

## Web-based Solution for GPS Data

# NOAA OPUS

*Since March 2001 the National Geodetic Survey (NGS) has operated the Online Positioning User Service (OPUS) to provide end-users with easy access to the US National Spatial Reference System (NSRS). This popular web-based application provides accurate, reliable and consistent geodetic coordinates with minimal user input. A submitted GPS data file is usually processed within a few minutes and the computed coordinates are accurate to a few centimetres.*

By Neil D. Weston, Tomás Soler, Gerald L. Mader, National Geodetic Survey, NOAA, USA

Although in principle the OPUS system can process GPS data collected from any part of the world, the majority of submissions are from North America. OPUS currently processes between 15,000 and 18,000 datasets per month and annual growth rate is around 70%. One consideration during the design phase was to keep the web-based interface simple. OPUS can presently accept GPS data files from any dual-frequency, geodetic-quality

receiver, either in native receiver format or in Receiver-INdependent EXchange format (RINEX). Multiple GPS data files can also be submitted in a zip file, each GPS data file being processed sequentially and independently to produce a set of coordinates for each occupation.

### User Input

The main upload page is currently limited to four input fields but does contain several buttons and links to information on OPUS, how to use the system, what policies govern its operation, and a link to Frequently Asked

Questions (FAQ). The input fields are used to identify a user's email address, to which the results are sent, GPS data file, antenna type and height. The third input field has a drop-down menu that provides a list of all supported GPS antennas. Once an antenna is selected this option ensures use of the correct antenna phase patterns. Antenna height in metres can be entered in the final field. If zero is entered here the returned coordinates will be for the Antenna Reference Point (ARP), usually at the base of the antenna. The OPUS page has an option for the selection of additional parameters such as State Plane Coordinates (SPC), reference stations during processing and request for an extended report. Another option is to save to the email address antenna type and height, SPC code, selected base stations and extended option choices. This feature is handy if a user has performed multiple occupations with the same antenna etc and would like to use the same information to process each data file. After filling in all fields, the file can be uploaded.

### Processing Steps

After uploading to OPUS the first step is to determine the date of occupation and the station's approximate location. The date is used to retrieve ancillary information from the International GNSS Service (IGS), such as the broadcast and precise ephemeris. The location is used to select up to three neighbouring reference stations from the IGS or CORS network, each of which will participate in a single baseline solution with the user's station. In the second step, three, independent, double-difference solutions are performed within the ITRF reference frame, between the user's station and each reference station. The results are compared and averaged, but if any section fails to meet the quality criteria

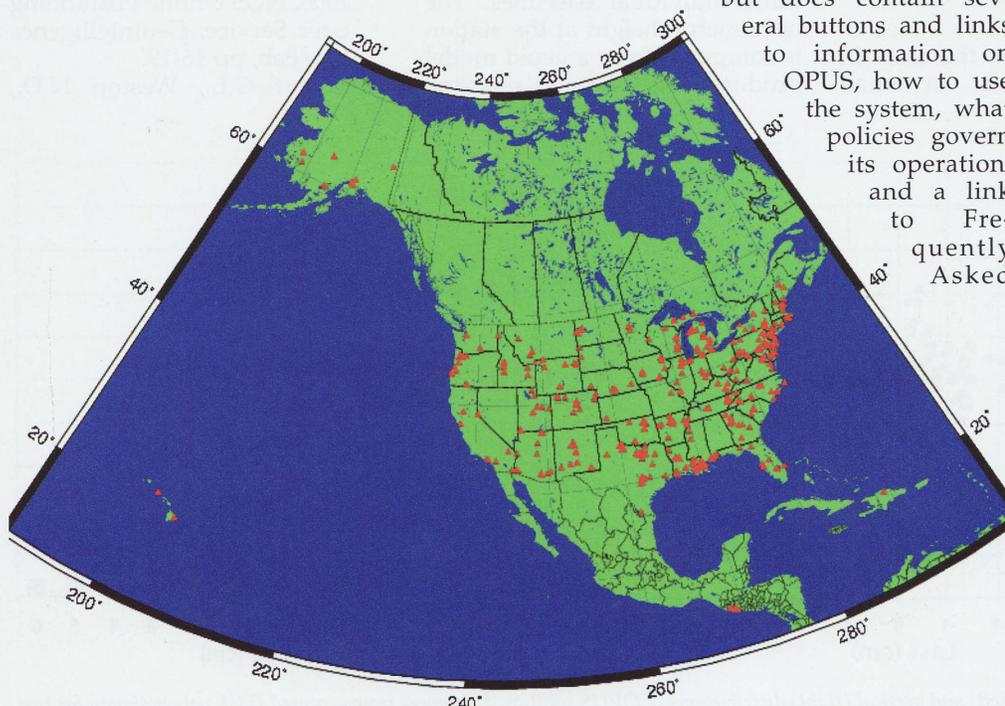


Figure 1, Geographic location of OPUS solutions processed on 6th June 2006.

NGS OPUS SOLUTION REPORT					
USER: user_USA@noaa.gov			DATE: June 08, 2006		
RINEX FILE: gait0910.06o			TIME: 11:18:51 UTC		
SOFTWARE:	page5_0601.10_master2.pl	START:	2006/04/01	00:00:00	
EPHEMERIS:	igs13686.eph [precise]	STOP:	2006/04/01	23:59:00	
NAV FILE:	brdc0910.06n	OBS USED:	48924 / 51370	:	95%
ANT NAME:	AOAD/M_T	NONE	# FIXED ANB:	256 / 275	: 93%
ARP HEIGHT:	0.0		OVERALL RMS:	0.020 (m)	
REF FRAME: NAD_83 (CORS96) (EPOCH:2002.0000)			ITRF00 (EPOCH:2006.2480)		
X:	1095790.781 (m)	0.010 (m)	1095790.088 (m)	0.010 (m)	
Y:	-4831328.045 (m)	0.017 (m)	-4831326.598 (m)	0.017 (m)	
Z:	4003934.404 (m)	0.019 (m)	4003934.291 (m)	0.019 (m)	
LAT:	39 8 2.34044	0.004 (m)	39 8 2.36961	0.004 (m)	
E LON:	282 46 44.48128	0.014 (m)	282 46 44.46647	0.014 (m)	
W LON:	77 13 15.51872	0.014 (m)	77 13 15.53353	0.014 (m)	
EL HGT:	108.930 (m)	0.024 (m)	107.646 (m)	0.024 (m)	
ORTHO HGT:	140.647 (m)	0.035 (m)	[Geoid03 NAVD88]		
UTM COORDINATES			STATE PLANE COORDINATES		
UTM (Zone 18)			SPC (1900 MD)		
Northing (Y) [meters]	4333993.903		162903.081		
Easting (X) [meters]	308035.021		380894.459		
Convergence [degrees]	-1.40216645		-0.13869297		
Point Scale	1.00005376		0.99995997		
Combined Factor	1.00003667		0.99994288		
US NATIONAL GRID DESIGNATOR: 18SUJ0803533994 (NAD 83)					

Figure 2, OPUS solution report for GPS data collected on 1st April 2006.

an additional reference station is selected for a fourth baseline. In the third and final step the ITRF coordinates are transformed into the NAD83 datum and other mapping projections such as UTM and SPC, before producing the final solution report. These three steps typically take about three to four minutes but can vary depending on occupation length.

**Output to User**

The report sent to the user in ASCII text format via email

consists of three main sections. The first contains information on user's dataset, such as start and stop time, antenna type and height, number of observations and overall accuracy. The second section reports positional information in the ITRF at the observation epoch, and NAD83 and UTM at the datum epoch. Peak-to-peak values are also stated and are useful in determining the level of agreement between the three individual baselines. The orthometric height at the station is computed from a geoid model produced by NGS and reported

if GPS data was collected in the conterminous US. The third section contains information on the three reference stations used in the solution and the distances to each reference station and to the nearest NGS-published control point. If the extended output option is selected, additional reference-station information is given. Figure 1 shows the geographic location for a number of processed datasets submitted on 6th June 2006. Figure 1 shows a typical solution report for 24 hours of data collected at a station (gait) on 1st April 2006. The extended output is also compatible with many post-processing applications from other third-party vendors.

**Performance**

To determine performance, two hours of GPS data from approximately two hundred CORS sites across North America were submitted and processed and their solutions compared with the published coordinates. The standard deviations were 0.8, 1.4, and 1.9cm for the local north, east and up components, respectively (Figure 3).

**Further Reading**

- ◆ Mader, G.L., Weston, N.D., 2006. NGS Online Positioning User Service, GeoIntelligence Jan/Feb, pp 16-19.
- ◆ Mader G.L., Weston N.D.,

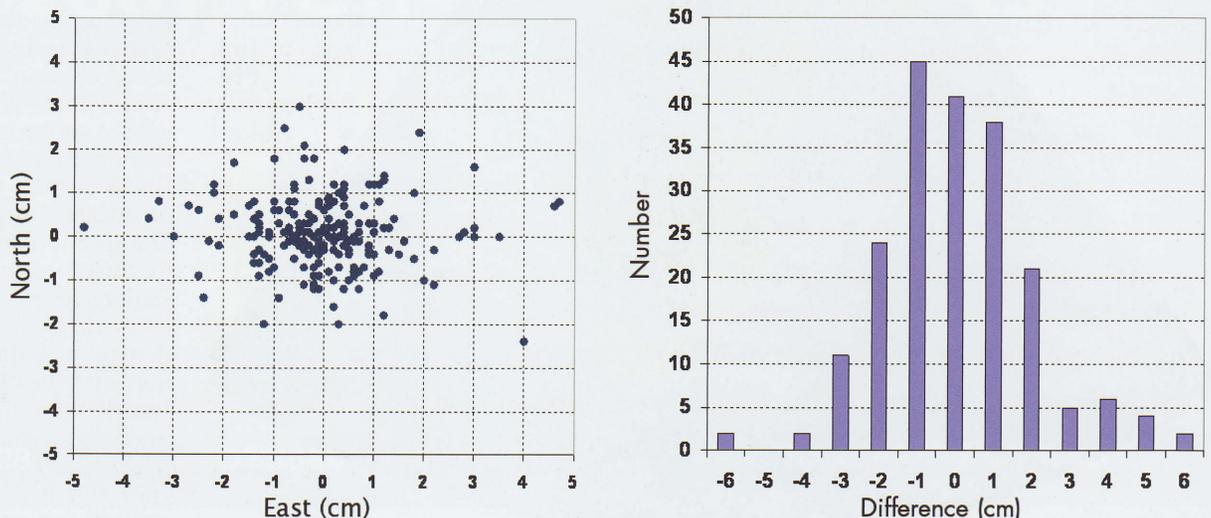


Figure 3, Horizontal (left) and vertical (right) distributions of OPUS solution differences from accepted ITRF values shown for two hundred CORS stations using two hours of data, the minimum required by OPUS

Morrison M.L., and Milbert D.G., 2003. The On-line Positioning User Service (OPUS). Prof. Surv. 23(5): 26, 28, 30.

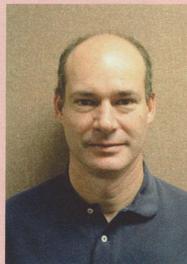
- ◆ Soler, T., Weston, N.D., Snay, R.A., Mader, G.L., and Foote, R.H., 2006. Precise Georeferencing Using On-line Positioning User Service (OPUS) Proceedings XXIII FIG Congress, Munich, Germany, October 8-13, 2006, p 12.
- ◆ Soler, T., Michalak, P., Weston, N., Snay, R., Foote, R. 2006, Accuracy of OPUS solutions for 1- to 4-h observing sessions, GPS Solutions, 10, pp 45-55.
- ◆ Stone, W., 2006, The Evolution of the National Geodetic Survey's Continuously Operating Reference Station network and Online Positioning User Service, Proceedings 2006 ION-IEEE Position, Location, and Navigation Symposium, April 25-27, 2006, San Diego, CA. ◆

### Biographies of the Authors

**Neil D. Weston** holds an MS in Applied Physics and will receive his PhD in Physics in May 2007. He is currently OPUS programme technical manager but also has an interest in 3D imaging and motion analysis.

**Tomás Soler** holds a MSCE from the University of Washington and a PhD in Geodetic Science from Ohio State University. He is chief technical officer in the Spatial Reference Systems Division. His research interest covers coordinate systems and transformations of reference frames.

**Gerald L. Mader** received his PhD in 1975 and currently serves as chief of the Geosciences Research Division of the National Geodetic Survey. His research interests include kinematic GPS positioning, antenna calibrations and automated GNSS data processing.



*Neil D. Weston*



*Tomás Soler*



*Gerald L. Mader*

*Neil D. Weston, Tomás Soler, Gerald L. Mader, National Geodetic Survey, NOAA, 1315 East West Hwy, SSMC #3, Rm 8113, Silver Spring, MD 20910, USA, email: [neil.d.weston@noaa.gov](mailto:neil.d.weston@noaa.gov)*

*J.D. Huntington*  
National Geodetic Survey  
Silver Spring, MD 20910