OSU Basics of GNSS Workshop February 2, 2012

Part 4. GNSS Survey Planning / OPUS

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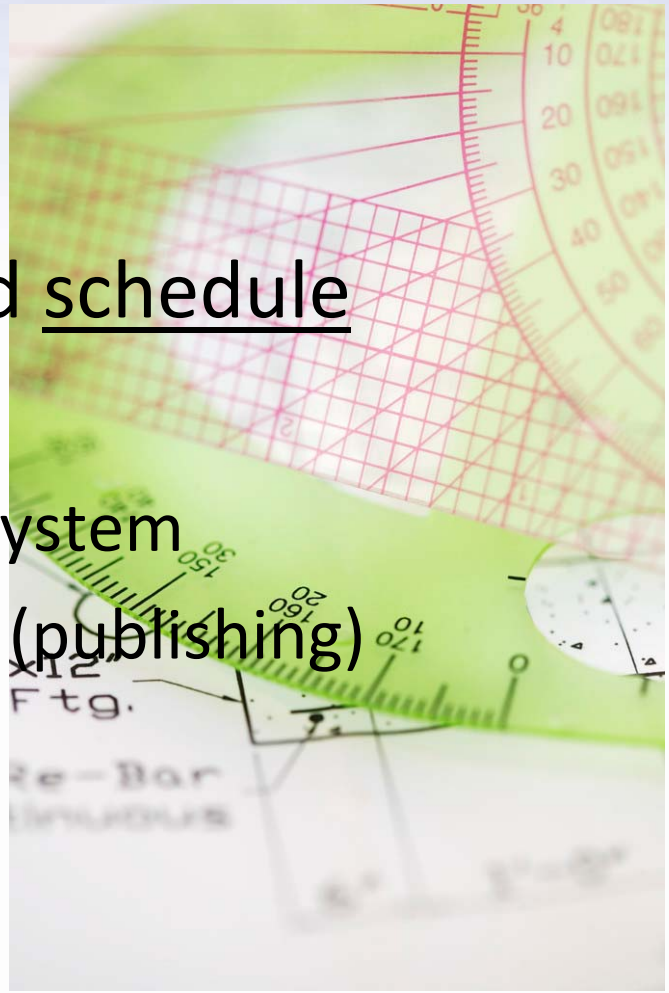
42 slides

Got to Have a Plan!!!



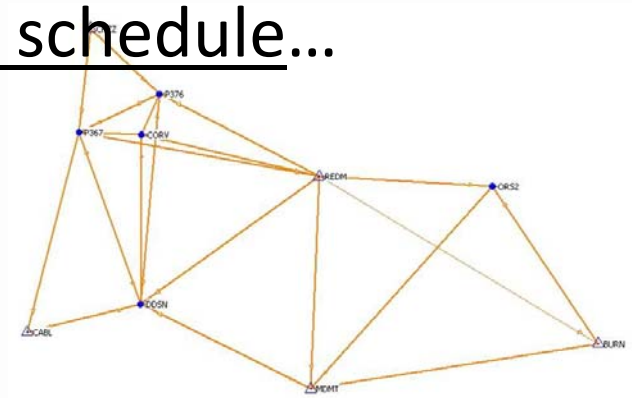
- GNSS survey goal, plan, and schedule
- CORS (active marks)
  - National Spatial Reference System
  - OPUS-S, OPUS-RS, OPUS-DB (publishing)
- Using passive marks
- Mission Planning

GPS survey planning

What is the survey goal?

- ✓ **Single point; small network; large network**
  - ✓ Project specifications; standards (FGDC); accuracy required
  - ✓ Horizontal and vertical datum
  - ✓ Geoid model choice; hybrid or pure gravimetric
  - ✓ Survey Style; DGPS, static; fast static; RTK; RTN
  - ✓ What will control the survey?
    - ✓ CORS; HARN; other passive marks or a combination?
    - ✓ What software will be used?

- ✓ <u>Then make a mission plan and schedule</u>…



GPS survey planning cont.

Use the FGDC Standards

- ✓ Federal Geographic Data Committee standards, Part 2
  - ✓ FGDC-STD-007.2-1998
  - ✓ Maintained by the National Geodetic Survey
- ✓ Sponsored by: Federal Geodetic Control Subcommittee

http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part2/index_html

GPS survey planning cont.

Standards for Geodetic Networks

✓Table 2.1 -- **Accuracy Standards**

Horizontal, Ellipsoid Height, and Orthometric Height

Accuracy 95-Percent
Classification Confidence

Less Than or Equal to:
1-Millimeter 0.001 meters
2-Millimeter 0.002 "
5-Millimeter 0.005 "
1-Centimeter 0.010 "
2-Centimeter 0.020 "
5-Centimeter 0.050 "
1-Decimeter 0.100 "
2-Decimeter 0.200 "
5-Decimeter 0.500 "
1-Meter 1.000 "
2-Meter 2.000 "
5-Meter 5.000 "
10-Meter 10.000 "

How good is your work?

*When control points in a survey are classified, they have been verified as being consistent with all other points in the network, not merely those within that particular survey.

http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part2/index_html

GPS survey planning cont.

Standards for Geodetic Networks

✓Section 2.2.2 -- **Accuracy Determination – Four Steps:**

l. The survey measurements, field records, sketches, and other documentation are examined to verify compliance with the specifications for the intended accuracy of the survey. This examination may lead to a modification of the intended accuracy.

2. Results of a minimally constrained, least squares adjustment of the survey measurements are examined to ensure correct weighting of the observations and freedom from blunders.

3. Local and network accuracy measures computed by random error propagation determine the provisional accuracy. In contrast to a constrained adjustment where coordinates are obtained by holding fixed the datum values of the existing network control, accuracy measures are computed by weighting datum values in accordance with the network accuracies of the existing network control.

4. The survey accuracy is checked by comparing minimally constrained adjustment results against established control. The result must meet a 95 percent confidence level. This comparison takes into account the network accuracy of the existing control, as well as systematic effects such as crustal motion or datum distortion. If the comparison fails, then both the survey and network measurements must be scrutinized to determine the source of the problem.

GPS survey planning cont.

Standards for Geodetic Networks

✓Section 2.2.3 -- **Accuracy Reporting**

When providing geodetic point coordinate data, a statement should be provided that the data meets a particular accuracy standard for both the *local accuracy* and the *network accuracy*.

For example, these geodetic control data meet the 2-centimeter local accuracy standard for the horizontal coordinate values and the 5-centimeter local accuracy standard for the vertical coordinate values (heights) at the 95-percent confidence level. A similar statement should be provided for these same data reporting the network accuracy.

http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part2/index_html

GPS survey planning cont.

What Horizontal and Vertical Datum will you use?

- ✓ Horizontal Datum
  - ✓ **NAD 83(2011)Epoch 2010.00 [NEW NSRS]**
  - ✓ NAD 83(CORS96)Epoch 2002 [Previous NSRS]
  - ✓ NAD 83(2007) [Most recent national adjustment of passive marks]
  - ✓ NAD 83(1998) [Oregon HARN]

- ✓ Vertical Datum
  - ✓ NAVD 88 [Current NSRS]

- ✓ Geoid Models
  - ✓ **GEOID11 [Coming soon March 2012]**
  - ✓ GEOID09 [Current NSRS Hybrid Model]
  - ✓ GEOID03 [Past NSRS Hybrid Model]
  - ✓ USGG2009 [Current NSRS Gravimetric Model]

GPS survey planning cont.

GPS (GNSS) Survey Styles

✓ **DGPS –** In standard DGPS (Differential GPS) technology, only corrections to C/A code pseudoranges are being transmitted, which brings rover positional errors down to values about 1m. DGPS is widely used by navigation users, in particular for urban transportation and in offshore areas. The remaining DGPS error source is multipath, which can be reduced by the use of special antenna and good planning.

✓**DGPS/RTK** - The compensation of atmospheric effects in traditional DGPS/RTK is not complete and the induced errors increase with the baseline length due to error decorrelation. For baselines of more than 15-20 km, ambiguity fixing is less reliable during periods of high ionospheric activity. There exist a number of so-called Network RTK techniques, where information from a network of base stations is used to better predict the variations of ionosphere delays and orbit errors.

✓ **Real-time kinematic Survey – (Dual Freq. RTK)** Base station setup required with either radio or cell phone connection with all rovers. Single base line differential correction performed which is based on the use of carrier phase. Carrier phase measurements are extremely precise (down to the fractions of millimeter), but they contain an unknown integer initialization constant, the so-called "phase ambiguity". Therefore RTK positioning has to resolve integer ambiguities to achieve the high level of precision.

GPS survey planning cont.

GPS (GNSS) Survey Styles

✓ **Static Survey** – >20 minutes logging data at each station – post processed baselines and then adjusted. OPUS is an automated tool which makes use of static data logging.

✓ **Fast-Static Survey** – <20 minutes logging data at each station

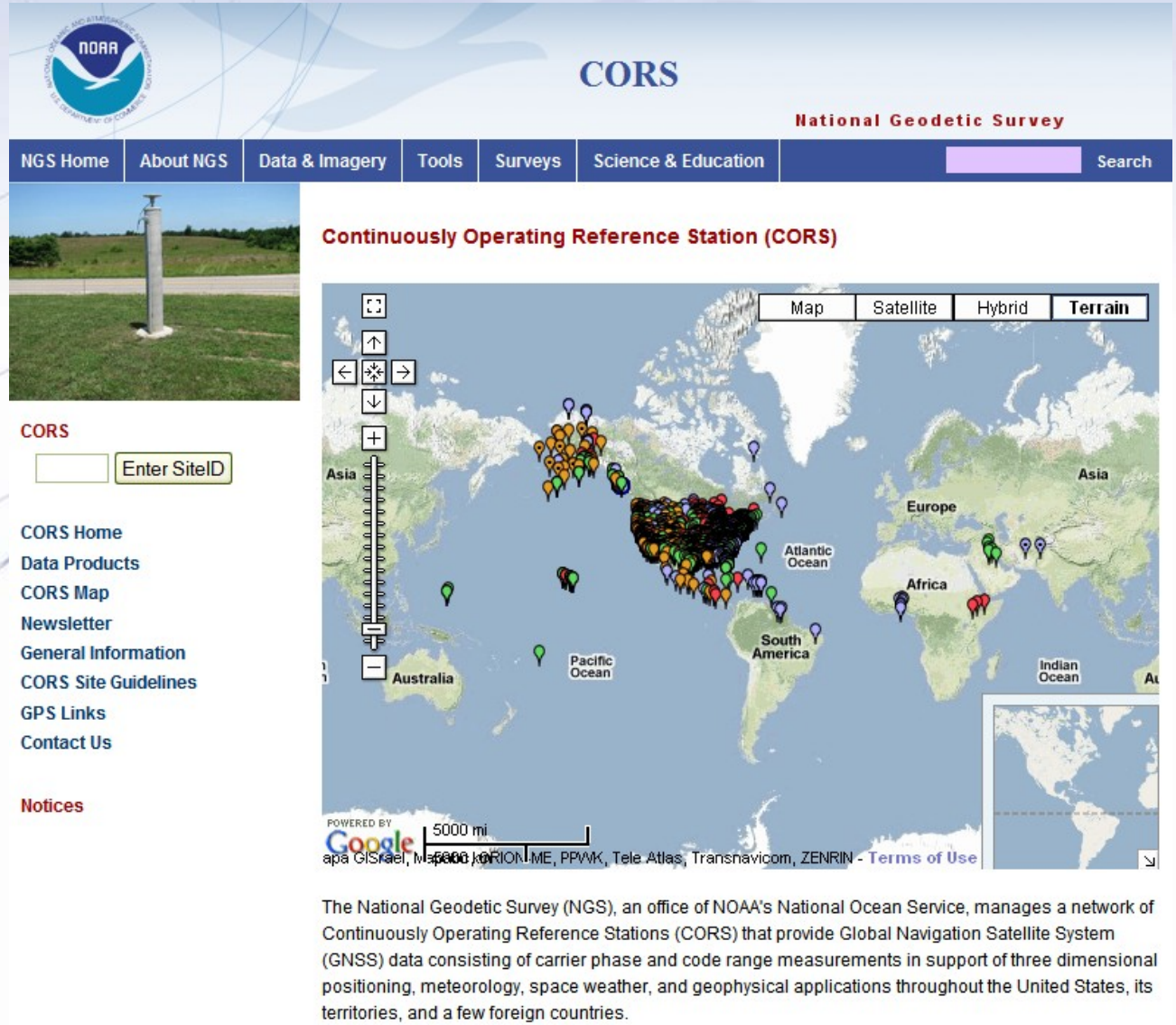
- ✓Both styles requires simultaneous observations for all stations in the current session. OPUS-RS is an automated tool which makes use of fast-static data logging.

✓ **Real-time Network – (RTN)** Rovers communicate with RTN servers via cell phone data link. Network solution possible. Oregon has a statewide RTN (ORGN) http://www.theorgn.org/

- ✓**Works with single or dual freq. receivers.**

GPS survey planning cont.

Continuous Operating Reference Stations (CORS)



The CORS term is tied to the NGS and refers to official national stations where data for the station is archived on NGS servers for all users.

GPS survey planning cont.

Oregon CORS and CGPS stations

GPS survey planning cont.

Other geodetic <u>passive mark datum</u> to constrain your network to…

- ✓ HARN = High Accuracy Reference Network
  - ✓ Passive marks available in the NGSIDB via datasheets.
    - ✓ In Oregon the latest horiz. HARN datum = NAD 83(1998)

- ✓ NAD 83(2007) = The most current national adjustment of ~70,000 passive monuments.
- ✓ NAD 83(2011) = In process and should be available by mid 2012. A new adjustment of ~80,000 passive monuments.

- ✓ others

GPS survey planning cont.

In addition to choosing a datum you need to choose a <u>coordinate system</u> made up of:

-a map projection

-a GEOID model

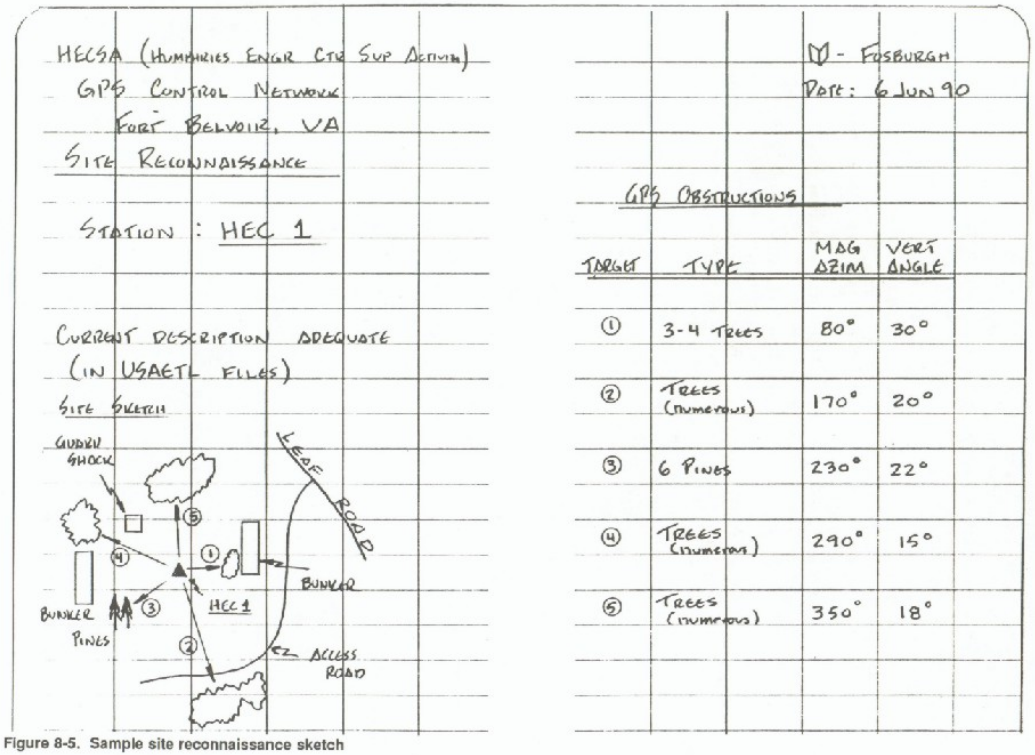
- ✓Oregon Station Plane Coordinate System (2 zones)
- ✓Oregon Coordinate Reference System (20 zones)
- ✓UTM Zones

✓All of these are planner coordinate systems with unique northing (y) and easting(x) values.

GPS survey mission planning

- ✓Research available control. What will control your GNSS Survey.
- ✓Set any new monuments for the network, and write descriptions on how to get to and access the mark
- ✓Recon the site and make notes, sketches and visibility diagrams
- ✓Take digital photos of the monument
  - ✓Close-up of the cap
  - ✓Horizon shot of each setup on the monument

Make notes, sketches and write descriptions at all monuments observed



HECSA (HUMPHRIES ENGR CTR SUP ACTIVITY)
GPS CONTROL NETWORK
FORT BELVOIR, VA
SITE RECONNAISSANCE

STATION : HEC 1

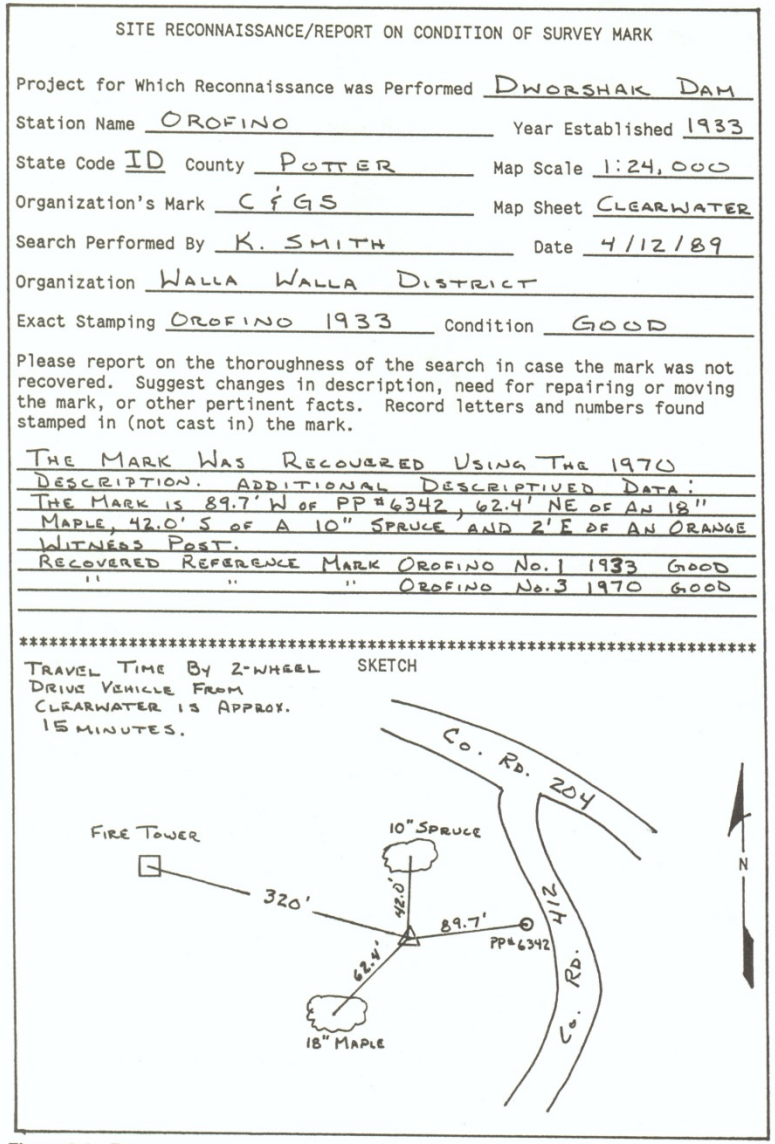
CURRENT DESCRIPTION ADEQUATE
(IN USAETL FILES)
SITE SKETCH

M - FOSBURGH
DATE: 6 JUN 90

GPS OBSTRUCTIONS

TARGET	TYPE	MAG AZIM	VERT ANGLE
①	3-4 TREES	80°	30°
②	TREES (NUMEROUS)	170°	20°
③	6 PINES	230°	22°
④	TREES (NUMEROUS)	290°	15°
⑤	TREES (NUMEROUS)	350°	18°

Figure 8-5. Sample site reconnaissance sketch



SITE RECONNAISSANCE/REPORT ON CONDITION OF SURVEY MARK

Project for Which Reconnaissance was Performed DWORSHAK DAM
Station Name OROFINO Year Established 1933
State Code ID County POTTER Map Scale 1:24,000
Organization's Mark C & GS Map Sheet CLEARWATER
Search Performed By K. SMITH Date 4/12/89
Organization WALLA WALLA DISTRICT
Exact Stamping OROFINO 1933 Condition GOOD

Please report on the thoroughness of the search in case the mark was not recovered. Suggest changes in description, need for repairing or moving the mark, or other pertinent facts. Record letters and numbers found stamped in (not cast in) the mark.

THE MARK WAS RECOVERED USING THE 1970 DESCRIPTION. ADDITIONAL DESCRIPTIVED DATA: THE MARK IS 89.7' W OF PP #6342, 62.4' NE OF AN 18" MAPLE, 42.0' S OF A 10" SPRUCE AND 2' E OF AN ORANGE WITNESS POST.
RECOVERED REFERENCE MARK OROFINO NO. 1 1933 GOOD
" " " OROFINO NO. 3 1970 GOOD

****

TRAVEL TIME BY 2-WHEEL DRIVE VEHICLE FROM CLEARWATER IS APPROX. 15 MINUTES.

SKETCH

Figure 8-6. Reconnaissance report on condition of survey

Make a visibility diagram in the field

STATION DIAGRAM

LAND & TIMBER DIVISION

MENASHA CORPORATION

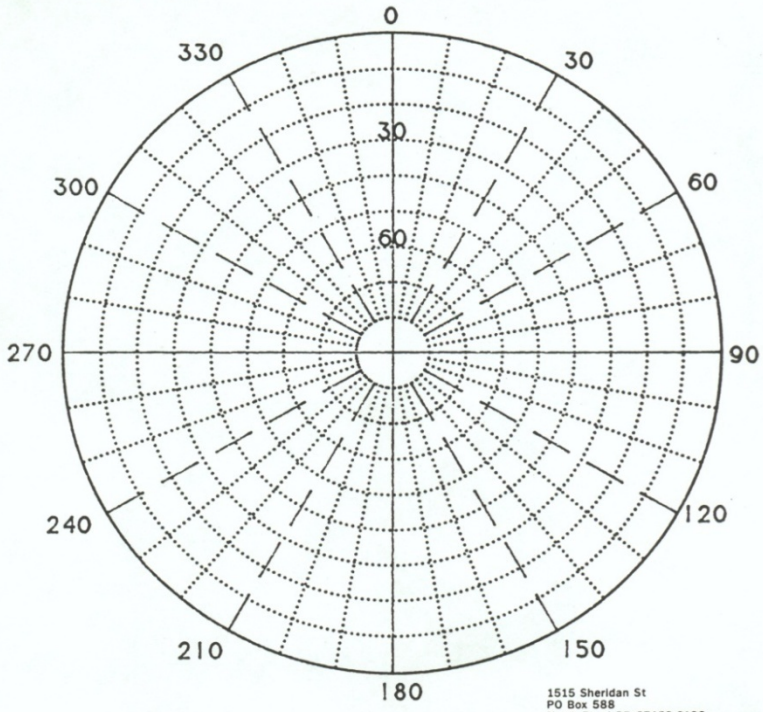
STA. NAME _____

OBSERVER _____

DATE _____

DESCRIPTION _____

LAT. / LONG. OR SEC/TWP/RGE _____

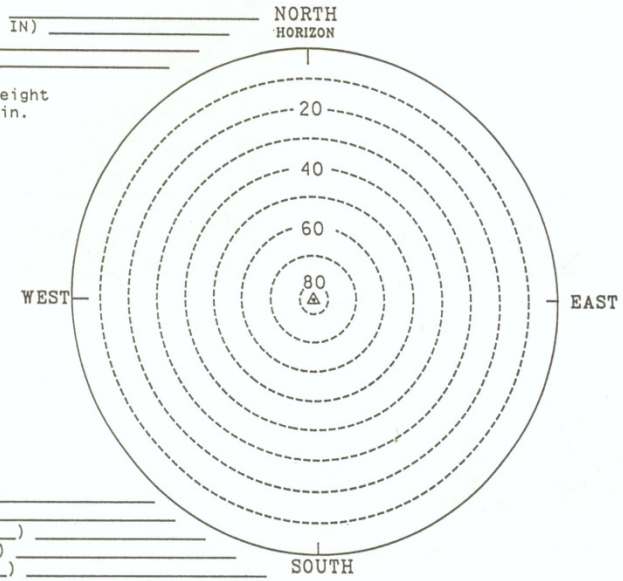


1515 Sheridan St
PO Box 588
North Bend OR 97459-0102
1-503-756-1193
1-503-756-7833 Fax

STATION VISIBILITY DIAGRAM

STATION NAME _____
AGENCY (CAST IN) _____
OBSERVER _____
DATE _____

Observer's Height
_____ ft.,in.



MAP SCALE _____
MAP SHEET _____
ELEV (NGVD___) _____
LAT (NAD___) _____
LONG (NAD___) _____

Indicate the horizontal and vertical limits of all objects obstucting veiw of the sky exceeding 15 degrees above the horizon.

NO.	AZIMUTH	VERT ANGLE	DESCRIPTION	NO.	AZIMUTH	VERT ANGLE	DESCRIPTION
1				11			
2				12			
3				13			
4				14			
5				15			
6				16			
7				17			
8				18			
9				19			
10				20			

Indicate distance, direction, frequency and power of known RF sources. Indicate distance, horizontal and vertical limits of any object in the vicinity that may cause radio signals to be reflected (multipath).

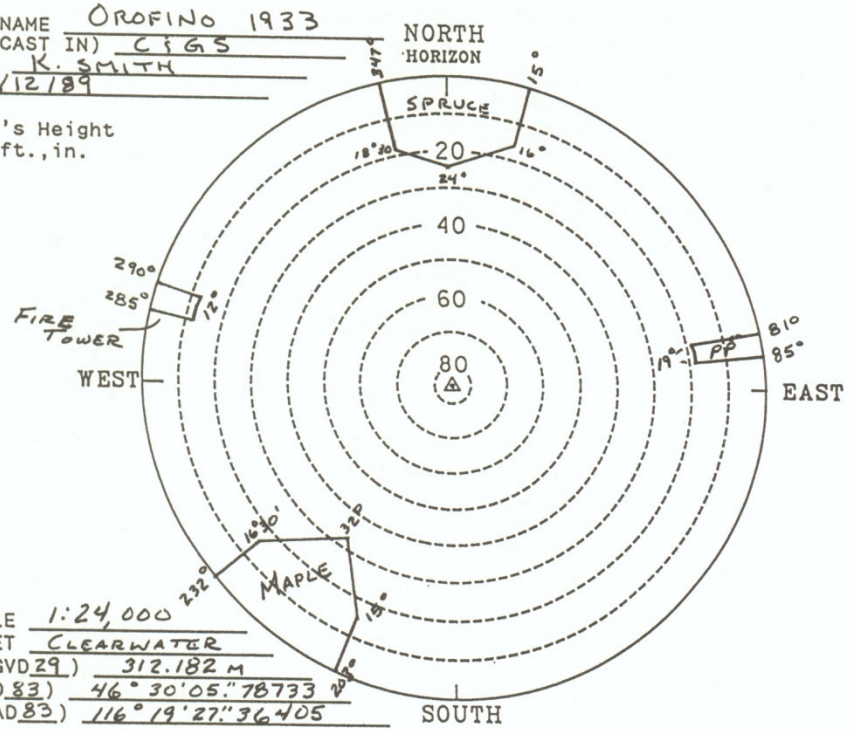
1. _____
2. _____
3. _____

Figure 8-9. Worksheet 8-2, Station Visibility Diagram

STATION VISIBILITY DIAGRAM

STATION NAME OROFINO 1933
AGENCY (CAST IN) CIGS
OBSERVER K. SMITH
DATE 4/12/89

Observer's Height
5' 10" ft., in.



MAP SCALE 1:24,000
MAP SHEET CLEARWATER
ELEV (NGVD 29) 312.182 M
LAT (NAD 83) 46° 30' 05." 78733
LONG (NAD 83) 116° 19' 27." 36405

Indicate the horizontal and vertical limits of all objects obstucting veiw of the sky exceeding 15 degrees above the horizon.

NO.	AZIMUTH	VERT ANGLE	DESCRIPTION	NO.	AZIMUTH	VERT ANGLE	DESCRIPTION
1	347°00'	18° 30'	EDGE SPRUCE	11			
2	358°30'	24°00'	PEAK SPRUCE	12			
3	15°00'	16°00'	EDGE SPRUCE	13			
4	81°00'	19°00'	N/EDGE PP	14			
5	85°30'	19°00'	S/EDGE PP	15			
6	203°00'	15°00'	EDGE MAPLE	16			
7	215°30'	32°00'	PEAK MAPLE	17			
8	232°00'	16°30'	EDGE MAPLE	18			
9				19			
10				20			

Indicate distance, direction, frequency and power of known RF sources. Indicate distance, horizontal and vertical limits of any object in the vicinity that may cause radio signals to be reflected (multipath).

1. 320' 285° TO 290° VERT ∡ 12° FIRE TOWER
2. (DUE TO DISTANCE FROM STATION & LOW ELEVATION ANGLE, THIS IS
3. PROBABLY NOT A THREAT OF CAUSING MULTIPATH)

Figure 8-8. Sample Station Visibility Diagram

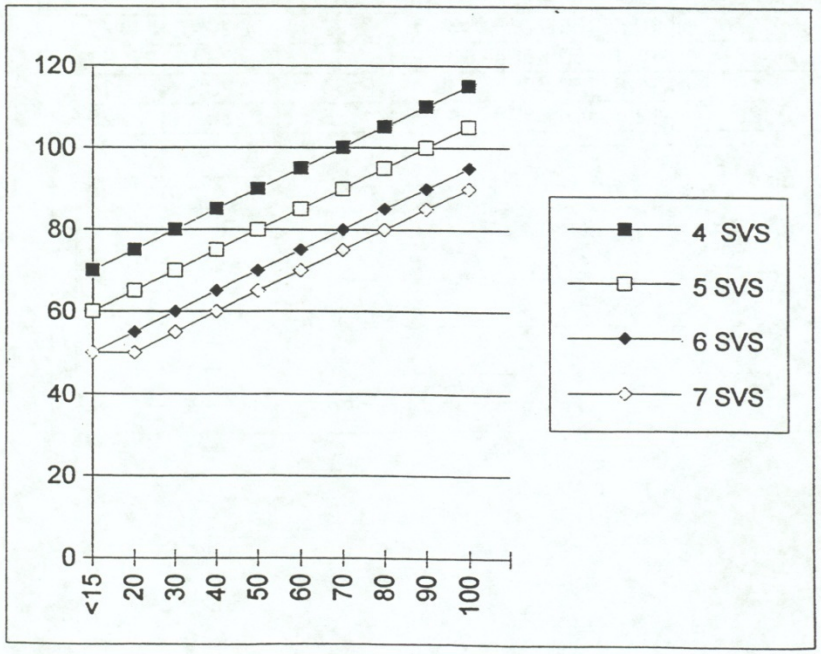
Shows azimuth and elevation of obstructions to satellites. This will be used in baseline processing software to optimize the observation time schedule so that satellites will be available.

Observation data logging times based on the number of satellites available. These suggested times are still valid!

REID MIDDLETON

SUGGESTED OBSERVATION TIMES
STATIC METHOD

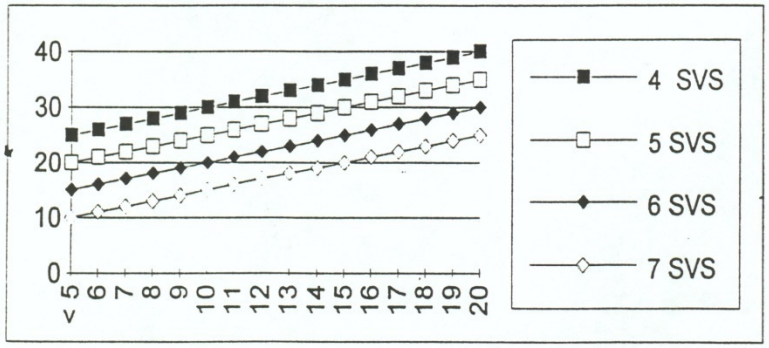
BASELINE LENGTH			4 SVS	5 SVS	6 SVS	7 SVS
KILOMETERS	MILES	FEET	MINUTES	MINUTES	MINUTES	MINUTES
<15	9.32	49,212	70	60	50	50
20	12.42	65,616	75	65	55	50
30	18.64	98,425	80	70	60	55
40	24.85	131,233	85	75	65	60
50	31.07	164,041	90	80	70	65
60	37.28	196,850	95	85	75	70
70	43.50	229,658	100	90	80	75
80	49.71	262,466	105	95	85	80
90	55.92	295,275	110	100	90	85
100	62.14	328,083	115	105	95	90



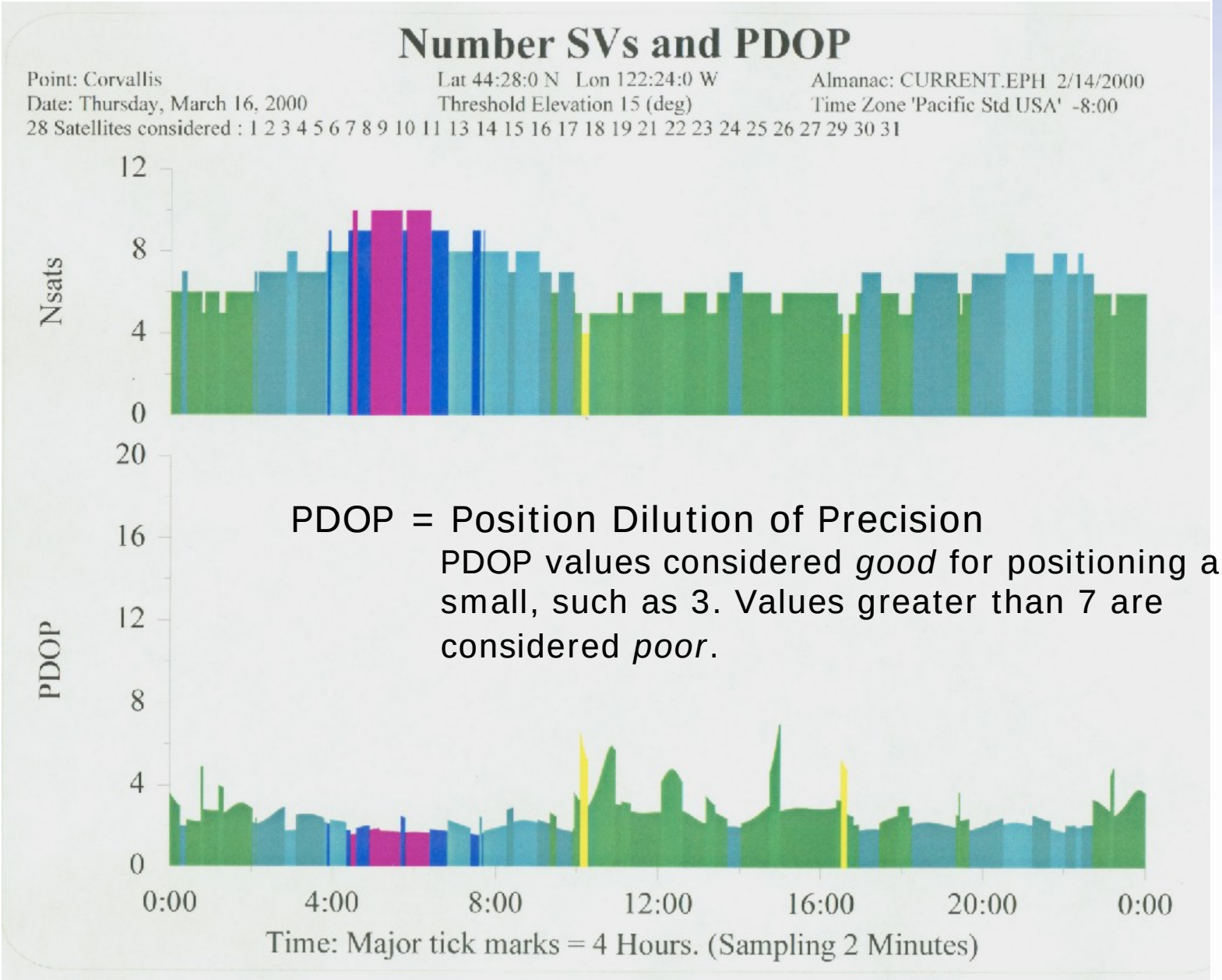
REID MIDDLETON

SUGGESTED OBSERVATION TIMES
FAST-STATIC METHOD

BASELINE LENGTH			4 SVS	5 SVS	6 SVS	7 SVS
KILOMETERS	MILES	FEET	MINUTES	MINUTES	MINUTES	MINUTES
< 5	3.11	16,404	25	20	15	10
6	3.73	19,685	26	21	16	11
7	4.34	22,965	27	22	17	12
8	4.97	26,246	28	23	18	13
9	5.59	29,527	29	24	19	14
10	6.21	32,808	30	25	20	15
11	6.84	36,089	31	26	21	16
12	7.46	39,370	32	27	22	17
13	8.08	42,650	33	28	23	18
14	8.70	45,931	34	29	24	19
15	9.32	49,212	35	30	25	20
16	9.94	52,493	36	31	26	21
17	10.56	55,774	37	32	27	22
18	11.18	59,055	38	33	28	23
19	11.81	62,335	39	34	29	24
20	12.42	65,616	40	35	30	25



From Trimble GPS Planning tool… shows #SV and PDOP



PDOP = Position Dilution of Precision

PDOP values considered *good* for positioning are small, such as 3. Values greater than 7 are considered *poor*.

Observation schedule shows: date; GPS day; session number; monument observed; observers name; observation logging time (maybe same for each session or different)

	Tues - April 14 104					Wed - April 15 105			Thurs - April 16 106				Fri April 17 107
	#1	#2	#3	#4	#5	#1	#2	#3	#1	#2	#3	#4	#1
John M.	2	Mercia	23	25	23	25	48	Mercia	25	51	28	48	25
Malcom	6	4	6	31	18	18	53	4	4	14	—	14	14
Mark	8	P+B	4	51	57	4	49	P+B	20	29	3	4	13
John D	9	9	9	39	2	3	56	9	3	39	9	9	33
Owen	10	28	10	28	61	5	42	48	10	28	51	51	28
Don	11	48	26	26	19	27	50	51	27	34	46	55	34
Dennis	21	21	21	21	21	16	54	21	6	38	21	54	15
Eric	22	HAFF	3	22	22	46	46	HAFF	16	16	20	56	16
Dave	61	39	5	20	20	20	43	25	5	43	25	2	43
Extra		X						X					

GPS Planning – Additional Reading

Go here:
http://www.geodesy.noaa.gov/PUBS_LIB/pub_GPS.shtml

Guidelines for Establishing GPS-derived Orthometric Heights (Standards: 2 cm and 5 cm) NOAA TM NOS NGS-59 Zilkoski, D.B., Carlson, E.E., & Smith, C.L. Mar 26, 2008 PDF

Guidelines for Establishing GPS-Derived Ellipsoid Heights - NOAA TM NOS NGS-58 Zilkoski, D.B., D'Onofrio, J.D., Frakes, S.J. Nov 1997 PDF *or* HTML

NGS User Guidelines for Single Base Real Time GNSS Positioning v1.0 Henning, W.E. Jan 2010 PDF

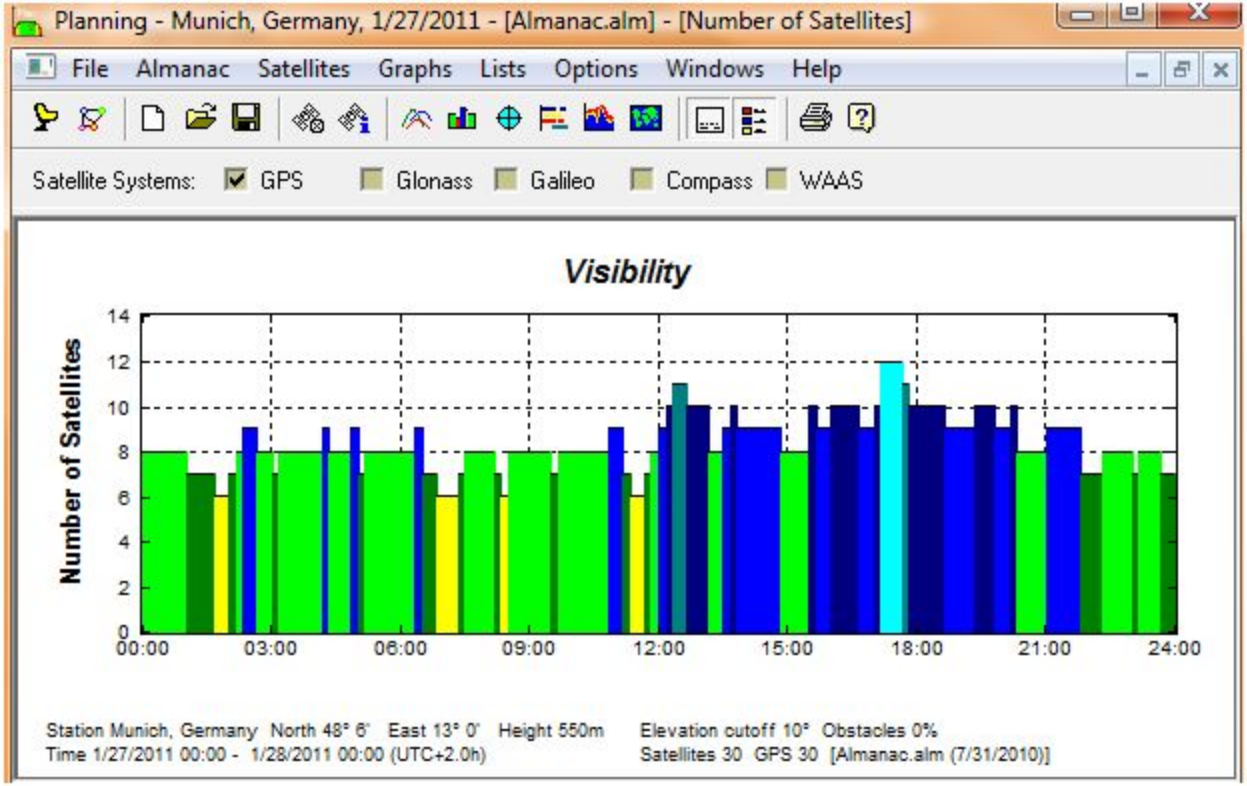
GPS Planning – Free Software Tools

Trimble Setup Planning Software v. 2.9
Download at:

http://www.trimble.com/planningsoftware_ts.asp

Download the latest ephemeris files, and almanacs at:

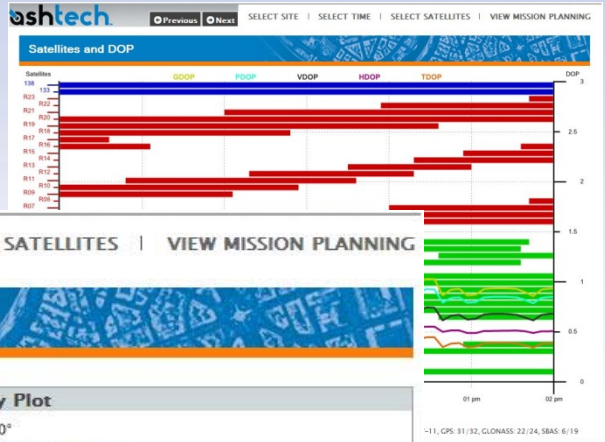
http://www.trimble.com/gpsdataresources.shtml



GPS Planning – Free Software Tools

Ashtech Web Mission Planning Tool

http://asp.ashtech.com/wmp/



ashtech Previous Next SELECT SITE | SELECT TIME | SELECT SATELLITES | VIEW MISSION PLANNING

Polar Diagram

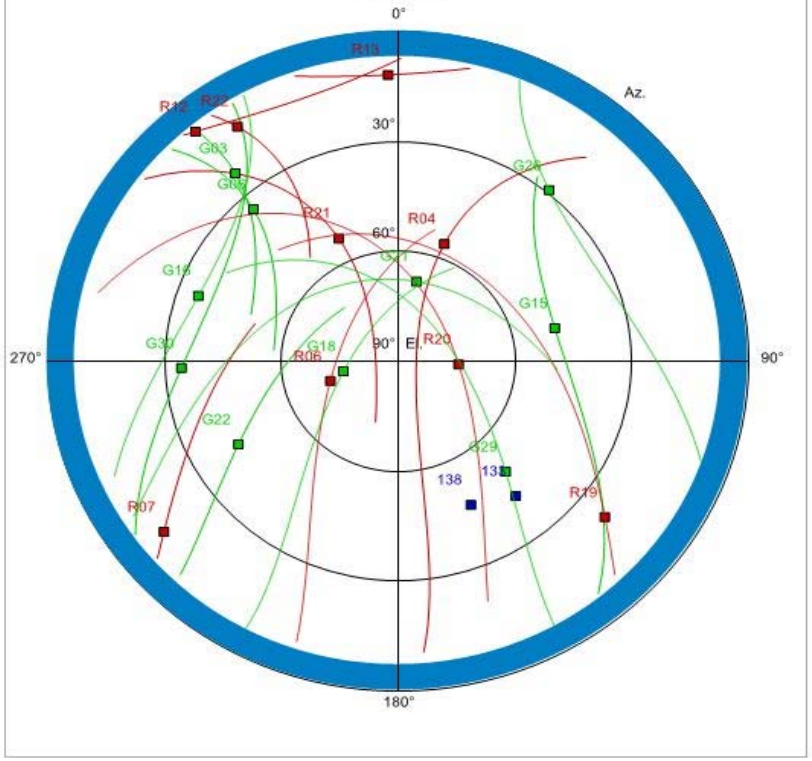
View Sat Positions at Time:

12:12:00 pm

Visible Satellites

System	PRN	Azimuth	Elevation
GPS	G16	289	36
GPS	G18	259	76
GPS	G21	12	68
GPS	G22	241	43
GPS	G26	40	29
GPS	G29	138	49
GPS	G30	268	34
GLONASS	R04	20	56
GLONASS	R06	253	72
GLONASS	R07	232	14
GLONASS	R12	320	8
GLONASS	R13	358	12
GLONASS	R19	129	22
GLONASS	R20	93	74
GLONASS	R21	335	53
GLONASS	R22	327	14
SBAS	133	141	42
SBAS	138	154	47

Sky Plot



Lat: 44°31'14.64251"N. Lon: 123°16'21.57375"W. Alt: 72m. Date: 01-27-11 08:00 am (local). Duration: 6H. Almanac: 01-27-11. GPS: 31/32. GLONASS: 22/24. SBAS: 6/19

Equipment Checklist

- ✓Receiver with memory available
- ✓Antenna
- ✓Antenna cables
- ✓RTK radio modem
- ✓**Batteries fully charged**
- ✓Battery-to-receiver cables
- ✓Back-up batteries or cigarette light adaptor
- ✓Tripods
- ✓Bipods
- ✓Tribrachs
- ✓Tribrach adaptors
- ✓Flashlight
- ✓**Digital Camera**
- ✓Measure tape or rod
- ✓Station information
- ✓Observation log sheets
- ✓Paper and pencil
- ✓Two way radio or cell phone
- ✓Observation schedule
- ✓Flagging, paint, PK nails, hammer
- ✓Traffic control equipment

- ✓Reference list
  - ✓Emergency phone numbers
  - ✓names, addresses, telephone numbers of
  - ✓ private-property owners relevant to this
  - ✓ project
  - ✓Gate keys or combinations
  - ✓Maps

✓If you plan to download and process data in the field, bring the following materials.

- ✓RS-232 cable
- ✓Computer
- ✓Office support module
- ✓Floppy disks

OBSERVATION LOG

1. **Station Number:** _____

2. **Station Name:** _____

3. **Receiver Serial Number:** _____

4. **Observation Times:**

   Begin: _____ **End:** _____

5. **Observation Date:** _____

6. **Observer:** _____

7. **Antenna Height:**

   Observation 1:

Reading 1	_____	Meters	_____	Feet
Reading 2	_____	Meters	_____	Feet
Reading 3	_____	Meters	_____	Feet
Average Obs. 1	_____	**Meters**	_____	**Feet**

   Observation 2:

Reading 1	_____	Meters	_____	Feet
Reading 2	_____	Meters	_____	Feet
Reading 3	_____	Meters	_____	Feet
Average Obs. 2	_____	**Meters**	_____	**Feet**

8. **Monument Description:**

   _____

9. **Monument Location:**

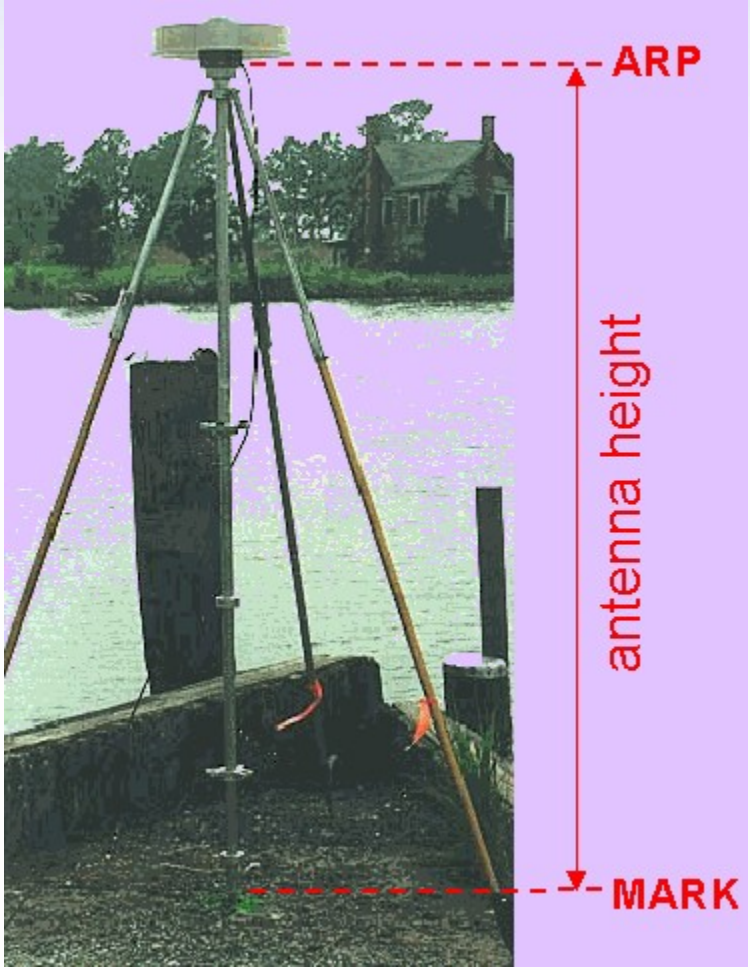
   _____

10. **Remarks:**

    _____

template: j:msoffice/msapps/template/obslog.dot

Record you observation on every point. REMEMBER THAT THE ANTENNA HEIGHT IS CRITICALLY IMPORTANT!!!



NGS OPUS Suite of Programs

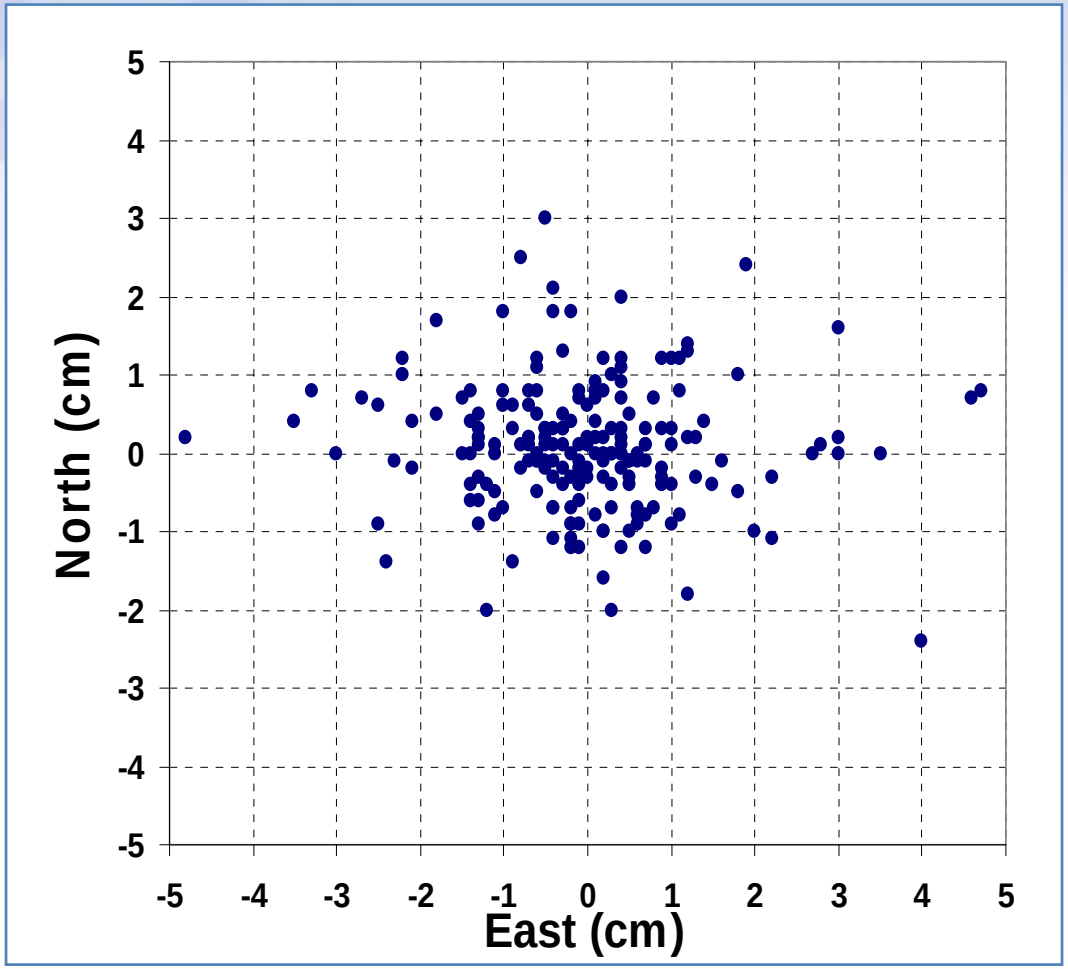
The Online Positioning User Service (OPUS)

- ✓ **OPUS-S** (static) >2 - 48 hours of data required
- ✓ **OPUS-RS** (rapid static) >15 min. – 2 hours of data required
- ✓ **OPUS-DB** (publish your observation to the OPUS database)
  -4+ hours required for submission using OPUS-S
- ✓ **OPUS-Projects** (baseline processing and adjustment of networks)

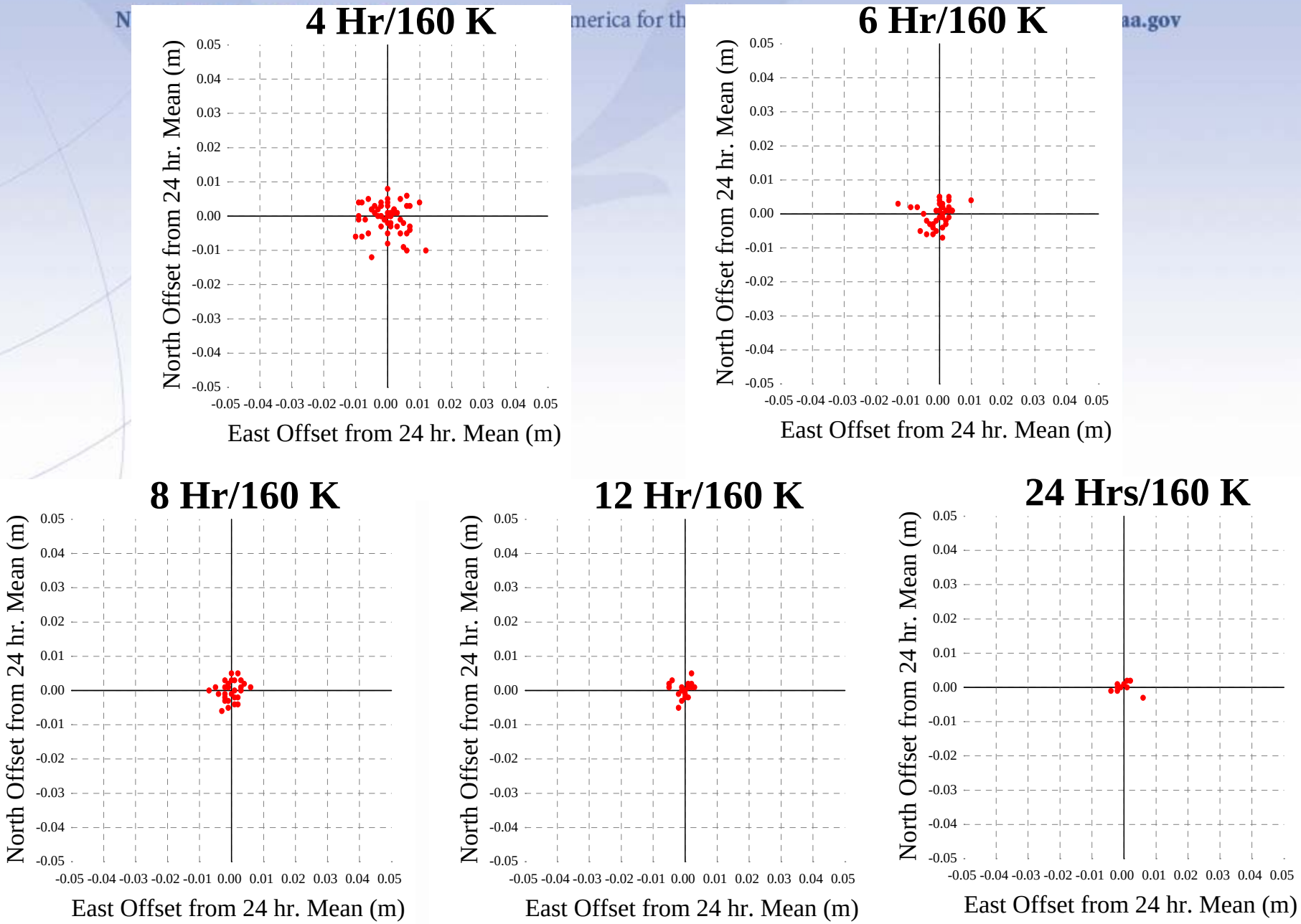
How Good Can I Do With OPUS-S?

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



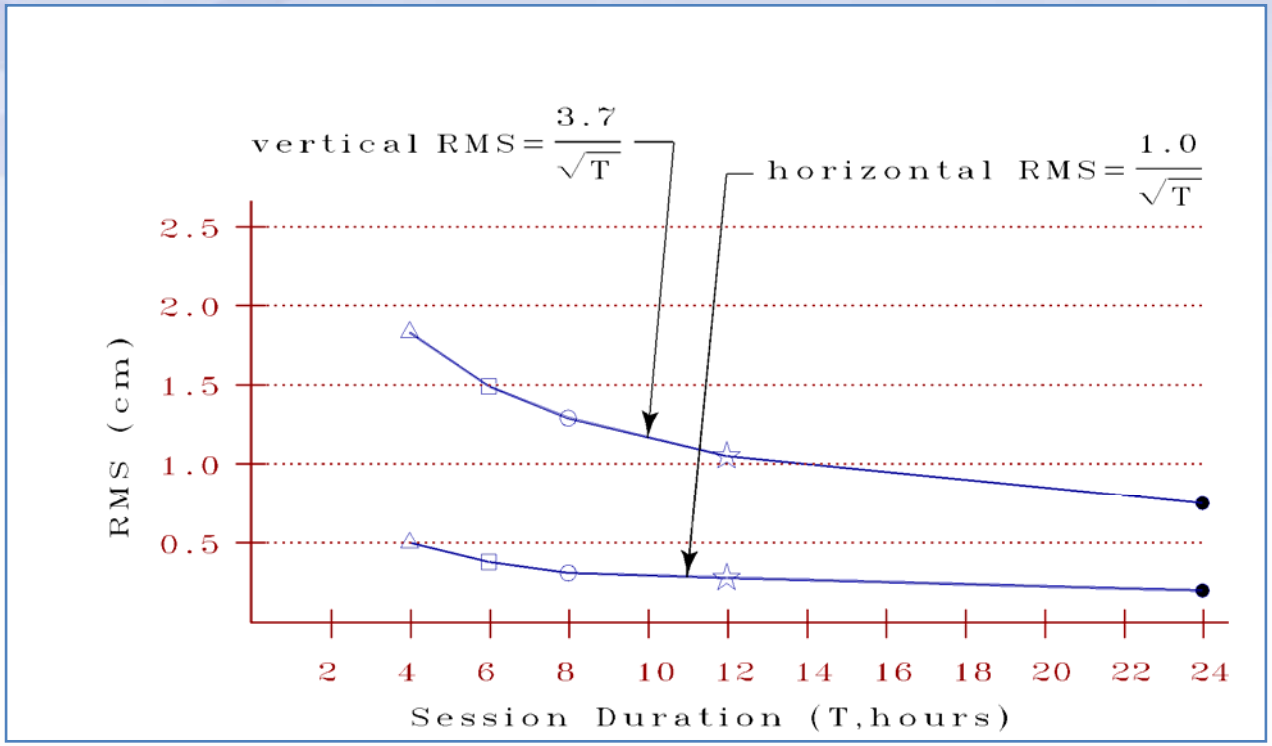
Weston, N. "OPUS: Online Positioning User Service", CGSIC USSLS MEETING, 2008-07-08, NEW ORLEANS, LA.



Time Scatter Plots (Horizontal)

How Good Can I Do With OPUS-S?

More generally, Eckl et al. (NGS) 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.

How Does OPUS-S Work?

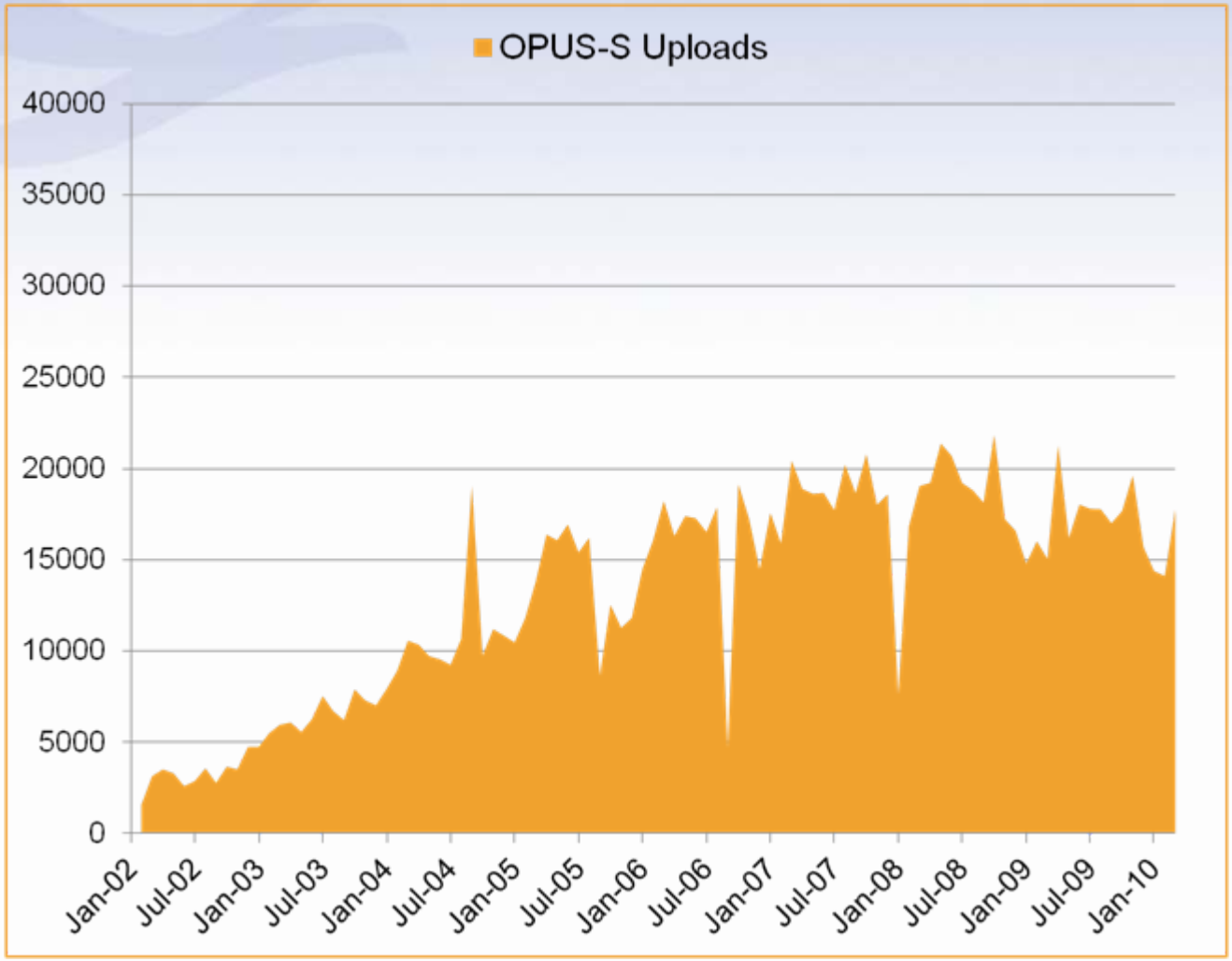
OPUS-S processing highlights:

- Everything is "done" in the **International Terrestrial Reference Frame** (ITRF).
- 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.

OPUS-S Uploads By Month

Shown here are the monthly upload counts to OPUS-S.

Submissions to OPUS-S comprise a non-trivial percentage of all "hits" on the NGS web sites.



Valid as of 2010-03-30. Values before January, 2005 are approximate.

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.**

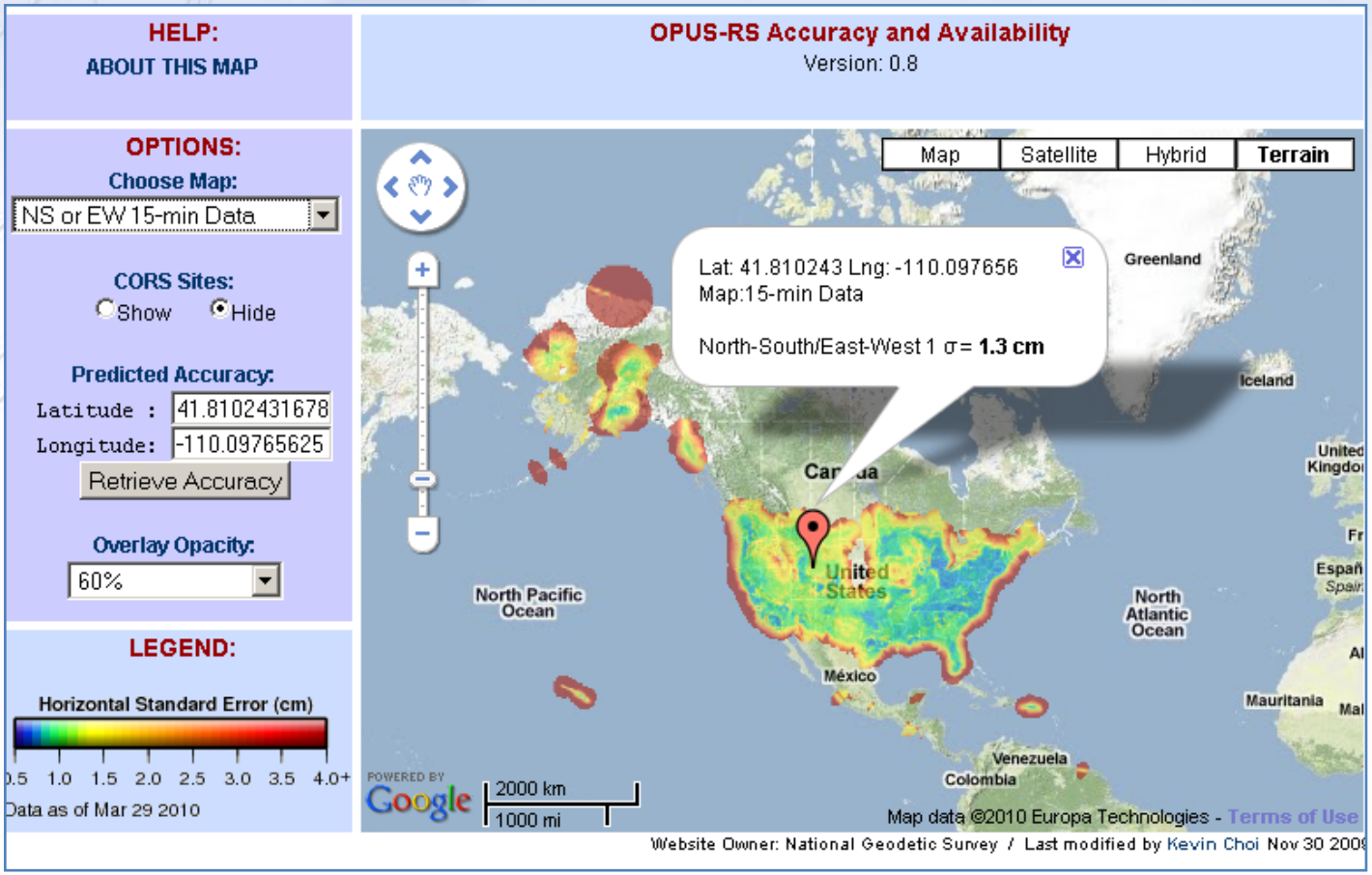
http://www.ngs.noaa.gov/OPUS/

The OPUS-RS Interface

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

How Good Can I Do With OPUS-RS?

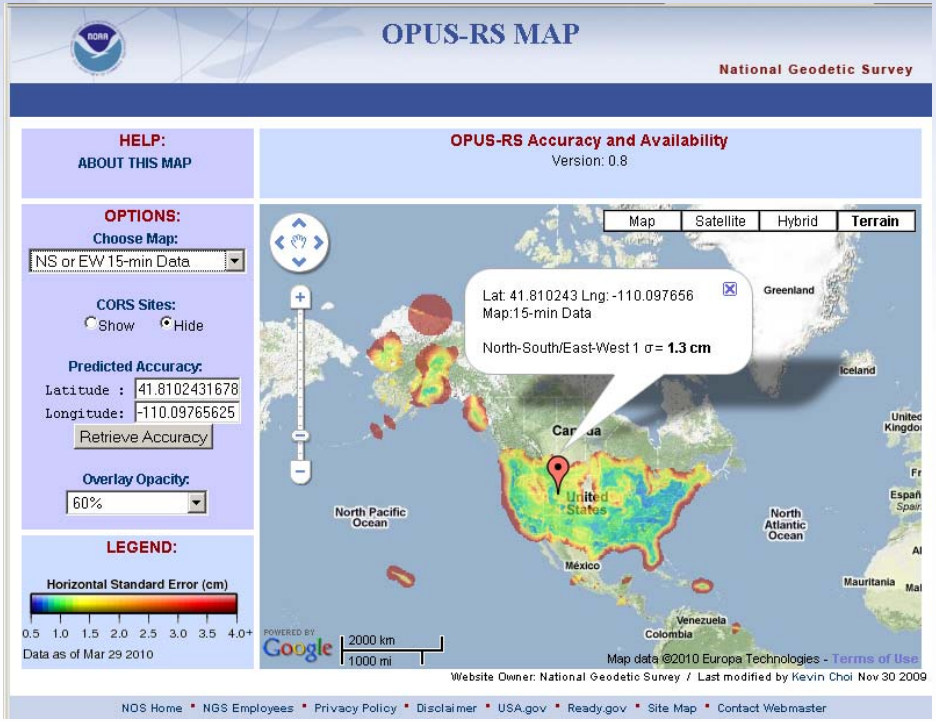
The OPUS-RS Accuracy and Availability Tool



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

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.



How Does OPUS-RS Work?

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

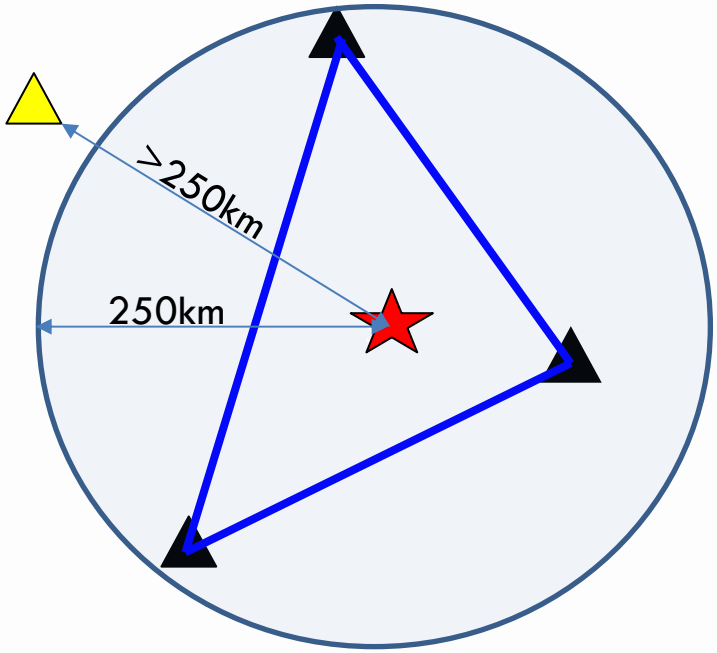
- **Having common satellite visibility with the user data.**
- **Having distances from the user's site <250 km.**

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.



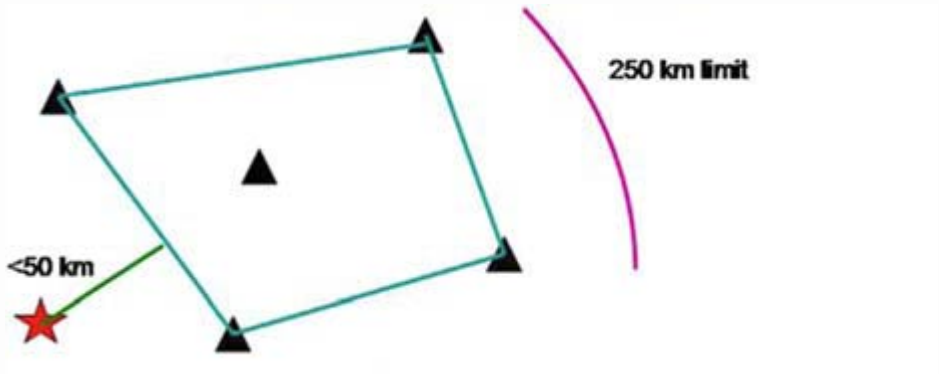
Choi, 2010, personal communication.

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.

OPUS-DB Interface

upload | *view* | about

published marks

published marks | register to publish | today's marks: Static Rapid-Static

sample datasheet

Retrieve datasheets by:

- map view
- map file (DRAFT kmz download)
- ZIP code
- county
- coordinate + radius
- mark designation
- email of submitter
- dates
- PID

IMPORTANT datasheet notes:

SCOPE: OPUS marks are not yet fully integrated with the NGS database (NGSIDB). Many more marks are available from the links below:

- NGSIDB: 1,000,000+ "bluebooked" marks
- NOS tidal bench marks

FORMAT: differs from traditional NGS datasheets in many ways, including:

- **POSITIONS** are individually generated from non-redundant OPUS solutions. ERRORS MAY EXIST! Users are encouraged to favor stations observed multiple times and manually compare the positions, each available from the *"See Also"* link in the datasheet header.
- **ERROR CHECKING** is the responsibility of the data publisher.
- **DATUM** for ellipsoidal coordinates may differ from NGSIDB. Orthometric heights are derived from GPS and the geoid model used by OPUS.
- **FORMAT** of coordinates differs from NGSIDB conventions

This 1st-generation datasheet is, essentially, a public OPUS solution report. We anticipate adding user-friendly features & enhanced integration with NGSIDB and our toolkit in future versions. Your comments are appreciated.

The "view" tab on the OPUS home page provides access to the results stored in the data base.

Questions ?