

GPS on Bench Mark

Quarter 2, 2018 Article

By: Brian Fisher

In this article we will look at what the GPS on Bench Mark Project is, what it will produce, why you should and when you can participate, and where you can go to find a mark to observe. NGS will produce a model with whatever data they have at the end of August this year. Right now is the opportunity for you to improve the data in and around your community by getting involved. GPS on BM is a necessary project to both improve the future models we use to obtain elevation information and to build a continued link to previous datum realizations of the past. If your community is realized to an older datum (like NGVD29 or NAVD88) or you are wondering how you will be able to migrate to the next datum in 2022, GPS on BM is an important project for you.

What is GPS on BM?

NOAA's National Geodetic Survey (NGS) encourages anyone with survey-grade Global Positioning System (GPS) receivers to help perform GPS on Bench Marks (GPS on BMs) to support the development of GEOID18 and transformation tools that will be produced for the North American-Pacific Geopotential Datum of 2022 (NAPGD2022).

What is a Bench Mark?

In a geodetic context, the terms "survey mark" and "bench mark" are **not** the same. A **bench mark** is a specific type of survey mark that has a known elevation (height) above or below an adopted surface or datum. **Survey mark** refers to any permanent marks or disks placed in the ground or attached to a permanent structure with known latitude, longitude or height information. Other terms used for survey mark are "survey point" or "control point." Colloquially (and incorrectly) bench mark is used interchangeably with survey mark.

For the purpose of this project the bench marks to be used must be:

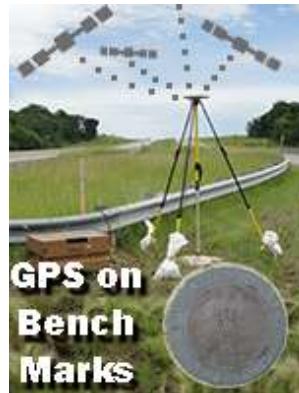
- NAVD88 datum
- Have an 'Adjusted' or 'Posted' value in the NGS IDB database
- Must be able to be directly observed by GPS and OPUS-Share

What is meant by GPS?

GPS can mean one of three things to NGS: Hand Held; OPUS-Share; Bluebook Survey. OPUS-Share will be the primary focus of this article, but for a full description of the other two see the link to the AZ Project Guide at the end of this article.

- OPUS-Share observations (4+ hours of data, description and photos) on bench marks that do not previously have a measured ellipsoid height
 - Single observations will be used as a 'check only' on models that are created
 - Two or more 'agreeing' observations will be used to improve the models being created.

Recover Observe Report



What is a Geoid?

There have been many definitions of the "geoid" over 150 years or so. Here is the one currently adopted at NGS:

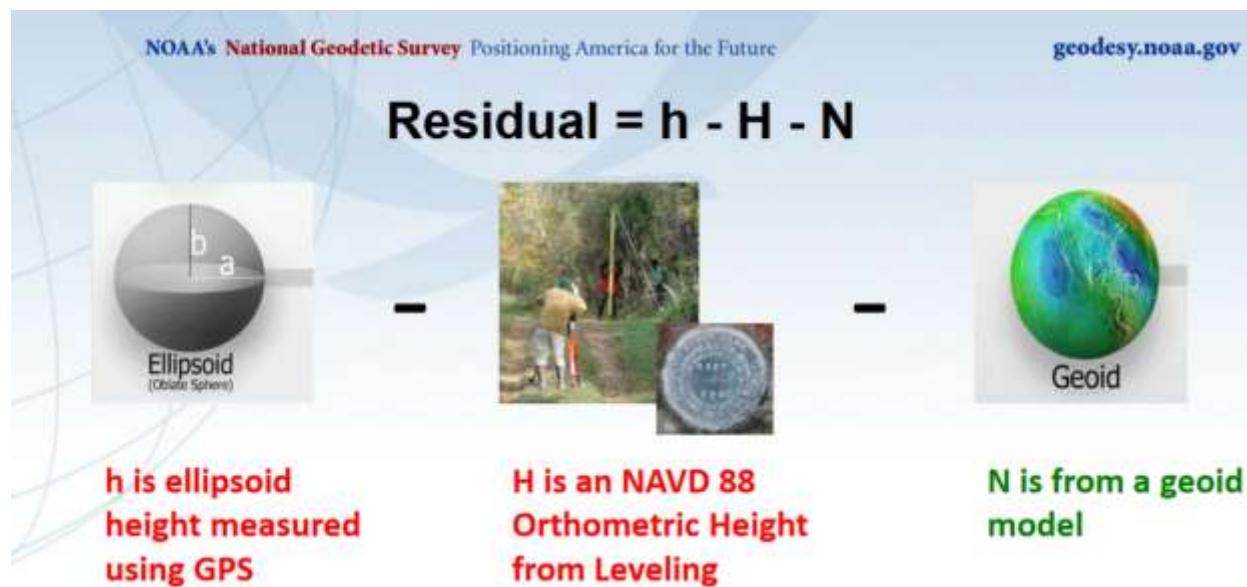
geoid: The equipotential surface of the Earth's gravity field which best fits, in a least squares sense, global mean sea level

Even though NGS adopted a definition, that does not mean they are perfect in the realization of that definition. For example, altimetry is often used to define "mean sea level" in the oceans, but altimetry is not global (missing the near polar regions). As such, the fit between "global" mean sea level and the geoid is not entirely confirmable. Also, there may be non-periodic changes in sea level (like a persistent rise in sea level, for example). If so, then "mean sea level" changes in time, and therefore the geoid should also change in time. These are just a few examples of the difficulty in defining "the geoid".

What Kind of Geoid is GEOID18?

GEOID18 will be a 'Hybrid Geoid'. Hybrid geoids convert NAD 83 ellipsoid heights to NAVD 88 orthometric heights. NGS will replace GEOID12B with GEOID18 in early 2019. This hybrid geoid model will provide improved GPS-derived NAVD 88 equivalent heights. It will be the last hybrid geoid model that NGS will create before NAVD 88 is replaced by the North American-Pacific Geopotential Datum of 2022 (NAPGD2022) in 2022.

What are the formulas used with a Geoid?



GPS on BM is a project to improve the residual between a GEOID and the two survey measured heights: Leveling and GPS. Theoretically, the difference between the three values should be zero. In practice, using actual GPS observations gives a residual, or measure of the misfit between the three. NGS uses the residual to evaluate the observations.

Why Participate?

Participation in GPS on BM will help improve the elevation (or orthometric height) component of the National Spatial Reference System (NSRS). The nation's height system, the North American Vertical Datum of 1988 (NAVD88), is founded on historic geodetic leveling surveys on

hundreds of thousands of bench marks that are often difficult and expensive to access. Many bench marks have not been positioned with GPS. By adding 'surveyed' GPS coordinates to these marks allows them to be used in NGS' modern height reference-surface modeling and GPS survey systems for easier access. ***In brief, this helps the local community where the observations are being made.***

Improve GEOID18

The latest hybrid geoid model, [GEOID12B](#), includes many "GPS on bench mark" observations, but GEOID18 would benefit from additional data collection in many areas (200+ marks in Arizona). GEOID18 will be the last hybrid geoid model that NGS will produce to provide NAVD88 equivalent heights. GPS on BM data for GEOID18 will be accepted through the end of August 2018.

Improve NCAT

NGS Coordinate Conversion and Transformation Tool (NCAT) allows users to easily convert between different coordinate systems and/or transform between different datums, in a single step. To do this however, the program requires data on historic points. The GPS on BM project will provide this needed data to improve the accuracy of the conversion tool. NGS will be producing tools with or without added data. Arizona GPS on BM will directly benefit the communities that submit additional data in their areas. This will also be that last opportunity to submit data for the NAVD88 datum. GPS on BM data for NCAT will be accepted through 2020, with an exact schedule to be selected later.

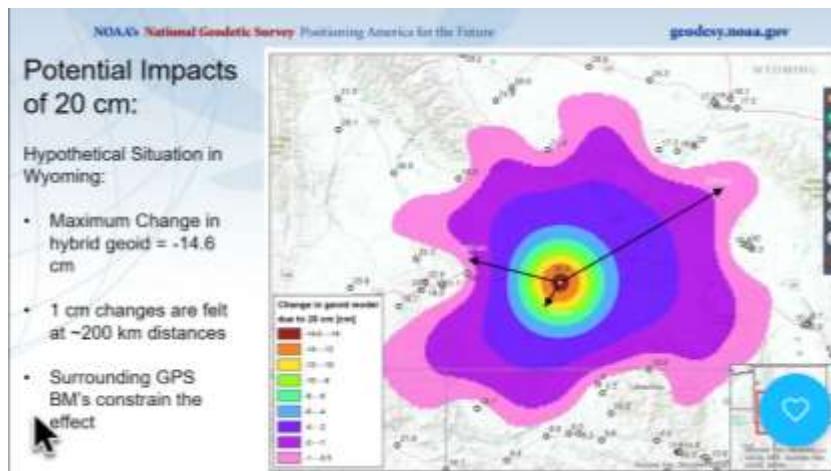
Time Constraints

GPS on BM data for GEOID18 will be accepted through the end of August 2018, and for NCAT through 2020, with an exact schedule to be selected later. This will be the last opportunity to submit data to NGS for inclusion in models and transformation tools that NGS creates.

Think outside the box

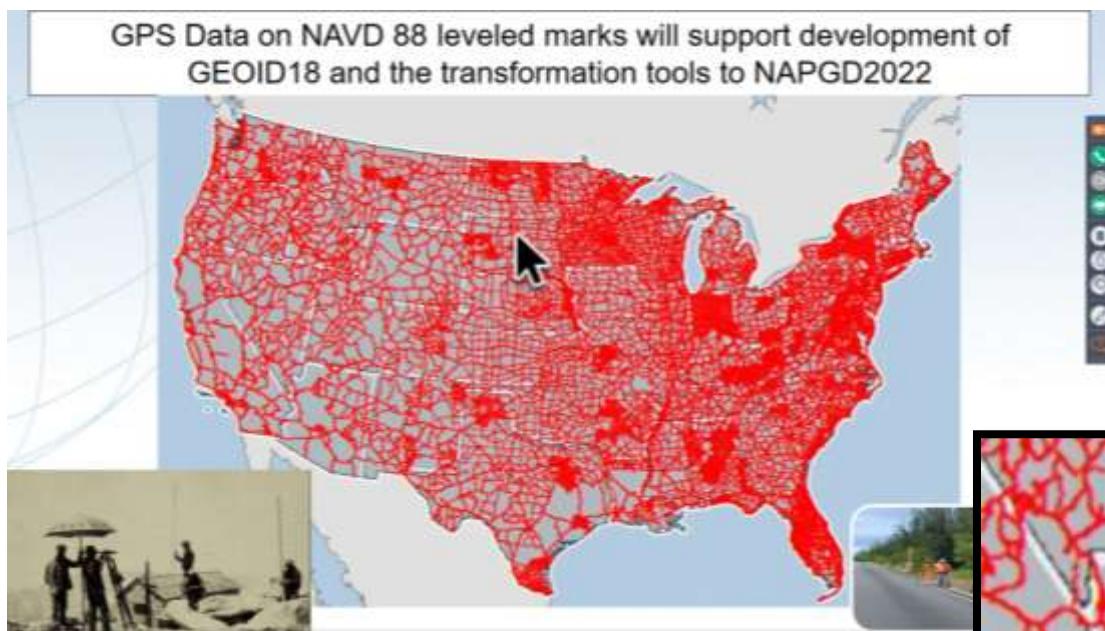
Selecting marks within your community can be identified in two ways: within your project or community boundary or within a radius of influence to your location. It is entirely probable that you will have few or even no marks within your area specifically because Arizona is sparsely covered compared to the rest of the lower 48 States. Leveling runs in Arizona are spaced farther apart than those in the eastern part of the country. Primary spacing of marks for the GPS on BM project have been set at 30 km / 19 miles for GEOID18, but marks as far away as 200 km / 124 miles can still influence the model in your area. When selecting marks in your area, think '**OUTSIDE THE BOX**'. Depending on the size of your community or project the closest marks may be some distance away, but still have influence and importance to you.





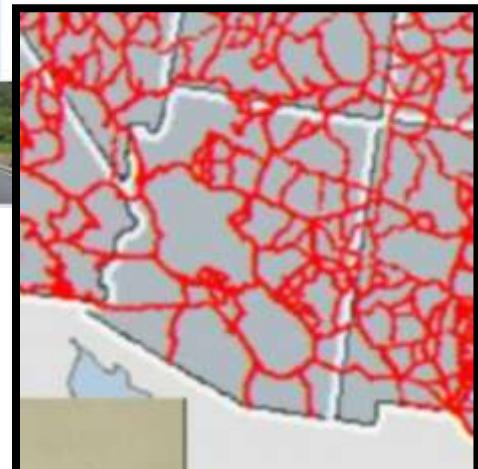
You may need to look as far as 100 km / 62 miles to even find a mark on an NAVD88 level line in Arizona. GEOID models are National in scope and do not discriminate over County or even State lines, so considering marks in these areas is also encouraged. Marks in Mexico are not being suggested at this time.

Graphic below shows the NAVD88 level lines in the lower 48. Note the southwest half of Arizona is visibly more spaced out than the majority of other parts in the country.



How to do it? It's easy as 1 - 2 - 3

1. **Recover:** Find local bench marks. Visit our website at Geodesy.noaa.gov/GPSonBM for a priority listing of marks to occupy and maps to help you find them. Contact your NGS geodetic advisor or State coordinator for more details, or email us at nsg.GPSonBM@noaa.gov.
2. **Observe:** Collect GPS on your selected bench mark following careful field procedures.
 - Complete reconnaissance at your selected mark to ensure its usability, and submit a mark recovery via DSWorld.
 - Validate the mark with the best method you have
 - RTN or RTK survey



- OPUS-Projects Survey
- Leveling
- Collect a 4+ hour GPS data file.
 - Use a fixed-height tripod (recommended), and brace the legs with sandbags or chain.
 - Verify antenna type, height and plumb.
- Take two photos of the mark, and note any changes to the existing mark description.
(Optional: use observer field log with this step.)

3. **Report:** Share your data by uploading to our Online Positioning User Service (OPUS) on the NGS website at Geodesy.noaa.gov/OPUS

Contribute!

NGS will use data collected to develop GEOID18, increasing access to NAVD 88 and enabling conversions to the new vertical datum in 2022. NGS will be making national scale models and tools with the data that they have. This GPS on BM effort is an opportunity for you to submit data to be used in the creation of those products. There is no mandate for you to participate, however your data can help improve the models and tools in your region.

Just for Arizona

For more information about GPS on BM in Arizona see this link to the [Arizona Project Guide](#). For additional data that can help in performing reconnaissance see [All AZ NAVD88 BM](#) and [Ownership file](#) (for general reference only and as a start of basic research on what kind of entity owns the land a BM is on).

Make sure to also check the NGS page for this project for more information:
<https://geodesy.noaa.gov/GPSonBM/index.shtml>. There is also an interactive web map that lists the priority marks.

Contact Brian Fisher, the Arizona Geodetic Coordinator with any questions,
GeodesyArizona@gmail.com