National Spatial Reference System
“Positioning Changes for 2022”

Civil GPS Service Interface Committee Meeting
Miami, Florida
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Mission: To define, maintain & provide access to the National Spatial Reference System (NSRS) to meet our Nation’s economic, social & environmental needs

National Spatial Reference System

* Latitude
* Longitude
* Height

* Scale
* Gravity
* Orientation

& their variations in time
U. S. Geometric Datums in 2022
# National Spatial Reference System (NSRS) Improvements in the Horizontal Datums

<table>
<thead>
<tr>
<th>NETWORK</th>
<th>TIME SPAN</th>
<th>NETWORK ACCURACY</th>
<th>METHOD OF REFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAD 27</td>
<td>1927-1986</td>
<td>10 meter</td>
<td>TRAVERSE &amp; TRIANGULATION - GROUND MARKS USED FOR REFERENCING THE NSRS.</td>
</tr>
<tr>
<td>NAD83(86)</td>
<td>1986-1990</td>
<td>1 meter</td>
<td></td>
</tr>
<tr>
<td>NAD83(199x)*</td>
<td>1990-2007</td>
<td>0.1 meter</td>
<td>GPS BECOMES THE MEANS OF POSITIONING – STILL GRND MARKS.</td>
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<tr>
<td>HARN</td>
<td></td>
<td></td>
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<tr>
<td>NAD83(2007)</td>
<td>2007 - 2011</td>
<td>0.01 meter</td>
<td>GPS – CORS STATIONS ARE MEANS OF REFERENCE FOR THE NSRS.</td>
</tr>
<tr>
<td>(CORS)</td>
<td></td>
<td></td>
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<tr>
<td>NAD83(2011)</td>
<td>2011 - 2022</td>
<td>0.01 meter</td>
<td></td>
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<tr>
<td>(CORS)</td>
<td></td>
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</tbody>
</table>
NSRS Reference Basis

Old Method - Ground Marks (Terrestrial)

Current Method - GNSS Stations (CORS)
Why Replace NAD83?

- Datum based on best known information about the earth’s size and shape from the early 1980’s (45 years old), and the terrestrial survey data of the time.

- NAD83 is **NON**-geocentric & hence inconsistent w/GNSS.

- Necessary for agreement with future ubiquitous positioning of GNSS capability.
NOAA Technical Report NOS NGS 62

Blueprint for 2022, Part 1: Geometric Coordinates

Dru Smith
Dan Roman
Steve Hilla

April 21, 2017
Future Geometric (3-D) Reference Frame

Blueprint for 2022: Part 1 – Geometric Datum

- Replace NAD83 with new geometric reference frame – by 2022.
- CORS-based, accessed via GNSS observations.
- Coordinates & velocities in ITRF (IGS) & new US reference frame.
- Passive control tied to new reference frame (not a component).
- Transformation tools will relate NAD83 to new US reference frame (NCAT with 2022 transformation).
Datum Names

The Old:
- NAD 83(2011)
- NAD 83(PA11)
- NAD 83(MA11)

The New:
- The North American Terrestrial Reference Frame of 2022 (NATRF2022)
- The Caribbean Terrestrial Reference Frame of 2022 (CATRF2022)
- The Pacific Terrestrial Reference Frame of 2022 (PATRF2022)
- The Mariana Terrestrial Reference Frame of 2022 (MATRF2022)
New geometric datum minus NAD 83 (horizontal)

For Florida = 0.8 > 1.02 m (2.6 > 3.3 ft.)
Estimated ellipsoidal height change from NAD 83 to new geometric datum

For Florida = -1.39 > -1.62 m (-4.5 > -5.3 ft.)
U.S. Vertical Datum in 2022
Why isn’t NAVD 88 good enough anymore?

* NAVD 88 is a terrestrial based vertical datum that changes as the land changes.

• 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
  – Were determined by leveling from a single point, allowing cross-country error build up
NEW VERTICAL DATUM (Rationale)

• A move away from differentially leveled passive control as the defining mechanism of the reference surface

• To be consistent with the shift in the geometric reference frame/ellipsoid (2022)

• Improvement in our technical abilities in reference surface realization (geopotential gravimetric reference surface - 1cm accuracy of the geoid (GNSS/GRAV-D))

• Goal - ability to establish 2cm orthometric height anywhere in U.S. using a minimum of 15 min. of GNSS data.

• The new geopotential reference surface will be aligned with the geometric reference frame/ellipsoid (i.e., no hybrid geoid)
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Blueprint for 2022, Part 2: Geopotential Coordinates

November 13, 2017
Scientific Decisions

• Blueprint for 2022, Part 2: Geopotential
  ✓ Global 3-D Geopotential Model (GGM)
    ✓ Will contain all GRAV-D data
    ✓ Able to yield any physical value on/above surface
  ✓ Special high-resolution geoid, DoV and surface gravity products consistent with GGM
    ✓ Not global: NA/Pacific, American Samoa, Guam/CNMI
  ✓ Time-Dependencies
    ✓ Geoid monitoring service
      ✓ Impacts of deglaciation, sea level rise, earthquakes, etc
Names

The Old:
NAVD 88
PRVD 02
VIVD09
ASVD02
NMVD03
GUVD04
IGLD 85
IGSN71
GEOID12B
DEFLEC12B

The New:
The North American-Pacific Geopotential Datum of 2022 (NAPGD2022)
Extent of 2022 gravimetric geoid model used for new geopotential reference frame
Gravity for the Redefinition of the American Vertical Datum (GRAV-D)

- Replace the Vertical Datum of the USA by 2022 (at today’s funding)
- GRAV-D is:
  - An airborne gravity survey of the entire country and its holdings
  - A 2022 gravimetric geoid accurate to 1 cm
  - Long-term monitoring of geoid change over time
  - Partnership surveys
- Working to launch a collaborative effort with the USGS for simultaneous magnetic measurement

Gravity and Heights are inseparably connected

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Expected changes to orthometric heights

For Florida = 0.1 > -0.3 m (4 > -11 in.)
**Other Updated NGS Products**


* **SPCS 2022** - Project to updated the State Plane Coordinate System of NAD83 in preparation for 2022. Current discussion between NGS and the stakeholders within each state (state specific).

* **OPUS PROJECT 4.0** - Updated OPUS Project program to modernize the NGS Bluebooking process and to allow for establishment of control networks (NGS published, FAA surveys, local control networks, etc.).
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Views expressed are those of the author and not necessarily those of NGS.