OPUS Developments at NGS

Dan Gillins, Ph.D., P.L.S.

OPUS IPT Team Lead, National Geodetic Survey

February 8, 2022

Daniel.Gillins@noaa.gov

Outline

1. Brief Overview on the variants of OPUS
2. Summary of recent developments
   – OPUS-Projects 4 & 5
3. Summary of ongoing developments
   – M-PAGES
4. Summary of future developments
   – OPUS 6

Online Positioning User Service (OPUS)

- **OPUS-Static – (2001)**
  - L1/L2 observables
  - Single occupation on a mark, ≥ 2 hours
  - GPS-only (currently true for all versions of OPUS)
  - Possible to "share" your solution if T > 4 hours
- **OPUS-Rapid Static – (2007)**
  - Single occupation on a mark, 15 min < T < 2 hours
  - L1/L2 observables and C1 or P1 and P2
- **OPUS-Projects – (~2012)**
  - Multiple occupations on numerous marks
  - Survey network least squares adjustments
  - Static GPS survey campaigns
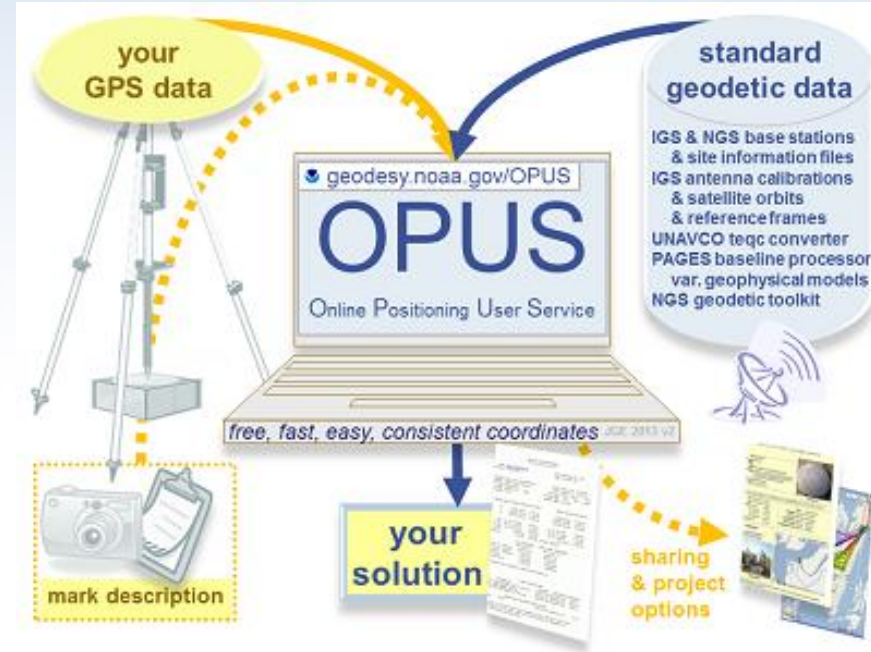
Summary of Recent Developments

- **July 2021 – released OPUS-Projects 4**
  - Streamlines process for publishing campaign-style GPS surveys on Datasheets
  - Prepares all required FGCS Blue Booking files
  - Enables submission of GPS survey projects to NGS for review and loading in the Integrated Database
- **September 2021 – released Beta OPUS-Projects 5**
  - Allows upload of processed GNSS vectors in the GVX format
    - RTK/RTN; rapid static; post-processed kinematic
  - Enables methods for collecting and publishing RTK GPS surveys on Datasheets

OPUS-Projects 4

https://geodesy.noaa.gov/OPUS-Projects/OpusProjects.shtml

- Allows upload of photos, description files, logs, and reports

- Prepares files for publication (Blue Booking)

- Ability to run ADJUST within OPUS-Projects

- Button to submit survey to NGS for review and loading in NGS Integrated Database

- **Detailed User Guide available**

1/9/2024

BETA OPUS-Projects 5

- Inclusion of previously processed GNSS vectors
    - Single-base RTK vectors
    - Network RTK vectors
    - Vectors processed in other software
- Automatically "weights" uploaded vectors in a network least squares adjustment
- Final adjustment results can be submitted to NGS for publication
- Feedback welcome! Available on BETA at: https://beta.ngs.noaa.gov/OP-bluebook/OpusProjects.shtml

GNSS **V**ector E**X**change Format (GVX)

Website: https://www.ngs.noaa.gov/data/formats/GVX/index.shtml

- Detailed documentation
- Schema (XSD)
- Example vector file

GVX is written in Extensible Markup Language (XML)

- Designed to store and carry data in plain text format
- Flexible representation of arbitrary data structures
- Extensible – new elements can be added later without breaking applications
- Both machine-readable and human-readable
- Schemas can be used to define "must haves" and "should haves"

Industry Invited to Provide Feedback

- Released GVX v. 1.0 released to industry on February 4, 2021
- Over 30 people attended mtg

Step 1: Upload Static GNSS Data Collected at Base Stations; Post-process with CORSs

Step 2: Upload GVX Files (Vectors)

Step 2: Upload GVX File

Baselines	GVX Baseline Statistics					
	vector count	vector used	Span Min (s)	Span Max (s)	PDOP Min	PDOP Max
bell-jmt2	6	6	301	319	1.32	1.66
bell-baco	13	13	301	362	1.26	2.12
brun-mas2	18	12	301	301	1.36	2.3
calv-dew1	16	15	301	333	1.36	2.2
e087-umbc	15	11	301	797	1.35	4.31
e087-mas2	3	3	301	301	1.65	2.34
fran-mas2	3	3	301	301	1.27	1.38
fran-paac	15	13	301	301	1.26	3.34
gorf-umbc	17	17	301	301	1.45	2.27
n102-bcc1	18	18	301	349	1.24	2
pond-baco	11	7	301	512	1.44	2.35
pond-jmt2	6	6	301	592	1.46	2.4
tane-paac	6	6	301	326	1.34	2.3
tane-pacb	12	12	301	325	1.49	2.09

Preferences
Project List
Solutions
Add Project Tracking Number
Show File
Send Email
Upload Serfil
Upload Description
Upload Field Logs
Refresh PID Information
Upload GNSS Vectors
Set up Adjustment
Upload Project Report
Review and Submit to IDB
Delete Project

Map   Satellite

+ Marks Marks&CORS −

jmt2
mas2
n102
paac
pacb
pond

Add MARKS

CORS
algo
corb
dene
gode
pafu
pass
york
Add/Del CORS

Summary of Ongoing Developments

- **M-PAGES: New GNSS baseline processing engine**
  - Processes all viable GNSS signals (GPS, GLONASS, Galileo, Beidou, QZS, IRN)
  - No dependence on external programs (teqc, gfzrnx, clockprep)
  - Modern programming language (Python)
  - Extensive documentation in HTML
- **Goals for OPUS**
  - Integrate M-PAGES in OPUS-S by September 2022
  - Integrate M-PAGES in OPUS-Projects 5 by December 2022

OPUS with M-PAGES

- Uses more satellites for processing

- More accurate

- Faster integer fixing

Upload your data file.
Solve your GNSS position & tie it to the National Spatial Reference System.
What is OPUS?   FAQs

[Choose File] No file chosen
* **data file** of dual-frequency GNSS observations. **sample**

[NONE   ▼]

antenna - choosing wrong may degrade your accuracy.

[2.002] *meters above your mark.*
antenna height of your antenna's reference point.

[daniel.gillins@noaa.gov   ]
* **email address** - your solution will be sent here. **Privacy Act Statement**

[Options] to **customize** your solution.

sample solutions

formats	[standard ▼]	**formats explained**	
base stations	**Use:**	**Exclude:**	identify any CORS you wish to explicitly 'Use' or 'Exclude' from your solution by typing in 4-char site IDs separated with line break
			-- **sample**
			-- **find site IDs**
state plane	[let OPUS choose ▼]	your **SPCS zone**	
constellations	☑GPS ☐GLO ☐GAL ☐BDS ☐QZS ☐SBA ☐IRN		

Summary of Future Developments

- **OPUS 6**
  - Provides solutions in the modernized NSRS
  - Develops files for submission to the new NSRS Database
  - Supports classical (angles/distances), leveling, and relative gravity surveys in addition to GNSS

Concluding Remarks

- Developments to OPUS provide easier access to the NSRS

- Geodetic data can be readily submitted to NGS for publication and development of models
  - Collection of RTK data is particularly highly efficient
  - Published data can be used to support the GPSonBM campaign

Questions?

- Daniel.Gillins@noaa.gov

Extra slides…

On Other Standard File Formats

Measurement Type	File Format	File Type	Current Status	Use at NGS
Reduced GNSS data (GNSS vector)	**GVX**	XML	Released final version 1.0 on 2/04/2021	OPUS-Projects v.5, OPUS v.6
Differential leveling (height differences)	**LVX**	XML	Under development. Version 0.3 under review	OPUS v.6
Classical (angles, distances)	**CVX**	XML	Under development. Version 0.3 under review	OPUS v.6
Relative gravity (gravity differences)	**RGX**	XML	Planned for 2021	OPUS v.6

OPUS-Projects v.5.0

Basic Steps

1. Upload static GNSS data (if any) for post-processing

2. Upload GVX file(s)

3. [optional] Upload description files from Windesc

4. Process static GNSS sessions and QA/QC results

5. Evaluate uploaded vectors; remove "poor" vectors from network

6. Run all network adjustments → MUST use ADJUST in order to adjust GVX vectors

7. Although currently not activated, will be able to submit results to NGS for review and publication

For More Technical Details, Refer to…

- Gillins, D.T., Kerr, D., and Weaver, B. (2019). "Evaluation of the Online Positioning User Service for Processing Static GPS Surveys: OPUS-Projects, OPUS-S, OPUS-Net, and OPUS-RS," *J. Surv. Eng*. (ASCE), 145(3):05019002.

- Gillins, D.T., Heck, J., Scott, G., Jordan, K., and Hippenstiel, R. (2019). "Accuracy of GNSS Observations from Three Real-time Networks in Maryland, USA," *Proc. 2019 FIG Working Week, Hanoi, Vietnam*, April 2019, 15 pp.

- Park, J., Kim, S., Shahbazi, A., Gillins, D., and Dennis, M. (2018). "Evaluation of Static GPS Surveying Campaigns Processed in OPUS-Projects," *Final Technical Report FY17 NA293P*, National Geodetic Survey, 58 pp.

- Jamieson, M., and Gillins, D.T. (2018). "Comparative Analysis of Online Static GNSS Post-Processing Services." *J. Surv. Eng*. (ASCE), 144(4):05018002.

- Allahyari, M., Olsen, M., Gillins, D.T., and Dennis, M. (2018). "A Tale of Two RTNs: Rigorous Evaluation of GNSS Survey Observations in Real-time Networks," *J. Surv. Eng*. (ASCE), 144(2):05018001.

- Weaver, B., Gillins, D.T., and Dennis, M. (2018). "Hybrid Survey Networks: Combining Real-time and Static GNSS Observations for Optimizing Height Modernization," *J. Surv. Eng*. (ASCE), 10.1061/(ASCE)SU.1943-5428.0000244, 144(1):05017006.

- Gillins, D., and Eddy, M. (2017). "Comparison of GPS Height Modernization Surveys using OPUS-Projects and Following NGS-58 Guidelines," J. Surv. Eng. (ASCE)., 143(1):05016007.

Summary on Vertical* Accuracy of OPUS-Projects

Vertical Standard		Total Time on Mark (h)	Recommended Number and Session Duration
cm	ft		
3.0	0.10	4	(2) 2-h
2.5	0.08	8	(2) 4-h
2.0	0.07	22	(3) 8-h
1.7	0.06	48	(2) 24-h

* = ellipsoid height

Empirical Evaluation of the Accuracy of RTNs

[Allahyari et al. 2018]