National Geodetic Survey's GPS on Bench Marks Campaign SIMPOSIO SIRGAS 2020

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GPSonBM Team:

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National Geodetic Survey's Mission

To define, maintain and provide access to the **National Spatial Reference System (NSRS)** to meet our Nation's economic, social, and environmental needs.

The **NSRS** is a consistent coordinate system that defines latitude, longitude, height, scale, gravity, orientation, and shoreline throughout the United States.



NGS' Long History of Crowd Sourcing Data

In February 2020, NGS celebrated 40 years of crowd sourced data collection since the <u>first</u> <u>NGS Bluebook</u> was released in 1980

Today, NGS continues to encourage data contributions for use in multiple applications:

- GPS and Leveling survey data
- CORS data
- Shoreline CUSP
- GPSonBM
- Mark Recovery



surge modeling, hazard delineation and mitigation,

environmental studies and may assist in nautical chart updates.

GNSS Observations on NAVD 88 Leveled Marks Crucial Data for GEOID18 & Transformation Tools



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GPS on Bench Marks New Data for Better Models and Tools

Main Goal:

Gather data to create Transformation Tools

Added benefits:

- Update Passive Control Status
- Automatic Reprocessing to create 2020.0 Reference Epoch Coordinates (REC's)
- Build a time series of observations

Potential Extensions:

- Identify marks suspected of movement
- Establish RTN Check Stations





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Minimal Data Requirements

- <u>GPS Observation</u>: Collect 4+ hours of data on a bench mark
- <u>Description</u>: Provide details of how to locate mark (To Reach)
 Example: Located in the SW corner of a 2 ft square concrete pad projecting 0.3 ft above ground, 3.3 ft S from S edge of sidewalk...

Accurate <u>antenna height</u> and <u>type</u> values

• 2 photos:

- <u>close-up photo</u> (avoid dark/blurry/dirt-covered)
- horizon photo (show equipment in use)



NOAA's National Geodetic Survey Positioning America for the Futuregeodesy.noaa.govExtensive Residual Analysis used to create a Prioritized List
Residual = h - H - N







h is ellipsoid height measured using GPS H is an NAVD 88 Orthometric Height from Leveling N is from a geoid model: either gravimetric or hybrid

Theoretically, the difference between these three values should be zero. In practice, using actual observations gives a residual, or measure of the misfit between the three. We use the residual to evaluate and quality control the observations.

NOAA's National Geodetic Survey Pos

2018 GPSonBM Target: GEOID18 data

- Requested: ~5,900 Marks
- Received:

- ~3,800 observations
- ~2,600+ marks

Agency Type	% of Marks Submitted
State Agency	76%
Private Sector	14%
Federal Agency	6%
County Agency	4%
Academic	2%
City Agency	2%
Professional Society	0.5%
Utility	0.5%

2018 Tracking Map

Great

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GEOID18 Technical Report

NGS will be releasing a Technical Report that describes the details of how the GEOID18 model was created, including:

- Technical Specifications
- Methodology
- Input Data
 - Gravimetric Geoid Model
 - GPS on Bench Marks
 - Least Squares Collocation
- Model Performance and Evaluation
- Relative Accuracy
- DEFLEC18





Figure 1: Impact of GRAV-D on GEOID18 — Difference between models using xGEOID19B and xGEOID19A. Blue outlines show the general GRAV-D Block boundaries used in xGEOID19B and GEOID18.

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Approximate Predicted Differences between Old & New: NAVD 88 minus NAPGD2022



GPSonBM data collection efforts are focused on the vertical datum transformations to resolve the irregular relationship between the surfaces. Horizontal transformations are smooth and will be done primary with CORS data.



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GPSonBM Measurements Build the Bridge between Old & New Datums Because the relationships between the old and new datums vary by location, the accuracy of the transformations in any particular place is directly related to the density of GPSonBM data available in that area.



2022 Transformation Tool Campaign Overview

- NGS will make **national scale**, **mapping grade** transformation grids with the data in the NGS Integrated Database or Shared through OPUS
- <u>NGS may age-limit the data & only use data</u> <u>submitted since 2010</u>
- We must interpolate over areas with data gaps
- Uncertainties in the transformed coordinates will grow larger as the distance from a GPSonBM data point increases
- To keep uncertainties reasonable, NGS has a National Coverage goal of 10 km spacing



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GPSonBM Transformation Tool Campaign Web Map

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NGS Home About NGS	Data & Imagery	Tools	Surveys	Science & Education		Search
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Updates	Report: Use onlin	ne tools to s	end the inform	ation to NGS.		
	Visit the W	eb Map	Visit th	e Dashboard	Download Prioritized I	Marks







[~6 MB]

[~15 MB]

Check out the web map: www.ngs.noaa.gov/GPSonBM/

The web map has several

functions that allow users to

search, explore, filter, and

export the data

National Coverage and Local Densification

- National coverage goal is illustrated by 10 km hexagons on the map.
- Priority marks within each hexagon are automatically selected based on their metadata
- Once the 10 km goal is reached, the opportunity to densify the model and improve local results is unlocked. 2 km hexagons appear along with new priority marks within those hexagons

Priority A Hexagons are Gold

Priority B hexagons are Blue

Hexagons where we have the data we need are marked Done and colored Green





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GPSonBM Transformation Tool Campaign: Progress Dashboard



GPS on Benchmarks - Proposed Observations

State Level Maps & Dashboards for Regional Coordination





Alaska GPS on Bench Marks - 2020 Field Priorities

Proposed Occupation Date =

1. Enter Information

PID of Mark to GPS

Satellite Visibility

Select... Company Name

Contact Name

Email Address

Telephone Contact

Mark Found Select... 2. Select Location

Specify the location for this entry by clicking/tapping the map or by using one of the following options.





3. Complete Form Add this information to the map. Submit Entry View Submissions



Search

Close

New Mark Recovery Webpage

Crowd sourced mark recoveries help update the GPSonBM map, let NGS and others know if the mark is still usable, and pictures make it easier to find.

PID: ①

Designation: ①

Stamping: ①

Latitude: 0

Lonaitude: ①

Country: 0

State: ①

County: 0

DE8888

CHA 05A

CHA-05A

N400131.85369

W0882207.65630

CHAMPAIGN

Select agency code

YYYYMMDD

ex. John Sm

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

Mark Recovery Links Survey Mark Recovery Home NGS Data Explorer NGS Photo Submission Guidelines Survey Mark Datasheets Preserving Marks During Pailroad Abandonment

Mark Descriptions

Mark Position

Mark Photos

Designation

Mark Type

Setting

Mark Stamping &

Mark Setting & Specific

Rod/Sleeve Depths

Magnetic Property

Mark Stability

Related Links

Geocaching

USACE's U-SMART Tool

Mark Condition Mark Descriptive Notes

Help

Survey mark refers to any permanent marks or disks placed in

Survey Mark Recovery

the ground or attached to a permanent structure with known latitude, longitude or height information. Its utility depends on the surveyor's ability to recover the mark in good condition. If a mark has been damaged or destroyed, the positional information may have been compromised. If the mark has been completely removed. it's no longer useful.

In an effort to maintain updated records on more than 800,000 survey marks set around the country and its territories, the National Geodetic Survey encourages the public to submit the current mark recovery information.

Submit Survey Mark Recovery Data

To submit your survey mark data to NGS, please use our online Mark Recovery Form

Mark Recovery Form

Mark Recovery Form Instructions:

- In the first field under the Marker ID section, enter the recovered mark's Permanent Identifier (PID) to auto-populate existing mark descriptive fields from the NGS database. Please review and update the fields as needed. If you don't know the mark's PID, please use the Survey Mark Datasheets tool to find it.
- In the Recoverer ID section, enter your user information including Agency Code and Agency. An
 individual can use the code "M" (non-specific designators) and recovery agency "INDIV".

Tools: Recovery Agency | Register an Agency | More Info

- 3. In the Recovery Information and Advanced sections, include all appropriate mark condition
- descriptors.

www.ngs.noaa.gov/surveys/mark-recovery

Your Agency Type: ①

Date mark was

recovered: 0

Name: ①

Mark Recovery F	orm							
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GEOID18 Model Improvements

- 32,357 GPS on Bench Marks data points were used to constrain the model to NAVD 88, PRVD02 and VIVD09, an increase of ~6,800 marks (26%) over GEOID12B
- Significant new analysis of GPSonBM data resulted in a much cleaner dataset
- Includes better elevation data and improved digital elevation modelling techniques
- Uses better gravity data and improved geoid modeling techniques
- New space-based gravity data from satellite gravity missions (GRACE & GOCE)
- Includes all available airborne gravity data 53 completed GRAV-D blocks

	CONUS, Canda, and Mexico	CONUS Only	Puerto Rico and US Virgin Islands
GPS on Bench Marks Count	32,357	31,580	127
Min. [cm]	-19.43	-10.12	-4.37
Max. [cm]	20.59	8.17	4.52
Mean [cm]	0.00	0.00	0.00
Std. Dev. [cm]	1.39	1.27	1.67

The overall fit of the final GEOID18 model to used bench marks is excellent. Over all of CONUS, the standard deviation is 1.27 cm

(GEOID12B was approximately 1.7 cm)