



Using and Understanding OPUS



MEMBER
IN
GOOD
STANDING

**New York State Association of Professional Land Surveyors
Saratoga Springs, NY
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www.aot.state.vt.us/geodetic/Advisor/advisorpresent.htm

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

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.

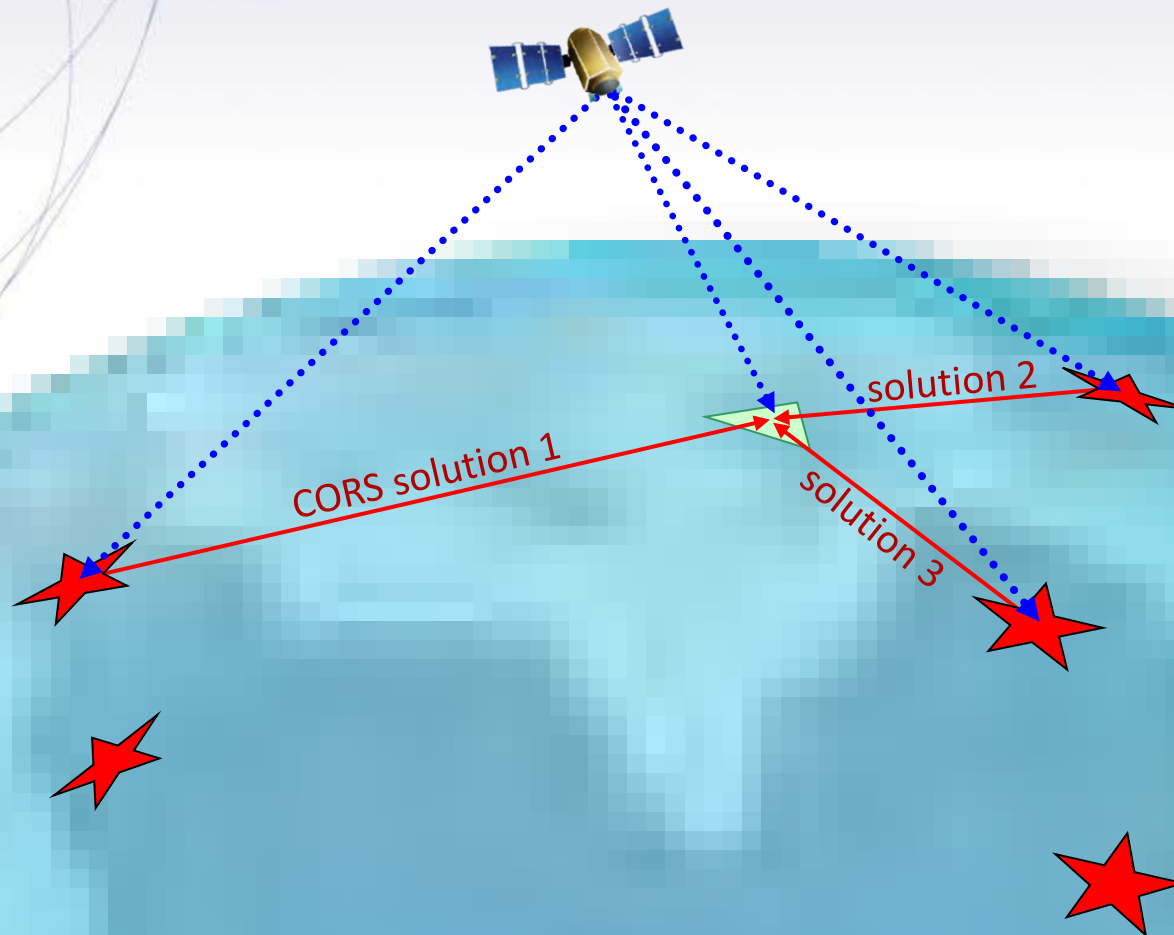
The OPUS-S Interface



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.

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

This process is repeated twice 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.

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://igsjb.jpl.nasa.gov/igsjb/center/analysis/noaa.acn>

How Does OPUS-S Work?

OPUS-S modeling highlights:

- Satellite coordinates from the **International GNSS Service (IGS)** precise ephemerides.
<http://igscb.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.

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.

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.

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.



OPUS: Online Positioning User Service

National Geodetic Survey

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



Prefer the old OPUS?



Antenna height of your antenna's reference point.

OPTIONS

extended solution

in/exclude CORS

SPC zone

geoid model – transition

project

profile

publish

Options 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
Sample

Use:

Exclude:

Look up site IDs



browse map

State plane coordinates

Override your native SPCS zone

let OPUS choose

Geoid Model

Customize your orthometric height model

GEOID09

Contribute to a project

Enter the project identifier provided by your project manager.

My profile

Customize OPUS defaults for future solutions

Publish my solution

Share your solutions

No, don't publish

Upload to Rapid-Static

Upload to Static

for data > 15 min. < 2 hrs.

for data > 2 hrs. < 48 hrs.

**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?



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.

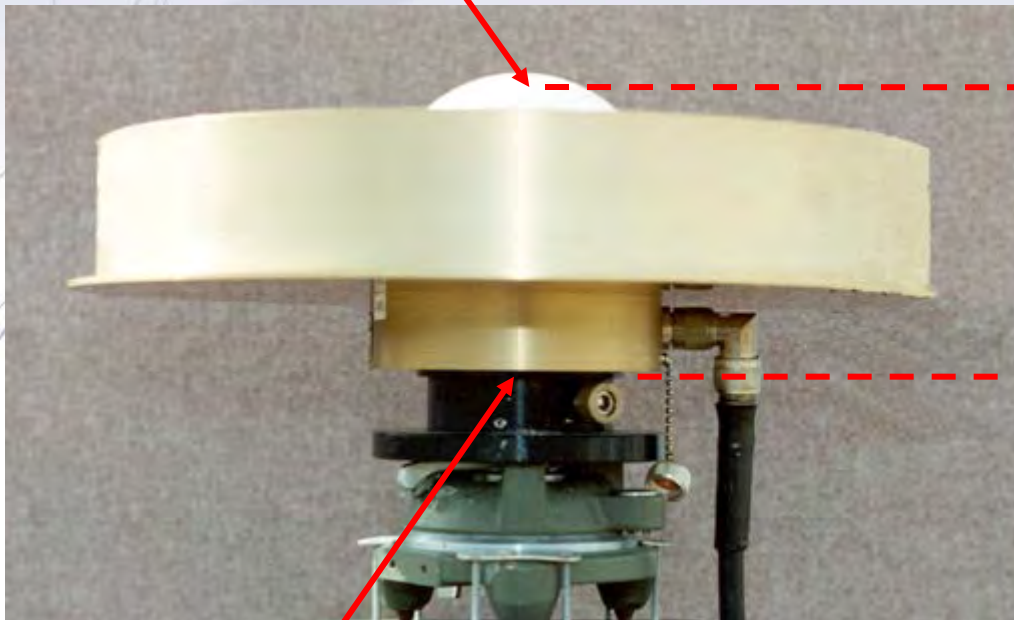
See GPS Antenna Calibration for photo's and diagrams that show where the ARP is on most antennas:

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

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

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

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

How Good Can I Do With OPUS-S?

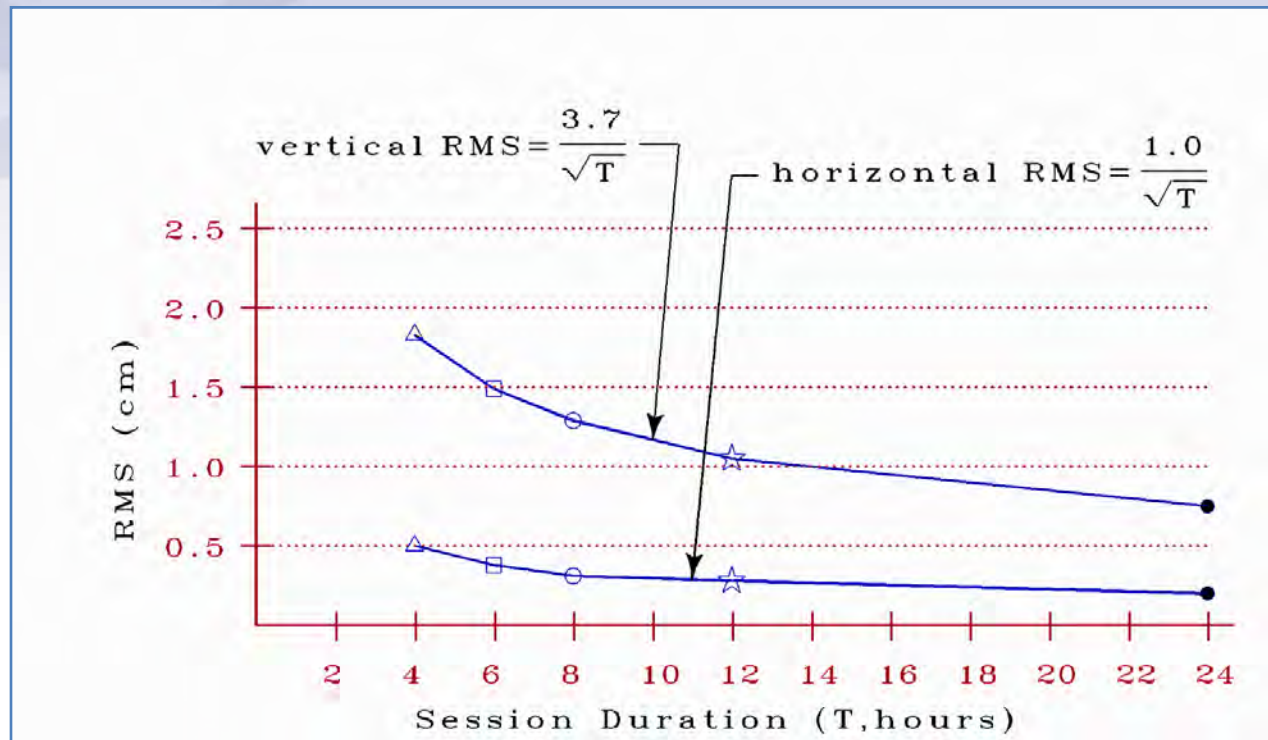
OPUS-S reliably addresses the more historically conventional requirements for GPS data processing. It typically yields accuracies of:

- 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.

How Good Can I Do With OPUS-S?

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



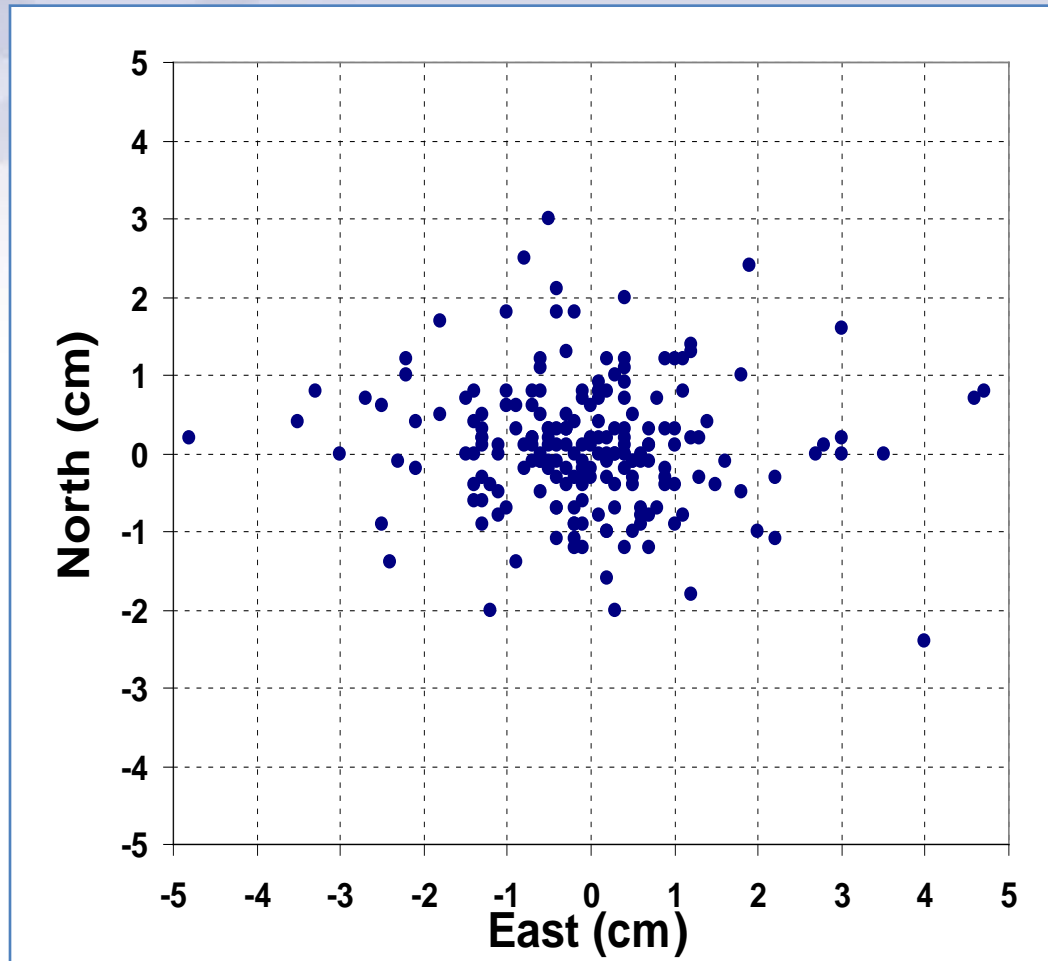
Eckl et al., 2001, "Accuracy of GPS-derived relative positions as a function of interstation distance and observing-session duration", J. of Geod. 75, 633-640).

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

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: <math><0.1\text{ cm}</math>
N-S RMS: 0.8 cm
E-W RMS: 1.4 cm



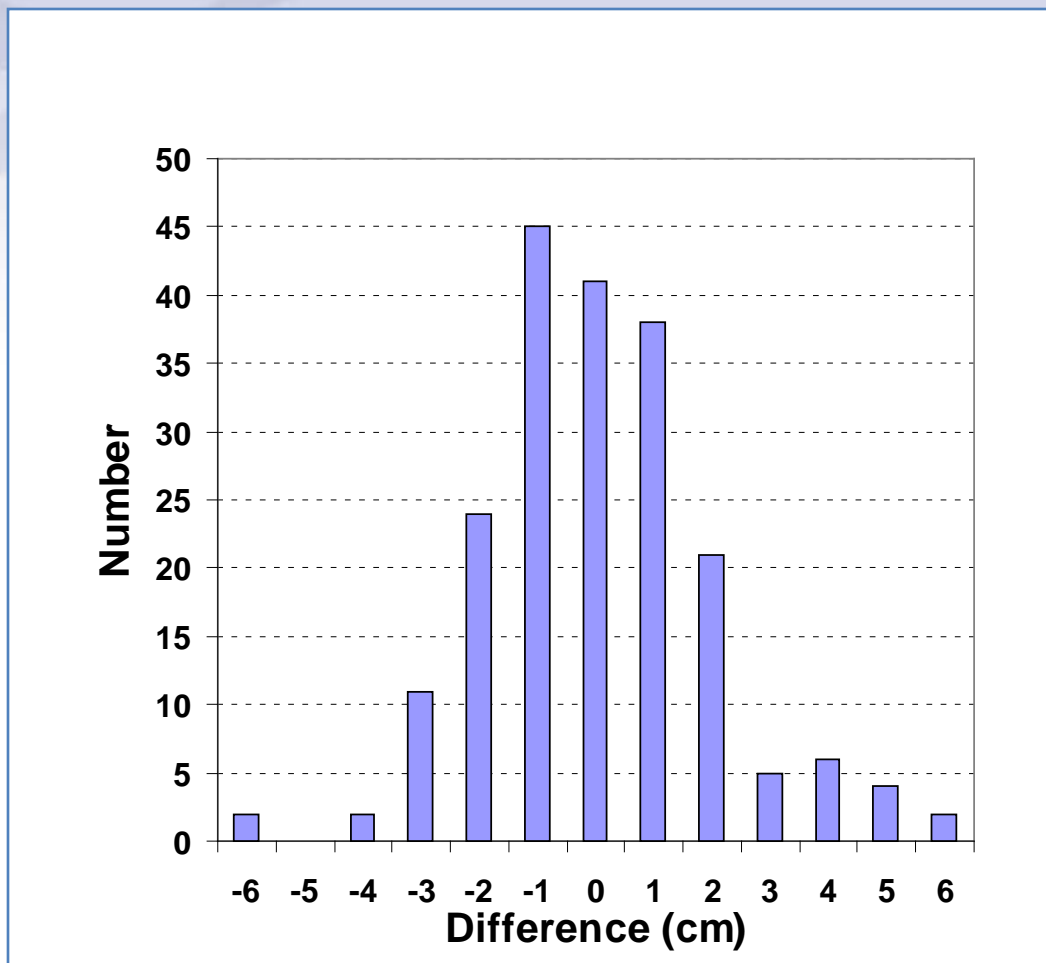
Weston, N. "OPUS: Online Positioning User Service", CGSIC USSLS MEETING, 2008-07-08, NEW ORLEANS, LA.

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.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 (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)

```

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.

BASE STATIONS USED

| PID | DESIGNATION | LATITUDE | LONGITUDE | DISTANCE (m) |
|--------|--------------------------------|-------------|--------------|--------------|
| DH4503 | P376 EOLARESVR_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 |

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BASE STATIONS USED
PID DESIGNATION LATITUDE LONGITUDE DISTANCE(m)
DH4503 P376 EOLARESVR_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

```

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NAV FILE: brdc0590.09n
ANT NAME: ASH700936C_M NONE
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OBS USED: 3984 / 6181 : 97%
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Easting (X) [meters] 475821.304      2277335.367
Convergence [degrees] -0.21381419      -1.98897513
Point Scale 0.99960719      0.99994603
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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
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

```

I apologize for stating the obvious, but ...

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

A Quick Example

```

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BASE STATIONS USED
PID DESIGNATION LATITUDE LONGITUDE DISTANCE (m)
DH4503 P376 EOLARESVR_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 ...

Check the quality control measures provided:

OBS USED > 90%

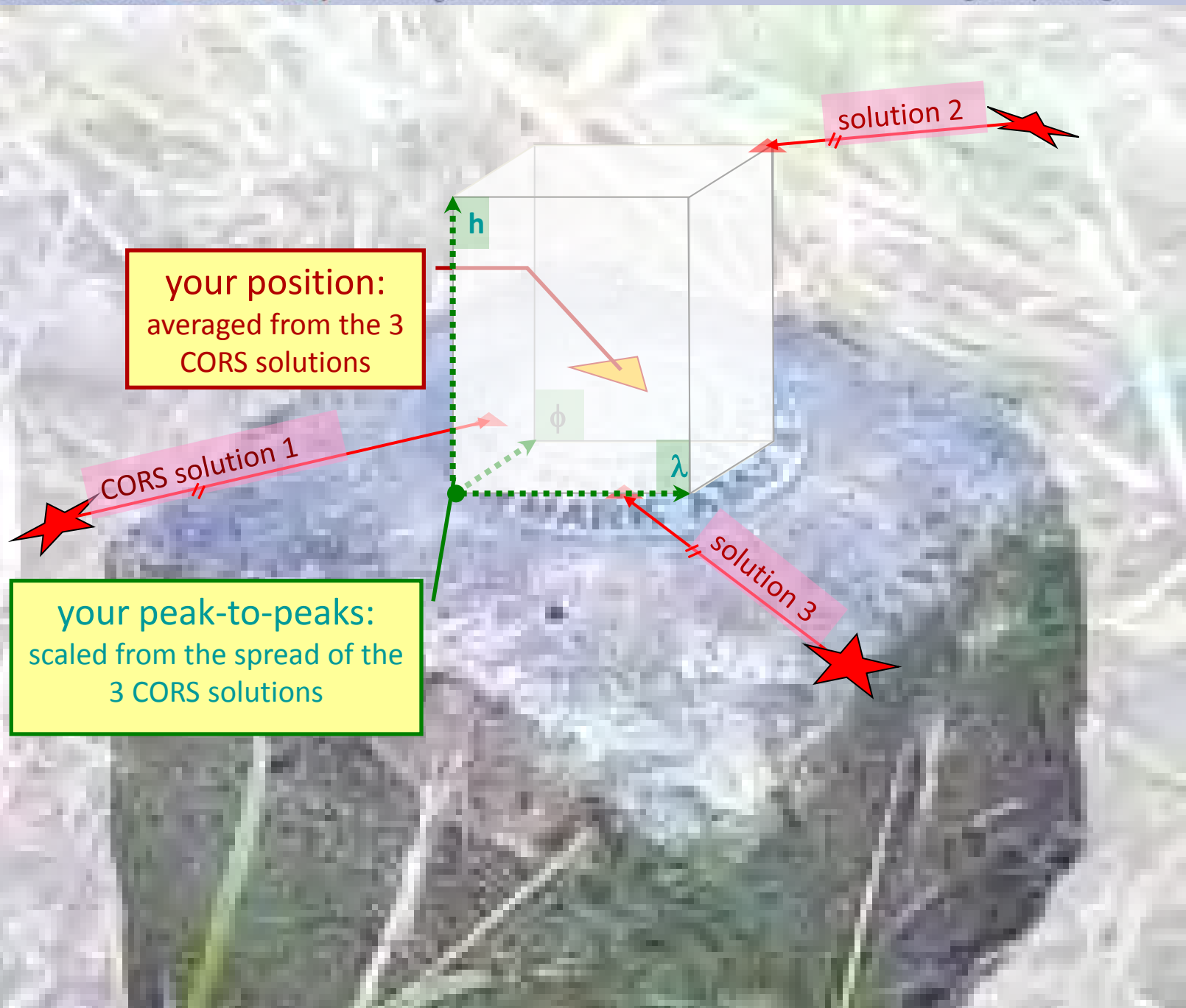
FIXED AMB > 50%

OVERALL RMS < 3 cm

peak-to-peak < 5 cm

In this example, we have a





your position:
averaged from the 3
CORS solutions

your peak-to-peaks:
scaled from the spread of the
3 CORS solutions

CORS solution 1

solution 2

solution 3

h

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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 (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 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 |

Computation of 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: 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 |

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: 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 |

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.

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

```

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.

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.

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.

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

```

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.

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 9IFDDFX
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 9IFDDFX
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 9IFDDFX
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...

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 | | | | |
| 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 | | | | |
| 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 | | | | |

OBS BY SATELLITE VS. BASELINE

| | | | | | | | | | |
|-----------|---------|-----|-----|-----|-----|-----|-----|----|-----|
| p376-corr | OVERALL | 03 | 06 | 07 | 08 | 10 | 13 | 16 | 19 |
| | 2000 | 238 | 237 | ... | 238 | 169 | 238 | 99 | 187 |
| | 20 | 23 | 25 | 27 | 28 | | | | |
| p376-corr | ... | 227 | 238 | ... | 129 | | | | |
| mcs0-corr | OVERALL | 03 | 06 | 07 | 08 | 10 | 13 | 16 | 19 |
| | 1973 | 238 | 234 | ... | 238 | 169 | 238 | 93 | 185 |
| | 20 | 23 | 25 | 27 | 28 | | | | |
| mcs0-corr | ... | 211 | 238 | ... | 129 | | | | |
| stay-corr | OVERALL | 03 | 06 | 07 | 08 | 10 | 13 | 16 | 19 |
| | 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-corv | 0.009 | 0.010 | 0.016 | ... | 0.007 | 0.014 | 0.005 | 0.015 | 0.009 | ... | 0.008 | 0.005 | ... | 0.010 |
| mcso-corv | 0.009 | 0.010 | 0.014 | ... | 0.010 | 0.011 | 0.006 | 0.015 | 0.012 | ... | 0.008 | 0.005 | ... | 0.010 |
| stay-corv | 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-corv | 2000 | 238 | 237 | ... | 238 | 169 | 238 | 99 | 187 | ... | 227 | 238 | ... | 129 |
| mcso-corv | 1973 | 238 | 234 | ... | 238 | 169 | 238 | 93 | 185 | ... | 211 | 238 | ... | 129 |
| stay-corv | 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.

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 -2469806.16816 -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-X= DX (m)    Yr-Y= DY (m)    Zr-Z= DZ (m)
P376    28616.43804    14471.37170    28116.64932  2002.00
MCSO    39754.25886    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.

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 |

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> zzyy1500.07o </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 REF NONE </ANTENNA_NAME>
    <ANTENNA_HEIGHT> 0.0 </ANTENNA_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_AMB>
      <NUMBER_FIXED> 218 </NUMBER_FIXED>
      <NUMBER_AMB> 242 </NUMBER_AMB>
      <PERCENTAGE> 90 </PERCENTAGE>
    </FIXED_AMB>
    <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>
        </LAT>
        <LONGITUDE>
          <DEGREES> 122 </DEGREES>
          <MINUTES> 57 </MINUTES>
          <SECONDS> 57.00000 </SECONDS>
        </LONGITUDE>
        <DISTANCE>
          <METERS> 0.0 </METERS>
        </DISTANCE>
      </ELLIP_COORD>
    </COORD_SET>
    <UNCERTAINTY> 0.003 </UNCERTAINTY>
  </POSITION>

```

```
1008 NOTE: Antenna offsets supplied by the user were zero. Coordinates
1008 returned will be for the antenna reference point (ARP).
1008
NGS OPUS SOLUTION REPORT
=====
USER: je DATE: January 13, 2006
RINEX FILE: cc RINEX FILE: cc TIME: 19:08:14 UTC

SOFTWARE: page5 0601.10 master3.pl START: 2005/02/28 05:00:00
EMPHEMERIS: igs14293.eph [precise] STOP: 2005/02/28 06:59:30
NAV FILE: brdc1500.07n OBS USED: 4228 / 4314 : 98%
ANT NAME: TRM41249.00 REF NONE # FIXED AMB: 25 / 29 : 86%
ARP HEIGHT: 0.0 OVERALL RMS: 0.013(m)

IGS14293.00 REF NONE NAV FILE: brdc1500.07n ITRF00 (EPOCH:2005.1596)
TRM41249.00 REF NONE ANTENNA_NAME: TRM41249.00 REF NONE ANTENNA_HEIGHT: 2002.0000
0.0
2007/05/30 00:00:00 (m) 0.018 (m) -2498423.872 (m) 0.018 (m)
2007/05/30 23:59:00 (m) 0.021 (m) -3802820.836 (m) 0.021 (m)
4454737.695 (m) 0.024 (m) 4454737.792 (m) 0.024 (m)

LAT: 29 54 48.44070 (m) 0.002 (m) 44 35 7.92698 0.002 (m)
E LON: 122 57 57.00000 (m) 0.014 (m) 236 41 43.42434 0.014 (m)
W LON: 122 57 57.00000 (m) 0.014 (m) 123 18 16.57566 0.014 (m)
EL HGT: 107.485 (m) 0.034 (m) 107.108 (m) 0.034 (m)
ORTHO HGT: 130.010 (m) 0.043 (m) [Geoid03 NAVD88]

COORDINATES STATE PLANE COORDINATES
Zone 10) SPC (3601 OR N)
Northing (Y) [meters] 4936954.907 105971.557
Easting (X) [meters] 475821.322 2277335.385
Convergence [degrees] 1381402 -1.98897497
Point Scale 0.99960719 0.99994603
Combined Factor 0.99959034 0.99992918

NEAREST NGS PUBLISHED CONTROL POINT
AH2486 CORVALLIS CORS ARP N443507.910 W1231816.519 0.0
```

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.

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.

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.

RSGPS

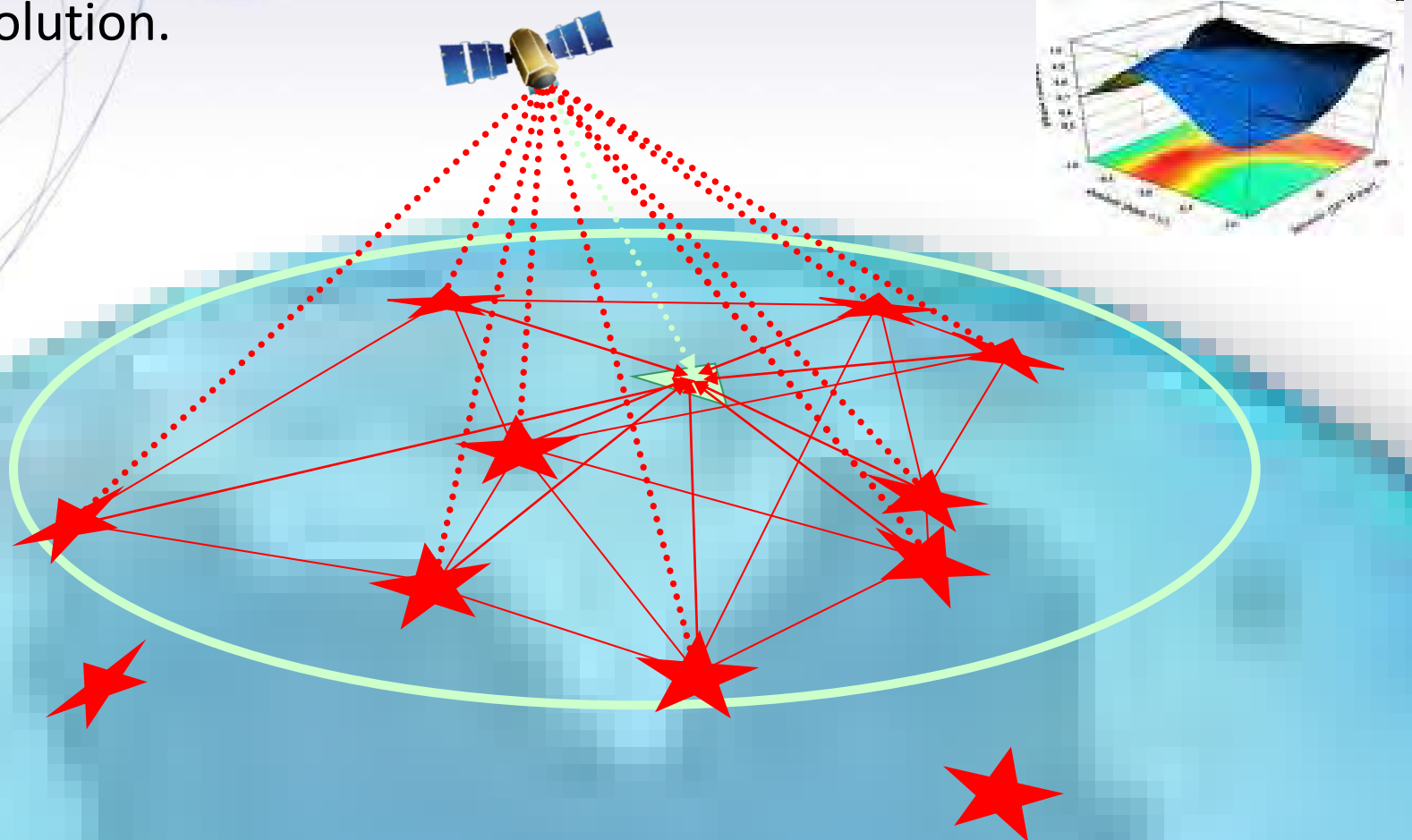
- Based (conceptually) on OSU MPGPS program
- Similar to Wide Area Rapid Static and Virtual Reference Station (VRS) computations
- 96 subroutines (21 in LAMBDA)
 - Least squares Ambiguity De-correlation Adjustment
- 9739 lines of code (1336 from LAMBDA)

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

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.

The OPUS-RS Interface

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

OPUS: Online Positioning User Service
 National Geodetic Survey

now using GEOID12A for improved NAVD 88 orthometric heights

Upload your data file.
 Tie your GPS observation to the National Spatial Reference System.
[What is OPUS?](#) [FAQs](#)

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

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[Projects BETA](#)
[Published Solutions](#)

[Contact OPUS](#)

no antenna selected

Antenna type - choosing wrong may degrade your accuracy.

meters above your mark.
Antenna height of your antenna's reference point.

* Email address - your solution will be sent here.

to customize your solution.

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

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

Website Owner: National Geodetic Survey / Last modified by NGS.OPUS Wednesday, 22-Aug-2012 11:42:26 EDT

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

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

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

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: 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 NEWPRTAIR_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.

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: igs15206.eph [precise]       STOP: 2009/02/28 06:59:30
NAV FILE: brdc0590.09n
ANT NAME: ASH700936C_M
ARP HEIGHT: 1.521
OBS USED: 5652 / 11169 : 51%
QUALITY IND. 48.23/108.85
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 | MC50 MARION CNTY | COOP CORS ARP | N445825.701 | W1225720.639 | 51226.8 |
| DI7529 | P367 NEWPRTAIR_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.

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: 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 NEWPRTAIR_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.

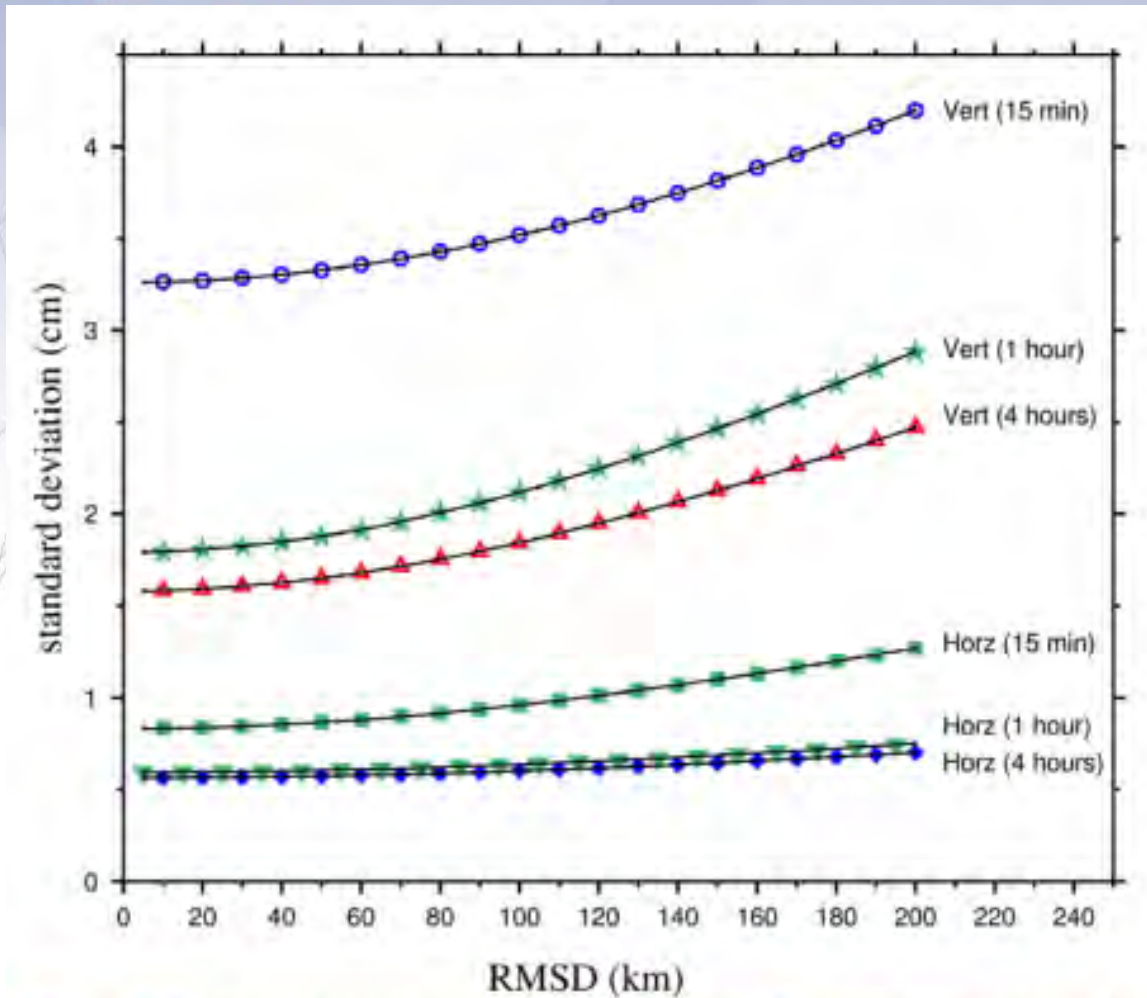
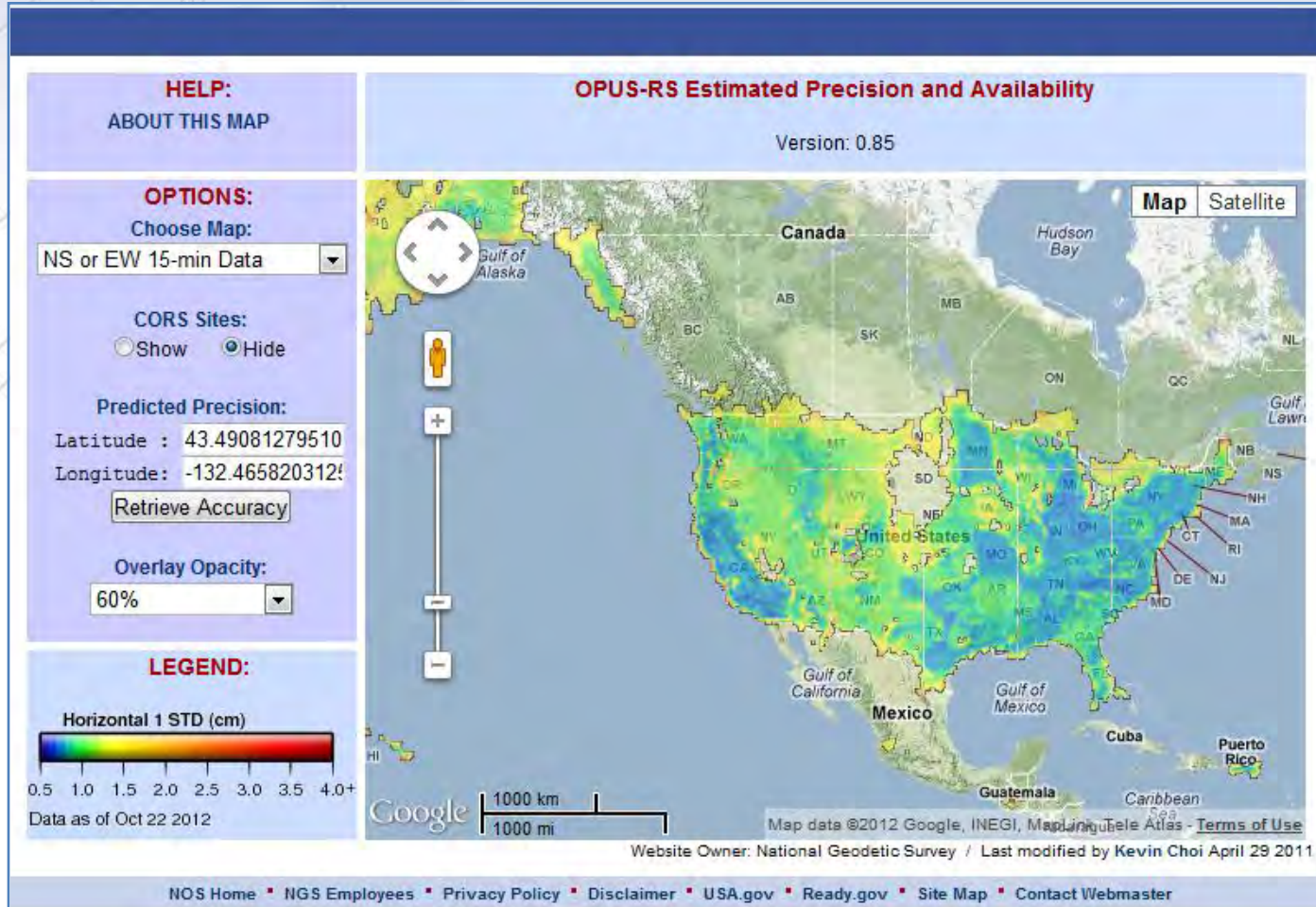


Figure 3. Predicted standard deviations in the vertical (ellipsoid height) and in each horizontal dimension (north-south or east-west), achievable with OPUS-RS, as a function of RMSD for data spans of 15 minutes, 1 hour and 4 hours and an IDOP value of 0.45.

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?

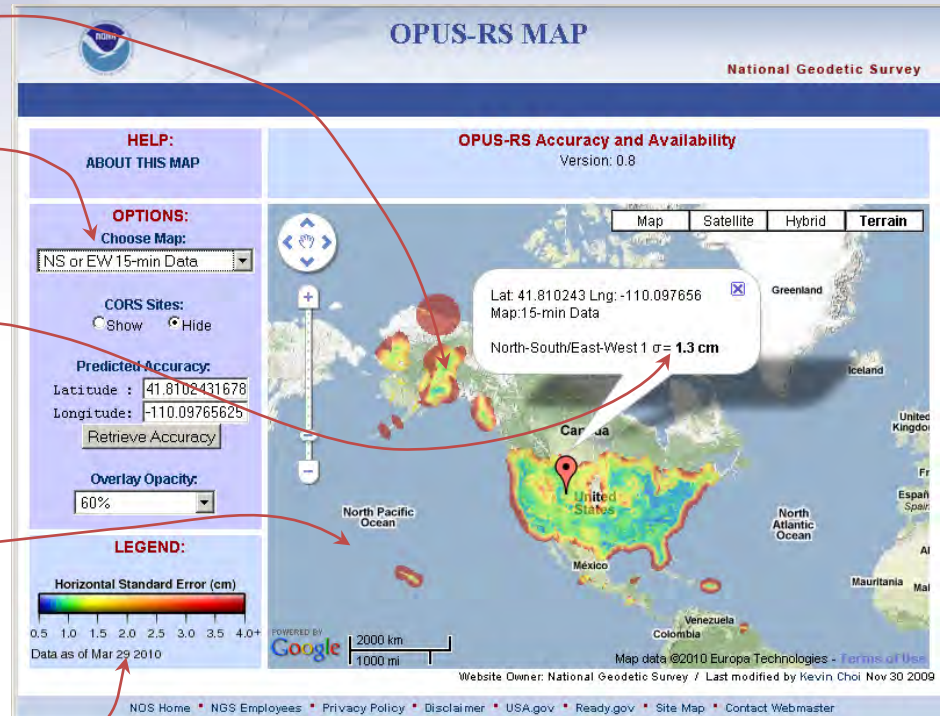
The OPUS-RS Accuracy and Availability Tool.



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

How Good Can I Do With OPUS-RS?

- 1 σ 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.



HELP:
ABOUT THIS MAP

OPTIONS:
Choose Map:
NS or EW 15-min Data

CORS Sites:
 Show Hide

Predicted Precision:
Latitude :
Longitude :
[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 Nov 26 2012

OPUS-RS Estimated Precision and Availability

Version: 0.85

Map Satellite

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

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HELP:
ABOUT THIS MAP

OPTIONS:
Choose Map:
NS or EW 1-hour Data

CORS Sites:
 Show Hide

Predicted Precision:
Latitude :
Longitude :
[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 Nov 26 2012

OPUS-RS Estimated Precision and Availability

Version: 0.85

Map Satellite

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HELP:
ABOUT THIS MAP

OPTIONS:
Choose Map:
Ellipsoid Height 15-min Data

CORS Sites:
 Show Hide

Predicted Precision:
Latitude :
Longitude :
[Retrieve Accuracy](#)

Overlay Opacity:
60%

LEGEND:

Ellipsoid Height 1 STD (cm)

1 2 3 4 5 6 7 8+

Data as of Nov 26 2012

OPUS-RS Estimated Precision and Availability

Version: 0.85

Map Satellite

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HELP:
ABOUT THIS MAP

OPTIONS:
Choose Map:
Ellipsoid Height 1-hour Data

CORS Sites:
 Show Hide

Predicted Precision:
Latitude :
Longitude :
[Retrieve Accuracy](#)

Overlay Opacity:
60%

LEGEND:

Ellipsoid Height 1 STD (cm)

1 2 3 4 5 6 7 8+

Data as of Nov 26 2012

OPUS-RS Estimated Precision and Availability

Version: 0.85

Map Satellite

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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?

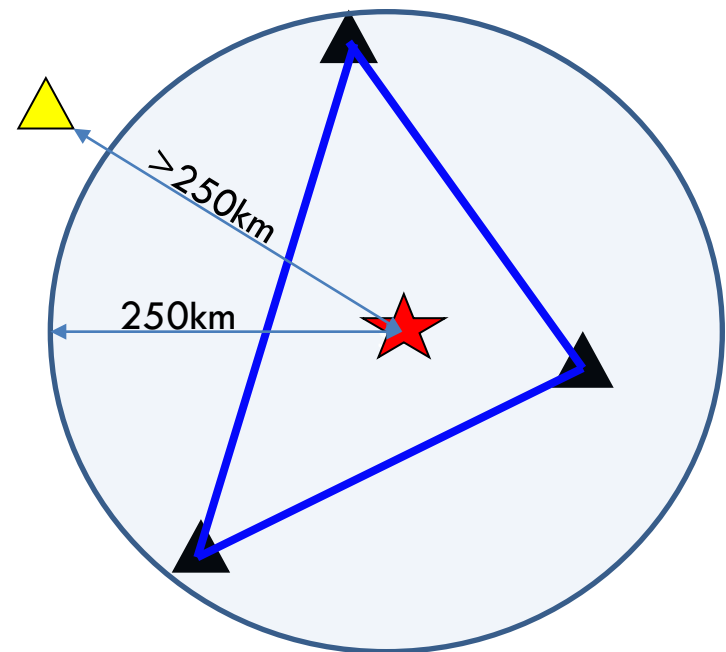
OPUS-RS selects three to nine “best” CORS based upon:

- 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.



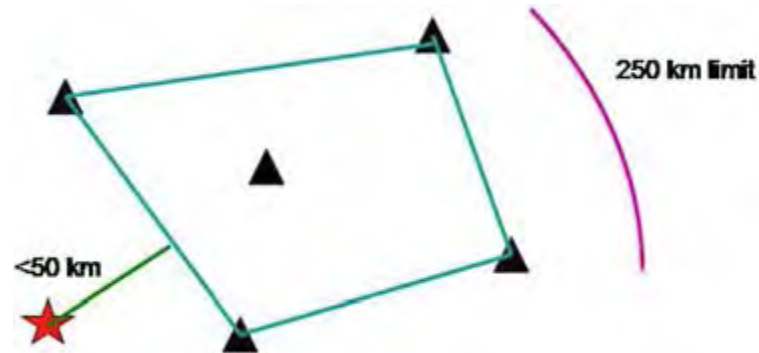
Choi, 2010, personal communication.

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.

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.

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) |