

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

Interactive Web-based GPS Network Processing and Adjustment Using NGS' OPUS-Projects

Gerald Mader, Mark Schenewerk, Neil Weston,
Joe Evjen, Krishna Tadepalli, Jaya Neti

National Geodetic Survey
Silver Spring, MD

FIG Working Week 2012
May 8, 2012
Rome, Italy

FIG Working Week 2012 1

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

What is OPUS?

On-line **P**ositioning **U**ser **S**ervice

- growing set of GNSS applications
- web-based access to NGS tools & resources

Currently, OPUS is composed of:

- OPUS-S static processing
- OPUS-RS. rapid-static processing
- OPUS-DB. data base and publishing
- OPUS-Projects. . network processing

FIG Working Week 2012 2

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

The OPUS-S Interface

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

The user need only provide:

- email address
- antenna type
- offset to the **Antenna Reference Point (ARP)**
- 2- to 48-hours of GPS L1 + L2 data

FIG Working Week 2012 3

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

OPUS-S Report

```

USER: mark.schenewerk@noaa.gov          DATE: March 31, 2010
RINEX FILE: corv059f.09e                TIME: 19:43:42 UTC

SOFTWARE: page5 0909.08 master40.pl 081023  START: 2009/02/28 05:00:00
EPHEMERIS: igs15206.eph [precise]          STOP: 2009/02/28 06:59:00
NAV FILE: brdc0590.09n                    OBS USED: 5984 / 6181 : 97%
ANT NAME: ASH700936C_M NONE                # FIXED AMB: 31 / 31 : 100%
ARP HEIGHT: 1.521                          OVERALL RMS: 0.009(m)

REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)  ITRF00 (EPOCH:2009.1596)
X: -2498422.603(m) 0.011(m) -2498423.344(m) 0.011(m)
Y: -3802821.159(m) 0.007(m) -3802819.941(m) 0.007(m)
Z: 4454736.661(m) 0.021(m) 4454736.734(m) 0.021(m)

LAT: 44 35 7.91060 0.016(m) 44 35 7.92618 0.016(m)
E LON: 236 41 43.48046 0.013(m) 236 41 43.42207 0.013(m)
W LON: 123 18 16.51954 0.013(m) 123 18 16.57793 0.013(m)
EL HGT: 106.011(m) 0.014(m) 105.627(m) 0.014(m)
ORTHO HGT: 128.542(m) 0.020(m) [NAVD88 (Computed using GEOID09)]

UTM COORDINATES STATE PLANE COORDINATES
UTM (Zone 10) SPC (3601 OR N)
Northing [Y] [meters] 4936954.909 105971.559
Easting [X] [meters] 475821.304 227735.367
Convergence [degrees] -0.21381419 -1.98897513
Point Scale 0.99960719 0.99994603
Combined Factor 0.99959057 0.99992941

US NATIONAL GRID DESIGNATOR: 10TDQ7582136954(NAD 83)

BASE STATIONS USED
PID DESIGNATION LATITUDE LONGITUDE DISTANCE(m)
DH4503 P376 EOLARESVR_OR2004 CORS ARP N445628.313 W1230608.100 42648.2
DR6258 MCSO MARION CNTY COOP CORS ARP N445825.701 W1225720.639 51226.8
DG5352 STAY STAYTON COOP CORS ARP N444950.530 W1224915.036 47030.9
    
```

OPUS-S Report is sent:

- To email address provided
- Within a few minutes

Typical accuracy:


- 1-2 cm horizontal
- 1-4 cm vertical

FIG Working Week 2012 4

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

OPUS-DB (Data Base)

FIG: N74124
Designation: OBSERVATORY RM 1
Stamping: OBSERVATORY 1966 NO 1 1980
Stability: May hold commonly subject to ground movement
Setting: Set in top of concrete monument
Mark: O
Condition: O
Description: Mark is on the grounds of the Gaithersburg Observatory Park, formerly the Gaithersburg International Latitude Observatory. Data collected on May 10, 2011, and the park was dedicated on May 12, 2011.
Observed: 2011-05-10T13:41:00Z See Also 2006-01-24
Source: OPUS - page 1009.28 Close-up View




OPUS-DB

- Option to publish OPUS-S qualified results
- Additional metadata entered (photos, descriptions, ...)
- Published in 1-2 days
- Far less labor intensive than previous method

REF. FRAME (CRS#)	NAD_83	EPOCH 2002.0000	SOURCE: NAVDES (Computed using GEOD09)	UNITS: m	SET PROFILE	DETAILS
LAT:	39° 8' 11.60207"	= 0.008 m	UTM 18 SPC 1900(AD)			
LONG:	-77° 11' 54.80848"	= 0.032 m				
ELL HT:	121.805	= 0.015 m	NORTHING:	434232.248m	163184.228m	
X:	1097643.438	= 0.031 m	EASTING:	309979.914m	382833.431m	
Y:	4830732.848	= 0.015 m	CONVERGENCE:	-1.38808043"	-0.12462172"	
Z:	4004164.072	= 0.013 m	POINT SCALE:	1.00004451	0.99996018	
ORTHO HT:	155.504	= 0.030 m	COMBINED FACTOR:	1.00002550	0.99994107	

CONTRIBUTED BY

[rick.flores](#)
National Geodetic Survey



Horizon View

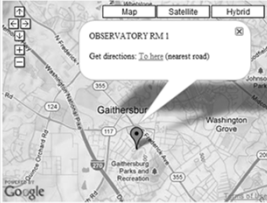


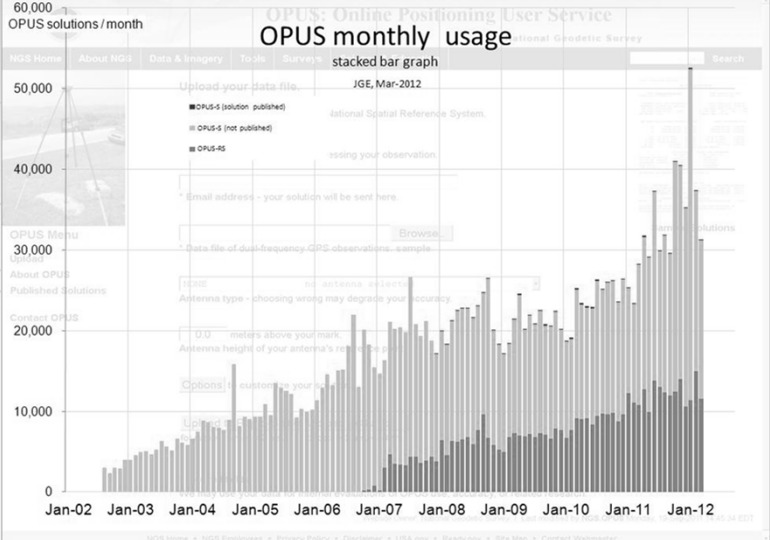
FIG Working Week 2012 5

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

OPUS: Online Positioning User Service

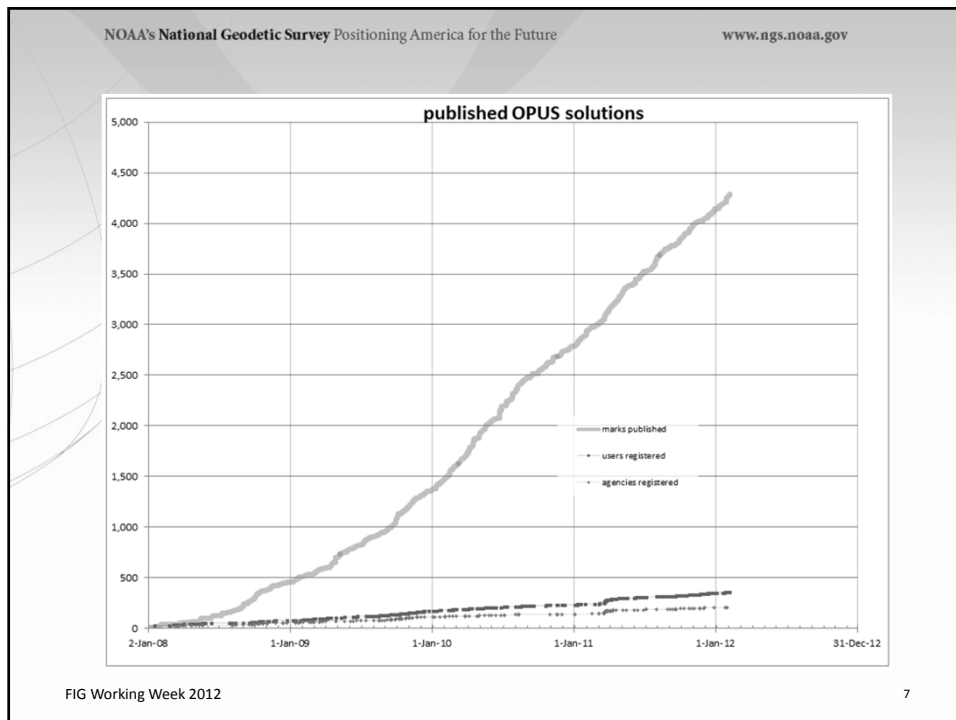
OPUS monthly usage stacked bar graph

JGE, Mar-2012



The graph displays three data series: OPUS-S (solution published), OPUS-S (not published), and OPUS-RS. The total number of solutions published (OPUS-S) shows a clear upward trend, starting from approximately 5,000 in early 2002 and reaching nearly 50,000 by early 2012.

FIG Working Week 2012 6



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

OPUS Lessons

OPUS:

- Is very popular
- Provides fast, accurate data processing
- Enables quick publishing in user-friendly format
- Desires single data file → multiple occupations + multiple marks in a single solution (i.e. a project)

FIG Working Week 2012 8

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

Project Challenges

“x” people occupying “y” marks over “z” days can generate a lot of data files

- File management
- Project QA & QC in progress

FIG Working Week 2012 9

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

OPUS-Projects - Major Steps

- Create reserves disk space
- Upload organizes data files
- Session review & process
- Manage review, adjust, publish

FIG Working Week 2012 10

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

OPUS: Online Positioning User Service

National Geodetic Survey

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

tools/OPUS Menu

Upload

About OPUS

OPUS Projects

View Published Solutions

<- back

Upload your Data File

Tie your GPS observation to the National Spatial Reference System. [\[what is OPUS?\] \[FAQs\]](#)

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

Browse...

* **Data file** of dual-frequency GPS observations. [\[sample\]](#)

Antenna type - choosing wrong may degrade your accuracy.

meters above your mark.

Antenna height of your Antenna's Reference Point.

to customize your solution.

Upload to RAPID-STATIC
for data > 15 min. < 2 hrs.
process your solution.

Upload to STATIC
for data > 2 hrs. < 48 hrs.

- * required fields
- We may use your data for internal evaluations of OPUS use, accuracy, or related research.

Sample Solutions

Station	Antenna	Antenna Height	Antenna Type	Antenna Model	Antenna Serial	Antenna Manufacturer	Antenna Description	Antenna Date	Antenna Status
12345678	Trimble	1.5	Trimble	5600	12345678	Trimble	Trimble 5600	2008-01-01	Active
87654321	Trimble	1.5	Trimble	5600	87654321	Trimble	Trimble 5600	2008-01-01	Active

FIG Working Week 2012 11

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

OPUS-Projects Home Page

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

Tools/OPUS Menu

Upload

About OPUS

OPUS Projects

Published Solutions

<- back

OPUS Projects

OPUS Projects gives users web-based access to simple management and processing tools for projects involving multiple sites and multiple occupations. The advantages of OPUS Projects are:

- Data uploading through OPUS
- Customizable data processing via the PAGES software suite.
- Visualization and management aids.

Create a new project.

Create
RESTRICTED to trained project managers. If you have completed OPUS Projects training, you are registered and may create a new project. All others, see the [Training Schedule](#).

Configure, edit, and process individual network sessions.

Session

Project Identifier:

Session Keyword:

Your Email:

Manage, edit, process, and publish the project.

Manage

Project Identifier:

Manager Keyword:

Website Owner: National Geodetic Survey / Last modified by the OPUS Projects Team

[NGS Home](#) • [NGS Employees](#) • [Privacy Policy](#) • [Disclaimer](#) • [USA.gov](#) • [Ready.gov](#) • [Site Map](#) • [Contact Webmaster](#)

FIG Working Week 2012 12

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

Create a Project

OPUS: Online Positioning User Service
National Geodetic Survey

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

OPUS Menu

Upload

About OPUS

OPUS Projects

Published Solutions

Create Project

* Email address:
Refers to Project Manager who must be registered with OPUS-Projects

* Project title:

* Project type: HMod FAA Other

* Approx. location: Latitude: and Longitude:

* Anticipated start:

* Approx. size: Stations: and Duration: days

* required fields

Website Owner: National Geodetic Survey / Last modified by NGS.OPUS Monday, 22-Nov-2010 15:53:52 EST

NGS Home • NGS Employees • Privacy Policy • Disclaimer • USA.gov • Ready.gov • Site Map • Contact Webmaster

FIG Working Week 2012 13

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

Upload to a Project

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:

* Data file of dual-frequency GPS observations.

NOISE 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.

to customize your solution.

Solution formats	Add details to your report	standard solution
Base stations	Type in 4-char site IDs, or select from map, any CORS you wish to explicitly include or exclude from your solution	Use: <input type="text"/> Exclude: <input type="text"/>
State plane coordinates	Override your native SPCS zone	let OPUS choose
Geoid Model	Customize your orthometric height model	GEoid99
Contribute to a project	Enter the project identifier provided by your project manager.	<input type="text"/>
My profile	Customize OPUS defaults for future solutions	<input type="text"/>
Publish my solution	Share your solutions	No, don't publish

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

FIG Working Week 2012 14

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

Project Sessions

OPUS Projects
National Geodetic Survey

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

OPUS Projects gives users web-based access to simple management and processing tools for projects involving multiple sites and multiple occupations. The advantages of OPUS Projects are:

- Data uploading through OPUS.
- Customizable data processing via the PAGES software suite.
- Visualization and management aids.

Create a new project.

Configure, edit, and process individual network sessions.

Session Project Identifier:

Session Keyword:

Your Email:

Session Keyword:

Your Email:

Manage, edit, process, and publish the project.

Manage Project Identifier:

Manager Keyword:

Website Owner: National Geodetic Survey / Last modified by the OPUS Projects Team

NGS Home • NGS Employees • Privacy Policy • Disclaimer • USA.gov • Ready.gov • Site Map • Contact Webmaster

15

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

Session Page

OPUS Solutions
National Geodetic Survey

Session: 2006-059-A

RESULTS FROM: OPUS Solutions

MARKS: meet preferences do not meet preferences are not included have error

CONTROLS: meet preferences do not meet preferences are not included


MARKS	HEIGHT	EPN	OBS	FIXED	RES	LAT	LONG	WGS78	
MARKS	TYPE	TYPE	TYPE	TYPE	TYPE	TYPE	TYPE	TYPE	
0617	TRM33429-00-GP	ICONE	2.000	precise	90.2	0.000	0.010	0.000	0.004
0618	TRM33429-00-GP	ICONE	2.000	precise	99.4	100.0	0.007	0.019	0.004
0619	TRM33429-00-GP	ICONE	2.000	precise	99.3	100.0	0.008	0.016	0.004

FIG Working Week 2012

16

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

Session Page



Solution Quality Indicators

MARKS	ANTENNA	HEIGHT	EPH	ORS	FIXED	RMS	LAT	LONG	HGT
		(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
0017	TRM33429-00-GP-NONE	2.000	precise	90.3	0.015	0.045	0.526	0.134	
0076	TRM33429-00-GP-NONE	2.000	precise	99.4	100.0	0.007	0.019	0.042	0.054
0079	TRM33429-00-GP-NONE	2.000	precise	99.3	100.0	0.008	0.016	0.031	0.024

PREFERENCES:
 SRS: AutoSelect
 AutoStation: +80.0 +80.0 +8.025 +8.020 +8.020 +8.040

Data Availability
 2006-02-28T12:00:00 GPST to 2006-02-28T14:03:00 GPST in 3 minute cells

MARKS	12	13	14
0017
0076
0079

FIG Working Week 2012 17

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

Session Processing

Process Session

Name: 2006-274A from 2006-10-01T20:01:30 GPST to 2006-10-02T01:59:30 GPST

MARK	HUB	CONSTRAINT	HEIGHT (m)	LATITUDE ("")	LONGITUDE ("")
<input checked="" type="checkbox"/>	2126	<input type="checkbox"/> NONE	EL HGT	13.986	N30 59 00.80011 W099 48 34.33127
<input checked="" type="checkbox"/>	2137	<input type="checkbox"/> NONE	EL HGT	33.182	N30 56 11.58187 W090 30 25 29780
CORS					
MARK	HUB	CONSTRAINT	HEIGHT (m)	LATITUDE ("")	LONGITUDE ("")
<input checked="" type="checkbox"/>	covg	<input checked="" type="checkbox"/> 3-D	EL HGT	-5.938	N30 28 33.28886 W090 05 43 94866
<input checked="" type="checkbox"/>	harm	<input checked="" type="checkbox"/> 3-D	EL HGT	15.817	N30 30 47.07074 W090 28 03 45449
<input checked="" type="checkbox"/>	msht	<input checked="" type="checkbox"/> 3-D	EL HGT	16.475	N31 19 39.16034 W089 20 10 65216
<input checked="" type="checkbox"/>	ndbc	<input checked="" type="checkbox"/> 3-D	EL HGT	-11.674	N30 21 22.61077 W089 36 37 00068

Processing Options

Reference Frame:

Geoid Model:

GNSS:

Tropo Model:

Tropo Interval (s):

Elevation Cutoff (°):

Constraints: Loose Normal Tight

Network Design: USER CORS MST TRI

FIG Working Week 2012 18

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

INCLUSION OF IGS SITES

Distant IGS sites

- Provide accurate reference frame
- Transfer IGS(NSRS) frame to local area
- Improve troposphere determination and heights

FIG Working Week 2012 19

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

BASIC HUB SITE STRATEGY

Single 24hr Hub station

- Is connected to each IGS station
- Gets placed accurately in IGS frame
- Provides consistent reference for each remote station
- Is suitable for projects up to several hundred km with > 2-4hr of data
- Tightly constrain IGS, loosely constrain hub

FIG Working Week 2012 20

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

Manager's Page

Results from: ALL SESSION SOLUTIONS

MARKS: meet preferences do not meet preferences are not included have error

CORES: meet preferences do not meet preferences are not included

Session	Solutions
2012	2
2013	2
2014	2
2015	2
2016	2
2017	2
2018	2

FIG Working Week 2012 21

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

Manager's Page

Sessions & Solutions

Session	Solutions
2012	2
2013	2
2014	2
2015	2
2016	2
2017	2
2018	2
2019	2
2020	2
2021	2
2022	2
2023	2
2024	2
2025	2
2026	2
2027	2
2028	2
2029	2
2030	2

MARKS: 0009, 0011, 0014, 0015, 0017, 0021, 0022, 0025, 0027, 0035, 0042, 0048, 0051, 0060, 0061, 0063, 0065, 0064, 0075, 0076, 0077, 0078, 0079, 0080

CORES: 001, 002, 003, 004, 005

FIG Working Week 2012 22

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

Mark Page

OPUS Projects BETA - Mark 2123 In "Training data set 1"

National Geodetic Survey

[NGS Home](#)
[About NGS](#)
[Data & Imagery](#)
[Tools](#)
[Surveys](#)
[Science & Education](#)
Search

2123 SURVEY DATASHEET Mock-up (Version 1.0)

[Help](#)
[Back](#)
[Refresh](#)
[Reset](#)
[RINEX](#)
[Photos](#)
[Save](#)



<p>Description</p> <p>stamp: M 179 name: M 179 type: D = Disk DD = Survey disk (other agency) setting: 31 = Pavement (street, sidewalk, curb, etc.) specific setting (optional):</p> <p>Description Take interstate I55 to State Road 442 east exit. 1 mi on SR 442, turn north on U.S. 51. After 1.5 mi on U.S. 51, turn east on Buckles Ln. Just past railroad, Buckles Ln take a sharp right. Mark is near this turn. Approximately 50 ft west, between the road and railroad.</p> <p>stability: --- no selection --- magnetic: --- no selection --- application: --- no selection --- condition: <input checked="" type="radio"/> Good condition <input type="radio"/> Poor, disturbed, mutilated, requires maintenance *required fields</p> <p>Occupations</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td>Start: 2006-10-02T20:23:30.000</td> <td>OPST: Antenna Model: TRM55971.00</td> <td>S/N: 11121318</td> <td>ARP (m): 1.888</td> </tr> <tr> <td>End: 2006-10-03T01:16:30.000</td> <td>OPST: Receiver Model: TRIMBLE 5600</td> <td>S/N: 11121318</td> <td>Formance: 1.888</td> </tr> <tr> <td>Start: 2006-10-03T08:23:30.000</td> <td>OPST: Antenna Model: TRM55971.00</td> <td>S/N: 11121318</td> <td>ARP (m): 1.888</td> </tr> </table>	Start: 2006-10-02T20:23:30.000	OPST: Antenna Model: TRM55971.00	S/N: 11121318	ARP (m): 1.888	End: 2006-10-03T01:16:30.000	OPST: Receiver Model: TRIMBLE 5600	S/N: 11121318	Formance: 1.888	Start: 2006-10-03T08:23:30.000	OPST: Antenna Model: TRM55971.00	S/N: 11121318	ARP (m): 1.888	<p>Close-up View</p>  <p>Horizon View</p> 
Start: 2006-10-02T20:23:30.000	OPST: Antenna Model: TRM55971.00	S/N: 11121318	ARP (m): 1.888										
End: 2006-10-03T01:16:30.000	OPST: Receiver Model: TRIMBLE 5600	S/N: 11121318	Formance: 1.888										
Start: 2006-10-03T08:23:30.000	OPST: Antenna Model: TRM55971.00	S/N: 11121318	ARP (m): 1.888										

FIG Working Week 2012 23

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

Mark Page

Solution Results From network-final

Coordinate Source: network-final	
REF FRAME: ITRF2000 (2006.7552)	NAD_83(CORS96) (2002.0000)
LAT: N30:35:23.60927 ±0.001 m	N30:35:23.59010 ±0.001 m
EAST LON: E269:30:47.26256 ±0.001 m	E269:30:47.28806 ±0.001 m
WEST LON: W090:29:12.73744 ±0.001 m	W090:29:12.71194 ±0.001 m
EL HGT: -8.792 ±0.007 m	-7.421 ±0.007 m
X: -46695.480 m ±0.000 m	-46694.813 m ±0.000 m
Y: -5495062.789 m ±0.001 m	-5495064.275 m ±0.001 m
Z: 3226832.681 m ±0.001 m	3226832.871 m ±0.001 m
ORTHO HGT: 19.491 m ±0.013 m [USGG2009]	
COORDINATE SYSTEM: SPC 1702 LA S UTM 15	
NORTHING: 231955.817 m	3386842.986 m
EASTING: 1081182.799 m	740977.296 m
CONVERGENCE: 0.42324519°	1.27952542°
POINT SCALE: 0.99997843	1.00031642
COMBINED FACTOR: 0.99997960	1.00031759
U.S. NATIONAL GRID: 15RYP4097786843(NAD 83)	

File	Antenna	ARP (m)	Eph	Obs (%)	Fixed (%)	RMS (m)	Lat (m)	Lon (m)	Hgt (m)	SOLUTION	
2123275a.06o	TRM55971.00	NONE	2.000	precise	93.9	92.2	-	0.001	0.001	0.007	network-final
2123276g.06o	TRM55971.00	NONE	2.000	precise	93.9	92.2	-	0.001	0.001	0.007	network-final
2123276s.06o	TRM55971.00	NONE	2.000	precise	93.9	92.2	-	0.001	0.001	0.007	network-final
2123277g.06o	TRM55971.00	NONE	2.000	precise	93.9	92.2	-	0.001	0.001	0.007	network-final
Preferences				BEST AVAILABLE	≥80.0	≥80.0	≤0.025	≤0.020	≤0.020	≤0.040	Preferences


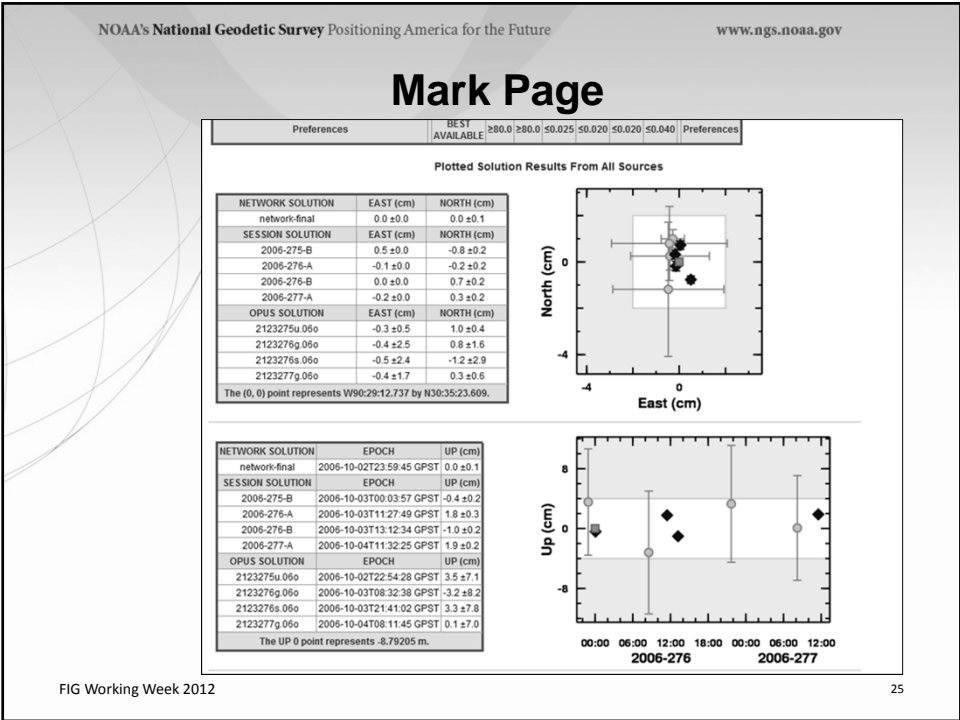


FIG Working Week 2012 24



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

Summary

- **OPUS**
 - Consistent, authoritative positioning
 - Minimal metadata
 - Machine talks to machine
- **OPUS-Projects**
 - File management
 - Near real time project monitoring
 - Project adjustment
- **OPUS-Data Base**
 - Quick publishing after reviews
 - A little more metadata

FIG Working Week 2012 26