The National Spatial Reference System: the Common Foundation of Surveying and GIS

2024 Big Sky GeoCon

April 18, 2024

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NSRS Modernization Delay

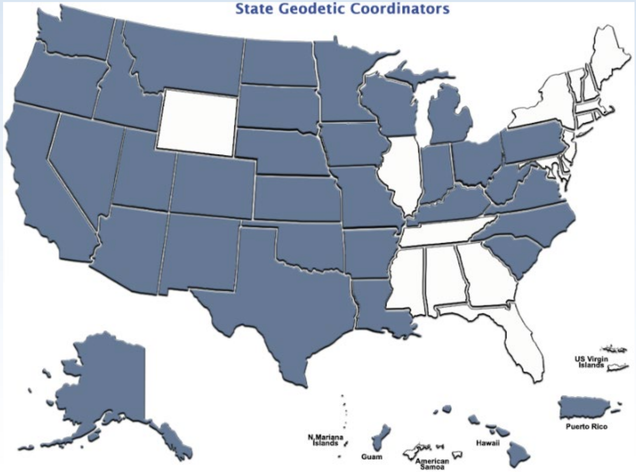
Operational, workforce retention and other issues have delayed NSRS Modernization

SPCS2022 zones will be finalized in 2024 but will not be rolled out until all of the NSRS is modernized.

Beta rollout planned for 2025, full rollout in 2026

https://geodesy.noaa.gov/datums/newdatums/delayed-release.shtml
https://geodesy.noaa.gov/datums/newdatums/FAQNewDatums.shtml

Importance of Coordination



39 Coordinators

NGS Resources

NGS Training Center

https://geodesy.noaa.gov/web/science_edu/training/

Educational Videos

https://geodesy.noaa.gov/datums/newdatums/WatchVideos.shtml

NGS Webinar Series

https://geodesy.noaa.gov/web/science_edu/webinar_series/

Geospatial Summit (2021, 2019 recorded sessions)

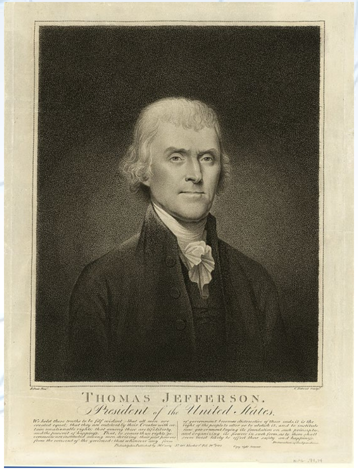
https://geodesy.noaa.gov/geospatial-summit/

Presentation Library

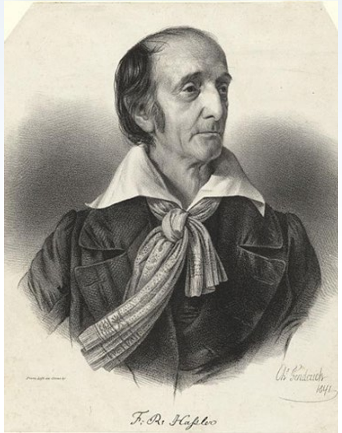
https://geodesy.noaa.gov/web/science_edu/presentations_library/

NOAA and NGS

Our Nation's First Civilian Science Agency



1807
Thomas Jefferson
Survey of the Coast



1811
Ferdinand Hassler
Superintendent

1836
U.S. Coast
Survey

1878
U.S. Coast and
Geodetic Survey

1970
NOAA is established

NGS'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.

....

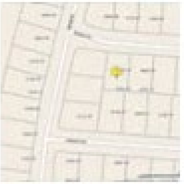
The **NSRS** is a consistent coordinate system that defines latitude, longitude, height, scale, gravity, orientation, and shoreline throughout the United States.

Land Surveying

Engineering & Construction

Physical Sciences

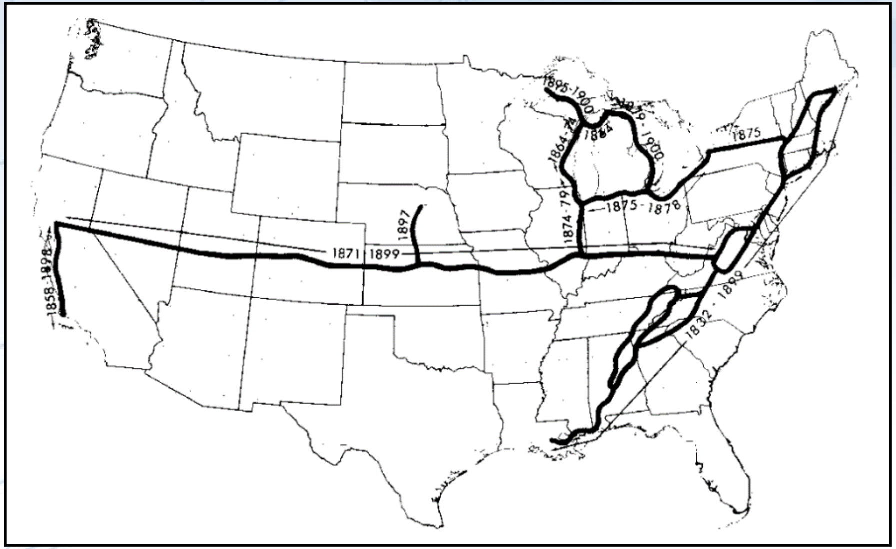
Floodplain Mapping



Land Parcels

Sectors that Rely on Geodesy

NGS's Historical Horizontal Networks



US Standard Datum 1900

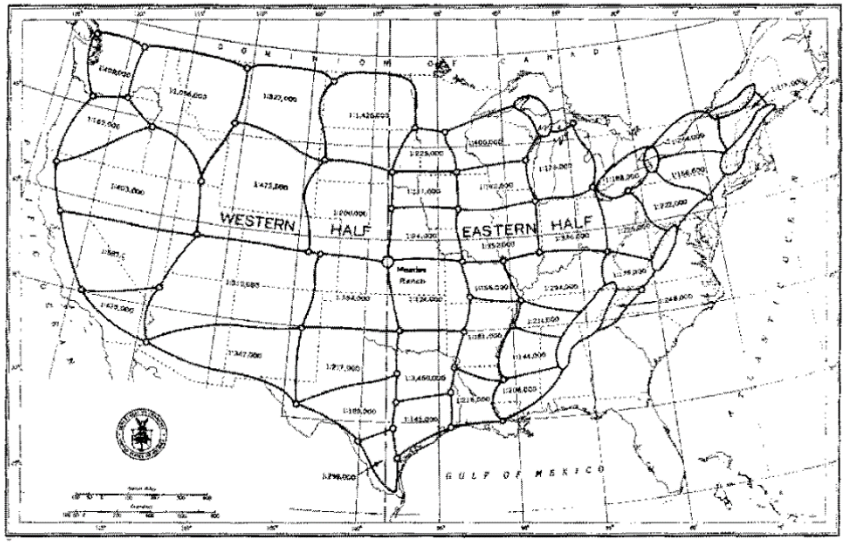
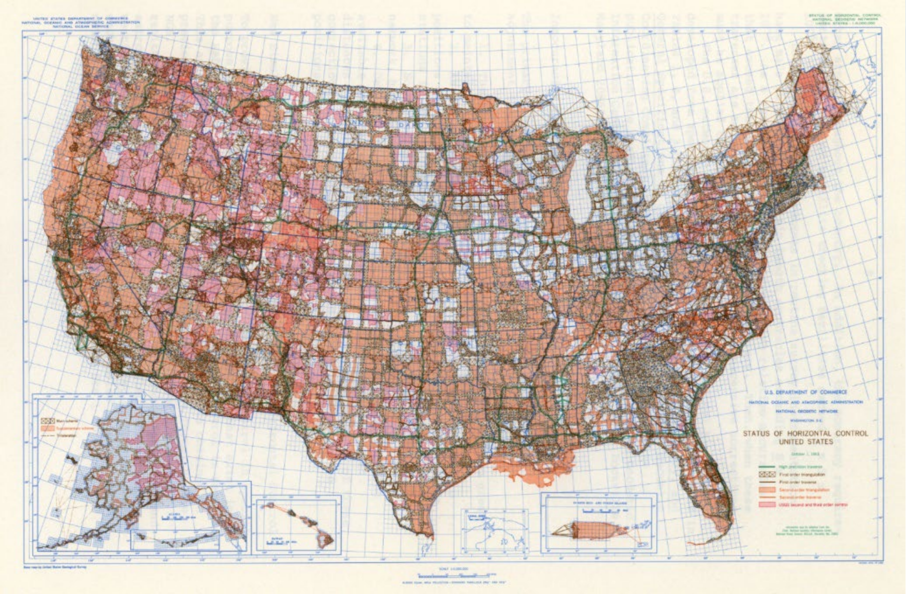


Figure 2.1. Adjustment closures for the North American Datum of 1927.

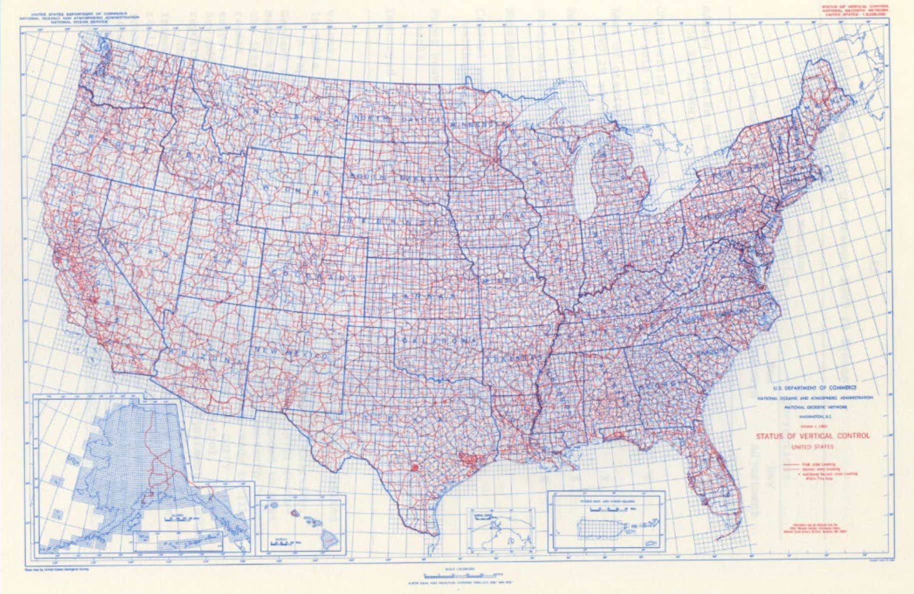
North American Datum of 1927 (NAD 27)

http://www.geodesy.noaa.gov/PUBS_LIB/NADof1983.pdf

1983 Control Networks



Status of Horizontal Control 1983



Status of Vertical Control 1983

The Bilby Tower

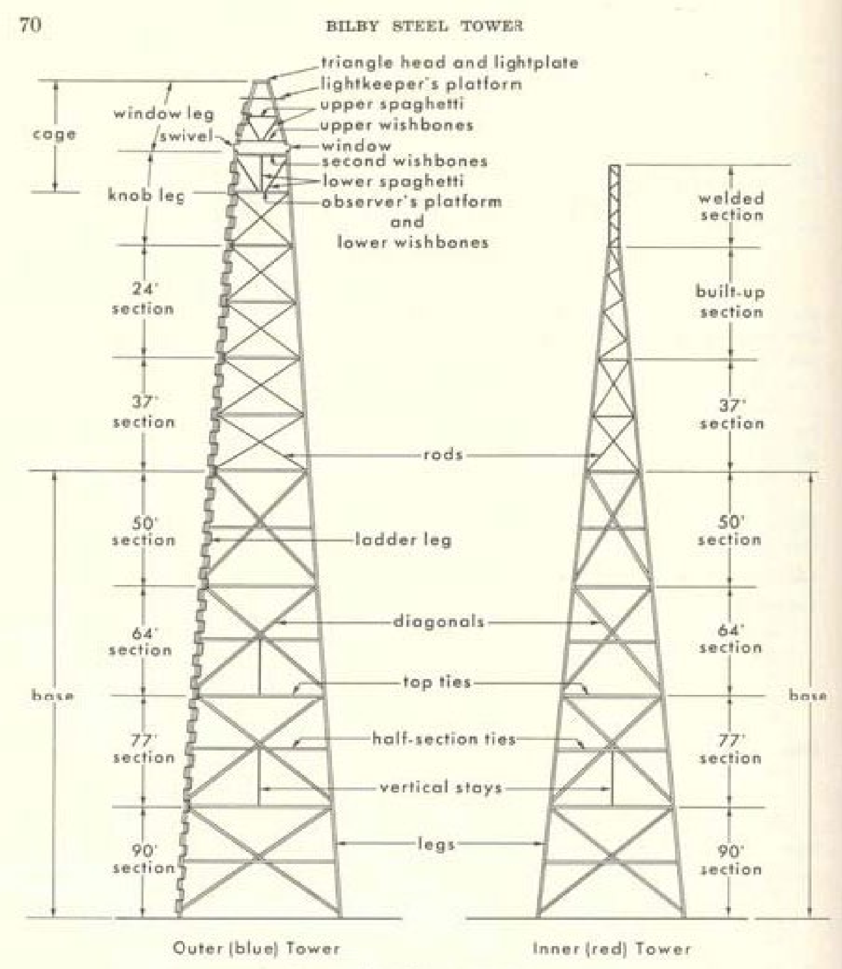
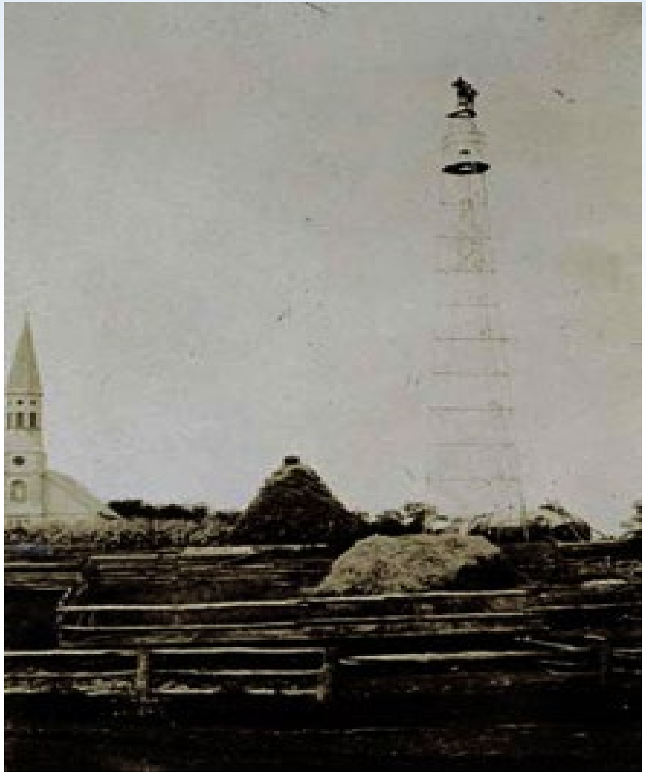
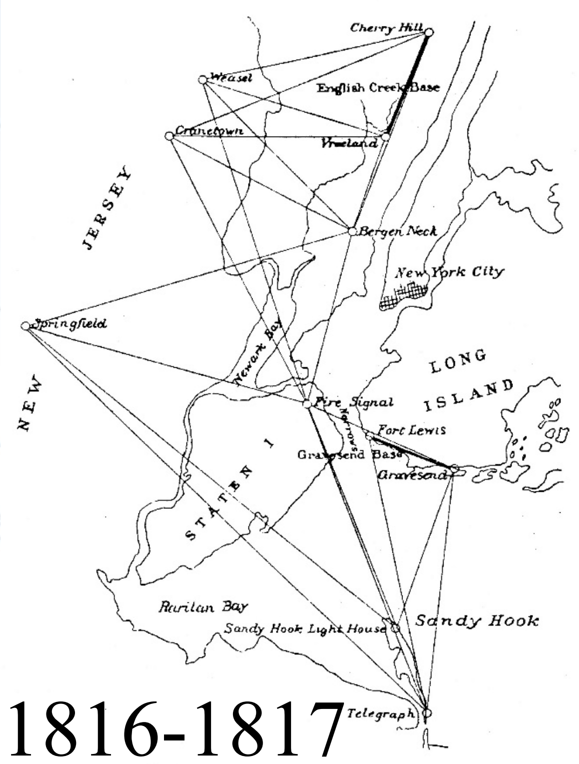


FIGURE A1.—Tower nomenclature.



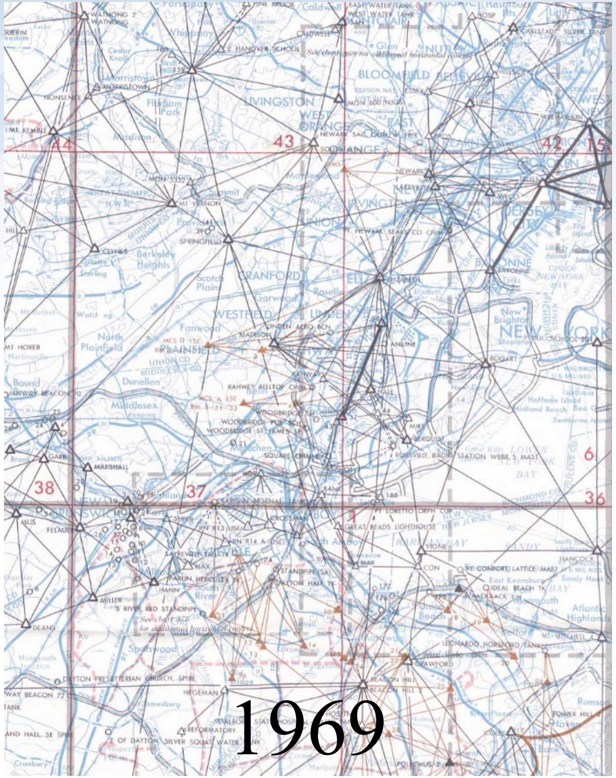
Horizontal Network

The Importance of Geodesy

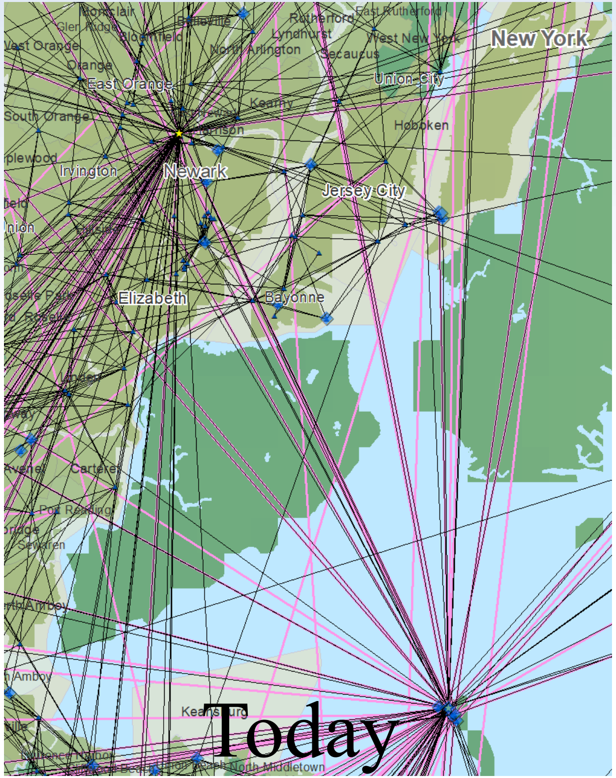


Hassler's First Field Work, 1816–1817

1816-1817

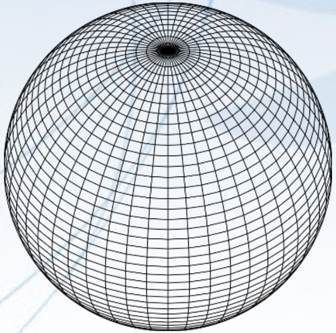


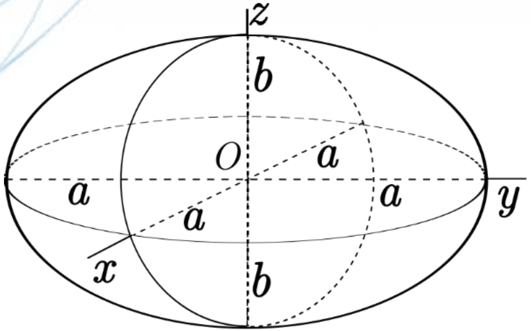
1969



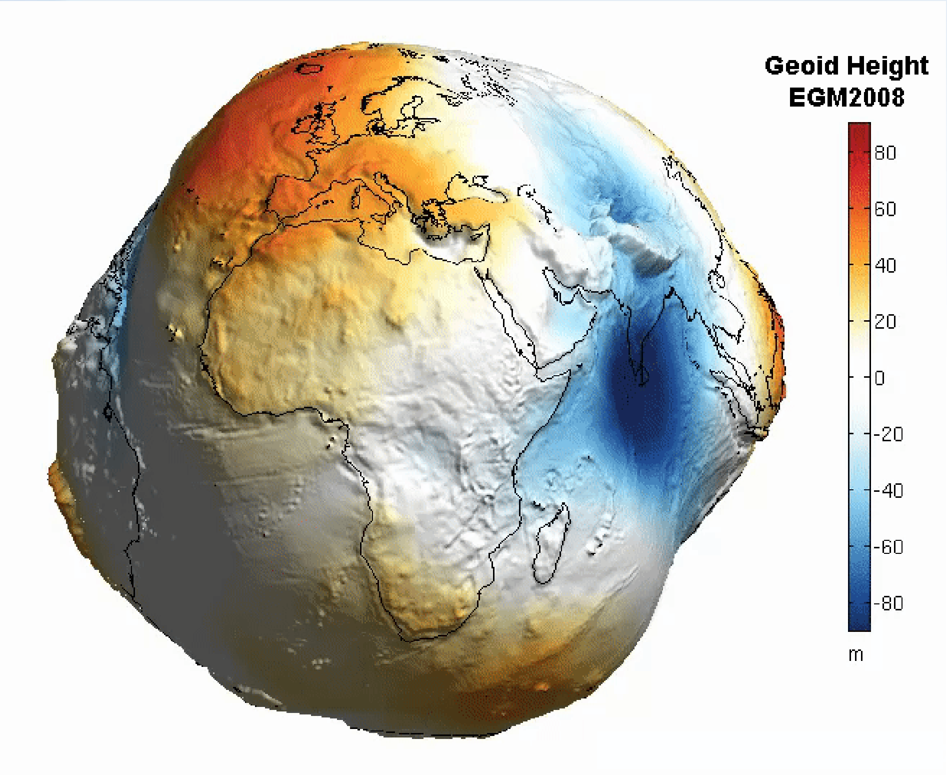
Today

The Earth is Infinitely Complex

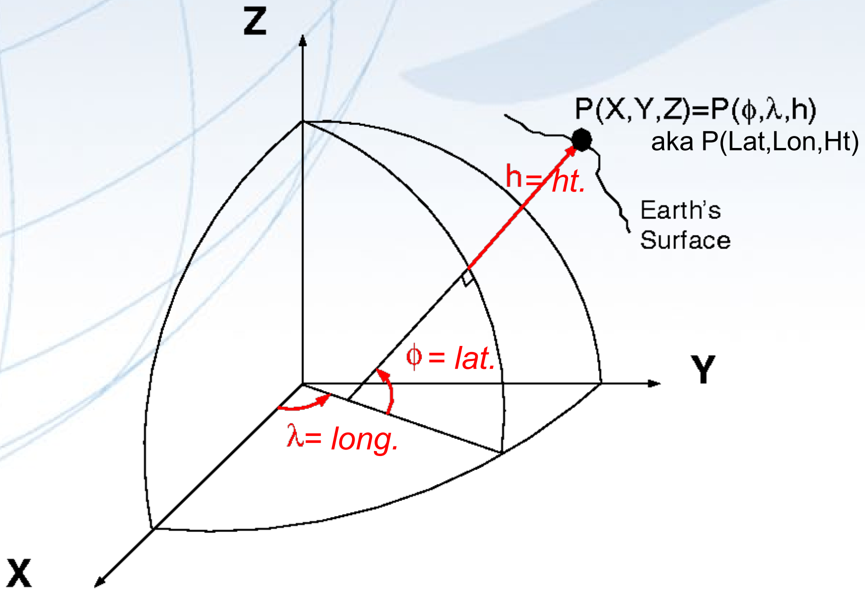




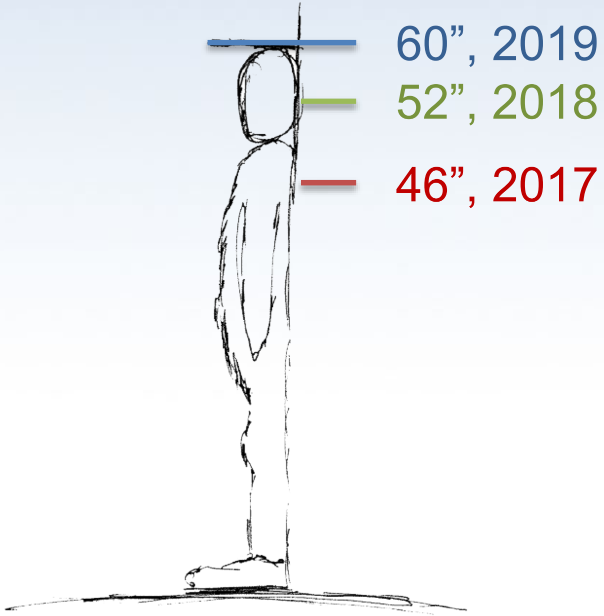
Build Models to Simplify



Datums and Reference Frames



X,Y,Z vs Lat, Lon, Ht



A reference surface or framework to reference your data to for consistency

Gravity is Fundamental

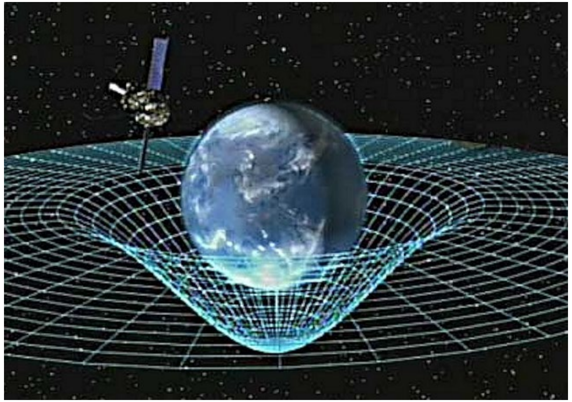
Aristotle (350BC)
- Objects fall proportional to mass

Al-Khazini (1121)
- Gravitational potential energy

Galileo (1590)
- Terminal velocity

Newton (1687)
- Gravity inverse-square law

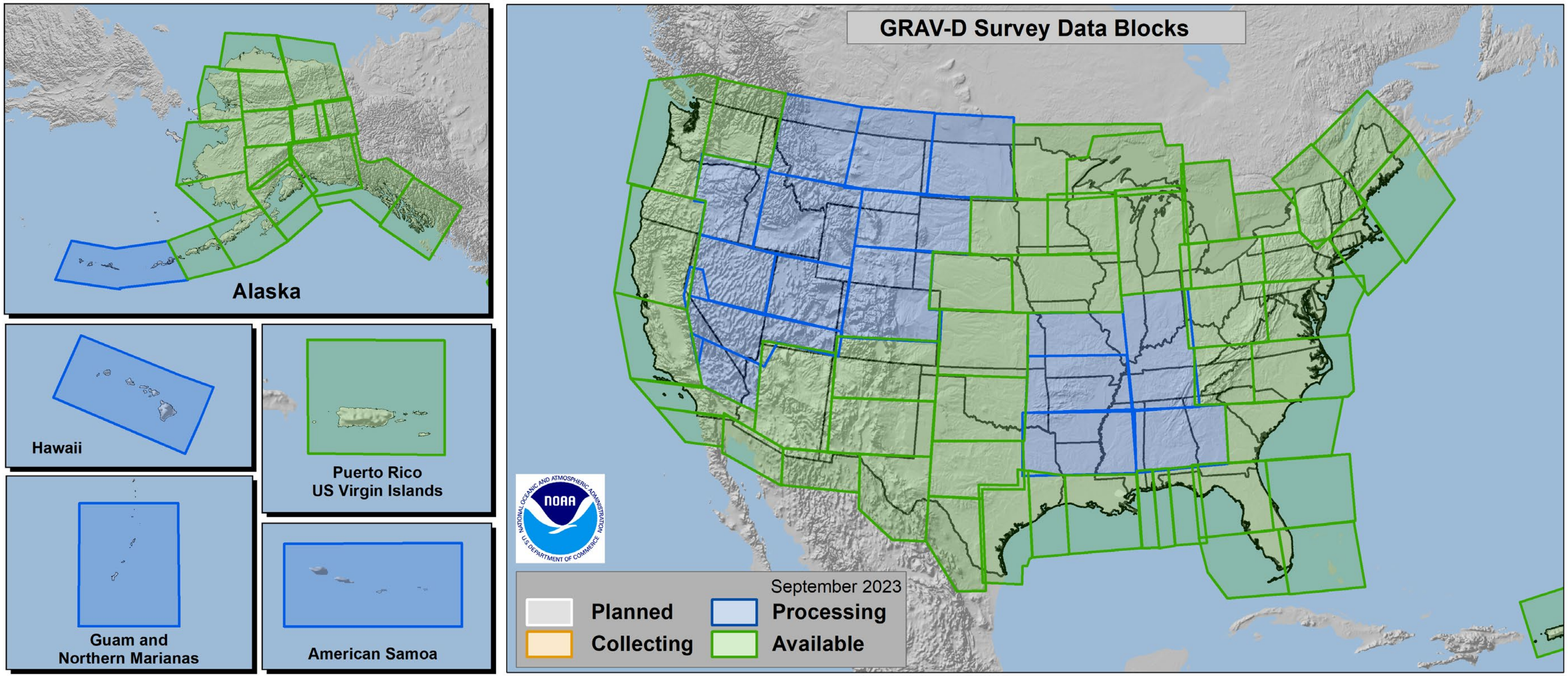
Einstein (1913)
- Theory of general relativity



Gravity of the Redefinition of the American Vertical Datum

GRAV-D

100% Complete (2/05/2023)



Why Modernize the NSRS

Current models built on old technology

- NAD 83 not truly Geocentric (~2.2m)
- NAVD 88 relies on marks in the ground and is not easily maintained
- Today's technology needs better accuracy

Main Benefits of Modernized NSRS

Fast, Accurate, Consistent Elevations Everywhere

Improved Public Safety

- Flood Plain Maps
- Emergency Route Planning

Accurate Positioning

- Autonomous vehicles, BIMs, Smart Cities

Best ways to determine coordinates in Modernized NSRS

1. **Resurvey**: Return to the field and collect new observations, relying upon geodetic control that has coordinates in the new datum

2. **Readjust**: Using existing observations, re-compute new coordinates based upon geodetic control (CORS) that has been defined in the new datum

3. **Transform**: Take finished products which have coordinates in the old datum and use transformation software to estimate coordinates in the new datum

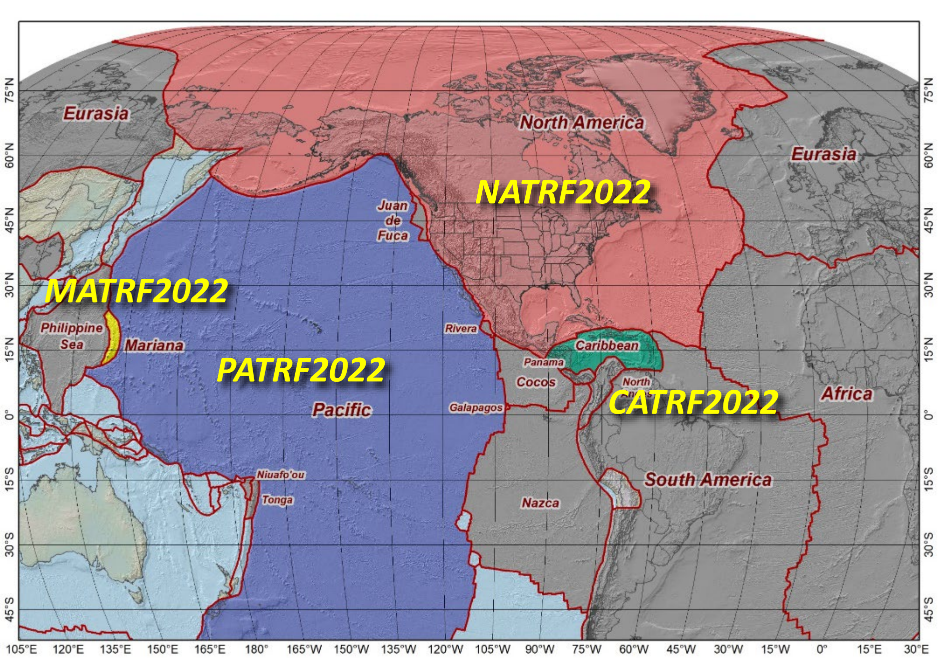
The Future Reference Frames

Tectonic Plate based

Each Plate is based on the same densified ITRF model

North America	NATRF
Caribbean	CATRF
Pacific	PATRF
Mariana	MATRF

The tectonic plates "fixed" for the 2022 Terrestrial Reference Frames

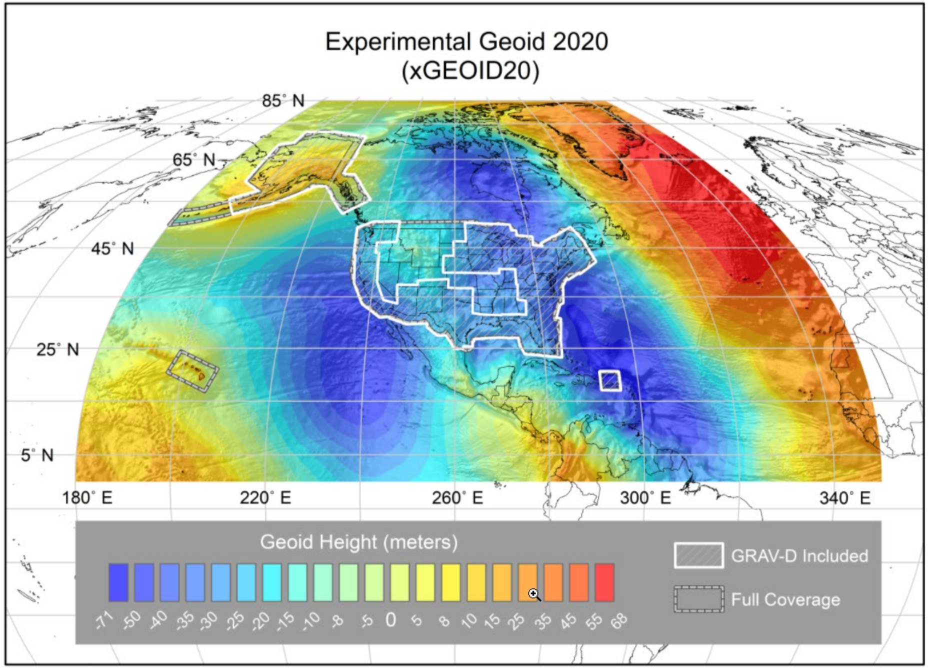


NAPGD2022 Geopotential Datum

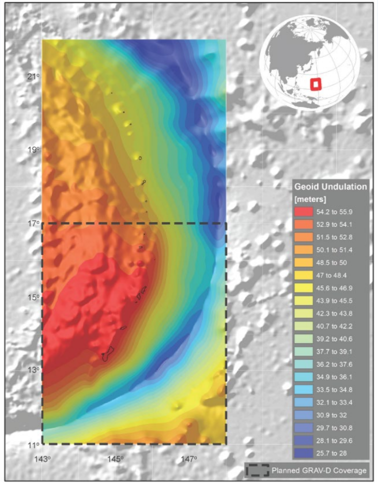
North American-Pacific Geopotential Datum of 2022

Not a vertical datum, it is more than just heights.

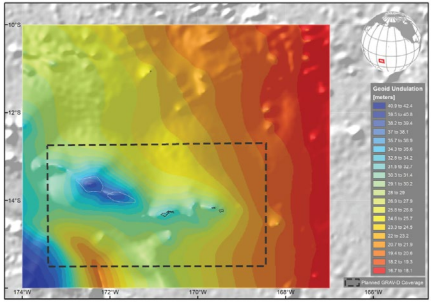
Models included:
- Geopotential
- Deflection
- Gravity
- Geoid



¼ Earth's Surface



Guam/CNMI



American Samoa

NSRS Modernization Catch Phrase

Shift and Drift

Not the Fast and Furious

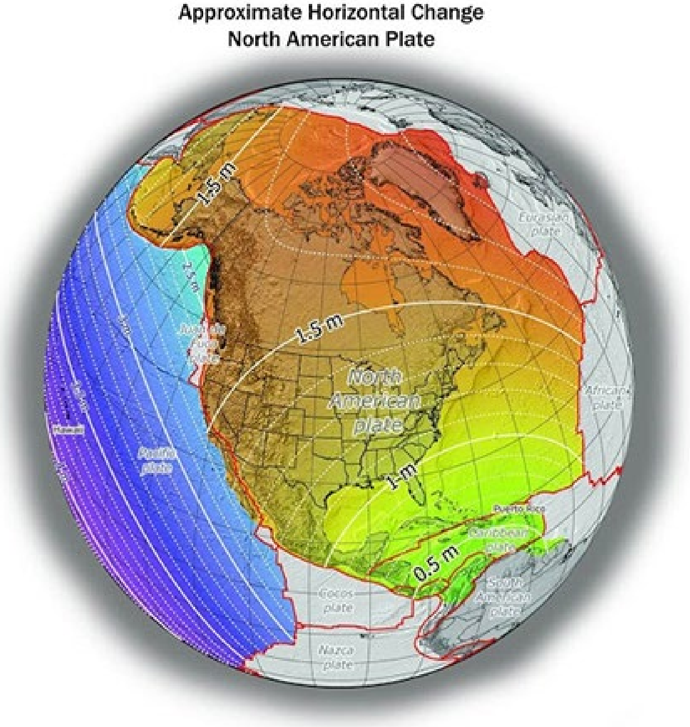
Shift and Drift

- A sudden ***shift***
  - Horizontal change: **0.5 to 4 m (1.5 to 13 ft)**
  - Ellipsoid height change: **±2 m (±6 ft)**
  - Elevation change: **-0.5 to +2 m (-1.5 to +6 ft)**

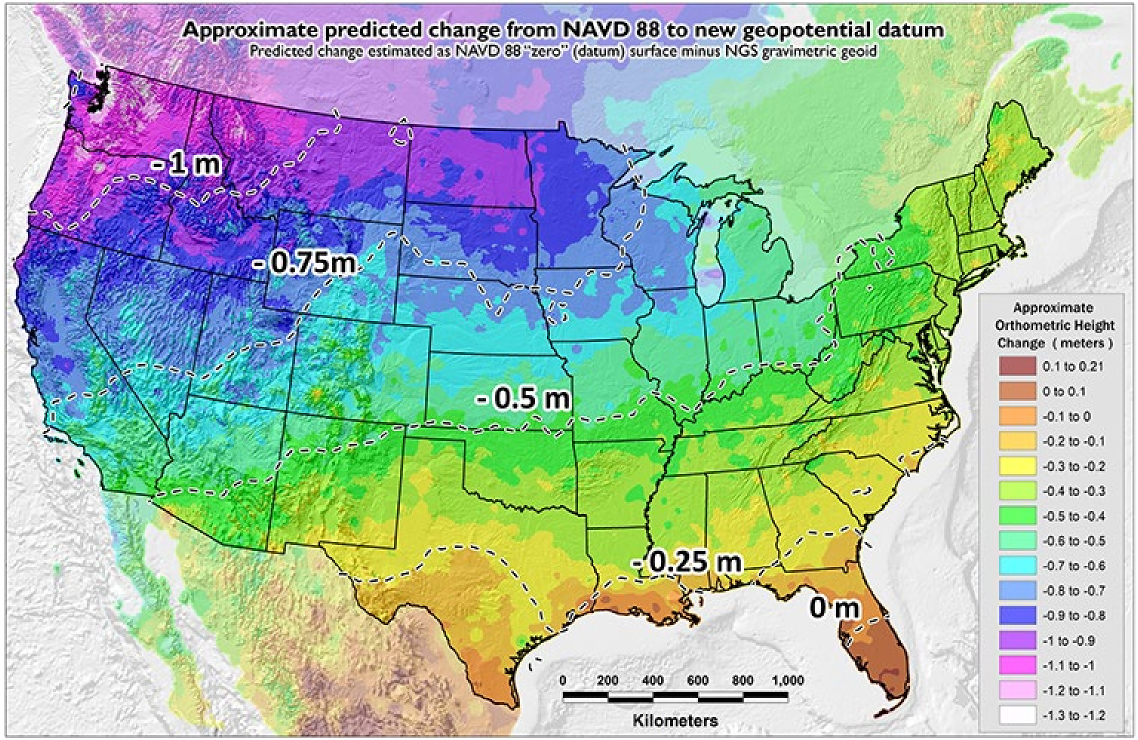
- A continuous ***drift***
  - Coordinates associated with specific dates

- Two components of drift:
  - Tectonic plate rotation (easy to model, 2D only)
  - All other residual motion (hard to model, 3D)

Shift: datum changes

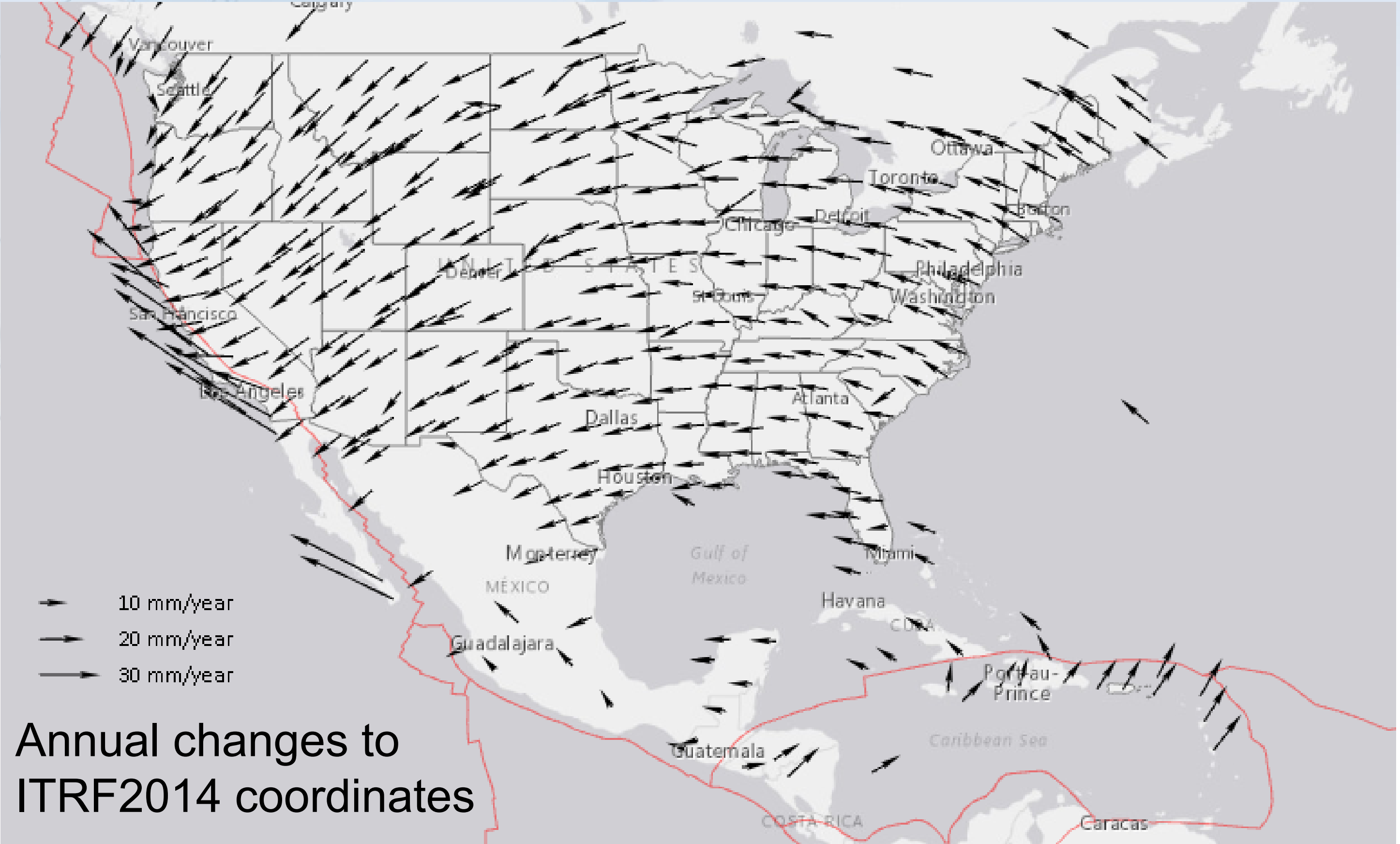


~1 to 1.5 meters North America
~2.5 to 4 meters in Pacific



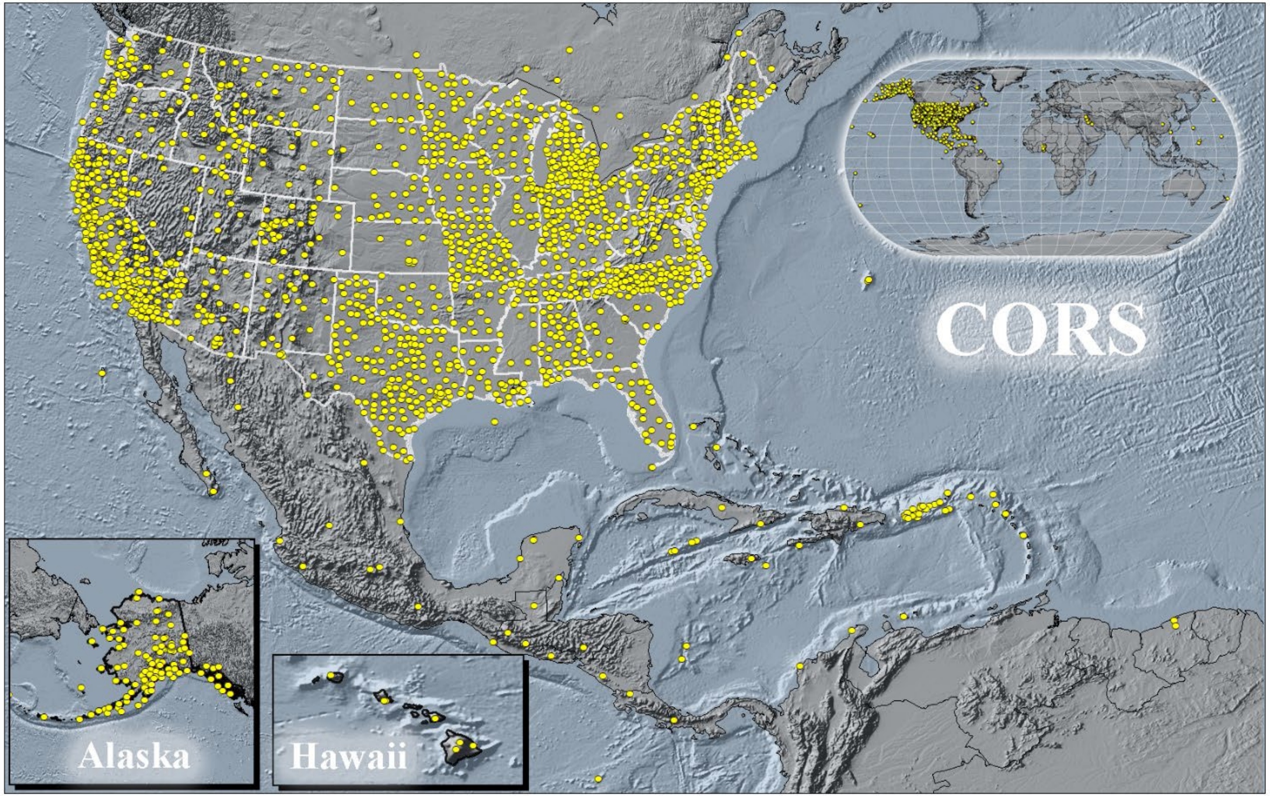
0 to 1.3 meters CONUS

Drift: Plate Tectonics and Velocities



Annual changes to ITRF2014 coordinates

Continuously Operating Reference Stations



P033
Ten Sleep
Wyoming

WYLC
Cheyenne
Wyoming

Vertical Motion

Subsidence

- Ground fluid withdrawal, sedimentation

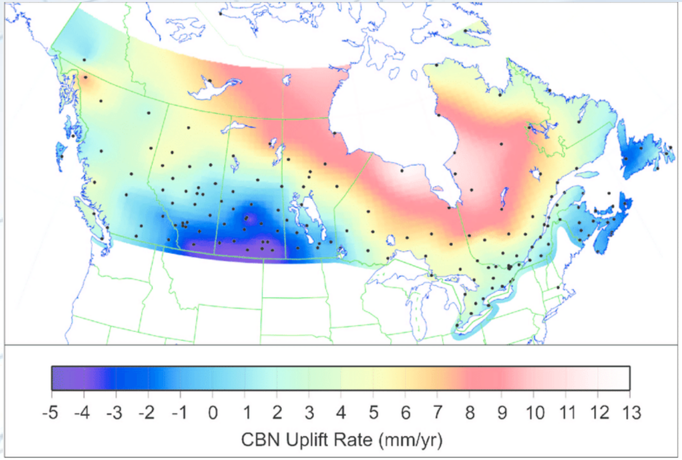
Glacial Isostatic Adjustment (GIA)

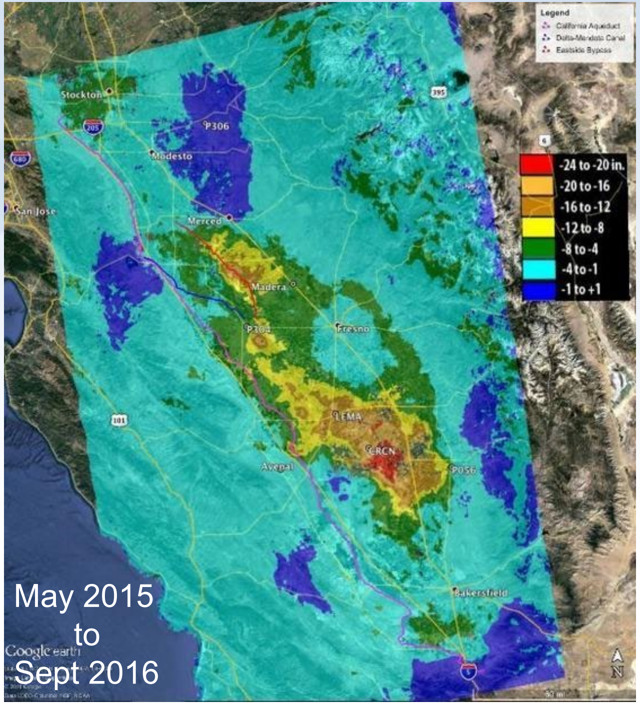
- Crustal rebound from glaciers (uplift)

Geophysical Phenomena

- Earthquakes, calderas, Earth tides

Vertical Motion

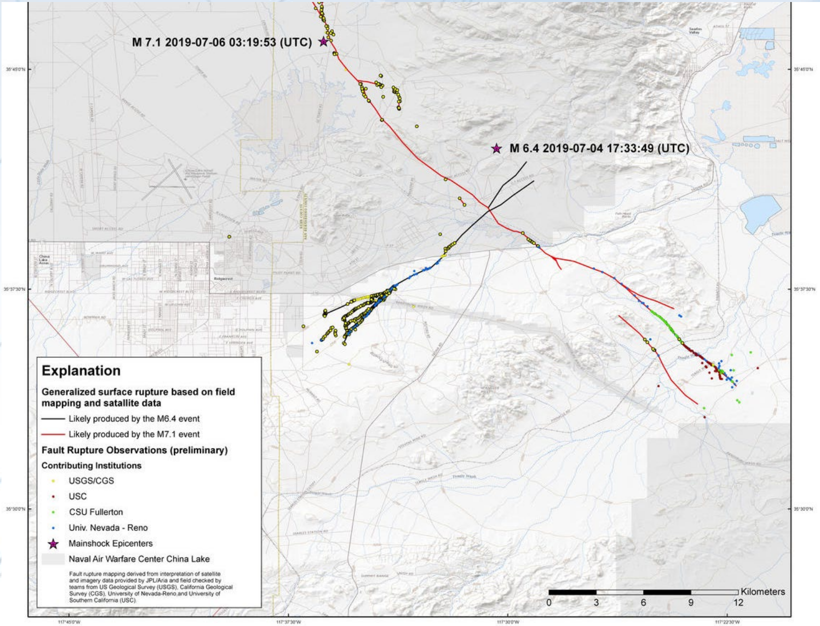




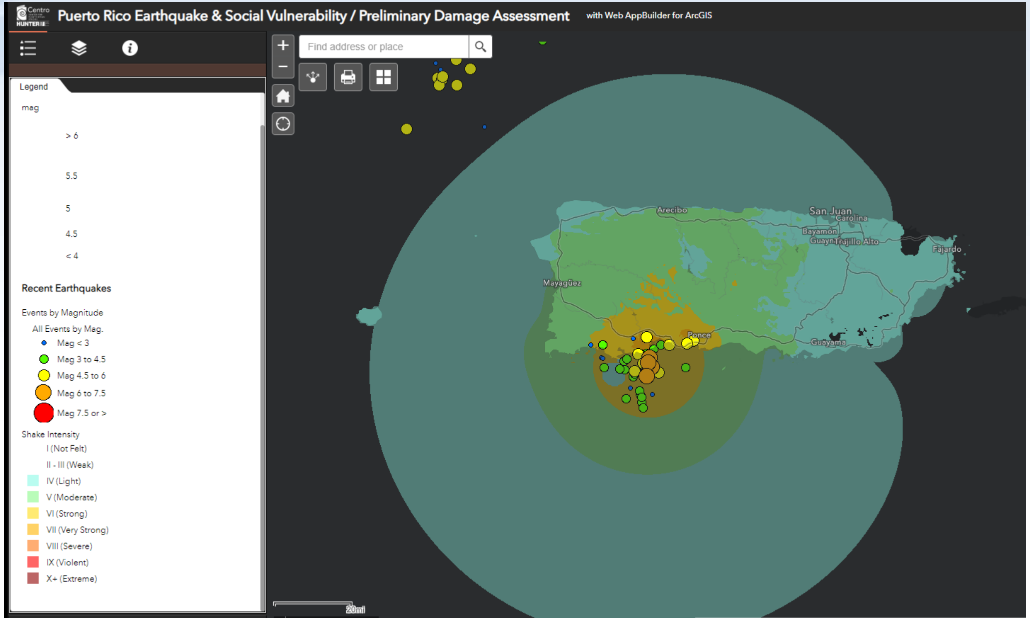
Hudson Bay Uplifting
8 -13 mm/year

San Joaquin Subsiding
20-24" in 16 months

Horizontal and Vertical Motion - Earthquakes



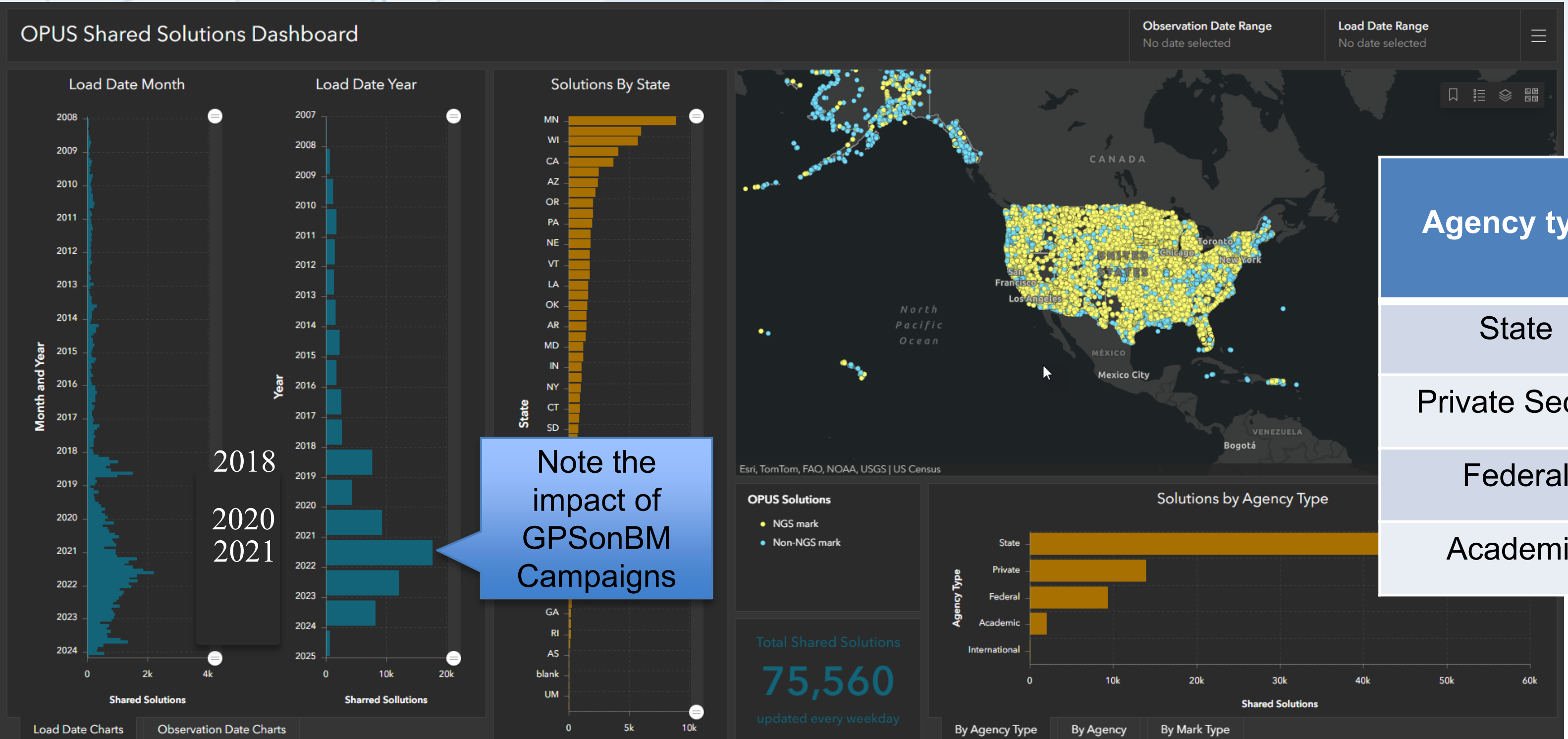
2019 China Lake, CA
6-10 feet Horizontally



2020 Puerto Rico
16 cm Vertically

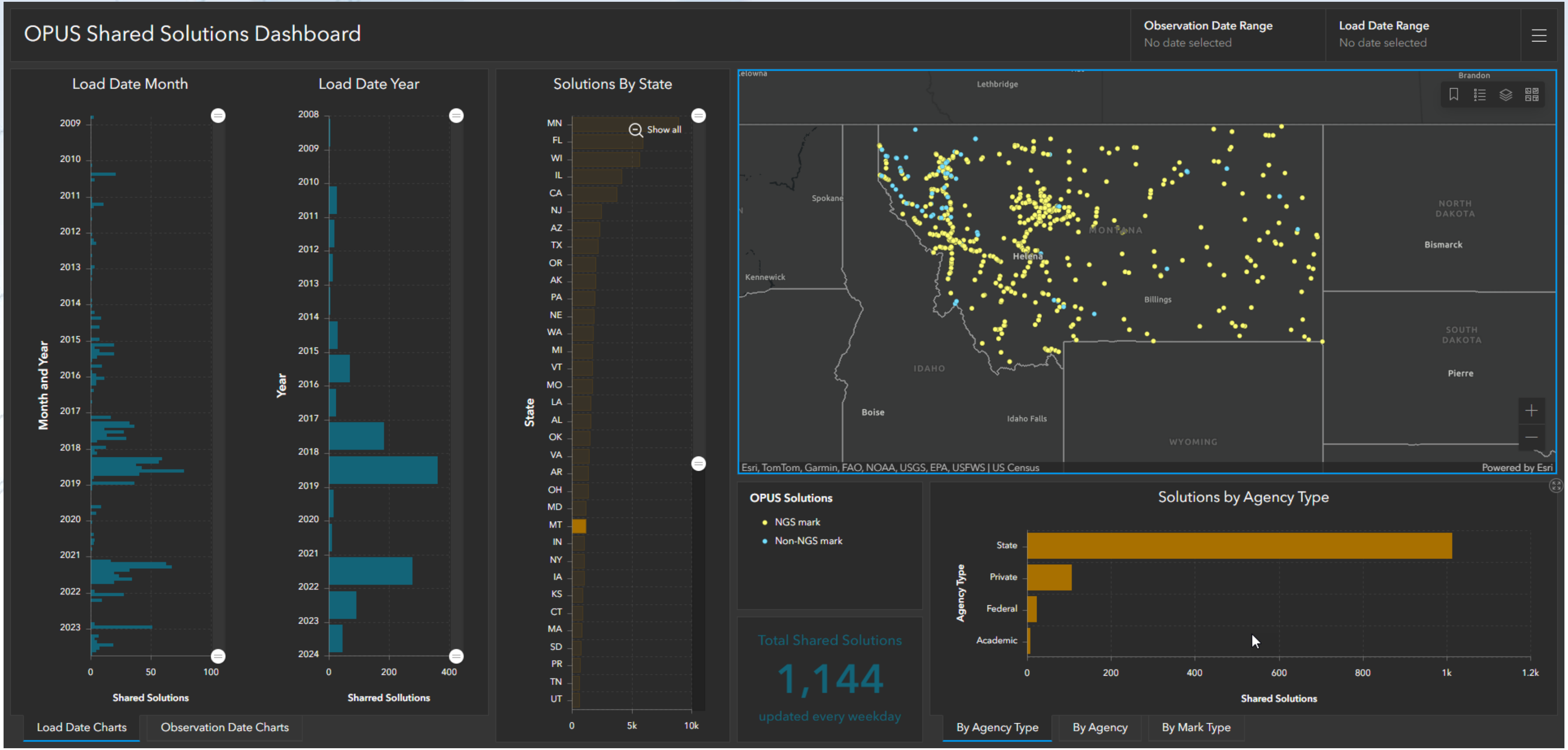
OPUS Shared Solutions Dashboard

Dashboard enables sorting and visualization of Shared Solutions by Month & Year, State, Agency Type, and submitting agency



Agency type	# Shared Solutions on NGS marks
State	~44,900
Private Sector	~7,900
Federal	~4,700
Academic	~1,800

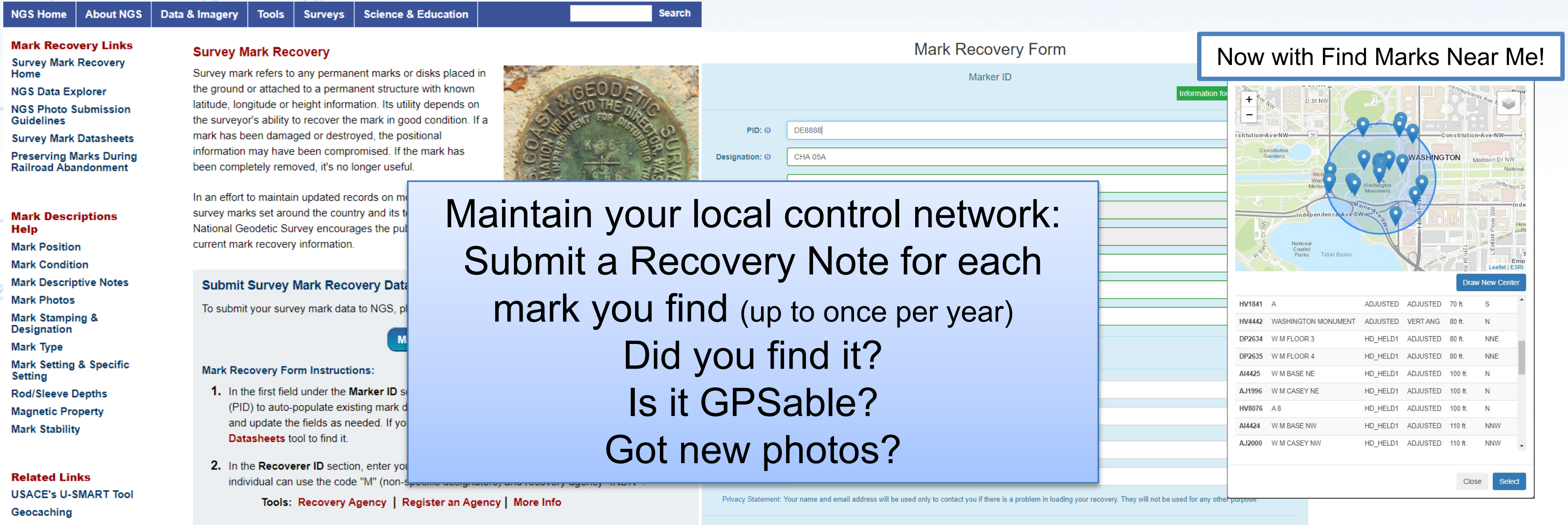
MT OPUS Shared Solutions



NGS 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.

https://geodesy.noaa.gov/surveys/mark-recovery



Now with Find Marks Near Me!

Maintain your local control network:
Submit a Recovery Note for each mark you find (up to once per year)
Did you find it?
Is it GPSable?
Got new photos?

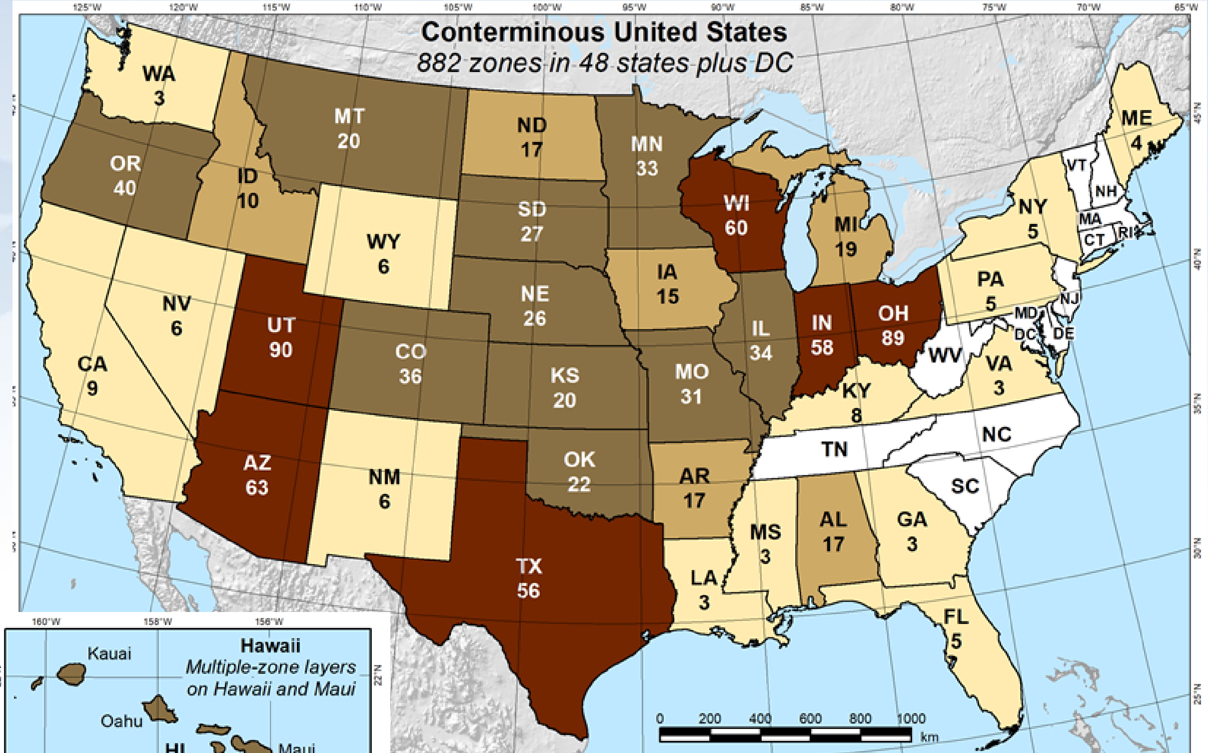
How Can You Prepare

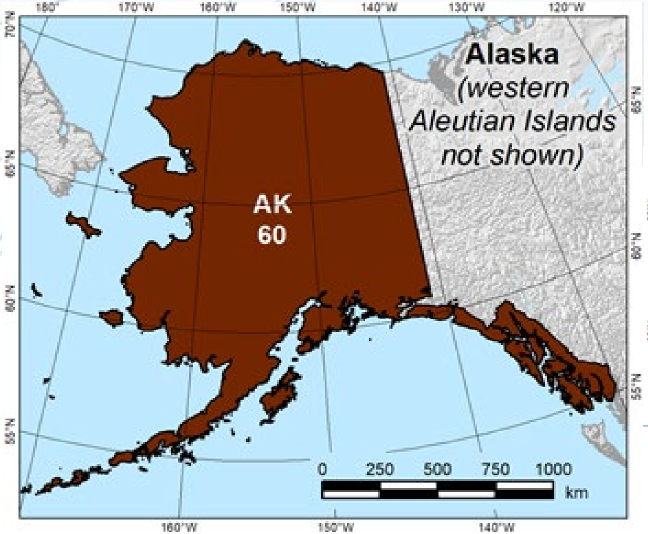
- Metadata is **essential**
  - Improves reliability and accuracy of data
  - Increases value and usefulness
- Transform and collect data in current datums
  - NAD 83 (2011), NAVD 88
- Make sure to note Geoid Models used for GNSS data

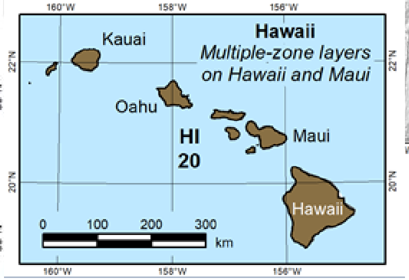
State Plane Coordinate System of 2022 (CONUS, Alaska and Hawaii)

Three territory zones not shown:

- Puerto Rico and U.S Virgin Islands
- American Samoa
- Guam and Commonwealth of the Northern Mariana Islands







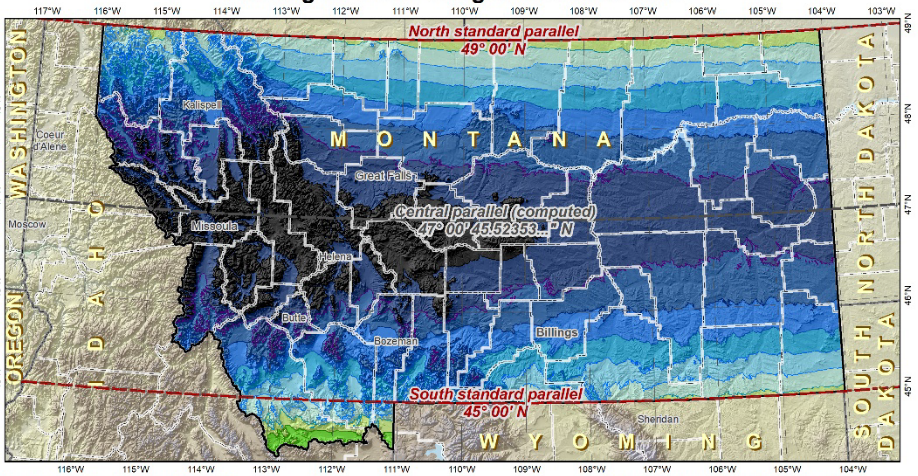
https://geodesy.noaa.gov/SPCS/

Total 965 zones (12/9/2021)

- 1 zone (18 states)
- 3 - 9 zones (14 states)
- 10 - 19 zones (6 states)
- 20 - 40 zones (11 states)
- 56 - 90 zones (7 states)

MT SPCS 2022

Existing SPCS 83 design: Montana Zone



Lambert Conformal Conic projection
North American Datum of 1983
Central parallel: 47° 00' 45.5..." N
Central parallel scale: 0.999 392 636...

NOAA's National Geodetic Survey

Areas within ±300 ppm distortion (1:3,333 = ±1.58 ft per mile):
2% of population
10% of all cities and towns
10% of entire zone area

Distortion values (ppm)
Entire zone:
Min = -475 Range = 1059
Max = +534 Mean = -588
Weighted mean = -617
(weighted by population)
Cities and towns:
Min = -892 Range = 860
Max = -32 Mean = -572

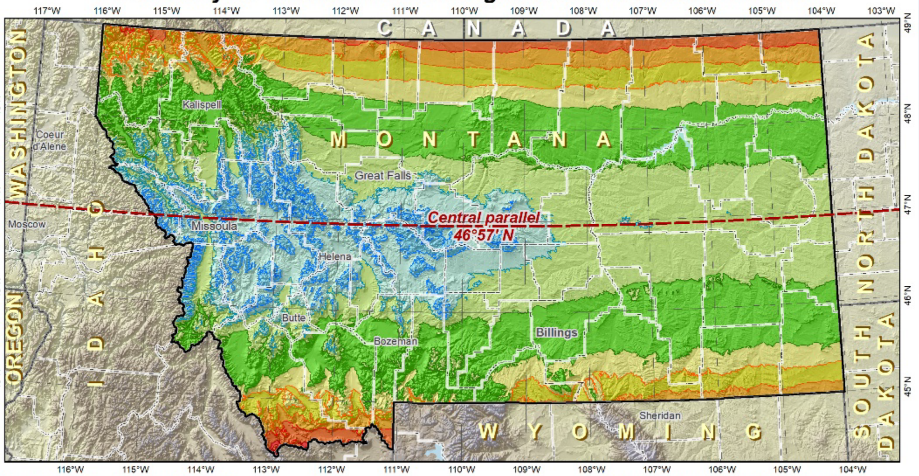
Linear distortion at topographic surface (parts per million)

< -800	to -400	to +300
to -800	to -300	to +400
to -700	to -200	to +500
to -600	±100	to +600
to -500	to +200	> +600

0 50 100 150 200 250 300 km

Created 5/16/2021 (Michael Dennis)

Preliminary SPCS2022 default design: Montana Statewide Zone



Lambert Conformal Conic projection
North American Terrestrial Reference Frame of 2022
Central parallel: 46° 57' N
Central parallel scale: 0.999 96 (exact)

NOAA's National Geodetic Survey

Areas within ±300 ppm distortion (1:3,333 = ±1.58 ft per mile):
98% of population
91% of all cities and towns
87% of entire zone area

Distortion values (ppm)
Entire zone:
Min = -475 Range = 1010
Max = +534 Mean = -20
Weighted mean = -54
(weighted by population)
Cities and towns:
Min = -323 Range = 814
Max = +491 Mean = -4

Linear distortion at topographic surface (parts per million)

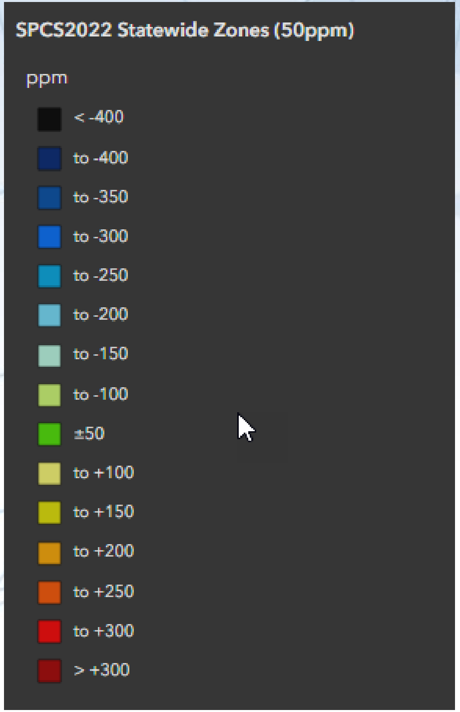
< -800	to -400	to +300
to -800	to -300	to +400
to -700	to -200	to +500
to -600	±100	to +600
to -500	to +200	> +600

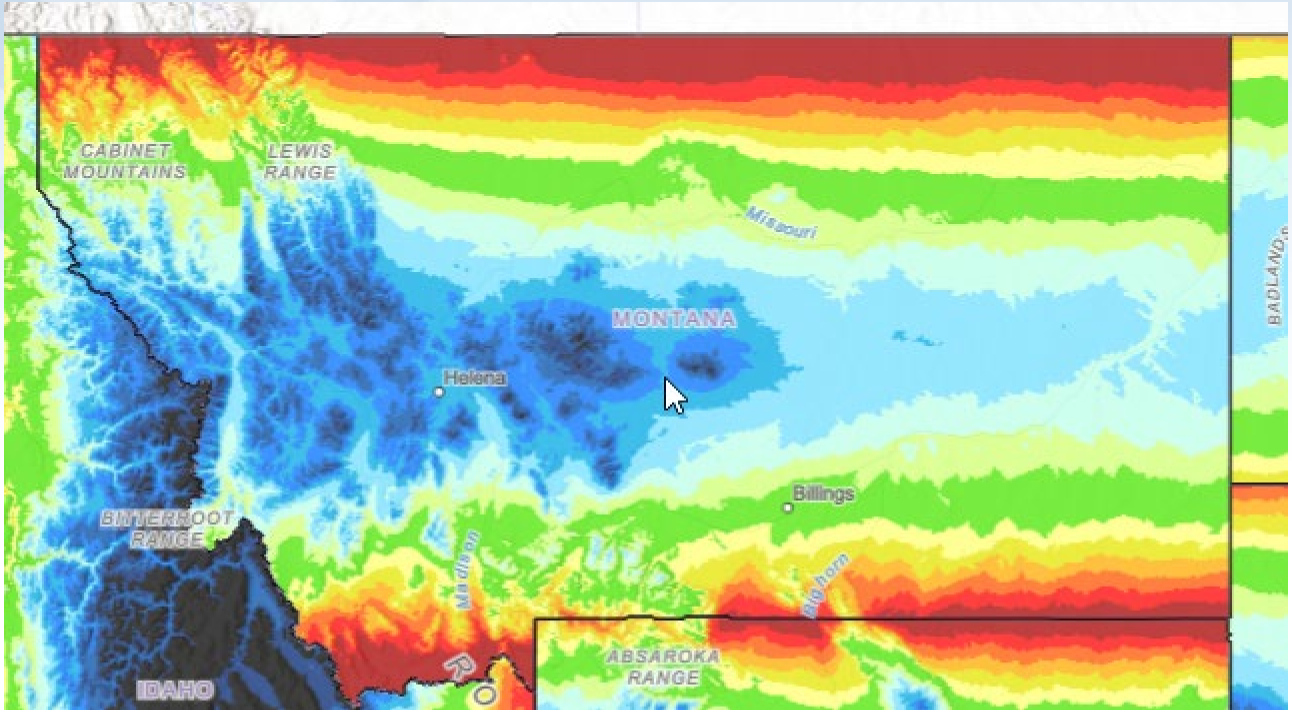
0 50 100 150 200 250 300 km

Created 5/16/2021 (Michael Dennis)

https://geodesy.noaa.gov/SPCS/

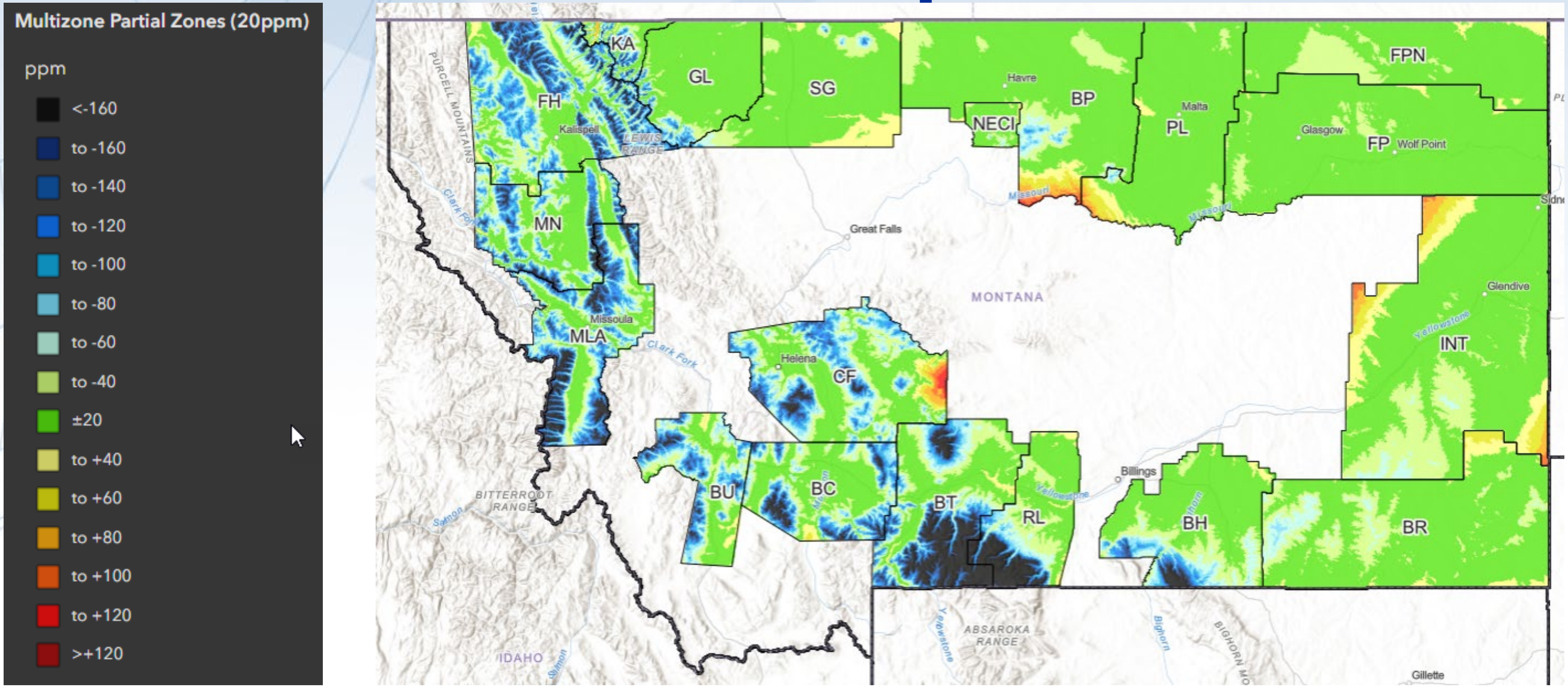
SPCS2022 Experience





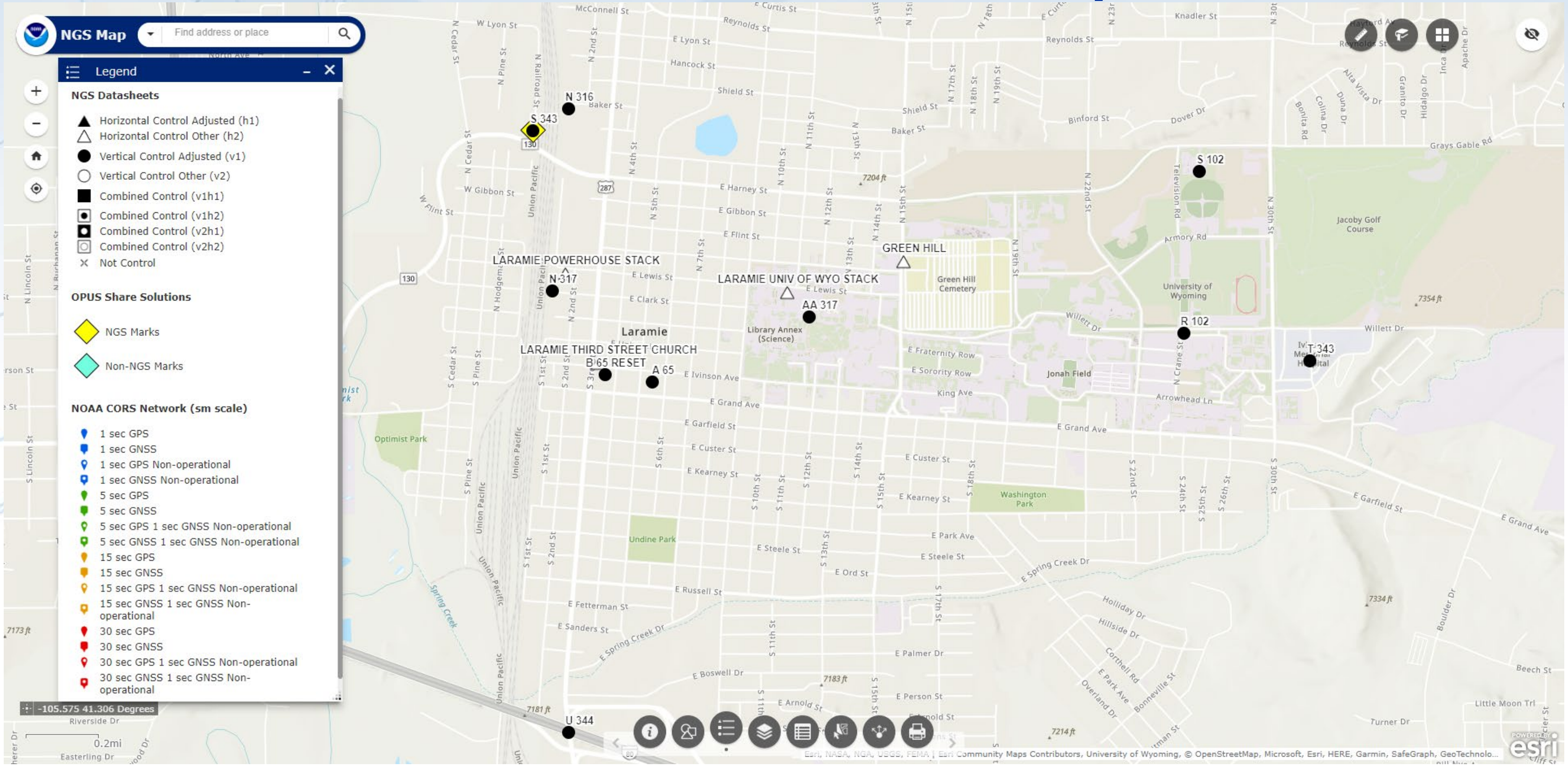
https://experience.arcgis.com/experience/dddb7bc0be6f4e56a1c370c8d529d1a0

SPCS2022 Experience



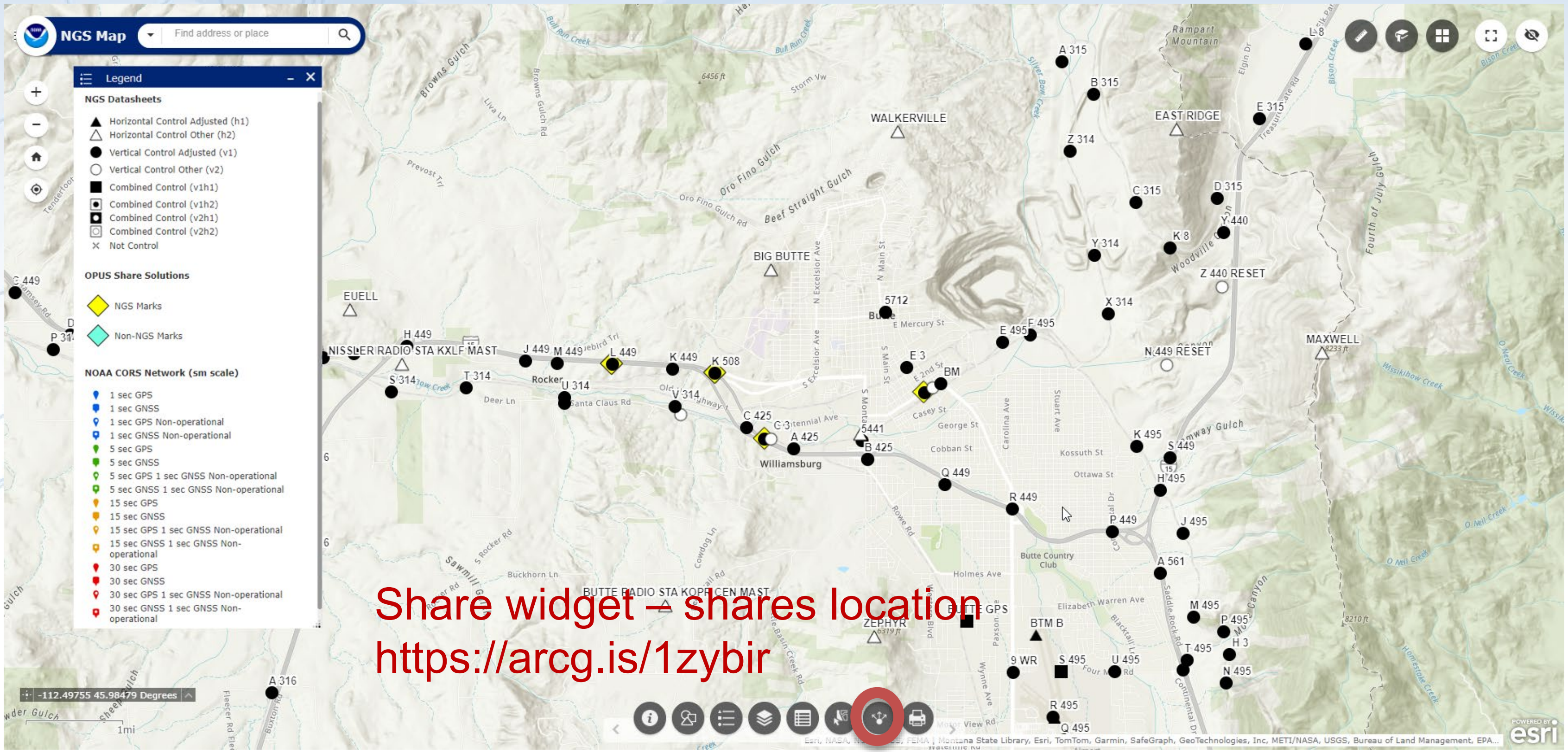
https://experience.arcgis.com/experience/dddb7bc0be6f4e56a1c370c8d529d1a0

Newish NGS Map



https://noaa.maps.arcgis.com/apps/webappviewer/index.html?id=190385f9aadb4cf1b0dd8759893032db

Newish NGS Map



Share widget – shares location
https://arcg.is/1zybir

https://noaa.maps.arcgis.com/apps/webappviewer/index.html?id=190385f9aadb4cf1b0dd8759893032db

NGS ArcGIS Online Resources

Feature Services

NGS Datasheets
NOAA CORS Network
GPS on Benchmarks Priority List
(4 layers - marks, hexagons)
GEOID18 GPS on Benchmarks
GEOID12B GPS on Benchmarks
OPUS Shared Solutions
Mark Recoveries Submitted to NGS

Raster Tile Services

GEOID18 Height (CONUS, PRVI)
GEOID18 Difference (CONUS, PRVI)
GEOID18 Uncertainty (CONUS, PRVI)
GEOID18 Improvements (CONUS, PRVI)

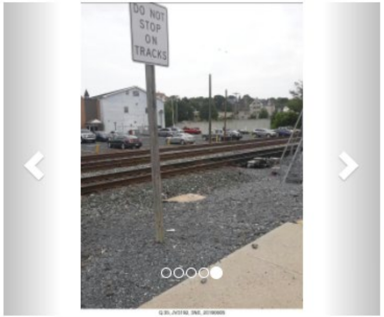
Passive Marks Page

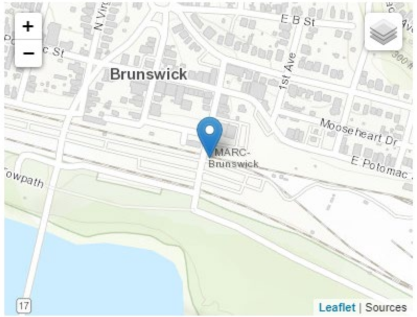
Enter PID: JV3192 Get Data Recover this mark

Designation:	Q 35
Setting:	36 = SET IN A MASSIVE STRUCTURE
Last Recovery Date/Condition/By:	05/16/2014 - Recovered in good condition - GEOCACHING

PID:	JV3192
Stability:	B
GNSS Useable:	Y
Orthometric Ht. (m):	75.185
Vertical Datum:	NAVD 88
Vertical Source:	ADJUSTED
Order/Class:	1/2
Geoid Ht (m).:	-33.056
Geoid Model:	GEOID18

State, County:	MD,FREDERICK
Country:	US
Latitude:	N 39° 18' 42.63"
Longitude:	W 077° 37' 37.59"
Ellipsoid Ht.:	
Position Datum:	NAD 83(1986)
Position Source:	HD_HELD1
Network Accuracy Hz (cm):	
Network Accuracy Ellip (cm):	





Projects

Leveling Projects

L24378/1

Start Date:	05/07/1979	Order:	1	Agency:	NGS
End Date:	06/06/1979	Class:	2	BM Count:	84

L9532/3

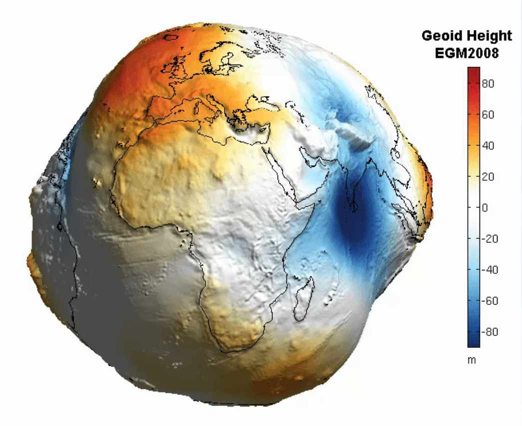
Start Date:	04/10/1942	Order:	2	Agency:	NGS
End Date:	04/21/1942	Class:	0	BM Count:	22

L8007

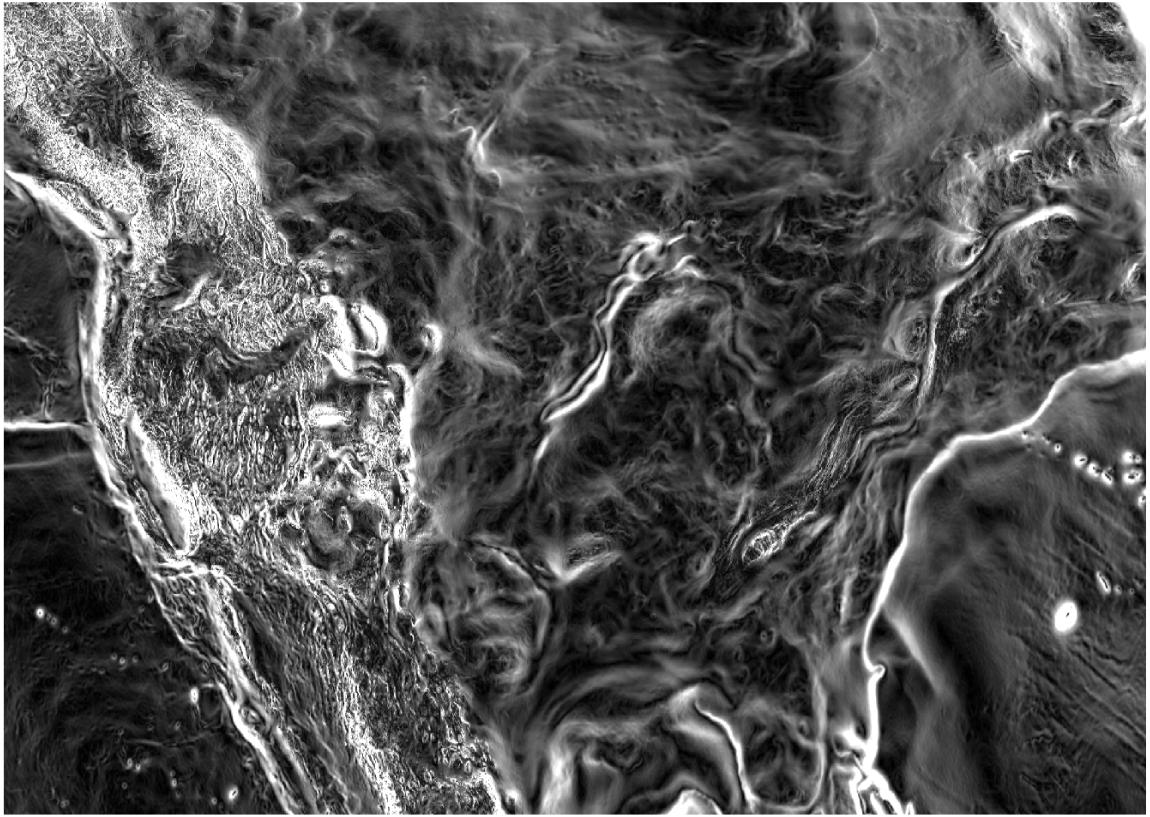
Start Date:	05/27/1938	Order:	1	Agency:	NGS
End Date:	06/25/1938	Class:	2	BM Count:	71

Descriptive Information

PID:	JV3192	Designation	Q 35
Setting Agency:	CGS	Setting Date:	1938
Marker Type:	DB	Magnetic Code:	
Stability Code:	B	Setting Class:	36
Setting Phrase:	BRIDGE FOUNDATION	Logo:	CGS
Stamping:	Q 35 1938	UDG Mark Type:	
UDG Magnetic Code:		UDG Mark Stability:	
UDG Mark Setting:		UDG Mark Set Date:	
Rod/Pipe Depth:		Sleeve Depth:	
Position Source:	O	Position Quality:	4
Position Technique:	X	Alias:	



Magnitude of the Deflection of the Vertical



Questions?

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