8 HOURS AS "TRUTH"	2060045.532	3598666.740	37.239	POINT POSITION
SOLUTION	D N	D E	D h	NOTES
DAY 92				
OPUS-S: 1ST 4 HOURS	0.000	-0.002	0.005	THESE ARE NOT INDEPENDENT OBSERVATIONS
OPUS-S: 2ND 4 HOURS	0.001	-0.002	-0.011	THEY SHOW DIFFERENCES WITH SLICING A PIECE OF
OPUS-S: 1ST 2 HOURS	-0.005	-0.003	-0.005	THE PIE, AND PROCESSING WITH THE TWO PROGRAMS
OPUS-RS: 1ST 2 HOURS	0.006	-0.007	0.002	"
OPUS -S: LAST 2 HOURS	-0.004	0.003	0.015	"
OPUS-RS: LAST 2 HOURS	0.004	-0.005	0.011	"
OPUS-RS: 1ST 1 HOUR	0.009	-0.008	0.008	"
OPUS-RS: LAST 1 HOUR	0.006	-0.007	-0.009	"
OPUS-RS: 15 MINUTES	0.009	-0.006	-0.005	"

SOME OPUS COMPARISONS WITH A "PERFECT" SITE

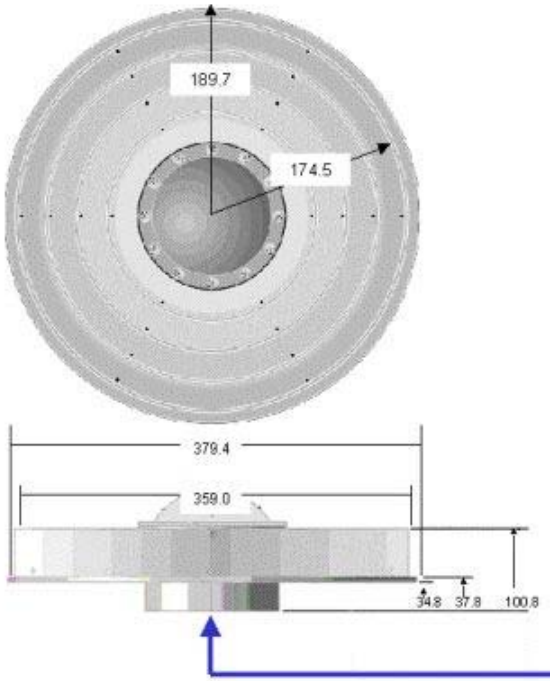
COMPARISON WITH 3/9/12 & 12/1/11

DAY 69				
OPUS-S: 9 HOURS	-0.001	-0.004	0.000	THESE ARE NOT INDEPENDENT OBSERVATIONS
OPUS-S:MID 2 HOURS	0.012	-0.010	-0.021	THEY SHOW DIFFERENCES WITH SLICING A PIECE OF
OPUS-RS: MID 2 HOURS	0.008	-0.008	0.000	THE PIE, AND PROCESSING WITH THE TWO PROGRAMS
OPUS-S: 2 HOURS	-0.014	0.013	-0.003	"
OPUS-RS: 2 HOURS	0.010	-0.009	0.022	"
OPUS-RS: 1 HOUR	0.010	-0.010	0.002	"
2011 DAY 335				
OPUS-RS: 15 MINUTES	0.009	-0.008	-0.005	THESE ARE NOT INDEPENDENT OBSERVATIONS
OPUS-RS: 1 HOUR	0.006	-0.008	-0.017	THEY SHOW DIFFERENCES WITH SLICING A PIECE OF
				THE PIE, AND PROCESSING WITH THE TWO PROGRAMS

ASHTECH 700936E ANTENNA AT CORB

ASH 700936E

Choke Ring Antenna



All dimensions in millimeters

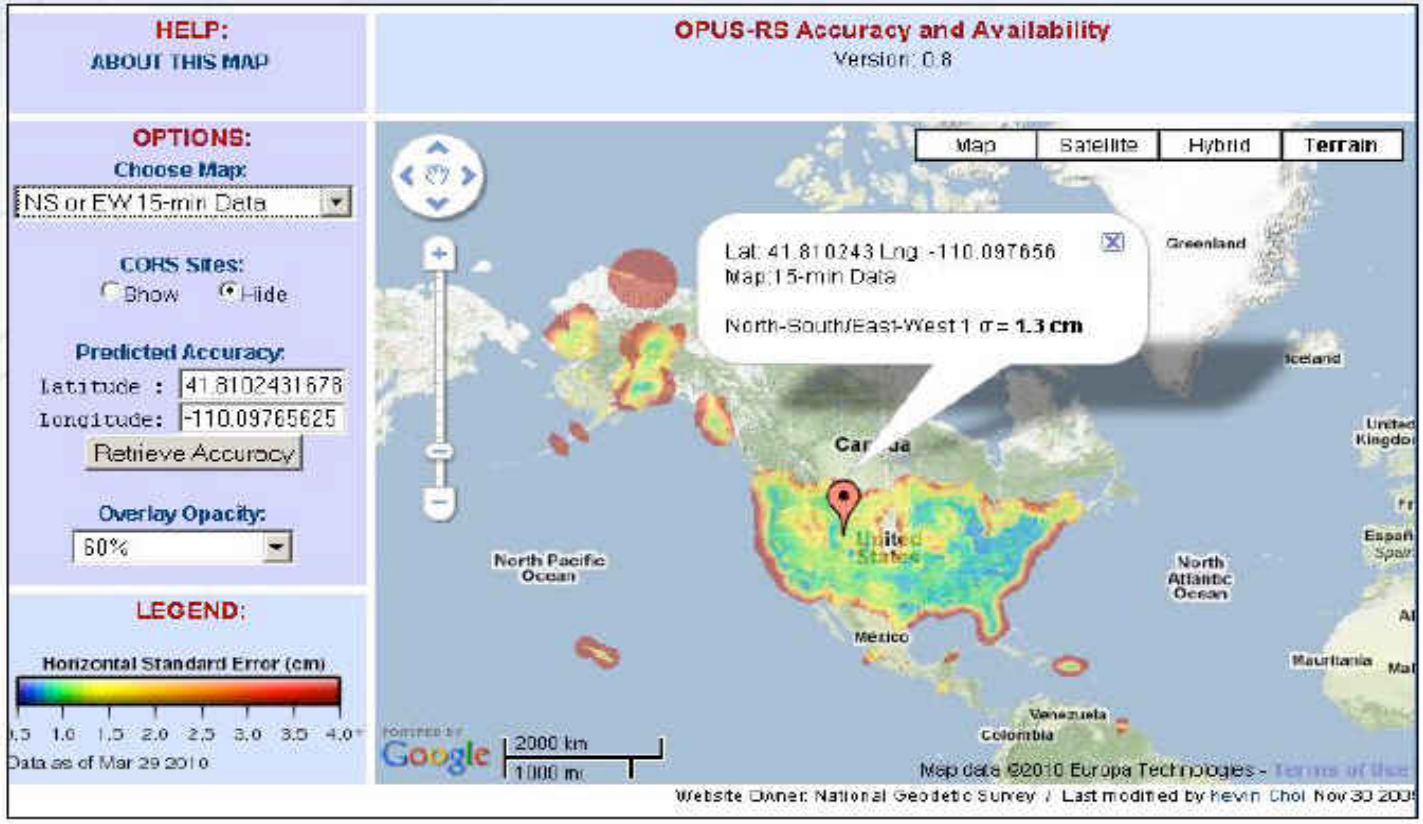
```
4.2  Antenna Type              : ASH700936E      NONE
     Serial Number             : CR16976
     Antenna Reference Point   : BPA
     Marker->ARP Up Ecc. (m)   : 0.0000
     Marker->ARP North Ecc(m)  : 0.0000
     Marker->ARP East Ecc(m)   : 0.0000
     Alignment from True N     : 0
     Antenna Radome Type       : NONE
     Radome Serial Number      : (A4 from rcvr_ant.tab; see instructions)
     Antenna Cable Type        : (vendor & type number)
     Antenna Cable Length      : (m)
     Date Installed            : 2012-02-09T20:50Z
     Date Removed              : (CCYY-MM-DDThh:mmZ)
     Additional Information    : (multiple lines)
```

Reference Surface for NGS Offset Measurements

NOAA's National Geodetic Survey Positioning America for the Future www.ngs.noaa.gov

How Good Can I Do With OPUS-RS?

The OPUS-RS Accuracy and Availability Tool.



http://www.ngs.noaa.gov/OPUSI/Plots/Gmap/OPUSRS_sigmap.shtml

http://www.ngs.noaa.gov/OPUSI/Plots/Gmap/OPUSRS_sigmap.shtml

OPUS-RS MAP

National Geodetic Survey

HELP:

ABOUT THIS MAP

OPUS-RS Estimated Precision and Availability

Version: 0.85

OPTIONS:

Choose Map:

NS or EW 15-min Data

CORS Sites:

Show Hide

Predicted Precision:

Latitude : 39.7747933829

Longitude: -89.6411132812

Retrieve Accuracy

Overlay Opacity:

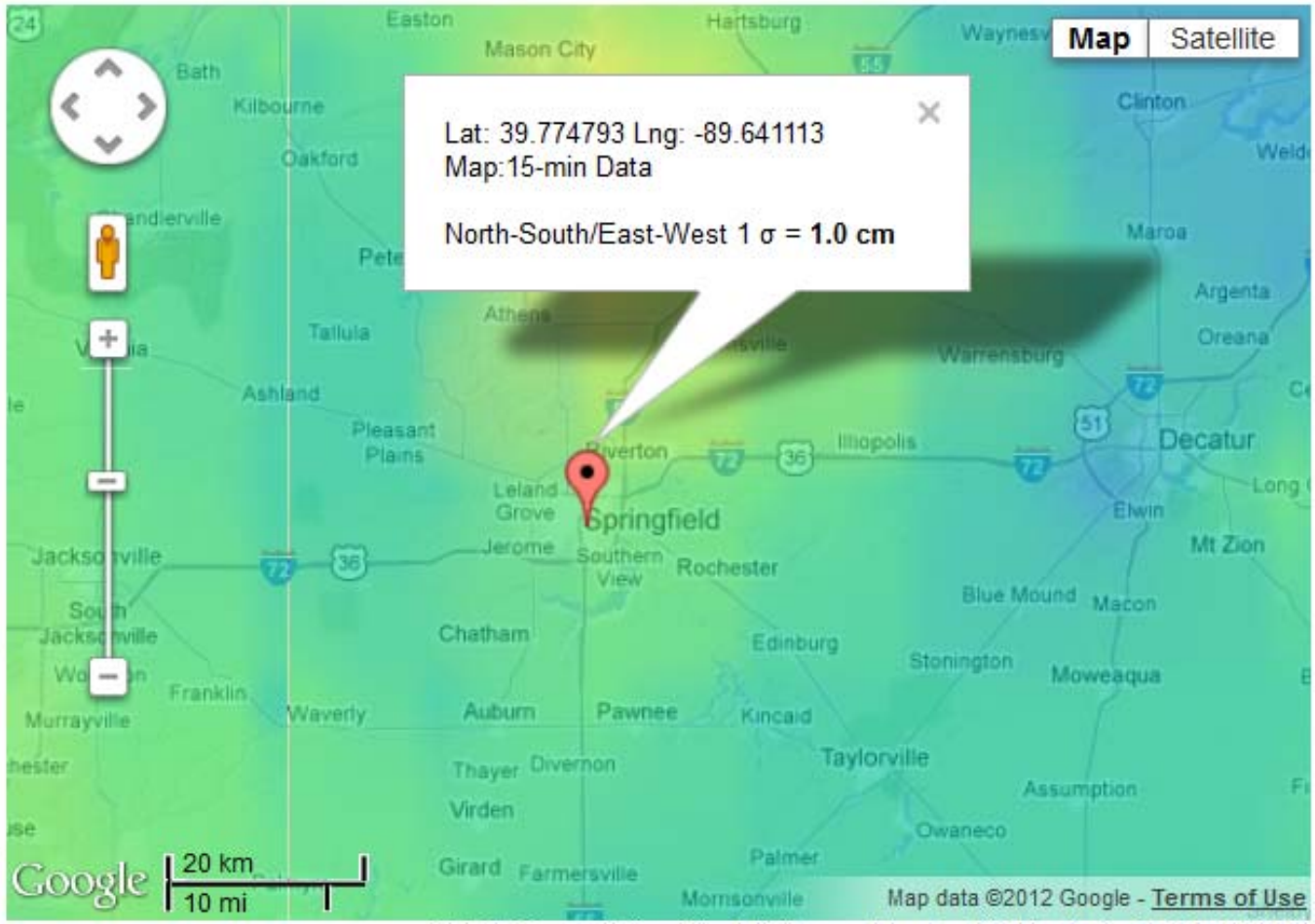
60%

LEGEND:

Horizontal 1 STD (cm)

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0+

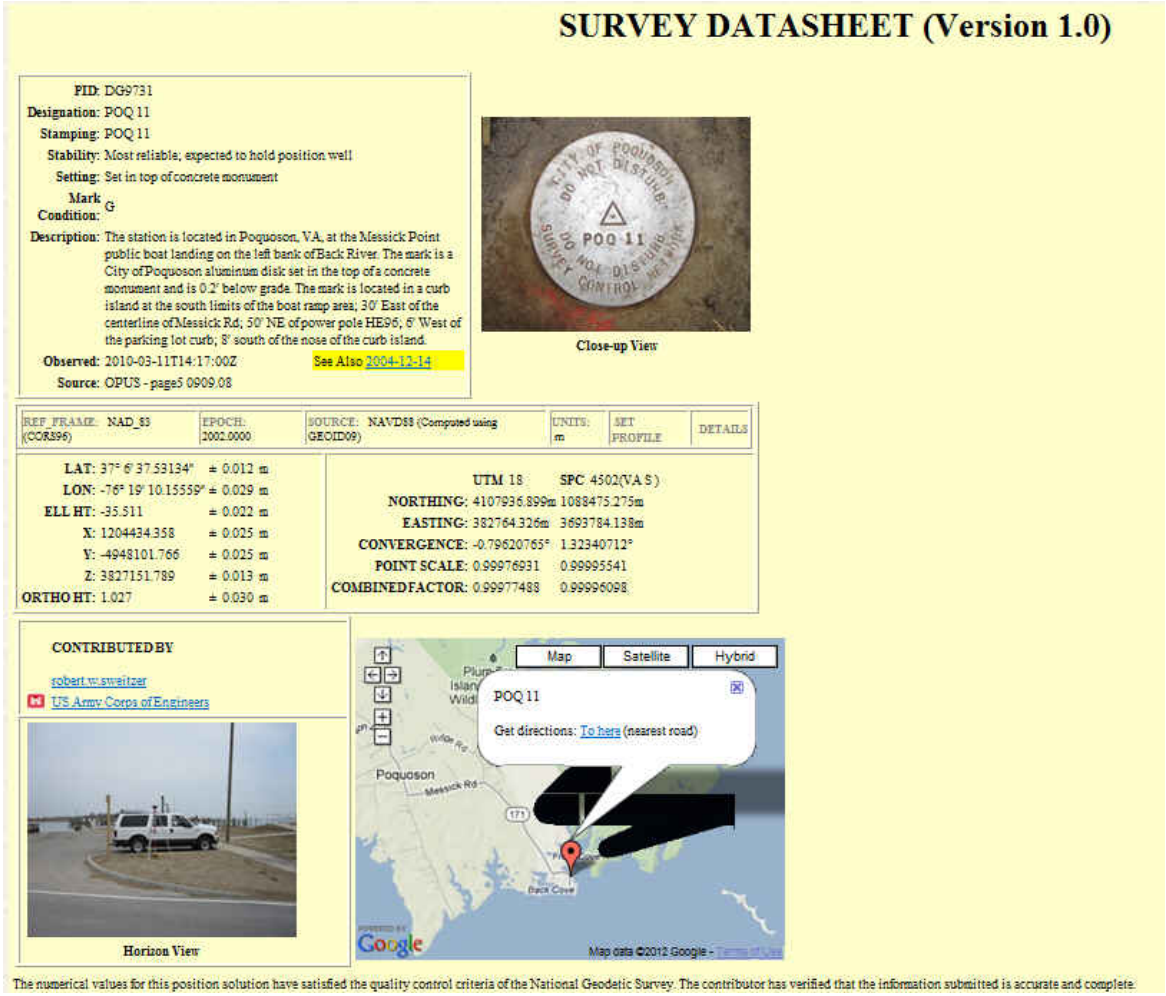
Data as of Feb 13 2012



Website Owner: National Geodetic Survey / Last modified by **Kevin Choi** April 29 2011

OPUS –DB:
CREATE A POINT IN THE NGS OPUS DATABASE

- OBS USED ≥ 70%
- # FIXED AMB ≥ 70%
- OVERALL RMS ≤ 3 cm
- PEAK TO PEAK ≤ 4 cm, 8 cm ellipsoid
- DESCRIPTION
- PICTURES



SURVEY DATASHEET (Version 1.0)

PID: DG9731
Designation: POQ 11
Stamping: POQ 11
Stability: Most reliable; expected to hold position well
Setting: Set in top of concrete monument
Mark Condition: G
Description: The station is located in Poquoson, VA, at the Messick Point public boat landing on the left bank of Back River. The mark is a City of Poquoson aluminum disk set in the top of a concrete monument and is 0.2' below grade. The mark is located in a curb island at the south limits of the boat ramp area; 30' East of the centerline of Messick Rd; 50' NE of power pole HE96; 6' West of the parking lot curb; 8' south of the nose of the curb island.
Observed: 2010-03-11T14:17:00Z See Also 2004-12-14
Source: OPUS - page5 0909.08

Close-up View

REF_FRAME: NAD_83 (CORS96)	EPOCH: 2002.0000	SOURCE: NAVD88 (Computed using GEOID09)	UNITS: m	SET PROFILE	DETAILS

LAT:	37° 6' 37.53134"	± 0.012 m		
LON:	-76° 19' 10.15559"	± 0.029 m		
ELL HT:	-35.511	± 0.022 m		
X:	1204434.358	± 0.025 m		
Y:	-4948101.766	± 0.025 m		
Z:	3827151.789	± 0.013 m		
ORTHO HT:	1.027	± 0.030 m		

	UTM 18	SPC 4502(VA S)
NORTHING:	4107936.899m	1088475.275m
EASTING:	382764.326m	3693784.138m
CONVERGENCE:	-0.79620765°	1.32340712°
POINT SCALE:	0.99976931	0.99995541
COMBINED FACTOR:	0.99977488	0.99996098

CONTRIBUTED BY
robert.w.sweitzer
US Army Corps of Engineers

Horizon View

Map Satellite Hybrid
POQ 11
Get directions: To here (nearest road)
Poquoson
Messick Rd
Back Cove
Google
Map data ©2012 Google -

The numerical values for this position solution have satisfied the quality control criteria of the National Geodetic Survey. The contributor has verified that the information submitted is accurate and complete.

http://testwww.ngs.noaa.gov/web/GoogleMaps/RTN/RTN.shtml

OPUS Menu

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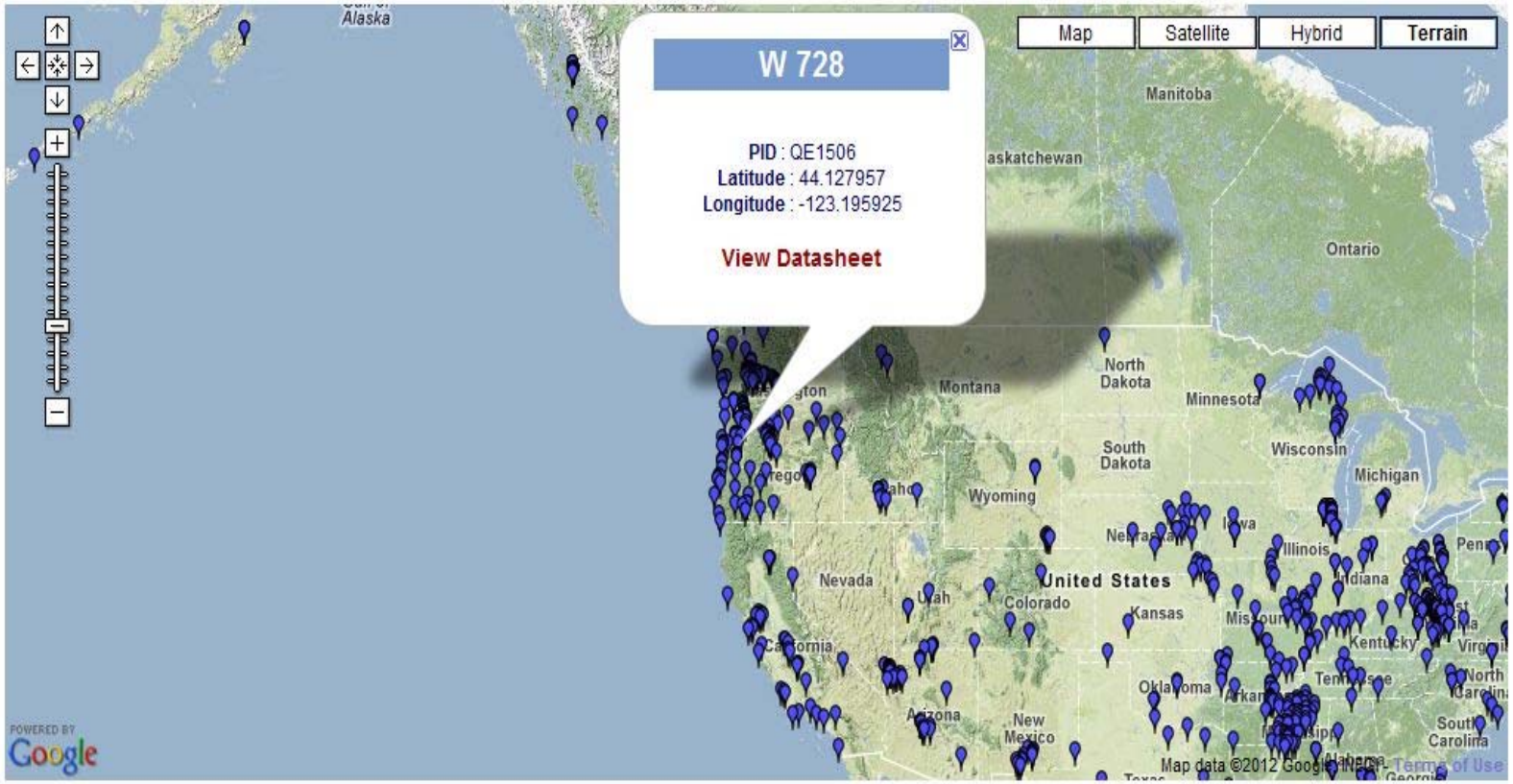
Browse map to locate and access datasheets.



Website Owner: National Geodetic Survey / Last modified by NGS.OPUS Tuesday, 24-Jan-2012 09:30:10 EST

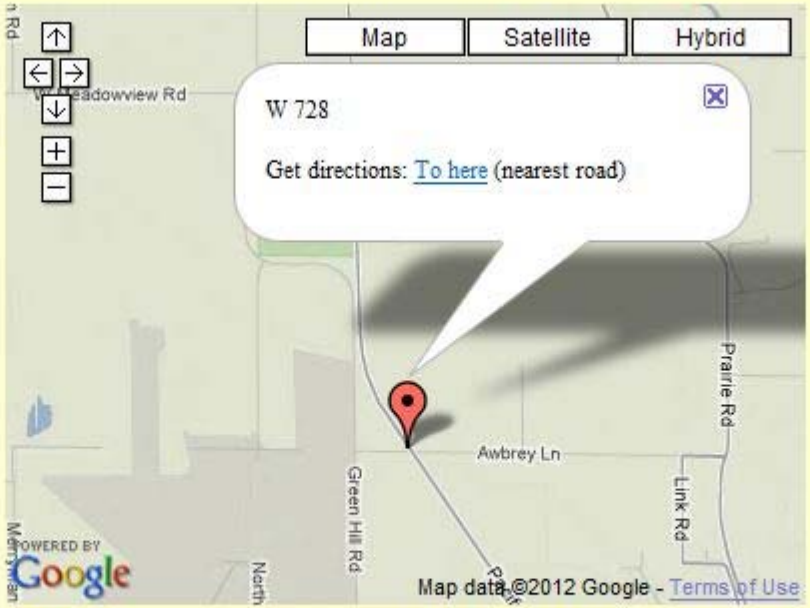
SURVEY DATASHEET (Version 1.0)

PID: QE1506
Designation: W 728
Stamping: W 728 1987
Stability: Monument will probably hold position well
Setting: Stainless steel rod without sleeve (10FT+ or 3.048M+)
Mark Condition: G
Description: Found mark as described. Designation and stamping are W 728 set in 1987.

CONTRIBUTED BY

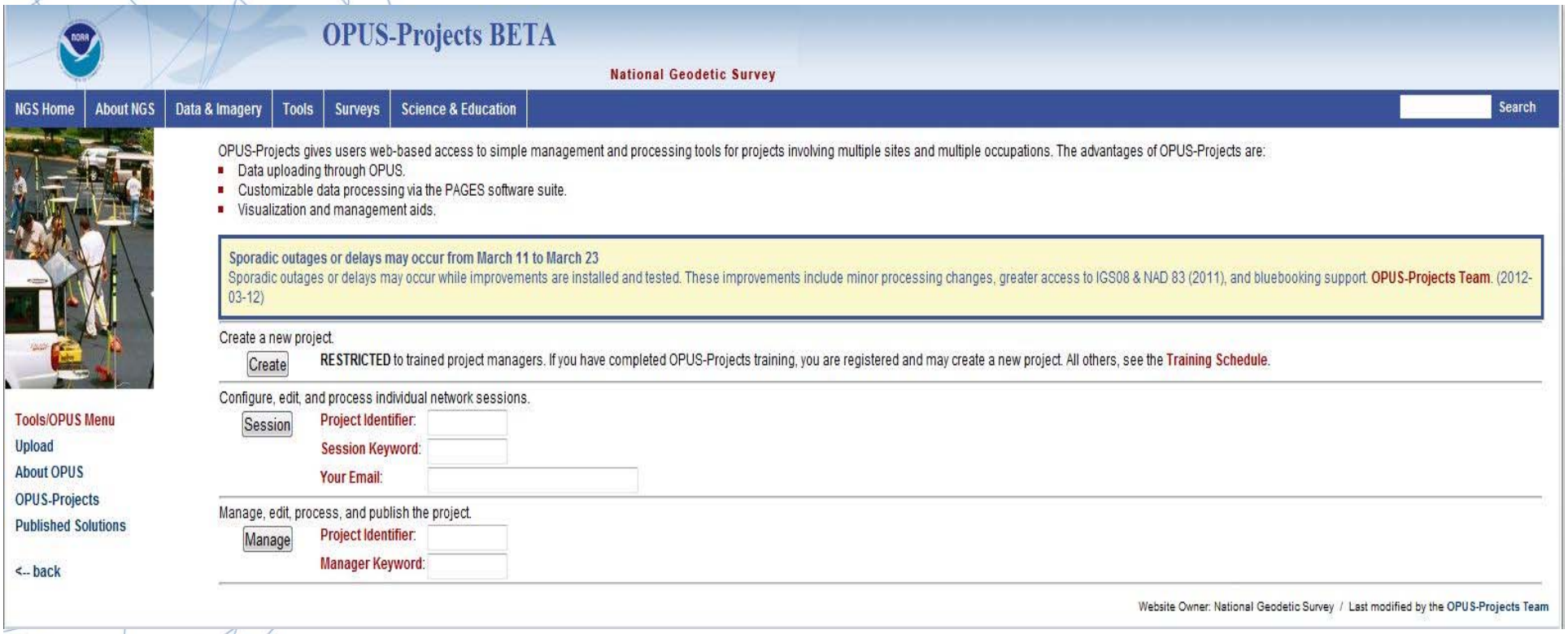
mark.l.armstrong
National Geodetic Survey

Horizon View



The numerical values for this position solution have satisfied the quality control criteria of the National Geodetic Survey. The contributor has verified that the information submitted is accurate a
complete.

OPUS – PROJECTS:
PROJECT SESSION PROCESSING



VARYING LEVELS OF ACCESS

OPUS - S

- DUAL FREQUENCY DATA
- ≥ 2, ≤48 HOURS DATA
- PAGES ENGINE
- OBS USED > 90%
- # FIXED AMB > 50%
- OVERALL RMS < 3 cm
- PEAK TO PEAK < 5 cm

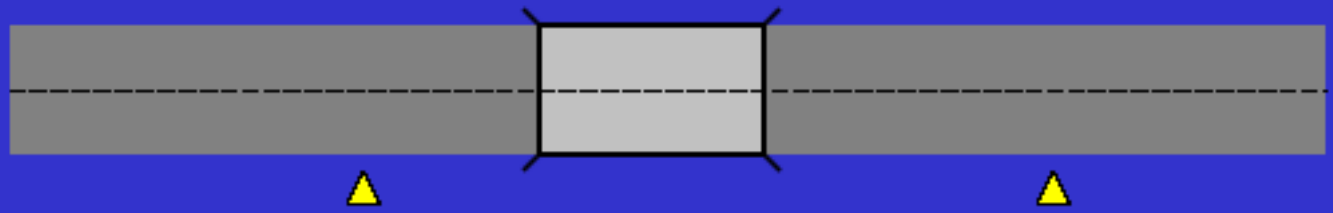
OPUS - DB

- OBS USED ≥ 70%
- # FIXED AMB ≥ 70%
- OVERALL RMS ≤ 3 cm
- PEAK TO PEAK ≤ 4 cm, 8 cm ellipsoid
- DESCRIPTION
- PICTURES

OPUS - RS

- DUAL FREQUENCY DATA
- ≥ 15 MINUTES, ≤2 HOURS DATA
- RSGPS ENGINE
- ≥ 3, ≤ 9 CORS, 250 KM
- OBS USED > 50%
- QUALITY INDICATOR ≥ 3
- NORMALIZED RESIDUAL ≈ 1

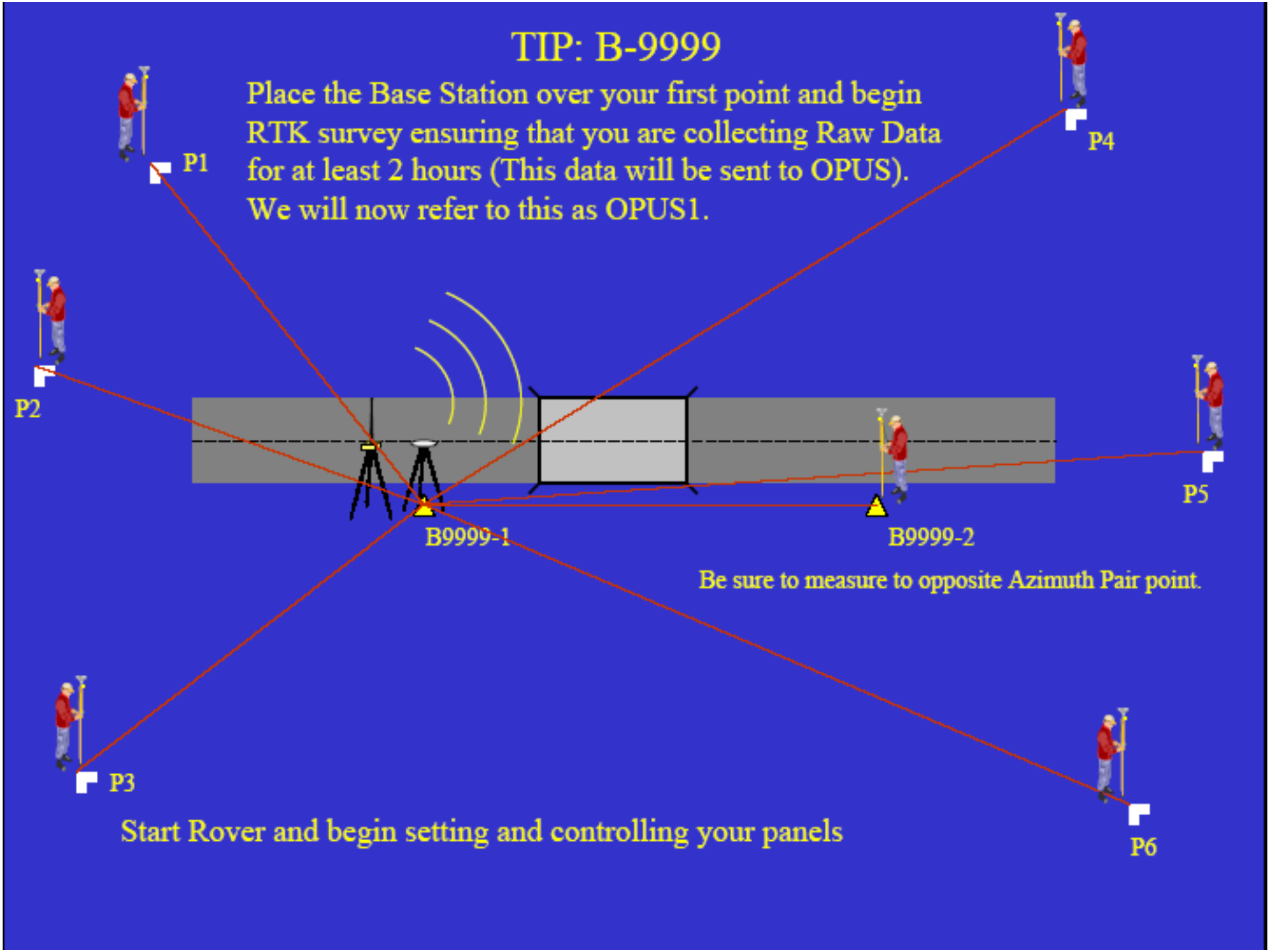
USING OPUS-S OR OPUS –RS WITH REAL TIME POSITIONING FOR SMALL PROJECTS



On a typical Bridge job we set an azimuth pair and have approximately 6-7 panels to control. Following is an example of how we can effectively control this site with 2 receivers.

TIP: B-9999

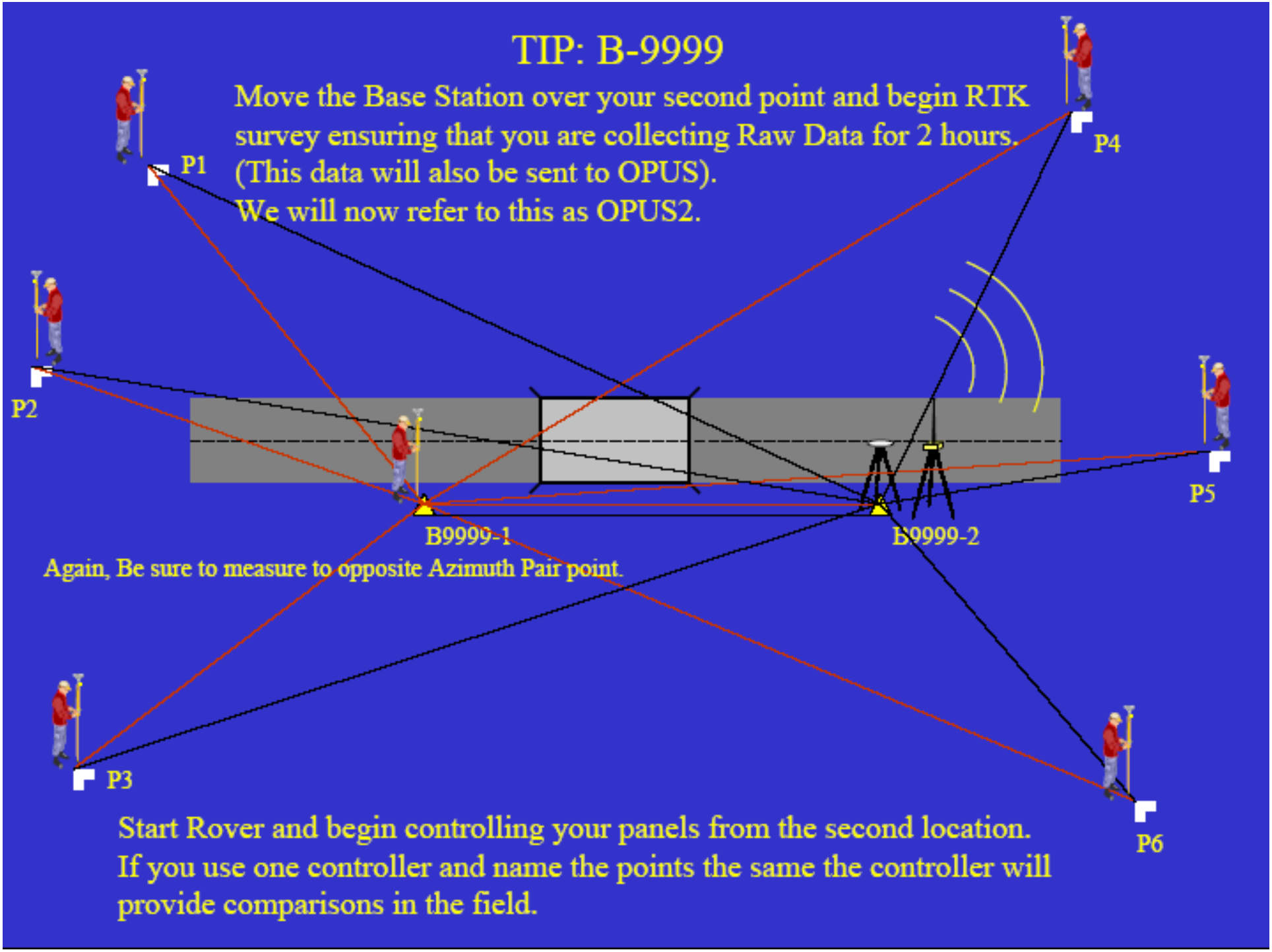
Place the Base Station over your first point and begin RTK survey ensuring that you are collecting Raw Data for at least 2 hours (This data will be sent to OPUS). We will now refer to this as OPUS1.



Be sure to measure to opposite Azimuth Pair point.

Start Rover and begin setting and controlling your panels

TIP: B-9999


Move the Base Station over your second point and begin RTK survey ensuring that you are collecting Raw Data for 2 hours. (This data will also be sent to OPUS).
We will now refer to this as OPUS2.
P1
P2
P3
P4
P5
P6
B9999-1
B9999-2
Again, Be sure to measure to opposite Azimuth Pair point.
Start Rover and begin controlling your panels from the second location.
If you use one controller and name the points the same the controller will provide comparisons in the field.