Need for a New 3D North American Datum

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A Simple Truth

• Some Users Will Not Worry About A Datum Change Until It Is Officially Published, then …

• They Will Ask You Why You Didn’t Inform Them Earlier About The Change

• Let’s not go down that road!

Modernizing the NSRS:
The NGS 10 year plan

Comments by
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Federal Geospatial Summit
May 10-11, 2010
Silver Spring, MD
Outline

• NGS and datums
• Accuracy vs. constancy
• The NGS 10 year plan
• Transitioning

NGS’s role and authority vis-a-vis “datums” (1 of 6)

• Coast and Geodetic Survey Act (Public Law 80-373) gives the Department of Commerce the right to (amongst numerous other things):
  - “…conduct …geodetic control surveys…”

• http://uscode.house.gov/download/pls/33C17.txt

NGS’s role and authority vis-a-vis “datums” (2 of 6)

• OMB Circular A-16 (revised):
  - Names DOC and NOAA as “lead agency” for Geodetic Control, and says:
    - “All NSDI framework data and users’ applications data require geodetic control to accurately register spatial data.”
  - “The National Spatial Reference System is the fundamental geodetic control for the United States.”
NGS’s role and authority vis-a-vis “datums” (3 of 6)

- OMB Circular A-16 (revised):
  - Because NGS is the only agency inside DOC or NOAA that sets geodetic control, the NSRS responsibility falls to NGS. The NGS mission reflects this OMB-granted responsibility:
    - NGS Mission: “To define, maintain, and provide access to the National Spatial Reference System to meet our nation’s economic, social, and environmental needs”
  - www.whitehouse.gov/omb/Circulars/a016/a016_rev.html

NGS’s role and authority vis-a-vis “datums” (4 of 6)

- FGCC Federal Register Notice (Vol. 54, No. 113, 1989)
  - Affirms "NAD 83 as the official civilian horizontal datum for U.S. surveying and mapping activities performed or financed by the Federal Government.
  - "Furthermore, to the extent practicable, legally allowable and feasible, all Federal agencies using or producing coordinate information should provide for an orderly transition from NAD 27 to NAD 83."

NGS’s role and authority vis-a-vis “datums” (5 of 6)

- FGCS Federal Register Notice (Vol. 58, No. 120, 1993)
  - Affirms "NAVD 88 as the official civilian vertical datum for surveying and mapping activities in the United States performed or financed by the Federal Government.
  - "To the extent practicable, legally allowable, and feasible, require that all Federal agencies using or producing vertical height information undertake an orderly transition to NAVD 88."
NGS's role and authority vis-a-vis “datums” (6 of 6)

• Summary:
  – OMB A-16 establishes DOC/NOAA (implying NGS) as lead agency for NSDI geodetic control (the NSRS)
  – NGS has defined the horizontal/vertical datum portions of the NSRS as NAD 83/NAVD 88
  – FGCC/S agrees that all civilian federal surveying and mapping be in NAD 83/NAVD 88

• These regulations
  – do not apply to DoD
  – nor to state and local surveying,
  – but these groups often do adopt the NSRS.

NGS 10 year plan

• Drafting and vetting to the public took 18 months
• Official NGS policy as of Jan 2008
• By 2018, without reliance on passive geodetic marks:
  • Replace NAVD 88 with a GNSS/geoid datum
  • Replace NAD 83 with a geocentric GNSS based datum

Accuracy vs. Constancy

• NGS is an agency based in science, and always seeking accuracy and truth in positioning
  – The Earth is dynamic / coordinates change
• NGS is an agency with a large user base that relies on near constancy of coordinates
  – Some dynamics can be modeled and removed for near-constancy (N.A. plate rotation : lat / lon)
  – Some dynamics should be tracked and regularly accounted for (subsidence in the Gulf coast : H)
Accuracy vs. Constancy

- Static datum: Coordinates do not change.
- Dynamic datum: All coordinates change (ITRF)
- Semi-dynamic datum: Changes are tracked at NGS, but not necessarily part of the datum unless they exceed some critical level

Transition Example: Digital TV

- Radio Frequency Spectrum is like "real estate". Only so much to go around.
- Somebody thought: "If we use multiplexing, and broadcast digital signals, we can get 5 times as many broadcasts in the same radio frequency spectrum!"

Transition Example: Digital TV

- 1996 Congress: "Transition coming in 2006!"
- 2005: Analog TVs still being mass produced
  - Congress: "Um, how does February 2009 sound?"
- 2006: Analog TVs still being mass produced
  - Congress: "Hey, we’re serious...2009 is coming"
- 2008: FCC finally creates a DTV website
- Feb 2009: Too few people have converters
  - Congress: "How does June 2009 sound?"
Transition Example: Digital TV

- At its core, this transition went poorly for many reasons, but one in particular:
  - There wasn’t a perceived need to convert to digital.
  - TV isn’t a necessity. (Though...Emergency Readiness?)
  - Nonetheless, available spectrum was running out with all the new technologies and making efficient use of existing spectrum made a lot of sense
  - To those who understood and cared
  - A classic example of a solution to a problem that people didn’t know existed.

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A problem that does exist

- The White Paper (Improving the NSRS.pdf) should explain the problems and raise awareness of them
- The burning question is no longer “why” but “how”
- Moving forward must be done with contemplation, caution and commitment

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Modernizing the Geometric Reference System: Replacing NAD 83

Comments by
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May 10-11, 2010
Silver Spring, MD

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Defining a ECEF Reference System

- ECEF = Earth centered, Earth fixed
- Z-axis = Earth’s pole of rotation
- X-axis = Intersection of equator and prime meridian
- Y-axis = Forms right-handed system with X- and Z-axes
- Scale = meter or distance that light travels in a vacuum during 1/299,792,458 seconds
- Ellipsoid = needed to define latitude and ellipsoidal height
- Complications arise from Earth’s dynamics (Polar motion, plate tectonics, earthquakes, subsidence, etc.)

3-D ECEF Coordinates

\[ P(X,Y,Z) = P(\phi, \lambda, h) \]

North American Datum of 1983 (NAD 83)

- Legal reference system in the United States
- National Geodetic Survey is responsible agency in U.S.
- First realized in 1986, revised for HARN, revised again for CORS
- Originally, NAD 83 was mostly a horizontal reference system
- Evolved to a 3-dimensional reference system, thanks to GPS
Origin is located about 2 meters from Earth’s center

- Redefined to be “mathematically equivalent” to ITRF96 in the late 1990's. That is, the U.S. and Canada jointly adopted a 14-parameter transformation from ITRF96 to NAD 83 such that if a person knows the ITRF96 coordinates of a point, then he/she can compute the corresponding NAD 83 coordinates and vice versa.

- Points located in “stable” North America should experience no significant horizontal motion relative to NAD 83.

**IMPROVING POSITIONAL ACCURACY**

<table>
<thead>
<tr>
<th>REFERENCE FRAME</th>
<th>TIME SPAN</th>
<th>ABSOLUTE ACCURACY</th>
<th>RELATIVE ACCURACY</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAD 27</td>
<td>1927-1986</td>
<td>10 Meters</td>
<td>First-Order (1 part in 0.1 million)</td>
</tr>
<tr>
<td>NAD 83</td>
<td>1986-1990</td>
<td>1 Meter</td>
<td>First-Order (1 part in 0.1 million)</td>
</tr>
<tr>
<td>HARN</td>
<td>1987-1997</td>
<td>0.1 Meter</td>
<td>B-Order (1 part in 1 million)</td>
</tr>
<tr>
<td>CORS</td>
<td>1994 -</td>
<td>0.03 Meter - Horizontal</td>
<td>0.04 Meter - Ellipsoid Height</td>
</tr>
</tbody>
</table>
Continuously Operating Reference Stations (CORS)

NAD 83 NAMING CONVENTIONS

- NAD 83 (UVWXYZ) – the part within parentheses is called the “Datum Tag”

- Original realization called NAD 83 (1986), because the adjustment was completed in 1986. This realization of NAD 83 was based mainly on triangulation, trilateration and doppler data.

- The HARN realizations are named NAD 83 (1987), NAD 83 (1988), ..., NAD 83 (2004) where the number in parentheses usually identifies the year when the GPS observations were performed.

- The CORS realization is called NAD 83 (CORS96) where 96 identifies that this realization was defined in terms of a transformation from ITRF96.

- NAD 83 (NSRS2007) was created for passive reference stations. It is designed to be consistent with NAD 83 (CORS96).
NAD 83 READJUSTMENT of 2007

• RESULTING REFERENCE FRAME CALLED NAD 83 (NSRS 2007)

Brief HARN History

FIRST SURVEYS OF HARN COMPLETED BETWEEN 1987 AND 1997

GPS HEIGHT MODERNIZATION SURVEYS OF HARN COMPLETED BETWEEN 1997 AND 2005

3-D ADJUSTMENT OF ALL HARN SURVEYS AND OTHER SELECTED GPS SURVEYS COMPLETED IN 2007

ADJUSTMENT USED CORS COORDINATES REFERRED TO NAD 83 (CORS96) FOR CONTROL TO REMOVE SMALL REGIONAL DISTORTIONS (3 - 6 CM)

Definitions

• A Geometric Reference System is a set of rules for assigning positional coordinates (and velocities) to points on or near the Earth.

• A Geometric Reference Frame is a realization of a Geometric Reference System that is obtained by assigning specific positional coordinates (and velocities) to a set of identifiable points.

• NAD 83 is a geometric reference system.

• NAD 83 (xxxx) is a geometric reference frame.
World Geodetic System of 1984 (WGS 84)

* GPS broadcast orbits give satellite positions in WGS 84
* Department of Defense is the responsible agency
* System originally agreed with NAD 83
* Revised to agree with International Terrestrial Reference Frame (ITRF) in early 1990’s

GPS Tracking Network
Defining WGS 84

WGS 84 Naming Conventions

• WGS 84 (transit) – this is the original realization of WGS 84 which is based on transit doppler satellite data

• WGS 84(G730), WGS 84(G873), WGS 84(G1150) – these realizations are based on GPS data, the number in parentheses identifies the GPS week that the military adopted the version.

• WGS 84 is a reference system.

• WGS 84 (xxxx) is a reference frame.
International Terrestrial Reference System (ITRS)

* Supports accurate 3-dimensional positioning
* International Earth Rotation and Reference Frame Service is responsible organization
* Defines international standard for origin, orientation, and scale
* Provides positions and velocities for several hundred sites worldwide

Positions and velocities revised every few years, producing the following International Terrestrial Reference Frames:
* Integrates results from various observing techniques:
  - Global Positioning System (GPS)
  - Very Long Baseline Interferometry (VLBI)
  - Satellite Laser Ranging (SLR)
  - Doppler Orbitography & Radiopositioning Integrated by Satellite = (DORIS)
* Combination of several solutions, each performed independently by an analysis center

SITES DEFINING ITRF96
7-Parameter Helmert Similarity Transformation (preserves shape)

The following equations represent an approximation based on the assumption that the rotation angles are small.

\[
\begin{align*}
    x_{\text{NAD}} &= T_x + (1 + S) \cdot x_{\text{ITRF}} + R_y \cdot y_{\text{ITRF}} - R_z \cdot z_{\text{ITRF}} \\
    y_{\text{NAD}} &= T_y - R_z \cdot x_{\text{ITRF}} + (1 + S) \cdot y_{\text{ITRF}} + R_x \cdot z_{\text{ITRF}} \\
    z_{\text{NAD}} &= T_z + R_x \cdot x_{\text{ITRF}} - R_y \cdot y_{\text{ITRF}} + (1 + S) \cdot z_{\text{ITRF}}
\end{align*}
\]

3 translations \((T_x, T_y, T_z)\) 
3 rotations \((R_x, R_y, R_z)\) 
One differential scale \((S)\)

Effect of translation on ellipsoid height

Identification of shaped ellipsoids

\(a = 6,378,137.000\) meters
\(1/f = 298.2572210088\)
Effect of rotation about the Y-axis

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Transformation Parameters
ITRF96 --> NAD_83(CORS96)

Translations:
T_x = 0.9910 meters
T_y = -1.9072 meters
T_z = -0.5129 meters

Rotations:
R_x = [25.79 + 0.0532*(t - 1997.0)]*k radians
R_y = [9.65 - 0.7423*(t - 1997.0)]*k radians
R_z = [11.66 - 0.0316*(t - 1997.0)]*k radians

Scale change: S = 0.0 (unitless)

Where: t = date in years (eg., 1999.3096 = 23 APR 1999) and k = 4.84813681*(10**-9)

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Transitive Property
(A \rightarrow D) = (A \rightarrow B) + (B \rightarrow C) + (C \rightarrow D)

So:
(ITRF2000 \rightarrow NAD83) = (ITRF2000 \rightarrow ITRF96) + (ITRF96 \rightarrow NAD83)

Reflective Property
(B \rightarrow A) = - (A \rightarrow B)

Again, these properties are based on a small angle assumption.
Horizontal Time-Dependent Positioning (HTDP)

- HTDP allows users to transform positional coordinates across time and between different ECEF reference frames.
- HTDP incorporates adopted 14-parameter transformations.

Replacing NAD 83

- Want the new reference system to be more geocentric
- Option 1: Adopt ITRF20xx
- Option 2: Adopt reference frame that agrees with ITRF20xx at some instant of time, but does not move relative to “stable” North America.

Option 1: Adopting ITRF20xx

- Advantage: Ideally there would be just one reference frame for everyone in the world. (Note: The current WGS84 realization is essentially equivalent to ITRF2000 and its next realization will be essentially equivalent to ITRF2008.)
- Disadvantage: All points in North America would have significant horizontal velocities
  - In central & eastern CONUS, between 1 and 2 cm/yr
  - In California, western Oregon, western Washington, Alaska and Canada, more than 2 cm/yr
Option 2: Frame fixed to North American plate

- Advantage: Points in "stable" North America would experience no significant horizontal motion.

- Disadvantage: Each tectonic plate would need its own reference frame. Hawaii is located on the Pacific plate, Puerto Rico on the Caribbean plate, and Guam on the Mariana plate. Also, points located near plate boundaries would still be moving significantly (e.g., California, Oregon, Washington, southern Alaska).
Analogy with time systems

- The world has adopted essentially two time systems:
  - Universal Coordinated Time (UTC) for global applications
  - Local time for applications within a single “time zone”
- The conversion between the two time systems is simply a matter of adding or subtracting an integral number of hours.

Can the geospatial community deal with two geometric reference systems?

- ITRF20xx for inter-plate applications
- Plate-specific reference frames for intra-plate applications
- A conversion between two given frames would simply involve applying a set of 3 rotation rates.

EPOCH DATE
...date for which published positional coordinates are valid.

Antenna Reference Point (ARP): GRAND MARAIS CORS ARP

ITRF00 POSITION (EPOCH 1997.0)
Computed in Jul., 2002 using 15 days of data
X = -25589.841 m latitude = 47 44 54.78843 N
Y = -4296483.071 m longitude = 090 20 28.49808 W
Z = 4698239.761 m ellipsoid height = 157.347 m

ITRF00 VELOCITY
Predicted with HTDP_2.6 June 2002.
VX = -0.0190 m/yr northward = -0.0020 m/yr
VY = -0.0016 m/yr eastward = -0.0190 m/yr
VZ = -0.0011 m/yr upward = 0.0003 m/yr

NAD_83 POSITION (EPOCH 2002.0)
Transformed from ITRF00 (epoch 1997.0) position in Jul., 2002.
X = -25589.302 m latitude = 47 44 54.75749 N
Y = -4296484.384 m longitude = 090 20 28.47182 W
Z = 4698239.781 m ellipsoid height = 158.242 m

NAD_83 VELOCITY
Transformed from ITRF00 velocity in Jul., 2002.
VX = 0.0000 m/yr northward = 0.0000 m/yr
VY = 0.0000 m/yr eastward = 0.0000 m/yr
VZ = 0.0000 m/yr upward = 0.0000 m/yr
IGS Reanalysis

- Several IGS Analysis Centers (including NGS) have each reprocessed all IGS data observed since 1994.
- NGS has also reprocessed all CORS data observed since 1994.
- This analysis included new calibration results for both GPS satellite transmission antennas and GPS receiver antennas.
- NGS will use results from this reanalysis to produce ITRF2008-compatible positions and velocities for stations in the CORS network.

NAD 83 (CORS96a)

- NGS will use new ITRF2008 coordinates and velocities for CORS to produce a new realization of NAD 83 to be called NAD 83 (CORS96a).
- NAD 83 (CORS96a) will be defined so that the 14-parameter transformation between it and NAD 83 (CORS96) will be the identity function.
- Hence, NAD 83 (CORS96a) coordinates should be consistent with NAD 83 (NSRS2007) coordinates and with the use of GEOID09 to convert NAD 83 (CORS96a) ellipsoid heights to NAVD 88 orthometric heights.

NAD 83 (CORS96a) - continued

- NAD 83 (CORS96a) coordinates will, nevertheless, differ from NAD 83 (CORS96) coordinates because they are being derived using
  - More GPS data
  - More rigorous computational procedures
  - More accurate models for systematic errors
- NAD 83 (CORS96a) should become available in the fall of 2010.
- CORS coordinates were last revised, in a wholesale manner, in 2002. Hence, current CORS coordinates are less accurate than desired.
What about vertical velocities?

Modernizing the Geopotential Datum: Replacing NAVD 88

Comments by Daniel R. Roman, Ph.D.
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May 10-11, 2010
Silver Spring, MD

Outline

• What is a vertical datum?
• Why isn’t NAVD 88 good enough anymore?
• Possible ways to fix NAVD 88
• How will I access the new vertical datum?
• Additional Information
What is a vertical datum?

- Many variations of the definition exist
- Strictly speaking, a vertical datum is:
  - A surface representing zero elevation
- Traditionally, a vertical datum has been thought of in a more broad sense:
  - A system for the determination of heights above a zero elevation surface

What is a vertical datum?

- A vertical datum always has two components:
  - Its definition
    - Parameters and other descriptors
  - Its realization
    - Its physical method of accessibility

What is a vertical datum?

- Example: North American Vertical Datum of 1988 (NAVD 88)
  - Definition: The surface of equal gravity potential to which orthometric heights shall refer in North America*, and which is 6.271 meters (along the plumb line) below the geodetic mark at “Father Point/Rimouski” (NGSIDB PID TY5255).
  - Realization: Over 500,000 geodetic marks across North America with published Helmert orthometric heights, most of which were originally computed from a minimally constrained adjustment of leveling and gravity data, holding the geopotential value at “Father Point/Rimouski” fixed.
Why isn’t NAVD 88 good enough anymore?

• NAVD 88 suffers from use of bench marks that:
  – Are almost never re-checked for movement
  – Disappear by the thousands every year
  – Are not funded for replacement
  – Are not necessarily in convenient places
  – Don’t exist in most of Alaska
  – Weren’t adopted in Canada
  – Were determined by leveling from a single point, allowing cross-country error build up

Why isn’t NAVD 88 good enough anymore?

• NAVD 88 suffers from:
  • A zero height surface that:
    – Has been proven to be ~50 cm biased from the latest, best geoid models (GRACE satellite)
    – Has been proven to be ~ 1 meter tilted across CONUS
      (again, based on the independently computed geoid from the GRACE satellite)
Why isn’t NAVD 88 good enough anymore?

- Approximate level of geoid mismatch known to exist in the NAVD 88 zero surface:

Possible ways to fix NAVD 88

- Short term fixes:
  - Provide fast methods of expanding NAVD 88 in areas where it is needed

- Long term fixes:
  - Re-level some / all of NAVD 88
  - Replace NAVD 88 bench marks
Possible ways to fix NAVD 88

- Short term fix: Height Modernization GPS surveys
  - Have provided a fast way to disseminate NAVD 88 bench mark heights to new marks through the use GPS and a constrained least squares adjustment
  - NOAA TM NOS NGS 58 and 59 guidelines
  - Keeps NAVD 88 useful and accessible, but does not address the majority of problems of NAVD 88 itself

GPSBM2009
(GEOID09 Control Data)

20446 total, less 1003 rejected, leaves 18,867 (CONUS) plus 576 (Canada)

Possible ways to fix NAVD 88

- Long term fix: Re-level some/all of NAVD 88

  - Re-leveling NAVD 88 would cost
    - between $200 Million and $2 Billion

  - This wouldn’t fix all of the problems associated with the use of bench marks though
Possible ways to fix NAVD 88

- Long term fix: Replace NAVD 88

- Find a method of defining a vertical datum that seeks to fix all of the known issues with NAVD 88

- Best option: Define the datum as a given geoid model and realize it through GNSS technology – GRAV-D

GRAV-D Trade-offs: Datum is only realizable to 2 cm at best at any given point (GNSS error + geoid error)

- However, this is an improvement over NAVD 88 realization error

- The datum could then be disseminated locally through very precise geodetic leveling

Relationship between Gravity and Heights

- \( g_1 \) = gravity on geoid at station 1
- \( g_1' \) = surface gravity at station 1
- \( g_2 \) = gravity on geoid at station 2
- \( g_2' \) = surface gravity at station 2
- \( H_1 \) = orthometric height to station 1
- \( H_2 \) = orthometric height to station 2

Note that surface location of station 1 is closer to the geoid than station 2. A steep gradient of geoids indicates higher gravity – less steep indicates lower gravity. The geoids being farther apart beneath station 2 to reflect lower local mass and gravity. Hence, \( H_1 \) should be less than \( H_2 \) – even through both have the same geopotential.
Geoid Power and Data Sources

Work with many groups to obtain other data sets as well as what we observe

- Spectrally merge the data sources to obtain a seamless gravity field
- Work with neighbors to incorporate regional data (North American Geoid/IAG CP 2.2)
- Use rigorous geodetic theory and/or forward modeling to make a geoid height model

Possible ways to fix NAVD 88

- Long term fix: Replace NAVD 88 (continued)

- GRAV-D International Issues
  - Canada has agreed to move to a geoid based vertical datum
  - Negotiations with USA underway
  - Mexico has discussed this with USA, but have not chosen to move to a geoid based datum yet
  - Central American, Caribbean: No policy to switch, but the datum will be freely available to them

How will I access the new vertical datum?

- Primary access (NGS mission)
  - Users with geodetic quality GNSS receivers will continue to use OPUS suite of tools
  - Ellipsoid heights computed, and then a gravimetric geoid removed to provide orthometric heights in the new datum
  - No passive marks needed
  - But, could be used to position a passive mark
Relationship between ellipsoid, geoid and orthometric heights.

**Equations:**

- $h$ (Ellipsoid Height) = Distance along ellipsoid normal (Q to P)
- $N$ (Geoid Height) = Distance along ellipsoid normal (Q to PO)
- $H$ (Orthometric Height) = Distance along plumb line (PO to P)

**Geoid Height or Undulation:**

$h - N \approx H$  

**How will I access the new vertical datum?**

- Secondary access (Use at your own risk)
  - Passive marks that have been tied to the new vertical datum
  - NGS will provide a "data sharing" service for these points, but their accuracy (due to either the quality of the survey or the age of the data) will not be a responsibility of NGS

- NAVD 88 conversion to new datum
  - A conversion will be provided between NAVD 88 and the new datum
  - Only where recent GNSS ellipsoid heights exist to provide modern heights in the new datum
Note that the ITRF00-NAD83 transformation is not included here. This was neglected to highlight the significant systematic features.

**How will I access the new vertical datum?**

**Example 1: Flood insurance survey**

1954: Leveling performed to bench mark

1954-1991: Subsidence

1991: Original 1954 leveling data is used to compute the NAVD 88 height which is then published for this BM.

**Using Existing Techniques:**

- Find bench mark (if you can)
- Get published NAVD 88 height
- Level off of bench mark
- No account for subsidence!
How will I access the new vertical datum?

Example 1: Flood insurance survey

**Using Future Techniques:**

Find a bench mark if you wish, or set a new one of your choosing.

Use GNSS/OPUS to get an orthometric height in the new datum.

Level off the bench mark as needed.

Subsidence is accounted for by CORS and a geoid that are monitored constantly!

H(2018?) from GNSS/geoid

How will I access the new vertical datum?

Example 2: "Bringing in" the datum

Nearest level lines are about 25 km and 50 km away respectively. Bench marks may or may not exist.

Will we live with a spur or maybe check in with another level line?

Lucky day, we find 6 undisturbed bench marks!

Now it’s time to bluebook the data, submit to NOS, wait for the backlog to clear...

And all this assumes the published heights are correct to begin with...
Example 2: “Bringing in” the datum

Choice 2: “Height Mod” survey

Create passive marks around area of interest

Using progressive GNSS surveys (NGS 59 Guidelines), transfer orthometric heights to Primary, Secondary and Local marks

Now it’s time to bluebook the data, submit to NGS, wait for it to be loaded into the IDB….

And all this assumes the published heights are correct to begin with…

Choice 3: Once GRAV-D is complete

Set up GNSS receiver over mark

Submit data to OPUS and receive orthometric height

Feeling generous? Share your results with others using the NGS online database (no bluebooking involved). If not, keep your height and walk away.

How will I access the new vertical datum?

Additional Information

The NGS 10 year plan (2008-2018)
http://www.ngs.noaa.gov/INFO/NGS10yearplan.pdf

The GRAV-D Project
http://www.ngs.noaa.gov/GRAV-D

Socio-Economic Benefits of CORS and GRAV-D
http://www.ngs.noaa.gov/PUBS_LIB/Socio-EconomicBenefitsoFCORSandGRAV-D.pdf