Mission and Vision of NGS

• To define, maintain and provide access to the National Spatial Reference System to meet our nation’s economic, social, and environmental needs.

• “Maintain the NSRS” means “NGS must track all of the temporal changes to the defining points of the NSRS in such a way as to always maintain the accuracy in the NSRS definition.”

• Vision - Modernize the Geopotential ("Vertical") and Geometric ("Horizontal") datums
Problems with NAD 83 and NAVD 88

- **NAD 83** is not as geocentric as it could be (approx. 2 m)
  - Surveyors don’t see this - **Yet**

- **NAD 83** is not well defined with positional velocities

- **NAVD 88** is realized by passive control (bench marks) most of which have not been releveled in at least 40 years

- **NAVD 88** does not account for local vertical velocities (subsidence and uplift)
  - Post glacial isostatic readjustment
  - Subsurface fluid withdrawal
  - Sediment loading
  - Sea level rise
    - **Annapolis** – 3.4 mm/yr (0.01 ft/yr)
    - **Baltimore** – 3.1 mm/yr (.01 ft/yr)
    - **Cambridge** – 3.5 mm/yr (.01 ft/yr)
    - **Chesapeake City** – 3.8 mm/yr (.01 ft/yr)
    - **Ocean City** – 5.5 mm/yr (.02 ft/yr)
    - **Solomons Island** – 3.4 mm/yr (0.01 ft/yr)
GLOBAL POSITIONING SYSTEM

- 1978 1st NAVSTAR Satellite Launched (October 22, 1978)
- 1995 Fully Operational
- 2000 Selective Availability turned off (May 1, 2000)
- 2005 Additional Band L2C
- 2010 Additional Frequency L5 added (May 28, 2010)
- 2020? 10-50 cm real-time accuracy?

- Three positioning and navigation systems
  - Navstar/GPS – US (Currently 31)
  - Glonass – Russia (Currently 24)
  - Galileo – EU (Currently 2)
  - Beidou/Compass – China (Complete by 2020?)
The National Geodetic Survey 10 year plan
Mission, Vision and Strategy
2008 – 2018

http://www.ngs.noaa.gov/INFO/NGS10yearplan.pdf

- Official NGS policy as of Jan 9, 2008
  - Modernized agency
  - Attention to accuracy
  - Attention to time-changes
  - Improved products and services
  - Integration with other fed missions

- 2018 (2022?) Targets:
  - NAD 83 and NAVD 88 re-defined
  - Cm-accuracy access to all coordinates
  - Customer-focused agency
  - Global scientific leadership
See the text version of an article about the NGS Geodetic Toolkit that appeared in the Professional Surveyor magazine, May 2003 Volume 23, Number 4

(See all the Professional Surveyor Articles about the NGS Geodetic Toolkit)

To learn more about a particular online program, click on its link for a description:

DEFLEC99
DYNAMIC HT
G99SSS
GEOID99
GEOID03
USGG2003
HTDP
IGLD85
Inverse/Forward/Invers3D/Forwr3D

LVL DH
Magnetic Declination
NADCON
NAVD 88 Modelled Gravity
Online Adjustment User Services
Online Adjustment Utilities User Services
OPUS
State Plane Coordinates

Surface Gravity Prediction
Tidal and Orthometric Elevations
U.S. National Grid
Universal Transverse Mercator Coordinates
VERTCON
XYZ Coordinate Conversion

OR... Know what you want to do?
Select a function from this list:

SELECT A TOOLKIT SHORTCUT
The NSRS has evolved

1 Million Monuments (Separate Horizontal and Vertical Systems) → 70,000 Passive Marks (3-Dimensional)

Passive Marks (Limited Knowledge of Stability) → 1,500+ GPS CORS (Time Dependent System Possible; 4-Dimensional)

GPS CORS → GNSS CORS
HORIZONTAL VELOCITIES
VERTICAL VELOCITIES
Subsidence in Eastern Maryland and Delaware

“Regional Investigations of Vertical Crustal Movements in the U.S., Using Precise Releveling and Mareograph Data”
S. Holdal and N. Morrison
(1974)
The International Terrestrial Reference System (ITRS) constitutes a set of prescriptions and conventions together with the modeling required to define origin, scale, orientation and time evolution.

ITRS is realized by the International Terrestrial Reference Frame (ITRF) based upon estimated coordinates and velocities of a set of stations observed by Very Long Baseline Interferometry (VLBI), Satellite Laser Ranging (SLR), Global Positioning System and GLONASS (GNSS), and Doppler Orbitography and Radio-positioning Integrated by Satellite (DORIS).

ITRF89, ITRF90, ITRF91, ITRF92, ITRF93, ITRF94, ITRF95, ITRF96, ITRF97, ITRF2000, ITRF2005, ITRF2008
International Terrestrial Reference Frame
4 Global Independent Positioning Technologies
Simplified Concept of NAD 83 vs. ITRF00

Identically shaped ellipsoids (GRS-80)

- **NAD 83 Origin**
  - Approx. 2.2 meters

- **ITRF 00 Origin**

- **h_{83}**
- **h_{00}**

Earth’s Surface

**Origin Differences**

- NAD 83 Origin
- ITRF 00 Origin

**Geodetic Parameters**

- Semi-major axis: \( a = 6,378,137.000 \) meters
- Flattening: \( 1/f = 298.25722210088 \)

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National Oceanic and Atmospheric Administration
The National Geodetic Vertical Datum of 1929 is referenced to 26 tide gauges in the US and Canada.
The North American Vertical Datum of 1988 is referenced to a single tide gauge in Canada.
NGVD 29

Referenced to 26 Tide Gages
(Father’s Point)

NAVD88 minus LMSL (1960-1978)
Problems using traditional leveling (to define a National Vertical Datum)

- Leveling the country can not be done again
  - Too costly in time and money (Estimated ~ $1B)

- Leveling yields cross-country error build-up; problems in the mountains

- Leveling requires leaving behind passive marks
  - Bulldozers and crustal motion do their worst
Height Modernization
Bottom line

1. Using GNSS is cheaper, easier than leveling

2. To use GNSS we need a good geoid model
Types of Geoid Height Models

• **Gravimetric (or Gravity) Geoid Height Models**
  – Defined by gravity data crossing the geoid
  – Refined by terrain models (DEM’s)
  – Scientific and engineering applications

• **Composite (or Hybrid) Geoid Height Models**
  – Gravimetric geoid defines all regions
  – Warped to fit available GPSBM control data
  – Defined by legislated ellipsoid (NAD 83) and local vertical datum (NAVD 88, 6 State/Territorial island Datums)
  – May be statutory for some surveying & mapping applications
Transition to the Future – GRAV-D

Gravity for the Redefinition of the American Vertical Datum

• Official NGS policy as of Nov 14, 2007
  – $38.5M over 10 years

• Airborne Gravity Snapshot

• Absolute Gravity Tracking

• Re-define the Vertical Datum of the USA by 2018
  (2022 more likely due to funding issues)
Gravity Survey Plan

- National Scale Part 1
  - Predominantly through airborne gravity
  - With Absolute Gravity for ties and checks
  - Relative Gravity for expanding local regions where airborne shows significant mismatch with existing terrestrial
What is GRAV-D?

GRAV-D
Planned Coverage

Alaska

“CONUS”

Guam / Northern Marianas

Hawaii

Puerto Rico / U.S.Virgin Islands

American Samoa
What is GRAV-D?

- GRAV-D will mean:
  - As the H=0 surface, the geoid will be tracked over time to keep the datum up to date
  - The reliance on passive marks will dwindle to:
    - Secondary access to the datum
    - Minimal NGS involvement
      - Maintenance/checking in the hands of users
    - Use at your own risk

GRAV-D will mean:

- As the H=0 surface, the geoid will be tracked over time to keep the datum up to date.
- The reliance on passive marks will dwindle to:
  - Secondary access to the datum
  - Minimal NGS involvement
    - Maintenance/checking in the hands of users
  - Use at your own risk
CONTINUOUSLY OPERATING REFERENCE STATIONS (CORS)

1550+ Installed and operated by various public and private partners

NOAA/National Geodetic Survey
NOAA/OAR Global Systems Division
U.S. Coast Guard - DGPS/NDGPS
Corps of Engineers - DGPS
FAA - WAAS/LAAS
State DOTs
County and City
Academia
Private Companies
International Partners
Antenna Reference Point (ARP): U OF MD BALT COOP CORS ARP

PID = DF6305

ITRF00 POSITION (EPOCH 1997.0)
Computed in Feb. 2008 using 930 days of data.

X = 1136717.441 m latitude = 39 15 24.38976 N
Y = -4812975.828 m longitude = 076 42 41.47606 W
Z = 4014471.484 m ellipsoid height = 64.678 m

ITRF00 VELOCITY
Estimated in Feb. 2008 using 930 days of data.

VX = -0.0170 m/yr northward = 0.0010 m/yr
VY = -0.0022 m/yr eastward = -0.0171 m/yr
VZ = -0.0002 m/yr upward = -0.0015 m/yr

NAD_83 (CORS96) POSITION (EPOCH 2002.0)
Transformed from ITRF00 (epoch 1997.0) position in Feb. 2008.

X = 1136717.980 m latitude = 39 15 24.36101 N
Y = -4812977.294 m longitude = 076 42 41.46823 W
Z = 4014471.606 m ellipsoid height = 65.956 m

NAD_83 (CORS96) VELOCITY
Transformed from ITRF00 velocity in Feb. 2008.

VX = -0.0006 m/yr northward = 0.0000 m/yr
VY = -0.0004 m/yr eastward = 0.0000 m/yr
VZ = -0.0031 m/yr upward = 0.0000 m/yr

ITRF00 – NAD 83(CORS96)
ΔHoriz = 0.906 m
ΔEHt = 1.278 m
FLAVORS OF OPUS

**OPUS-S**
- $$ Receivers
- 2 Hours of data
- Results not shared

**OPUS-RS**
- $$ Receivers
- 15 Minutes of data
- Results not shared

**OPUS-DB**
- $$ Receivers
- 4 Hours of data
- Results shared

**OPUS-Projects**
- $$ Receivers
- 2-4 Hours of data
- Multiple Receivers
- Network Solution
- Results shared or not

**LOCUS**
- Leveling On Line Computing Service
- Integration with GPS?
- Results shared or not
SURVEY DATASHEET (Version 1.0)

FID: EBEBS1
Designation: PHI MAPP 06
Stamping: CONTROL MARKER 06 2008
Stability: May hold, commonly subject to ground movement
Setting: Set in top of concrete monument
Description: Mark is located in Prince George County, Maryland along the Potomac Electric power pathway near where it crosses Md. Rte 5 approximately 2,000 feet north of intersection with Brandywine Road and is 305 feet east of the northbound edge of paving and is 316.5 feet from Pepco pole number 5216 in the approximate centerline of the power pathway
Observed: 2008-04-14T15:53:00Z
Source: OPUS - page 50612.06

LAT: 38° 42' 29.01738" ± 0.005 m
LON: -76° 52' 38.92153" ± 0.008 m
ELL HT: 36.589 ± 0.016 m
X: 113,467.156 ± 0.011 m
Y: -48,334,572.611 ± 0.014 m
Z: 390,701.225 ± 0.007 m
ORTHO HT: 69.367 ± 0.030 m

UTM 18 SPC 1900(MD)
NORTHING: 428,003.473m 11,503,943m
EASTING: 336,753.420m 410,556.007m
CONVERGENCE: -1.17' 2464.7" 0.0765983°
POINT SCALE: 0.99992813 0.99995411
COMBINED FACTOR: 0.99992241 0.99995437

CONTRIBUTED BY

nabenz
McCron Inc

Get directions: To here (nearest road)
Ten-Year Milestones (2018)

1) NGS will compute a pole-to-equator, Alaska-to-Newfoundland geoid model, preferably in conjunction with Mexico and Canada as well as other interested governments, with an accuracy of 1 cm in as many locations as possible.

2) NGS redefines the vertical datum based on GNSS and a gravimetric geoid.

3) NGS redefines the national horizontal datum to remove disagreements with the ITRF.
Predicted Positional Changes in 2022
Vicinity of Catonsville, MD.
(Computed for CCBC, pid AJ7985)

HORIZONTAL = 1.10 m (3.6 ft)
ELLIPSOID HEIGHT = -1.30 m (-4.3 ft)
Predicted with HTDP

ORTHOMETRIC HEIGHT = -0.41 m (-1.3 ft)
Predicted with HTDP and USGG2009
GOOD COORDINATION BEGINS WITH GOOD COORDINATES

GEOGRAPHY WITHOUT GEODESY IS A FELONY