

Using and Understanding OPUS



**New York State Association of Professional Land Surveyors
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What is OPUS?

- OPUS, the **On-line Positioning User Service**, is a growing set of applications offering web-based access to the tools and resources provided by the NGS.
- Currently, OPUS is composed of
 - OPUS-S.....static processing
 - OPUS-RS.....rapid-static processing
 - Publishing.....database of solutions

Reviewing each of these individually...

What is OPUS?

- On-line Positioning User Service
 - Submit dual frequency (GPS) Data
 - 15 min - 2 hours data OPUS_RS (Rapid Static)
 - 2 hours - 48 hours data OPUS_S (Static)
 - Processed by NGS computers relative to CORS
 - Results received in minutes via e-mail
 - Provides consistent access to NSRS

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The OPUS-S Interface

Beautiful in its simplicity, the user need only provide:

- Their email address.
- The antenna type.
- The offset to the **antenna reference point** (ARP).
- 2- to 48-hours of GPS L1 + L2 data.

In turn, the user receives:

- Coordinates accurate to a few centimeters.

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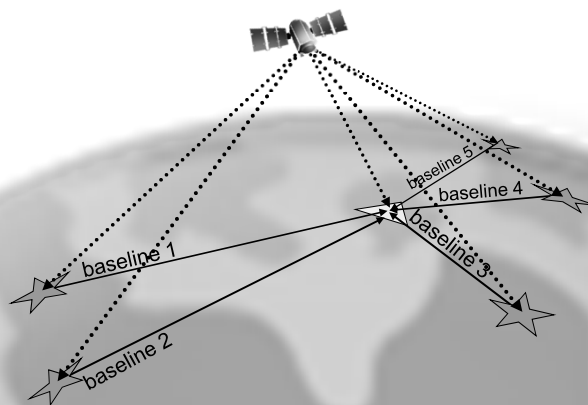
The OPUS-S Interface

This is the OPUS home page used to submit data to the OPUS processing queues. To use OPUS-S, complete the four fields, then click the “Upload to STATIC” button. In a few minutes, an email arrives with the results.

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Static: OPUS determines your position with a differential GPS static solution, using hours of data.

This process is repeated four more times from other CORS.



How Does OPUS-S Work?

The primary steps of OPUS-S processing are:

1. Prepare and quality control the submitted data.
2. Estimate a crude point-position using TEQC.
3. Compute distances to every available CORS.
4. Select the three “best” CORS based upon:
 - Being closest to the user’s site.
 - Having common satellite visibility with the user data.
 - Having more than 80% of the possible data available.
 - Having low multipath measures.
5. Complete the single-baseline processing using PAGES.
6. Check the solution quality and replace a CORS if needed.
7. Generate and email the report to the user.

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How Does OPUS-S Work?

OPUS-S uses PAGES for data processing.

PAGES is a state-of-the-art processing engine developed by the NGS.

Besides OPUS-S, PAGES is used for orbit production, reference frame definition, network monitoring and many other GPS data processing tasks.

<http://geodesy.noaa.gov/GRD/GPS/DOC/toc.html>
<http://igscb.jpl.nasa.gov/igscb/center/analysis/noaa.acn>

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How Does OPUS-S Work?

OPUS-S modeling highlights:

- Satellite coordinates from the **International GNSS Service (IGS)** precise ephemerides.
<http://igsb.jpl.nasa.gov/components/usage.html>.
- CORS coordinates and hardware histories from the NGS site information data base.
- Receiver antenna phase center offsets and variations from the NGS absolute antenna model data base.
<http://geodesy.noaa.gov/ANTCAL/>.
- **International Earth Rotation Service (IERS)** 2003 solid Earth tide model.
http://www.iers.org/nn_11216/IERS/EN/Publications/TechnicalNotes/tn32.html.
- Surface met from a climatological model.
Boehm et al., "Short Note: A global model of pressure and temperature for geodetic applications", J. Geod., 2007.

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How Does OPUS-S Work?

OPUS-S processing highlights:

- Everything is "done" in the **IGS08 Reference Frame**.
- SV coordinates are held rigidly fixed.
- CORS coordinates are heavily constrained.
- Neutral atmosphere (tropo) dry component modeled.
- Neutral atmosphere (tropo) wet component estimated.
- Double-differenced, ion-free carrier phase observable.
- Carrier phase ambiguities are fixed to their integer values where possible; float ambiguities are estimated otherwise.
- Individual baselines are processed and the results combined generating mean coordinates and peak-to-peak uncertainties.

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How Does OPUS-S Work?

Some thoughts on phase ambiguity integer fixing.

The ambiguities, (charged and neutral) atmosphere delays and station heights strongly alias into each other.

There are really only two ways to “break” this aliasing:

1. Introduce more data.
2. Introduce additional information.

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How Does OPUS-S Work?

OPUS-S uses the former strategy.

Depending upon the circumstances, 1- to 2-hours of observations are sufficient to decorrelate the ambiguities, atmosphere and heights allowing reliable estimation of all. Thus the requirement for a minimum of 2-hours in OPUS-S.

As an aside, be aware that while simply having more data helps, it is actually the change in orientation of the satellites over the data span that forces the decorrelation.

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The screenshot shows the OPUS: Online Positioning User Service web interface. The header includes the NGS logo and the title "OPUS: Online Positioning User Service" with the subtitle "National Geodetic Survey". A navigation bar contains links: NGS Home, About NGS, Data & Imagery, Tools, Surveys, Science & Education, and a search bar.

On the left, there is a "Prefer the old OPUS?" link and an "OPUS Menu" section with links for "Upload" and "About OPUS".

Several text boxes highlight specific features:

- extended solution**: Points to the "Options" button.
- in / exclude CORS**: Points to the "Base stations" section.
- SPC zone**: Points to the "State plane coordinates" section.
- geoid model – transition**: Points to the "Geoid Model" section.
- project**: Points to the "Contribute to a project" section.
- profile**: Points to the "My profile" section.
- publish**: Points to the "Publish my solution" section.

The main content area includes:

- Antenna height of your antenna's reference point.**
- Options to customize your solution.**
- Solution formats**: A dropdown menu set to "standard solution".
- Base stations**: A section for "Type in 4-char site IDs, or select from map, any CORS you wish to explicitly include or exclude from your solution". It includes "Use:" and "Exclude:" checkboxes, a "Look up site IDs" button with a map, and a "browse map" link.
- State plane coordinates**: A section for "Override your native SPCS zone" with a dropdown set to "let OPUS choose".
- Geoid Model**: A section for "Customize your orthometric height model" with a dropdown set to "GEOID09".
- Contribute to a project**: A section for "Enter the project identifier provided by your project manager." with a text input field.
- My profile**: A section for "Customize OPUS defaults for future solutions" with a dropdown.
- Publish my solution**: A section for "Share your solutions" with a dropdown set to "No, don't publish".
- Upload buttons**: "Upload to Rapid-Static" (for data > 15 min. < 2 hrs.) and "Upload to Static" (for data > 2 hrs. < 48 hrs.).

At the bottom, a dark box contains the text: **OPUS-RS or OPUS-Static (15 min-2 hr) (2-48 hr)**.

Antenna Type, height – easy, right?

- Type?
 - Verify by looking up in ANTCAL
 - Orient the antenna indicator to true north
 - Centered over the mark? (check plummet or bubble)
- Height?
 - Height to what? (antenna ARP, not L1-phase center)
 - Fixed-height tripods are easier than slip-legs.
 - Vertical, NOT slant-height.
 - Is your fixed-height tripod really fixed? (measure!)

HOW IS THE ANTENNA HEIGHT MEASURED?



ARP

The height is measured vertically (NOT the slant height) from the mark to the ARP of the antenna. The height is measured in meters.

The ARP is almost always the center of the bottom-most, permanently attached, surface of the antenna.

See GPS Antenna Calibration for photo's and diagrams that show where the ARP is on most antennas:

<http://geodesy.noaa.gov/ANTCAL/>

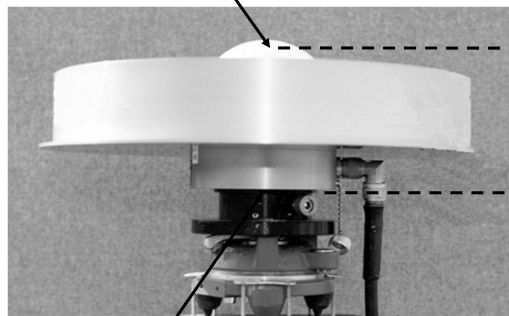
If the default height of 0.0000 is entered, OPUS will return the position of the ARP.

MARK

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WHY DO I NEED THE ANTENNA TYPE?

The antenna phase centers are located somewhere around here.



phase ctr.

The antenna offsets are the distance between the phase centers and the ARP

ARP

You do not need to know these offsets. They are passed to the processing software through the antenna type

The Antenna Reference Point (ARP) is almost always located in the center of the bottom surface of the antenna.

Incorrect or missing antenna type → big vertical errors

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What else can go wrong?

- Site
 - instability, multi-path
 - mark ID (search database, check stamping)
- Weather
 - wild, local troposphere issues?
 - space weather: ionospheric issues?
- “Truth” (orbits, CORS, etc.)
 - Rapid (next-day) orbits required for publishing

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How Good Can I Do With OPUS-S?

OPUS-S reliably addresses the more historically conventional requirements for GPS data processing. It typically yields accuracies of:

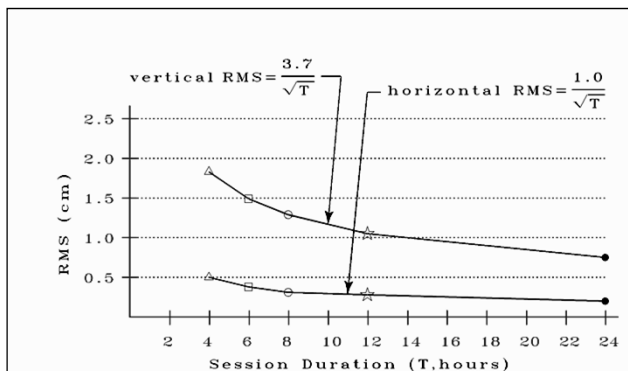
1 – 2 cm horizontally
2 – 4 cm vertically

However, there is no guarantee that this stated accuracy will result from any given data set. Confirming the quality of the OPUS solution remains the user's responsibility. That's the “price” for automated processing.

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How Good Can I Do With OPUS-S?

More generally, Eckl et al. (NGS, 1999) preformed a similar but more extensive test using the same software but outside OPUS.



Eckl et al., 2001, "Accuracy of GPS-derived relative positions as a function of interstation distance and observing-session duration", J. of Geod. 75, 633-640).

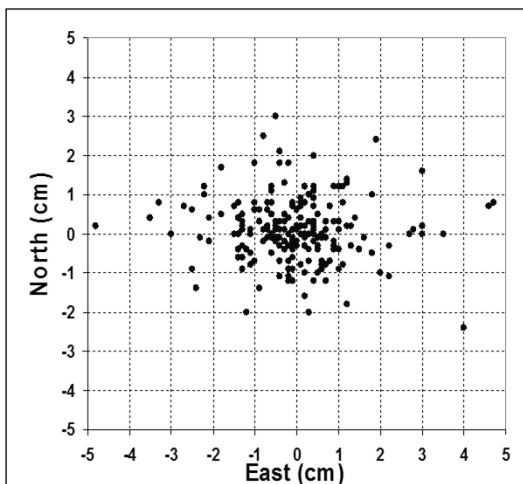
Their results provide a good "rule of thumb" for accuracy versus session duration when using OPUS-S and in many other applications.

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How Good Can I Do With OPUS-S?

As a quality test, 2-hour data sets from more than 200 CORS were submitted to OPUS-S and the results compared to the accepted coordinates.

Mean: <0.1 cm
N-S RMS: 0.8 cm
E-W RMS: 1.4 cm



Weston, N. "OPUS: Online Positioning User Service", CGSIC USSLS MEETING, 2008-07-08, NEW ORLEANS, LA.

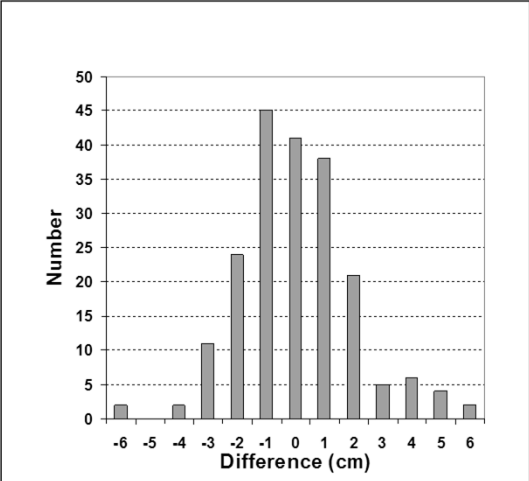
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How Good Can I Do With OPUS-S?

Same data sets.
Same analysis but
for the vertical.

The vertical is
always a little more
interesting.

Mean: <0.1 cm
U-D RMS: 1.9 cm



Weston, "OPUS: Online Positioning User Service", CGSIC USSLS MEETING, 2008-07-08, NEW ORLEANS, LA

A Quick Example

USER: mark.schenewerk@noaa.gov		DATE: March 31, 2010	
RINEX FILE: corv059f.09g		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_N NONE		# FIXED ANTS: 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	2277335.367	
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			
FID	DESIGNATION	LATITUDE	LONGITUDE DISTANCE(m)
DR4503	P376 BOLARESVR_CR2004 CORS ARP	N445628.313 W1230608.100	42648.2
DE6258	MCSO MARION CNTY COOP CORS ARP	N445825.701 W1225720.639	51226.8
DG5352	STAY STAYTON COOP CORS ARP	N444950.530 W1224915.036	47030.9

Here is part of the report
for this submission.

FYI, these results differ 2.1
cm horizontally and 1.6 cm
vertically from the
accepted position
projected to the epoch of
the data.

A Quick Example

```
USER: mark.schenewerk@noaa.gov DATE: March 31, 2010
RINEX FILE: corv059f.09o 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 (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)

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UTM COORDINATES STATE PLANE COORDINATES
UTM (Zone 10) SPC (3601 OR N)
Northing (Y) [meters] 4936954.909 105971.559
Easting (X) [meters] 475821.304 2277335.367
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 ECLARESVR_OR2004 CORS ARP N445628.313 W1230608.100 42648.2
DE6258 MCSO MARION CNTY COOP CORS ARP N445825.701 W1225720.639 51226.8
DG5352 STAY STAYTON COOP CORS ARP N444950.530 W1224915.036 47030.9
```

Again, I'm assuming familiarity with the report, but ...

... at the risk of stating the obvious, there are a few items I want to draw attention to.

A Quick Example

```
USER: mark.schenewerk@noaa.gov DATE: March 31, 2010
RINEX FILE: corv059f.09o 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 (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)
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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 ECLARESVR_OR2004 CORS ARP N445628.313 W1230608.100 42648.2
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DG5352 STAY STAYTON COOP CORS ARP N444950.530 W1224915.036 47030.9
```

I apologize for stating the obvious, but ...

When reviewing your OPUS solution, double check that the information you provided is correct.

A Quick Example

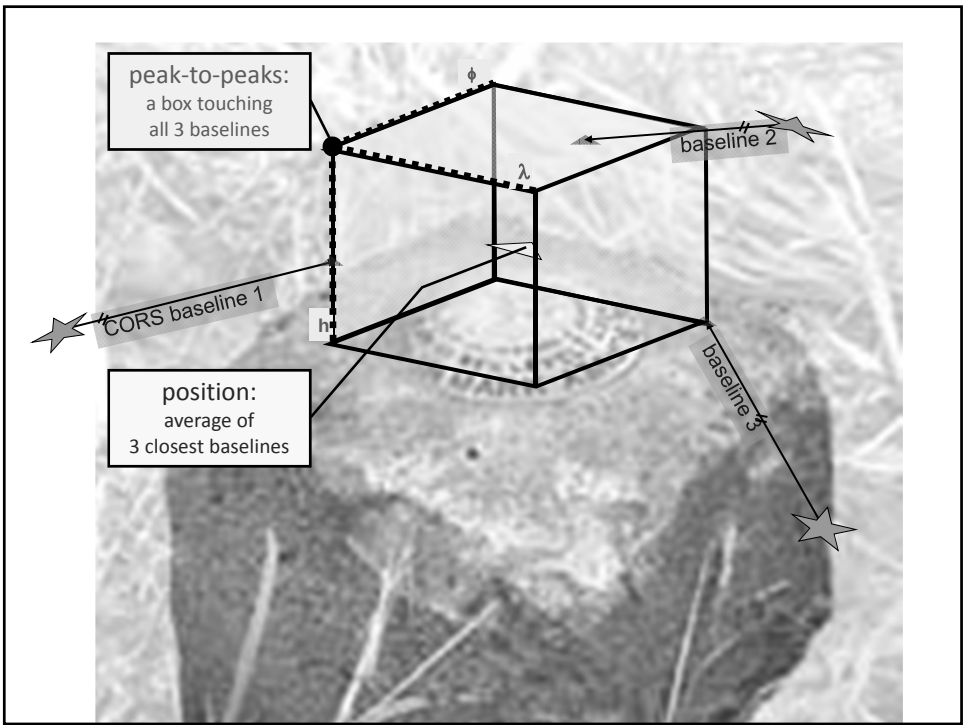
USER: mark.schenewerk@noaa.gov	DATE: March 31, 2010
RINEX FILE: corv059f.09o	TIME: 19:43:42 UTC
SOFTWARE: page5 0909.08 master40.pl 081023	START: 2009/02/28 05:00:00
EPHEMERIS: igls15206.eph [precise]	STOP: 2009/02/28 06:50:00
NAV FILE: brdc0590.09n	OBS USED: 5984 / 6181 : 97%
ANT NAME: ASH700936C_M 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)
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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)
DR4503 F376 BOLARESVR_OR2004 CORS ARP	N445628.313 W1230608.100 42648.2
DE6258 WCO MARION CNTY COOP CORS ARP	N445825.701 W1225720.639 51226.8
D65352 STAY STAYTON COOP CORS ARP	N444950.530 W1224915.036 47030.9

I apologize for stating the obvious, but ...

Check the quality control measures provided:

- OBS USED** > 90%
- # FIXED AMB** > 50%
- OVERALL RMS** < 3 cm
- peak-to-peak** < 5 cm

In this example, we have a



The Extended Report

BASE STATION INFORMATION									
STATION NAME: p376 a 2 (EOLARESVR_OR2004; Salem, OR United States)									
MONUMENT: NO DOMES NUMBER									
XYZ	-2469806.7634	-3788348.6049	4482853.4377	MON	@ 1997.0000	(M)			
XYZ	-0.0141	0.0030	-0.0043	VEL	(M/YR)				
NEU	-0.0000	0.0000	0.0083	MON	TO ARP	(M)			
NEU	0.0009	0.0009	0.1068	ARP	TO L1 PHASE CENTER	(M)			
NEU	0.0002	0.0017	0.1251	ARP	TO L2 PHASE CENTER	(M)			
XYZ	-0.1715	0.0365	-0.0523	VEL	TIMES 12.1597	YRS			
XYZ	-0.0032	-0.0049	0.0059	MON	TO ARP				
XYZ	-0.0402	-0.0633	0.0761	ARP	TO L1 PHASE CENTER				
XYZ	-2469806.9782	-3788348.6366	4482853.4674	L1	PHS CEN @ 2009.1596				
XYZ	0.0000	0.0000	0.0000	+ XYZ ADJUSTMENTS					
XYZ	-2469806.9782	-3788348.6366	4482853.4674	NEW	L1 PHS CEN @ 2009.1596				
XYZ	-2469806.9381	-3788348.5733	4482853.3913	NEW	ARP @ 2009.1596				
XYZ	-2469806.9348	-3788348.5684	4482853.3855	NEW	MON @ 2009.1596				
LLH	44 56 28.32921	236 53 51.83975	180.9607	NEW	L1 PHS CEN @ 2009.1596				
LLH	44 56 28.32918	236 53 51.83971	180.8539	NEW	ARP @ 2009.1596				
LLH	44 56 28.32918	236 53 51.83971	180.8456	NEW	MON @ 2009.1596				
STATION NAME: mcso a 1 (MARION CNTY COOP; Salem, Oregon, U.S.A.)									
MONUMENT: NO DOMES NUMBER									
XYZ	-2458668.9460	-3792427.4770	4485327.2930	MON	@ 1997.0000	(M)			
XYZ	-0.0131	0.0018	-0.0047	VEL	(M/YR)				
NEU	0.0000	0.0000	0.0000	MON	TO ARP	(M)			
NEU	0.0025	0.0013	0.1065	ARP	TO L1 PHASE CENTER	(M)			
NEU	-0.0007	0.0013	0.1254	ARP	TO L2 PHASE CENTER	(M)			
XYZ	-0.1593	0.0219	-0.0572	VEL	TIMES 12.1597	YRS			
XYZ	0.0000	0.0000	0.0000	MON	TO ARP				
XYZ	-0.0389	-0.0624	0.0770	ARP	TO L1 PHASE CENTER				
XYZ	-2458669.1442	-3792427.5176	4485327.3129	L1	PHS CEN @ 2009.1596				
XYZ	-0.0000	-0.0000	0.0000	+ XYZ ADJUSTMENTS					
XYZ	-2458669.1442	-3792427.5176	4485327.3129	NEW	L1 PHS CEN @ 2009.1596				
XYZ	-2458669.1053	-3792427.4551	4485327.2358	NEW	ARP @ 2009.1596				
XYZ	-2458669.1053	-3792427.4551	4485327.2358	NEW	MON @ 2009.1596				
LLH	44 58 25.71729	237 2 39.30118	52.9227	NEW	L1 PHS CEN @ 2009.1596				
LLH	44 58 25.71721	237 2 39.30112	52.8162	NEW	ARP @ 2009.1596				
LLH	44 58 25.71721	237 2 39.30112	52.8162	NEW	MON @ 2009.1596				

If the extended report option was selected, next you'll see the BASE STATION section.

Here, the components contributing to the base stations' coordinates are shown in detail. These and the following information are expressed in the ITRF currently in use.

The Extended Report

BASE STATION INFORMATION									
STATION NAME: p376 a 2 (EOLARESVR_OR2004; Salem, OR United States)									
MONUMENT: NO DOMES NUMBER									
XYZ	-2469806.7634	-3788348.6049	4482853.4377	MON	@ 1997.0000	(M)			
XYZ	-0.0141	0.0030	-0.0043	VEL	(M/YR)				
NEU	-0.0000	0.0000	0.0083	MON	TO ARP	(M)			
NEU	0.0009	0.0009	0.1068	ARP	TO L1 PHASE CENTER	(M)			
NEU	0.0002	0.0017	0.1251	ARP	TO L2 PHASE CENTER	(M)			
XYZ	-0.0032	-0.0049	0.0059	MON	TO ARP				
XYZ	-0.0402	-0.0633	0.0761	ARP	TO L1 PHASE CENTER				
XYZ	-2469806.9782	-3788348.6366	4482853.4674	L1	PHS CEN @ 2009.1596				
XYZ	0.0000	0.0000	0.0000	+ XYZ ADJUSTMENTS					
XYZ	-2469806.9782	-3788348.6366	4482853.4674	NEW	L1 PHS CEN @ 2009.1596				
XYZ	-2469806.9381	-3788348.5733	4482853.3913	NEW	ARP @ 2009.1596				
XYZ	-2469806.9348	-3788348.5684	4482853.3855	NEW	MON @ 2009.1596				
LLH	44 56 28.32921	236 53 51.83975	180.9607	NEW	L1 PHS CEN @ 2009.1596				
LLH	44 56 28.32918	236 53 51.83971	180.8539	NEW	ARP @ 2009.1596				
LLH	44 56 28.32918	236 53 51.83971	180.8456	NEW	MON @ 2009.1596				
STATION NAME: mcso a 1 (MARION CNTY COOP; Salem, Oregon, U.S.A.)									
MONUMENT: NO DOMES NUMBER									
XYZ	-2458668.9460	-3792427.4770	4485327.2930	MON	@ 1997.0000	(M)			
XYZ	-0.0131	0.0018	-0.0047	VEL	(M/YR)				
NEU	0.0000	0.0000	0.0000	MON	TO ARP	(M)			
NEU	0.0025	0.0013	0.1065	ARP	TO L1 PHASE CENTER	(M)			
NEU	-0.0007	0.0013	0.1254	ARP	TO L2 PHASE CENTER	(M)			
XYZ	-0.1593	0.0219	-0.0572	VEL	TIMES 12.1597	YRS			
XYZ	0.0000	0.0000	0.0000	MON	TO ARP				
XYZ	-0.0389	-0.0624	0.0770	ARP	TO L1 PHASE CENTER				
XYZ	-2458669.1442	-3792427.5176	4485327.3129	L1	PHS CEN @ 2009.1596				
XYZ	-0.0000	-0.0000	0.0000	+ XYZ ADJUSTMENTS					
XYZ	-2458669.1442	-3792427.5176	4485327.3129	NEW	L1 PHS CEN @ 2009.1596				
XYZ	-2458669.1053	-3792427.4551	4485327.2358	NEW	ARP @ 2009.1596				
XYZ	-2458669.1053	-3792427.4551	4485327.2358	NEW	MON @ 2009.1596				
LLH	44 58 25.71729	237 2 39.30118	52.9227	NEW	L1 PHS CEN @ 2009.1596				
LLH	44 58 25.71721	237 2 39.30112	52.8162	NEW	ARP @ 2009.1596				
LLH	44 58 25.71721	237 2 39.30112	52.8162	NEW	MON @ 2009.1596				

This section includes a priori information.

The Extended Report

BASE STATION INFORMATION									
STATION NAME: p376 a 2 (ECLARESVR_OR2004; Salem, OR United States)									
MONUMENT: NO DCMES NUMBER									
XYZ	-2469806.7634	-3788348.6049	4482853.4377	MON	@	1997.0000	(M)		
XYZ	-0.0141	0.0030	-0.0043	VEL	(M/YR)				
NEU	-0.0000	0.0000	0.0083	MON	TO	ARP	(M)		
NEU	0.0009	0.0009	0.1068	ARP	TO	L1 PHASE CENTER	(M)		
NEU	0.0000	0.0013	0.1254	ARP	TO	L2 PHASE CENTER	(M)		
XYZ	-0.1715	0.0365	-0.0523	VEL	TIMES	12.1597	YRS		
XYZ	-0.0032	-0.0049	0.0059	MON	TO	ARP			
XYZ	-0.0402	-0.0633	0.0761	ARP	TO	L1 PHASE CENTER			
XYZ	-2469806.9782	-3788348.6366	4482853.4674	L1	PHS	CEN	@	2009.1596	
+ XYZ ADJUSTMENTS									
XYZ	-2469806.9782	-3788348.6366	4482853.4674	NEW	L1	PHS	CEN	@	2009.1596
XYZ	-2469806.9381	-3788348.5733	4482853.3913	NEW	ARP	@	2009.1596		
XYZ	-2469806.9348	-3788348.5684	4482853.3855	NEW	MON	@	2009.1596		
LLH	44 56 28.32921	236 53 51.83975	180.9607	NEW	L1	PHS	CEN	@	2009.1596
LLH	44 56 28.32918	236 53 51.83971	180.8539	NEW	ARP	@	2009.1596		
LLH	44 56 28.32918	236 53 51.83971	180.8456	NEW	MON	@	2009.1596		
STATION NAME: mcsa a 1 (MARION CNTY COOP; Salem, Oregon, U.S.A.)									
MONUMENT: NO DCMES NUMBER									
XYZ	-2458668.9460	-3792427.4770	4485327.2930	MON	@	1997.0000	(M)		
XYZ	-0.0131	0.0018	-0.0047	VEL	(M/YR)				
NEU	0.0000	0.0000	0.0000	MON	TO	ARP	(M)		
NEU	0.0025	0.0013	0.1065	ARP	TO	L1 PHASE CENTER	(M)		
NEU	-0.0007	0.0013	0.1254	ARP	TO	L2 PHASE CENTER	(M)		
XYZ	-0.1593	0.0219	-0.0572	VEL	TIMES	12.1597	YRS		
XYZ	0.0000	0.0000	0.0000	MON	TO	ARP			
XYZ	-0.0389	-0.0624	0.0770	ARP	TO	L1 PHASE CENTER			
XYZ	-2458669.1442	-3792427.5176	4485327.3129	L1	PHS	CEN	@	2009.1596	
XYZ	-0.0000	-0.0000	-0.0000	+ XYZ ADJUSTMENTS					
XYZ	-2458669.1442	-3792427.5176	4485327.3129	NEW	L1	PHS	CEN	@	2009.1596
XYZ	-2458669.1053	-3792427.4551	4485327.2358	NEW	ARP	@	2009.1596		
XYZ	-2458669.1053	-3792427.4551	4485327.2358	NEW	MON	@	2009.1596		
LLH	44 58 25.71729	237 2 39.30118	52.9227	NEW	L1	PHS	CEN	@	2009.1596
LLH	44 58 25.71721	237 2 39.30112	52.8162	NEW	ARP	@	2009.1596		
LLH	44 58 25.71721	237 2 39.30112	52.8162	NEW	MON	@	2009.1596		

Computation of the coordinates at the mean epoch of the data.

The Extended Report

BASE STATION INFORMATION									
STATION NAME: p376 a 2 (ECLARESVR_OR2004; Salem, OR United States)									
MONUMENT: NO DCMES NUMBER									
XYZ	-2469806.7634	-3788348.6049	4482853.4377	MON	@	1997.0000	(M)		
XYZ	-0.0141	0.0030	-0.0043	VEL	(M/YR)				
NEU	-0.0000	0.0000	0.0083	MON	TO	ARP	(M)		
NEU	0.0009	0.0009	0.1068	ARP	TO	L1 PHASE CENTER	(M)		
NEU	0.0002	0.0017	0.1251	ARP	TO	L2 PHASE CENTER	(M)		
XYZ	-0.1715	0.0365	-0.0523	VEL	TIMES	12.1597	YRS		
XYZ	-0.0032	-0.0049	0.0059	MON	TO	ARP			
XYZ	-0.0402	-0.0633	0.0761	ARP	TO	L1 PHASE CENTER			
XYZ	-2469806.9782	-3788348.6366	4482853.4674	L1	PHS	CEN	@	2009.1596	
XYZ	0.0000	0.0000	0.0000	+ XYZ ADJUSTMENTS					
XYZ	-2469806.9782	-3788348.6366	4482853.4674	NEW	L1	PHS	CEN	@	2009.1596
XYZ	-2469806.9381	-3788348.5733	4482853.3913	NEW	ARP	@	2009.1596		
XYZ	-2469806.9348	-3788348.5684	4482853.3855	NEW	MON	@	2009.1596		
LLH	44 56 28.32921	236 53 51.83975	180.9607	NEW	L1	PHS	CEN	@	2009.1596
LLH	44 56 28.32918	236 53 51.83971	180.8539	NEW	ARP	@	2009.1596		
LLH	44 56 28.32918	236 53 51.83971	180.8456	NEW	MON	@	2009.1596		
STATION NAME: mcsa a 1 (MARION CNTY COOP; Salem, Oregon, U.S.A.)									
MONUMENT: NO DCMES NUMBER									
XYZ	-2458668.9460	-3792427.4770	4485327.2930	MON	@	1997.0000	(M)		
XYZ	-0.0131	0.0018	-0.0047	VEL	(M/YR)				
NEU	0.0000	0.0000	0.0000	MON	TO	ARP	(M)		
NEU	0.0025	0.0013	0.1065	ARP	TO	L1 PHASE CENTER	(M)		
NEU	-0.0007	0.0013	0.1254	ARP	TO	L2 PHASE CENTER	(M)		
XYZ	-0.1593	0.0219	-0.0572	VEL	TIMES	12.1597	YRS		
XYZ	0.0000	0.0000	0.0000	MON	TO	ARP			
XYZ	-0.0389	-0.0624	0.0770	ARP	TO	L1 PHASE CENTER			
XYZ	-2458669.1442	-3792427.5176	4485327.3129	L1	PHS	CEN	@	2009.1596	
XYZ	-0.0000	-0.0000	-0.0000	+ XYZ ADJUSTMENTS					
XYZ	-2458669.1442	-3792427.5176	4485327.3129	NEW	L1	PHS	CEN	@	2009.1596
XYZ	-2458669.1053	-3792427.4551	4485327.2358	NEW	ARP	@	2009.1596		
XYZ	-2458669.1053	-3792427.4551	4485327.2358	NEW	MON	@	2009.1596		
LLH	44 58 25.71729	237 2 39.30118	52.9227	NEW	L1	PHS	CEN	@	2009.1596
LLH	44 58 25.71721	237 2 39.30112	52.8162	NEW	ARP	@	2009.1596		
LLH	44 58 25.71721	237 2 39.30112	52.8162	NEW	MON	@	2009.1596		

And the coordinates at the mean epoch of the data.

The Extended Report

BASE STATION INFORMATION				
STATION NAME: p376 a 2 (EOLARESVR_OR2004; Salem, OR United States)				
MONUMENT: NO DOMES NUMBER				
XYZ	-2469806.7634	-3788348.6049	4482853.4377	MON @ 1997.0000 (M)
XYZ	-0.0141	0.0030	-0.0043	VEL (M/YR)
NEU	-0.0000	0.0000	0.0083	MON TO ARP (M)
NEU	0.0009	0.0009	0.1068	ARP TO L1 PHASE CENTER (M)
NEU	0.0002	0.0017	0.1251	ARP TO L2 PHASE CENTER (M)
XYZ	-0.1715	0.0365	-0.0523	VEL TIMES 12.1597 YRS
XYZ	-0.0032	-0.0049	0.0059	MON TO ARP
XYZ	-0.0402	-0.0633	0.0761	ARP TO L1 PHASE CENTER
XYZ	-2469806.9782	-3788348.6366	4482853.4674	L1 PHS CEN @ 2009.1596
XYZ	0.0000	0.0000	0.0000	* XYZ ADJUSTMENTS
XYZ	-2469806.9782	-3788348.6366	4482853.4674	NEW L1 PHS CEN @ 2009.1596
XYZ	-2469806.9381	-3788348.5733	4482853.3913	NEW ARP @ 2009.1596
XYZ	-2469806.9348	-3788348.5684	4482853.3855	NEW MON @ 2009.1596
LLH	44 56 28.32921	236 53 51.83975	180.9607	NEW L1 PHS CEN @ 2009.1596
LLH	44 56 28.32918	236 53 51.83971	180.8539	NEW ARP @ 2009.1596
LLH	44 56 28.32918	236 53 51.83971	180.8456	NEW MON @ 2009.1596
STATION NAME: mcs0 a 1 (MARION CNTY COOP; Salem, Oregon, U.S.A.)				
MONUMENT: NO DOMES NUMBER				
XYZ	-2458668.9460	-3792427.4770	4485327.2930	MON @ 1997.0000 (M)
XYZ	-0.0131	0.0018	-0.0047	VEL (M/YR)
NEU	0.0000	0.0000	0.0000	MON TO ARP (M)
NEU	0.0025	0.0013	0.1065	ARP TO L1 PHASE CENTER (M)
NEU	-0.0007	0.0013	0.1254	ARP TO L2 PHASE CENTER (M)
XYZ	-0.1593	0.0219	-0.0572	VEL TIMES 12.1597 YRS
XYZ	0.0000	0.0000	0.0000	MON TO ARP
XYZ	-0.0389	-0.0624	0.0770	ARP TO L1 PHASE CENTER
XYZ	-2458669.1442	-3792427.5176	4485327.3129	L1 PHS CEN @ 2009.1596
XYZ	-0.0000	-0.0000	-0.0000	* XYZ ADJUSTMENTS
XYZ	-2458669.1442	-3792427.5176	4485327.3129	NEW L1 PHS CEN @ 2009.1596
XYZ	-2458669.1053	-3792427.4551	4485327.2358	NEW ARP @ 2009.1596
XYZ	-2458669.1053	-3792427.4551	4485327.2358	NEW MON @ 2009.1596
LLH	44 58 25.71729	237 2 39.30118	52.9227	NEW L1 PHS CEN @ 2009.1596
LLH	44 58 25.71721	237 2 39.30112	52.8162	NEW ARP @ 2009.1596
LLH	44 58 25.71721	237 2 39.30112	52.8162	NEW MON @ 2009.1596

So, if you add the
a priori coordinates
+ ARP TO L1,
+ MON TO ARP
+ VEL offsets,
you will get the
coordinates at the mean
epoch of the data, shown
here highlighted in
yellow, used in the
processing.

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The Extended Report

REMOTE STATION INFORMATION				
STATION NAME: corv 1				
MONUMENT: NO DOMES NUMBER				
XYZ	-2498423.7849	-3802820.9571	4454737.7025	MON @ 2009.1595 (M)
NEU	-0.0014	0.0010	1.5210	MON TO ARP (M)
NEU	0.0014	-0.0010	0.1089	ARP TO L1 PHASE CENTER (M)
NEU	0.0010	0.0005	0.1274	ARP TO L2 PHASE CENTER (M)
XYZ	-0.5945	-0.9067	1.0667	MON TO ARP
XYZ	-0.0429	-0.0635	0.0774	ARP TO L1 PHASE CENTER
XYZ	-2498424.4223	-3802821.9273	4454738.8466	L1 PHS CEN @ 2009.1596
BASELINE NAME: p376 corv				
XYZ	0.4450	1.0132	-0.9754	* XYZ ADJUSTMENTS
XYZ	-2498423.9773	-3802820.9141	4454737.8713	NEW L1 PHS CEN @ 2009.1596
XYZ	-2498423.9344	-3802820.8506	4454737.7938	NEW ARP @ 2009.1596
XYZ	-2498423.3399	-3802819.9439	4454736.7271	NEW MON @ 2009.1596
LLH	44 35 7.92601	236 41 43.42229	107.2518	NEW L1 PHS CEN @ 2009.1596
LLH	44 35 7.92597	236 41 43.42234	107.1429	NEW ARP @ 2009.1596
LLH	44 35 7.92601	236 41 43.42229	105.6219	NEW MON @ 2009.1596
BASELINE NAME: mcs0 corv				
XYZ	0.4343	1.0202	-0.9746	* XYZ ADJUSTMENTS
XYZ	-2498423.9880	-3802820.9071	4454737.8721	NEW L1 PHS CEN @ 2009.1596
XYZ	-2498423.9451	-3802820.8436	4454737.7946	NEW ARP @ 2009.1596
XYZ	-2498423.3506	-3802819.9369	4454736.7279	NEW MON @ 2009.1596
LLH	44 35 7.92603	236 41 43.42171	107.2523	NEW L1 PHS CEN @ 2009.1596
LLH	44 35 7.92599	236 41 43.42176	107.1434	NEW ARP @ 2009.1596
LLH	44 35 7.92603	236 41 43.42171	105.6224	NEW MON @ 2009.1596
BASELINE NAME: stay corv				
XYZ	0.4437	1.0153	-0.9543	* XYZ ADJUSTMENTS
XYZ	-2498423.9786	-3802820.9120	4454737.8923	NEW L1 PHS CEN @ 2009.1596
XYZ	-2498423.9357	-3802820.8485	4454737.8149	NEW ARP @ 2009.1596
XYZ	-2498423.3412	-3802819.9418	4454736.7482	NEW MON @ 2009.1596
LLH	44 35 7.92653	236 41 43.42219	107.2658	NEW L1 PHS CEN @ 2009.1596
LLH	44 35 7.92648	236 41 43.42224	107.1569	NEW ARP @ 2009.1596
LLH	44 35 7.92653	236 41 43.42219	105.6359	NEW MON @ 2009.1596

Next are summaries of the
solutions relative to each
base station.

We'll discuss this a few
minutes, but, for now,
simply be aware that
OPUS "solves" each
baseline separately, then
compares and averages
these results to create the
report.

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The Extended Report

REMOTE STATION INFORMATION									
STATION NAME: corv 1									
MONUMENT: NO DOMES NUMBER									
XYZ	-2498423.7849	-3802820.9571	4454737.7025	MON	@	2009.1595	(M)		
NEU	-0.0014	0.0010	1.5210	MON	TO	ARP	(M)		
NEU	0.0014	-0.0010	0.1089	ARP	TO	L1 PHASE CENTER	(M)		
NEU	0.0010	0.0005	0.1274	ARP	TO	L2 PHASE CENTER	(M)		
XYZ	-0.5945	-0.9067	1.0667	MON	TO	ARP			
XYZ	-0.0429	-0.0635	0.0774	ARP	TO	L1 PHASE CENTER			
XYZ	-2498424.4223	-3802821.9273	4454738.8466	L1	PHS	CEN	@	2009.1596	
BASELINE NAME: p376 corv									
XYZ	0.4450	1.0132	-0.9754	+ XYZ ADJUSTMENTS					
XYZ	-2498423.9773	-3802820.9141	4454737.8713	NEW	L1	PHS	CEN	@	2009.1596
XYZ	-2498423.9344	-3802820.8506	4454737.7938	NEW	ARP	@	2009.1596		
XYZ	-2498423.3399	-3802819.9439	4454736.7271	NEW	MON	@	2009.1596		
LLH	44	35	7.92601	236	41	43.42229	107.2518	NEW	L1 PHS CEN @ 2009.1596
LLH	44	35	7.92597	236	41	43.42234	107.1429	NEW	ARP @ 2009.1596
LLH	44	35	7.92601	236	41	43.42229	105.6219	NEW	MON @ 2009.1596
BASELINE NAME: mcso corv									
XYZ	0.4343	1.0202	-0.9746	+ XYZ ADJUSTMENTS					
XYZ	-2498423.9880	-3802820.9071	4454737.8721	NEW	L1	PHS	CEN	@	2009.1596
XYZ	-2498423.9451	-3802820.8436	4454737.7946	NEW	ARP	@	2009.1596		
XYZ	-2498423.3506	-3802819.9369	4454736.7279	NEW	MON	@	2009.1596		
LLH	44	35	7.92603	236	41	43.42171	107.2523	NEW	L1 PHS CEN @ 2009.1596
LLH	44	35	7.92599	236	41	43.42176	107.1434	NEW	ARP @ 2009.1596
LLH	44	35	7.92603	236	41	43.42171	105.6224	NEW	MON @ 2009.1596
BASELINE NAME: stay corv									
XYZ	0.4437	1.0153	-0.9543	+ XYZ ADJUSTMENTS					
XYZ	-2498423.9786	-3802820.9120	4454737.8923	NEW	L1	PHS	CEN	@	2009.1596
XYZ	-2498423.9357	-3802820.8485	4454737.8149	NEW	ARP	@	2009.1596		
XYZ	-2498423.3412	-3802819.9418	4454736.7482	NEW	MON	@	2009.1596		
LLH	44	35	7.92653	236	41	43.42219	107.2658	NEW	L1 PHS CEN @ 2009.1596
LLH	44	35	7.92648	236	41	43.42224	107.1569	NEW	ARP @ 2009.1596
LLH	44	35	7.92653	236	41	43.42219	105.6359	NEW	MON @ 2009.1596

Here we see the best guess for “my” site’s a priori information. This is based upon the information I provided when I uploaded the data file to OPUS-S and a crude point position solution. Remember that these are also in the IGS08.

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The Extended Report

REMOTE STATION INFORMATION									
STATION NAME: corv 1									
MONUMENT: NO DOMES NUMBER									
XYZ	-2498423.7849	-3802820.9571	4454737.7025	MON	@	2009.1595	(M)		
NEU	-0.0014	0.0010	1.5210	MON	TO	ARP	(M)		
NEU	0.0014	-0.0010	0.1089	ARP	TO	L1 PHASE CENTER	(M)		
NEU	0.0010	0.0005	0.1274	ARP	TO	L2 PHASE CENTER	(M)		
XYZ	-0.5945	-0.9067	1.0667	MON	TO	ARP			
XYZ	-0.0429	-0.0635	0.0774	ARP	TO	L1 PHASE CENTER			
XYZ	-2498424.4223	-3802821.9273	4454738.8466	L1	PHS	CEN	@	2009.1596	
BASELINE NAME: p376 corv									
XYZ	0.4450	1.0132	-0.9754	+ XYZ ADJUSTMENTS					
XYZ	-2498423.9773	-3802820.9141	4454737.8713	NEW	L1	PHS	CEN	@	2009.1596
XYZ	-2498423.9344	-3802820.8506	4454737.7938	NEW	ARP	@	2009.1596		
XYZ	-2498423.3399	-3802819.9439	4454736.7271	NEW	MON	@	2009.1596		
LLH	44	35	7.92601	236	41	43.42229	107.2518	NEW	L1 PHS CEN @ 2009.1596
LLH	44	35	7.92597	236	41	43.42234	107.1429	NEW	ARP @ 2009.1596
LLH	44	35	7.92601	236	41	43.42229	105.6219	NEW	MON @ 2009.1596
BASELINE NAME: mcso corv									
XYZ	0.4343	1.0202	-0.9746	+ XYZ ADJUSTMENTS					
XYZ	-2498423.9880	-3802820.9071	4454737.8721	NEW	L1	PHS	CEN	@	2009.1596
XYZ	-2498423.9451	-3802820.8436	4454737.7946	NEW	ARP	@	2009.1596		
XYZ	-2498423.3506	-3802819.9369	4454736.7279	NEW	MON	@	2009.1596		
LLH	44	35	7.92603	236	41	43.42171	107.2523	NEW	L1 PHS CEN @ 2009.1596
LLH	44	35	7.92599	236	41	43.42176	107.1434	NEW	ARP @ 2009.1596
LLH	44	35	7.92603	236	41	43.42171	105.6224	NEW	MON @ 2009.1596
BASELINE NAME: stay corv									
XYZ	0.4437	1.0153	-0.9543	+ XYZ ADJUSTMENTS					
XYZ	-2498423.9786	-3802820.9120	4454737.8923	NEW	L1	PHS	CEN	@	2009.1596
XYZ	-2498423.9357	-3802820.8485	4454737.8149	NEW	ARP	@	2009.1596		
XYZ	-2498423.3412	-3802819.9418	4454736.7482	NEW	MON	@	2009.1596		
LLH	44	35	7.92653	236	41	43.42219	107.2658	NEW	L1 PHS CEN @ 2009.1596
LLH	44	35	7.92648	236	41	43.42224	107.1569	NEW	ARP @ 2009.1596
LLH	44	35	7.92653	236	41	43.42219	105.6359	NEW	MON @ 2009.1596

In the associated “blocks”, the estimated adjustment and resulting coordinates from each baseline solution are shown.

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The Extended Report

REMOTE STATION INFORMATION									
STATION NAME:		corv		1					
MONUMENT: NO DOMES NUMBER									
XYZ	-2498423.7849	-3802820.9571	4454737.7025	MCN @ 2009.1595 (M)					
NEU	-0.0014	0.0010	1.5210	MCN TO ARP (M)					
NEU	0.0014	-0.0010	0.1089	ARP TO L1 PHASE CENTER (M)					
NEU	0.0010	0.0005	0.1274	ARP TO L2 PHASE CENTER (M)					
XYZ	-0.5945	-0.9067	1.0667	MCN TO ARP					
XYZ	-0.0429	-0.0635	0.0774	ARP TO L1 PHASE CENTER					
XYZ	-2498424.4223	-3802821.9273	4454738.8466	L1 PHS CEN @ 2009.1596					
BASELINE NAME: p376 corv									
XYZ	0.4450	1.0132	-0.9754	+ XYZ ADJUSTMENTS					
XYZ	-2498423.9773	-3802820.9141	4454737.8713	NEW L1 PHS CEN @ 2009.1596					
XYZ	-2498423.9344	-3802820.8506	4454737.7938	NEW ARP @ 2009.1596					
XYZ	-2498423.3399	-3802819.9439	4454736.7271	NEW MCN @ 2009.1596					
LLH	44 35	7.92601	236 41 43.42229	107.2518	NEW L1 PHS CEN @ 2009.1596				
LLH	44 35	7.92597	236 41 43.42234	107.1429	NEW ARP @ 2009.1596				
LLH	44 35	7.92601	236 41 43.42229	105.6219	NEW MCN @ 2009.1596				
BASELINE NAME: mcso corv									
XYZ	0.4343	1.0202	-0.9746	+ XYZ ADJUSTMENTS					
XYZ	-2498423.9880	-3802820.9071	4454737.8721	NEW L1 PHS CEN @ 2009.1596					
XYZ	-2498423.9451	-3802820.8436	4454737.7946	NEW ARP @ 2009.1596					
XYZ	-2498423.3506	-3802819.9369	4454736.7279	NEW MCN @ 2009.1596					
LLH	44 35	7.92603	236 41 43.42171	107.2523	NEW L1 PHS CEN @ 2009.1596				
LLH	44 35	7.92599	236 41 43.42176	107.1434	NEW ARP @ 2009.1596				
LLH	44 35	7.92603	236 41 43.42171	105.6224	NEW MCN @ 2009.1596				
BASELINE NAME: stay corv									
XYZ	0.4437	1.0153	-0.9543	+ XYZ ADJUSTMENTS					
XYZ	-2498423.9786	-3802820.9120	4454737.8923	NEW L1 PHS CEN @ 2009.1596					
XYZ	-2498423.9357	-3802820.8485	4454737.8149	NEW ARP @ 2009.1596					
XYZ	-2498423.3412	-3802819.9418	4454736.7482	NEW MCN @ 2009.1596					
LLH	44 35	7.92653	236 41 43.42219	107.2658	NEW L1 PHS CEN @ 2009.1596				
LLH	44 35	7.92648	236 41 43.42224	107.1569	NEW ARP @ 2009.1596				
LLH	44 35	7.92653	236 41 43.42219	105.6359	NEW MCN @ 2009.1596				

Near the top, in light blue, you can see the pieces need to compute the estimated (NEW) L1 phase center.

Below, in light green, are the three estimates from the each baseline.

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The Extended Report

G-FILES									
Axx2009 228 9 228									
B2009 228 5 0	9 228 659 1	page5 v0909.08IGS	226 1 2 27NGS	2010 7 91FDDFX					
Iant_info.003	NGS	20100616							
C00090001	286164051	30 144713755	32 281166583	28 X0599ACORVX0599AP376					
D 1 2	9032521	1 3 -2281991	2 3 -5618980						
Axx2009 228 9 228									
B2009 228 5 0	9 228 659 1	page5 v0909.08IGS	226 1 2 27NGS	2010 7 91FDDFX					
Iant_info.003	NGS	20100616							
C00090002	397542453	32 103924818	30 305905079	27 X0599ACORVX0599AMCSO					
D 1 2	8318045	1 3 -1709106	2 3 -6334467						
Axx2009 228 9 228									
B2009 228 5 0	9 228 659 1	page5 v0909.08IGS	226 1 2 27NGS	2010 7 91FDDFX					
Iant_info.003	NGS	20100616							
C00090003	425824609	35 -48539879	22 193670380	18 X0599ACORVX0599ASTAY					
D 1 2	6847311	1 3 -1553171	2 3 -7047523						

Following the baseline information are some Bluebook records...

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The Extended Report

POST-FIT RMS BY SATELLITE VS. BASELINE												
	OVERALL	03	06	07	08	10	13	16	19			
p376-corr	0.009	0.010	0.016	...	0.007	0.014	0.005	0.015	0.009			
	20	23	25	27	28							
p376-corr	...	0.008	0.005	...	0.010							
	OVERALL	03	06	07	08	10	13	16	19			
mcs0-corr	0.009	0.010	0.014	...	0.010	0.011	0.006	0.015	0.012			
	20	23	25	27	28							
mcs0-corr	...	0.008	0.005	...	0.010							
	OVERALL	03	06	07	08	10	13	16	19			
stay-corr	0.010	0.014	0.016	...	0.009	0.014	0.006	0.013	0.012			
	20	23	25	27	28							
stay-corr	...	0.011	0.005	...	0.012							
	OVERALL	03	06	07	08	10	13	16	19			
p376-corr	2000	238	237	...	238	169	238	99	187			
	20	23	25	27	28							
p376-corr	...	227	238	...	129							
	OVERALL	03	06	07	08	10	13	16	19			
mcs0-corr	1973	238	234	...	238	169	238	93	185			
	20	23	25	27	28							
mcs0-corr	...	211	238	...	129							
	OVERALL	03	06	07	08	10	13	16	19			
stay-corr	2011	238	238	...	238	169	238	99	199			
	20	23	25	27	28							
stay-corr	...	229	238	...	125							

Following the Bluebook information are solution statistics and observation counts in tabular form ordered by satellite (rows) and baseline (columns)...

The Extended Report

These tables can be a challenge to read, especially for longer data spans, because the lines wrap in the standard 80-column format. Here's the same table without line-wrapping and with the extra header lines removed.

POST-FIT RMS BY SATELLITE VS. BASELINE														
	OVERALL	03	06	07	08	10	13	16	19	20	23	25	27	28
p376-corr	0.009	0.010	0.016	...	0.007	0.014	0.005	0.015	0.009	...	0.008	0.005	...	0.010
mcs0-corr	0.009	0.010	0.014	...	0.010	0.011	0.006	0.015	0.012	...	0.008	0.005	...	0.010
stay-corr	0.010	0.014	0.016	...	0.009	0.014	0.006	0.013	0.01	...	0.011	0.005	...	0.012
OBS BY SATELLITE VS. BASELINE														
	OVERALL	03	06	07	08	10	13	16	19	20	23	25	27	28
p376-corr	2000	238	237	...	238	169	238	99	187	...	227	238	...	129
mcs0-corr	1973	238	234	...	238	169	238	93	185	...	211	238	...	129
stay-corr	2011	238	238	...	238	169	238	99	199	...	229	238	...	125

The Extended Report

```

Covariance Matrix for the xyz OPUS Position
(meters^2).
0.0000069978    0.0000004873    -0.0000000972
0.0000004873    0.0000053511    -0.0000002879
-0.0000000972   -0.0000002879    0.0000040822

Covariance Matrix for the enu OPUS Position
(meters^2).
0.0000060540    0.0000007189    -0.0000006244
0.0000007189    0.0000048712    -0.0000010998
-0.0000006244   -0.0000010998    0.0000055059

Horizontal network accuracy =    0.00573 meters.
Vertical network accuracy   =    0.00460 meters.

```

Next are covariance matrices for the XYZ and NEU vectors, and the network horizontal and vertical accuracy...

The network horizontal and vertical accuracies are a relatively new addition and will become the standard in the future.

Because of the way OPUS-S works (now), these values are derived from empirically determined relationships in the CORS network plus statistics from the individual baseline solutions.

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The Extended Report.

```

Derivation of NAD 83 vector components

Position of reference station ARP in NAD_83(CORS96) (EPOCH:2002.0000).
Xa(m)      Ya(m)      Za(m)
P376 -2469806.16916  -3788349.79220  4482853.31622  2002.00
MCSO -2458668.34414  -3792428.66602  4485327.16392  2002.00
STAY -2455840.11392  -3807675.15002  4474103.71103  2002.00

Position of reference station monument in NAD_83(CORS96) (EPOCH:2002.0000).
Xr(m)      Yr(m)      Zr(m)
P376 -2469806.16496  -3788349.78730  4482853.31032  2002.00
MCSO -2458668.34414  -3792428.66602  4485327.16392  2002.00
STAY -2455840.11392  -3807675.15002  4474103.71103  2002.00

Velocity of reference station monument in NAD_83(CORS96) (EPOCH:2002.0000).
Vx (m/yr)  Vy (m/yr)  Vz (m/yr)
P376      0.00440    0.00380    0.00560
MCSO      0.00550    0.00260    0.00520
STAY      0.00460    0.00290    0.00490

Vectors from unknown station monument to reference station monument
in NAD_83(CORS96) (EPOCH:2002.0000).
Xr-Xu= DX(m)  Yr-Yu= DY(m)  Zr-Zu= DZ(m)
P376      28616.43804  14471.37170  28116.64932  2002.00
MCSO      39754.23886  10392.49298  30590.50292  2002.00
STAY      42582.48908  -4853.99102  19367.05003  2002.00

```

Additional information related to the derivation of NAD 83(2011) vector components...

You'll see four "blocks": the reference sites' ARP and MON coordinates, their velocities and the solution vector components all expressed in the NAD 83(2011) frame.

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The Extended Report

The state plane coordinates expressed using the international foot or US Survey foot (depending on state legislation) rather than meters ...

```
STATE PLANE COORDINATES - International Foot
SPC (3601 OR N)
Northing (Y) [feet] 347675.719
Easting (X) [feet] 7471572.725
Convergence [degrees] -1.98897513
Point Scale 0.99994603
Combined Factor 0.99992941
```

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OPUS Output - Standard OPUS Output - XML

```
FILE: corv0590.05o 000416827
<?xml version="1.0" encoding="UTF-8"?>
<OPUS_SOLUTION>
  <USER_INFORMATION>
    <USER_EMAIL>joe.evjen@gmail.com</USER_EMAIL>
    <SOLUTION_DATE>February 19, 2008</SOLUTION_DATE>
    <SOLUTION_TIME>01:16:22 UTC</SOLUTION_TIME>
    <RINEX_FILE_NAME>zzy1500.07o</RINEX_FILE_NAME>
  </USER_INFORMATION>
  <DATA_INFORMATION>
    <SOFTWARE>
      <PAGES_VERSION>page5 0612.06</PAGES_VERSION>
      <OPUS_VERSION>master3.pl</OPUS_VERSION>
    </SOFTWARE>
    <EMPHEMERIS>igs14293.eph [precise]</EMPHEMERIS>
    <NAV_FILE>brdc1500.07n</NAV_FILE>
    <ANTENNA_NAME>TRM41249.00</ANTENNA_NAME>
    <ARP_HEIGHT>0.0</ARP_HEIGHT>
    <START_TIME>2007/05/30 00:00:00</START_TIME>
    <END_TIME>2007/05/30 23:59:00</END_TIME>
    <OBS_USED>
      <NUMBER_USED>52955</NUMBER_USED>
      <TOTAL_OBS>55069</TOTAL_OBS>
      <PERCENTAGE>96</PERCENTAGE>
    </OBS_USED>
    <FIXED_AMP>
      <NUMBER_FIXED>218</NUMBER_FIXED>
      <NUMBER_AMP>242</NUMBER_AMP>
      <PERCENTAGE>90</PERCENTAGE>
    </FIXED_AMP>
    <OVERALL_RMS UNIT="m">0.021</OVERALL_RMS>
  </DATA_INFORMATION>
  <POSITION>
    <REF_FRAME>NAD_83(CORS96)</REF_FRAME>
    <EPOCH>2002.0000</EPOCH>
    <COORD_SET>
      <RECT_COORD>
        <COORDINATE AXIS="X" UNIT="m" UNCERTAINTY="0.003">-496255.901</COORDINATE>
        <COORDINATE AXIS="Y" UNIT="m" UNCERTAINTY="0.022">-5510741.494</COORDINATE>
        <COORDINATE AXIS="Z" UNIT="m" UNCERTAINTY="0.017">-3162058.243</COORDINATE>
      </RECT_COORD>
      <ELLIP_COORD>
        <LAT>
          <DEGREES>29</DEGREES>
          <MINUTES>54</MINUTES>
          <SECONDS>48.44070</SECONDS>
        </ELLIP_COORD>
      </COORD_SET>
    </POSITION>
  </OPUS_SOLUTION>
```

OPUS-RS. . .rapid-static processing

- A Little OPUS-RS History.
- The OPUS-RS Interface.
- How Good Can I Do With OPUS-RS?
- A Quick Example (cont.).
- The Extended Report (cont.).
- How Does OPUS-RS Work?
- OPUS-S and OPUS-RS Uploads By Month.

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A Little OPUS-RS History

Although successful, OPUS obviously does not satisfy the needs of all users. Discussions with the user community about future development began almost immediately after OPUS was made public.

These early discussions clearly indicated that the most desired enhancement would be a tool capable of producing a similar quality result from a shorter data span.

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A Little OPUS-RS History

Work by several groups demonstrated that reliably producing results of similar quality to OPUS from shorter data spans was possible.

Collaboration between the NGS and the Satellite Positioning and Inertial Navigation (SPIN) group at The Ohio State University enabled Schwarz (DST) to implement a new processing engine capable of generating those results.

In early 2007, OPUS-RS was made publically available after its own trial period. To better delineate uses, the original OPUS processing stream was renamed OPUS-S.

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RSGPS

- Based (conceptually) on OSU MPGPS program
- Similar to Wide Area Rapid Static and Virtual Reference Station (VRS) computations
- 96 subroutines (21 in LAMBDA)
 - Least squares Ambiguity De-correlation Adjustment
- 9739 lines of code (1336 from LAMBDA)

46

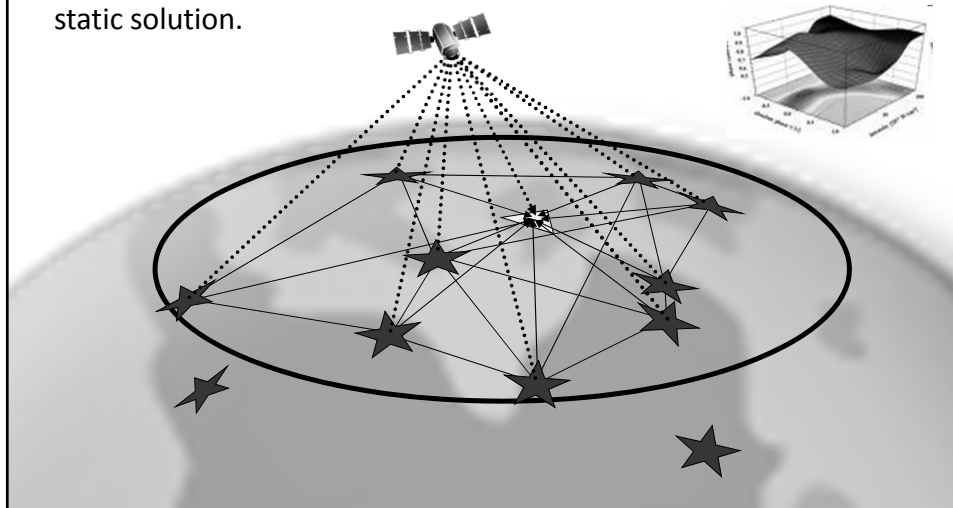
OPUS-RS

- Uses RSGPS program instead of PAGES (based on OSU MPGPS program)
- Uses P1 and P2 as well as L1 and L2 obs
- Resolves all ambiguities with LAMBDA
- Geometry free linear combination used to determine DD ionospheric delays

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Rapid-static: OPUS first creates an atmospheric delay model from surrounding CORS data.

Your position is then quickly determined by differential GPS static solution.



The OPUS-RS Interface

With OPUS-RS, the beautiful simplicity remained. In fact the entry form is the same as for OPUS-S. The user provides:

- Their email address.
- An antenna type.
- The vertical offset to the ARP.
- 15-minutes to 2-hours of GPS L1 + L2 data.

The user receives:

- Coordinates accurate to a few centimeters.

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The OPUS-RS Interface

<http://geodesy.noaa.gov/OPUS/>

The same interface is used except one clicks the "Upload to RAPID-STATIC" button instead.

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A Quick Example

USER: mark.schenewerk@noaa.gov	DATE: April 01, 2010
RINEX FILE: corv059f.09o	TIME: 16:17:51 UTC
SOFTWARE: rsgps 1.35 RS11.pr1 1.57	START: 2009/02/28 05:00:00
EPHEMERIS: igs15206.eph [precise]	STOP: 2009/02/28 06:59:30
NAV FILE: brdc0590.09n	OBS USED: 5652 / 11169 : 51%
ANT NAME: ASH700936C_M	QUALITY IND. 48.23/108.85
ARP HEIGHT: 1.521	NORMALIZED RMS: 0.280
REF FRAME: NAD_83 (CORS96) (EPOCH:2002.0000)	ITRF00 (EPOCH:2009.15959)
X: -2498422.589(m) 0.015 (m)	-2498423.330 (m) 0.015 (m)
Y: -3802821.147 (m) 0.012 (m)	-3802819.929 (m) 0.012 (m)
Z: 4454736.644 (m) 0.021 (m)	4454736.717 (m) 0.021 (m)
LAT: 44 35 7.91061 0.004 (m)	44 35 7.92619 0.004 (m)
E LON: 236 41 43.48069 0.011 (m)	236 41 43.42230 0.011 (m)
W LON: 123 18 16.51931 0.011 (m)	123 18 16.57770 0.011 (m)
EL HGT: 105.986 (m) 0.026 (m)	105.602 (m) 0.026 (m)
ORTHO HGT: 128.517 (m) 0.030 (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] 475821.309	2277335.372
Convergence [degrees] -0.21381414	-1.98897509
Point Scale 0.99960719	0.99994603
Combined Factor 0.99959058	0.99992942
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
DG5352 STAY STAYTON COOP CORS ARP	N444950.530 W1224915.036 47030.9
DE6258 MCSO MARION CNTY COOP CORS ARP	N445825.701 W1225720.639 51226.8
DI7529 P367 NEWPTAIR_OR2007 CORS ARP	N443506.870 W1240341.598 60113.5

Shown here is part of the OPUS-RS report for the same CORV data discussed earlier.

The results differ by 2.4 cm horizontally and 0.2 cm vertically from the accepted position projected to the epoch of the data.

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A Quick Example

USER: mark.schenewerk@noaa.gov	DATE: April 01, 2010
RINEX FILE: corv059f.09o	TIME: 16:17:51 UTC
SOFTWARE: rsgps 1.35 RS11.pr1 1.57	START: 2009/02/28 05:00:00
EPHEMERIS: igs15206.eph [precise]	STOP: 2009/02/28 06:59:30
NAV FILE: brdc0590.09n	OBS USED: 5652 / 11169 : 51%
ANT NAME: ASH700936C_M	QUALITY IND. 48.23/108.85
ARP HEIGHT: 1.521	NORMALIZED RMS: 0.280
REF FRAME: NAD_83 (CORS96) (EPOCH:2002.0000)	ITRF00 (EPOCH:2009.15959)
X: -2498422.589(m) 0.015 (m)	-2498423.330 (m) 0.015 (m)
Y: -3802821.147 (m) 0.012 (m)	-3802819.929 (m) 0.012 (m)
Z: 4454736.644 (m) 0.021 (m)	4454736.717 (m) 0.021 (m)
LAT: 44 35 7.91061 0.004 (m)	44 35 7.92619 0.004 (m)
E LON: 236 41 43.48069 0.011 (m)	236 41 43.42230 0.011 (m)
W LON: 123 18 16.51931 0.011 (m)	123 18 16.57770 0.011 (m)
EL HGT: 105.986 (m) 0.026 (m)	105.602 (m) 0.026 (m)
ORTHO HGT: 128.517 (m) 0.030 (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] 475821.309	2277335.372
Convergence [degrees] -0.21381414	-1.98897509
Point Scale 0.99960719	0.99994603
Combined Factor 0.99959058	0.99992942
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
DG5352 STAY STAYTON COOP CORS ARP	N444950.530 W1224915.036 47030.9
DE6258 MCSO MARION CNTY COOP CORS ARP	N445825.701 W1225720.639 51226.8
DI7529 P367 NEWPTAIR_OR2007 CORS ARP	N443506.870 W1240341.598 60113.5

Note that the solution quality measures are slightly different.

OBS USED > 50%
QUALITY IND. > 3
NORM. RMS ≈ 1
Uncertainties < 5 cm

The uncertainties are standard deviations from the solution, not the peak-to-peak values reported by OPUS-S.

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A Quick Example

```

USER: mark.schenewerk@noaa.gov          DATE: April 01, 2010
RINEX FILE: corv059f.09o                TIME: 16:17:51 UTC

SOFTWARE: rsgps 1.35 RS11.prl 1.57      START: 2009/02/28 05:00:00
EPHEMERIS: igl15206.eph [precise]        STOP: 2009/02/28 06:59:30
NAV FILE: brdc0590.09n                  OBS USED: 5652 / 11169 : 51%
ANT NAME: ASH700936C_M                  QUALITY IND. 48.23/108.85
ARP HEIGHT: 1.521                       NORMALIZED RMS: 0.280

REF FRAME: NAD_83 (CORS96) (EPOCH:2002.0000)    ITRF00 (EPOCH:2009.15959)

X: -2498422.589(m) 0.015(m) -2498423.330(m) 0.015(m)
Y: -3802821.147(m) 0.012(m) -3802819.929(m) 0.012(m)
Z: 4454736.644(m) 0.021(m) 4454736.717(m) 0.021(m)

LAT: 44 35 7.91061 0.004(m) 44 35 7.92619 0.004(m)
E LON: 236 41 43.48069 0.011(m) 236 41 43.42230 0.011(m)
W LON: 123 18 16.51931 0.011(m) 123 18 16.57770 0.011(m)
EL HGT: 105.986(m) 0.026(m) 105.602(m) 0.026(m)
ORTHO HGT: 128.517(m) 0.030(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] 475821.309 2277335.372
Convergence [degrees] -0.21381414 -1.98897509
Point Scale 0.99960719 0.99994603
Combined Factor 0.99959058 0.99992942

US NATIONAL GRID DESIGNATOR: 10TDQ7582136954 (NAD 83)

BASE STATIONS USED
PID DESIGNATION LATITUDE LONGITUDE DISTANCE(m)
DR4503 P376 EOLARESVR_OR2004 CORS ARP N445628.313 W1230608.100 42648.2
DG5352 STAY STAYTON COOP CORS ARP N444950.530 W1224915.036 47030.9
DE6258 MCSO MARION CNTY COOP CORS ARP N445825.701 W1225720.639 51226.8
DI7529 P367 NEWPTAIR_OR2007 CORS ARP N443506.870 W1240341.598 60113.5

```

Although the quality indices, normalized RMS and uncertainties are OK, the percentage of observations used gives this solution a 🙄

If you are uncomfortable with your solution, the same diagnostic steps discussed for OPUS-S can be applied here too.

The Extended Report

Of necessity, the OPUS-RS extended report is larger than the corresponding OPUS-S solution. Too large to be conveniently shown here. But while seemingly intimidating, the OPUS-RS extended report sections are basically the same as those in the OPUS-S extended report.

Some additional sections include:

- A covariance matrix for the reference-station-only solution.
- A correlation as well as a covariance matrix.
- Various Dilutions Of Precision (DOPs).

How Good Can I Do With OPUS-RS?

OPUS-RS can produce quality results from more challenging “short” data sets, but it is slightly more restrictive in the data sets allowed. Because of the restrictions, which will be discussed later, the NGS recently made available the “OPUS-RS Accuracy and Availability” tool (Choi, NGS).

Typical estimated and empirical accuracies within the continental U.S. are comparable to OPUS-S.

Remember that the estimated accuracies suggested by this tool are just that - estimates. Confirming the quality of the OPUS solution remains the user’s responsibility.

55

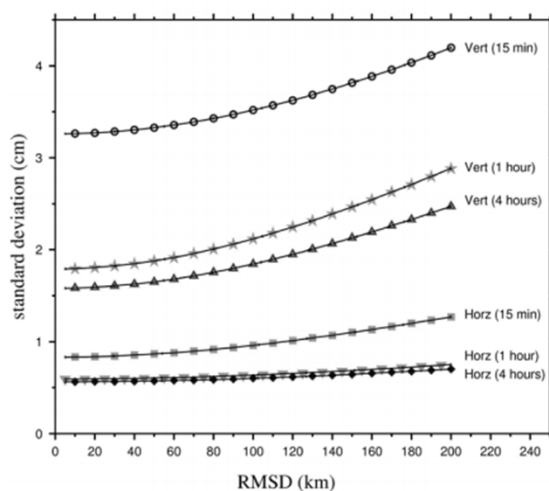
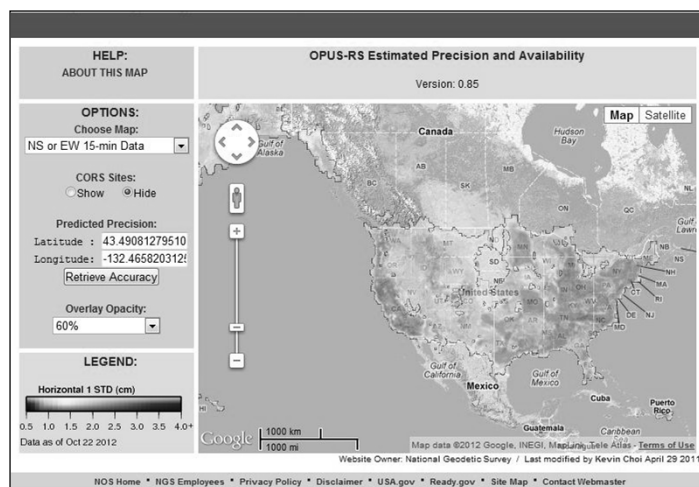


Figure 3. Predicted standard deviations in the vertical (ellipsoid height) and in each horizontal dimension (north-south or east-west), achievable with OPUS-RS, as a function of RMSD for data spans of 15 minutes, 1 hour and 4 hours and an IDOP value of 0.45.

Snay, R., K. Choi, G. Mader, C. Schwarz, T. Soler, and N. Weston (2011). How precise is OPUS? Part 1: Experimental results, *The American Surveyor*, 8(5), 49-50, 52, 53-54.

How Good Can I Do With OPUS-RS?

The OPUS-RS Accuracy and Availability Tool.

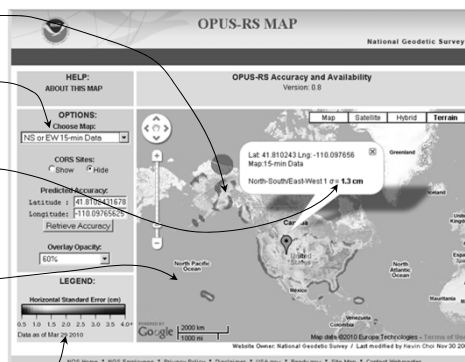


http://www.ngs.noaa.gov/OPUS/Plots/Gmap/OPUSRS_sigmap.shtml

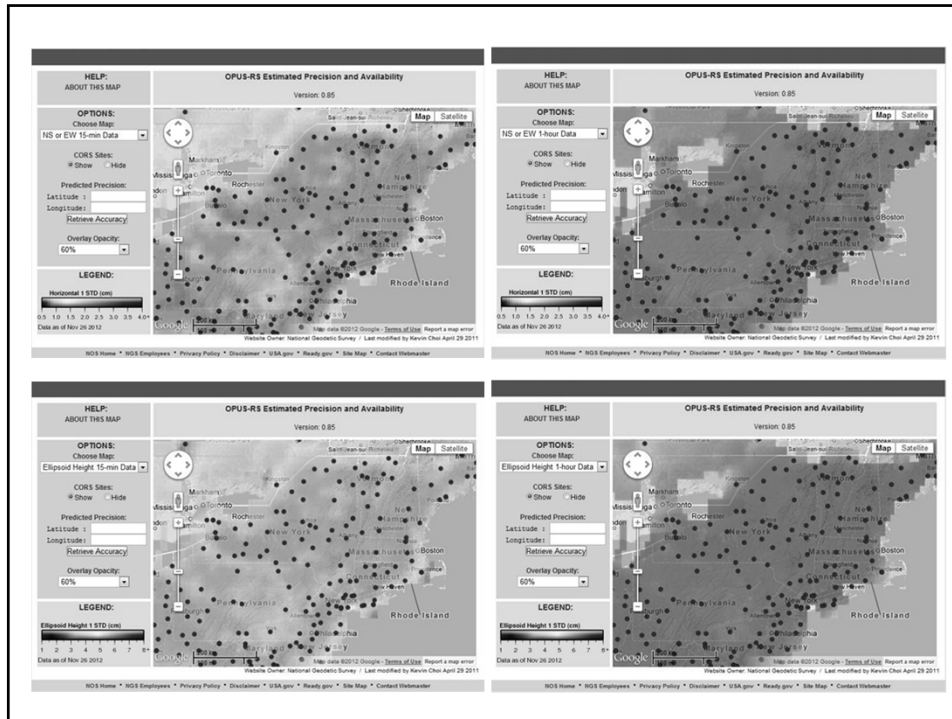
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How Good Can I Do With OPUS-RS?

- 1σ for each 0.2 degree grid.
- Horizontal and vertical standard errors for 15 minutes and 1-hour length data.
- Inverse Distance Weighting method to interpolate the sigmas.
- Areas outside the color overlay are where there are less than three active CORS sites within 250 km range. OPUS-RS will usually fail at these locations.
- Automated Weekly update
 - Use updated CORS list and observation data availability
- Global coverage including non-US territories.



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How Does OPUS-RS Work?

OPUS-RS uses the RSGPS program which was developed specifically for this purpose.

Like OPUS-S, OPUS-RS uses state-of-the-art models, but the strategy to fix phase ambiguities to their integer values differs.

To fix integers, OPUS-RS introduces more information:

- Pseudorange and carrier phase.
- More reference stations if possible.

How Does OPUS-RS Work?

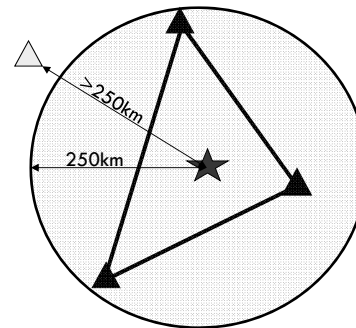
OPUS-RS selects three to nine “best” CORS based upon:

- Having common satellite visibility with the user data.
- Having distances from the user’s site <250 km.

This is shown here graphically.
The star represents the user’s site. The triangles are CORS.

No CORS farther than 250 km from the user’s site will be included.

The three CORS minimum is shown.
No more than nine are used.



Choi, 2010, personal communication.

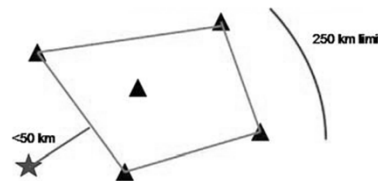
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How Does OPUS-RS Work?

In addition, user’s site must be no more than 50 km from the (convex) polygon created by the selected CORS.

Again in this figure, the star represents the user’s site; the triangles are CORS. Five CORS and their resulting polygon are shown in this example.

If the user’s site, the star, is more than 50 km outside this polygon, alternate CORS will be considered. If none can be found, the processing will abort.



Schwarz et al., “Accuracy assessment of the National Geodetic Survey’s OPUS-RS utility”, 2009, *GPS Solutions*, 13(2), 119-132.

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How Does OPUS-RS Work?

OPUS-RS uses no less than 1-hour of CORS data and no more than the submitted data's span plus 15-minutes before and after.

The CORS data are used to estimate the atmospheric delays at each CORS and predict them at the user's site.

OPUS-RS then processes each baseline to the user's site individually to produce an improved a priori position.

Switching modes, the previously determined values and all data are used in an "integer-fixed" solution for the user's site.

Schwarz et al., "Accuracy assessment of the National Geodetic Survey's OPUS-RS utility", 2009, *GPS Solutions*, 13(2), 119-132.

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OPUS static vs. rapid static

	static	rapid static
input (dual-frequency GPS)	2-48 hours	15 minutes-2 hours
output	normal, extended, XML datasheet, project	normal, extended, XML
accuracy (95%confidence)	1-2 cm horizontal 3-6 cm ellipsoidal height	1-2 cm horizontal 4-8 cm ellipsoidal height
network geometry	3 CORS, preferably within 1000 km of rover	3-9 CORS, surrounding & within 250 km of rover
availability	global	90% of CONUS (subject to CORS configuration)

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