



# OPUS Developments at NGS

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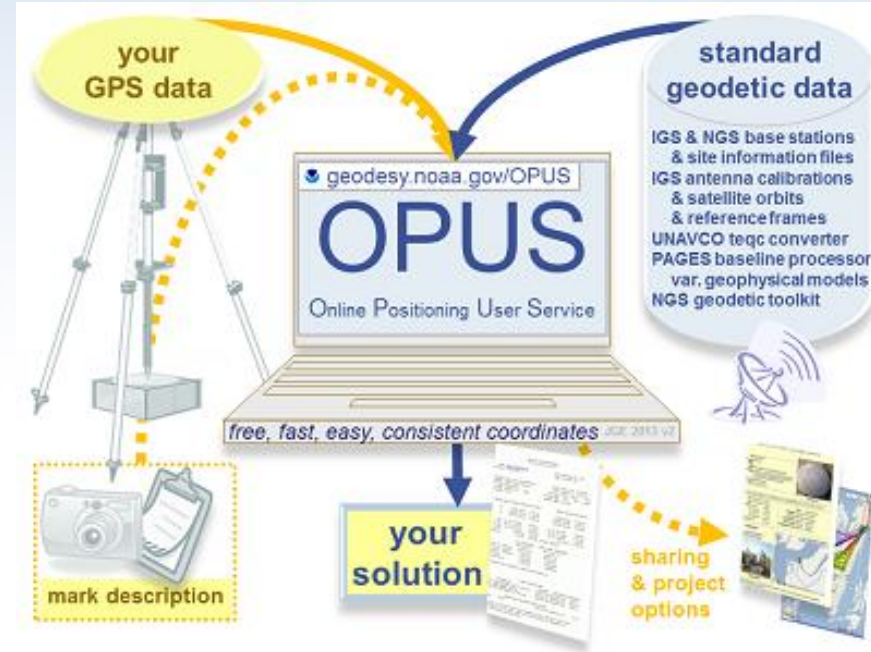
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# Outline

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,  $\geq 2$  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,  $15 \text{ min} < T < 2$  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**

Results From ALL ADJUSTMENTS

Controls: ? ← →

LEGEND: MARKS: ● meet preferences ● do not meet preferences ● are not included ● have error  
 CORs: ● meet preferences ● do not meet preferences ● are not included

Baselines: [Progress Bar]

Map Satellite + Marks Marks&CORS -

Occupation From ALL ADJUSTMENTS

MARKS	Adjustments		MARKS
	network final	network final-horizontal-free	
bld3	●	●	bld3
bred	●	●	bred
wthr	●	●	wthr

# 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 Vector EXchange 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

The screenshot displays the NOAA National Geodetic Survey software interface. The main map shows the Eastern United States with several GNSS stations marked by green circles and connected to a central base station in Washington, D.C. by blue lines. The interface includes a sidebar on the left with various controls and a legend on the right.

**Legend:**

- MARKS: CORS, GNSS Static Surveys only, Other GNSS Surveys only, Mixed GNSS Surveys
- STATUS: meet preferences, do not meet preferences, are not included, have error
- Baselines: Network Adjustment, GNSS Session, RTK, Other GNSS

**Left Sidebar (Controls):**

- 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** (highlighted with a red box)
- Set up Adjustment
- Upload Project Report
- Review and Submit to IDB
- Delete Project

**Right Sidebar (MARKS):**

- MARKS: baco, bcc1, dew1, jmt2, mas2, paac, pacb, umbc
- Add MARKS
- CORS: algo, corb, dene, gode, pafu, pass, vork

# Step 2: Upload GVX Files (Vectors)

**Upload GNSS Vector (.gvx) File**

GNSS Vector Exchange Format (GVX) is designed by NOAA/NGS, aiming to provide a standard format for exchanging GNSS vectors derived from varying GNSS survey methods and manufacturer hardware. Each GVX file contains necessary data of a GNSS vector for inclusion in a survey network for least square adjustment, as well as metadata which describes the vector.

For more information about .GVX format, please visit: [NOAA/NGS's GVX: The GNSS Vector Exchange File Format](#).

**Browse GNSS Vector File(s):**

GVX in This Project	
Name	GNSS vectors
052.jxl.gvx	18
053.jxl.gvx	15
054.jxl.gvx	13
057.jxl.gvx	15
058.jxl.gvx	18
058.jxl_dtg.gvx	18
059.jxl.gvx	18
060.jxl.gvx	18
064.jxl.gvx	9
065.jxl.gvx	17

Name	GNSS vectors
058.jxl_dtg.gvx - 58.73 KB Found in project <a href="#">Remove</a>	18

**Left Sidebar:**

- 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 Footer:** Google Maps, Fredericks, Salisbury, 20 km, Terms of Use, Report a map error, Add/Del C

# 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

The screenshot shows a software interface for uploading GVX files. On the left is a sidebar with the following buttons: 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, and Delete Project. The main area is a map of the Washington/Baltimore region with a network of baselines shown as purple dashed lines and green diamond markers. On the right is a 'MARKS' panel with a list of station names (jmt2, mas2, n102, paac, pacb, pond) and CORS codes (algo, corb, dene, gode, pafu, pass, york). Below the list are buttons for 'Add MARKS' and '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, gfzrnrx, 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**

No file chosen  
*\* data file of dual-frequency GNSS observations. [sample](#)*

**antenna** - 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. [Privacy Act Statement](#)*


to **customize** your solution.

**formats**  [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**  your **SPCS zone**

**constellations**  GPS  GLO  GAL  BDS  QZS  SBA  IRN



**sample solutions**

# 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](mailto: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)	<b>GVX</b>	XML	Released final version 1.0 on 2/04/2021	OPUS-Projects v.5, OPUS v.6
Differential leveling (height differences)	<b>LVX</b>	XML	Under development. Version 0.3 under review	OPUS v.6
Classical (angles, distances)	<b>CVX</b>	XML	Under development. Version 0.3 under review	OPUS v.6
Relative gravity (gravity differences)	<b>RGX</b>	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.
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- 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](https://doi.org/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

