

National Geodetic Survey: Modernizing the National Spatial Reference System 2022

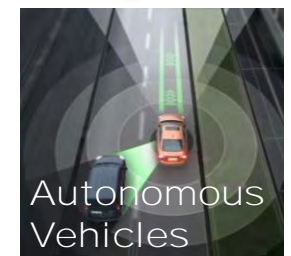
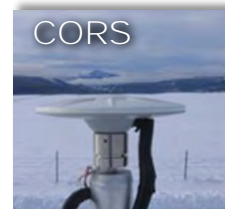
HIGICC
Honolulu Geospatial Expo 2022
August 5, 2022

Edward Carlson
NOAA's National Geodetic Survey
Pacific Region Geodetic Advisor

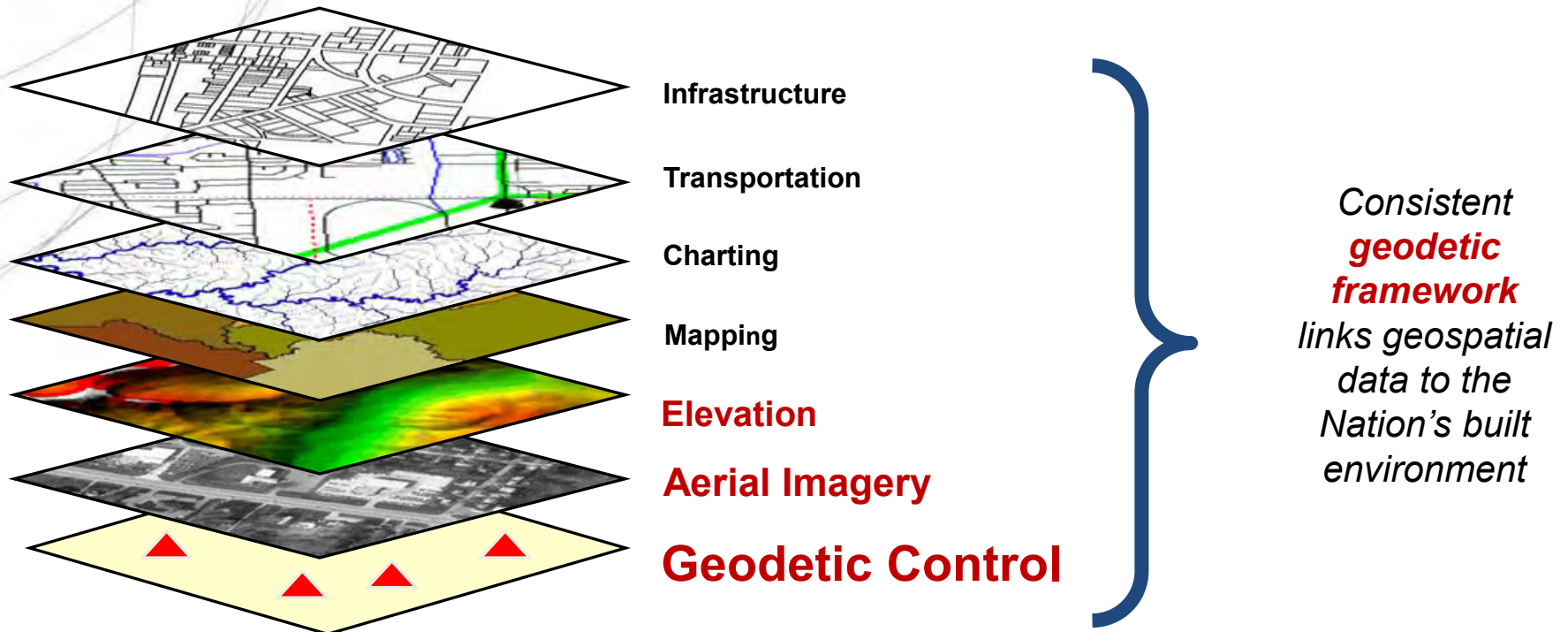


U.S. Department of Commerce National Oceanic & Atmospheric Administration National Geodetic Survey

Mission: To define, maintain & provide access to the
National Spatial Reference System (NSRS)
to meet our Nation's economic, social & environmental needs



Geospatial Framework = National Spatial Reference System

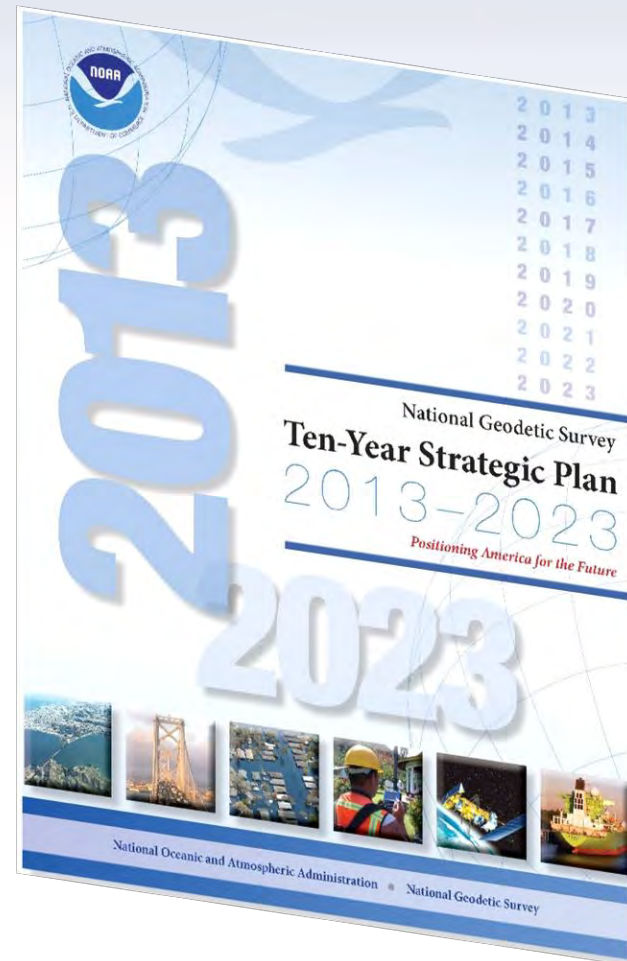


Why modernize the National Spatial Reference System?

- **Main driver:** *Global Navigation Satellite System (GNSS)*
- **ACCESS!**
 - GNSS equipment is fast, inexpensive, reliable (and improving)
 - Reduces reliance on finding survey control (“bench marks”)
- **ACCURACY!**
 - Insensitive to distance-dependent errors; reliable
 - Less vulnerable to control instability (referenced to CORS)
 - Time-dependent coordinates accommodate areas in motion
- **CONSISTENCY!**
 - Eliminates systematic errors in current datums
 - Aligned with global/international reference frames
 - Integrated system for both positions and heights (“elevations”)

2022 Datums Goals

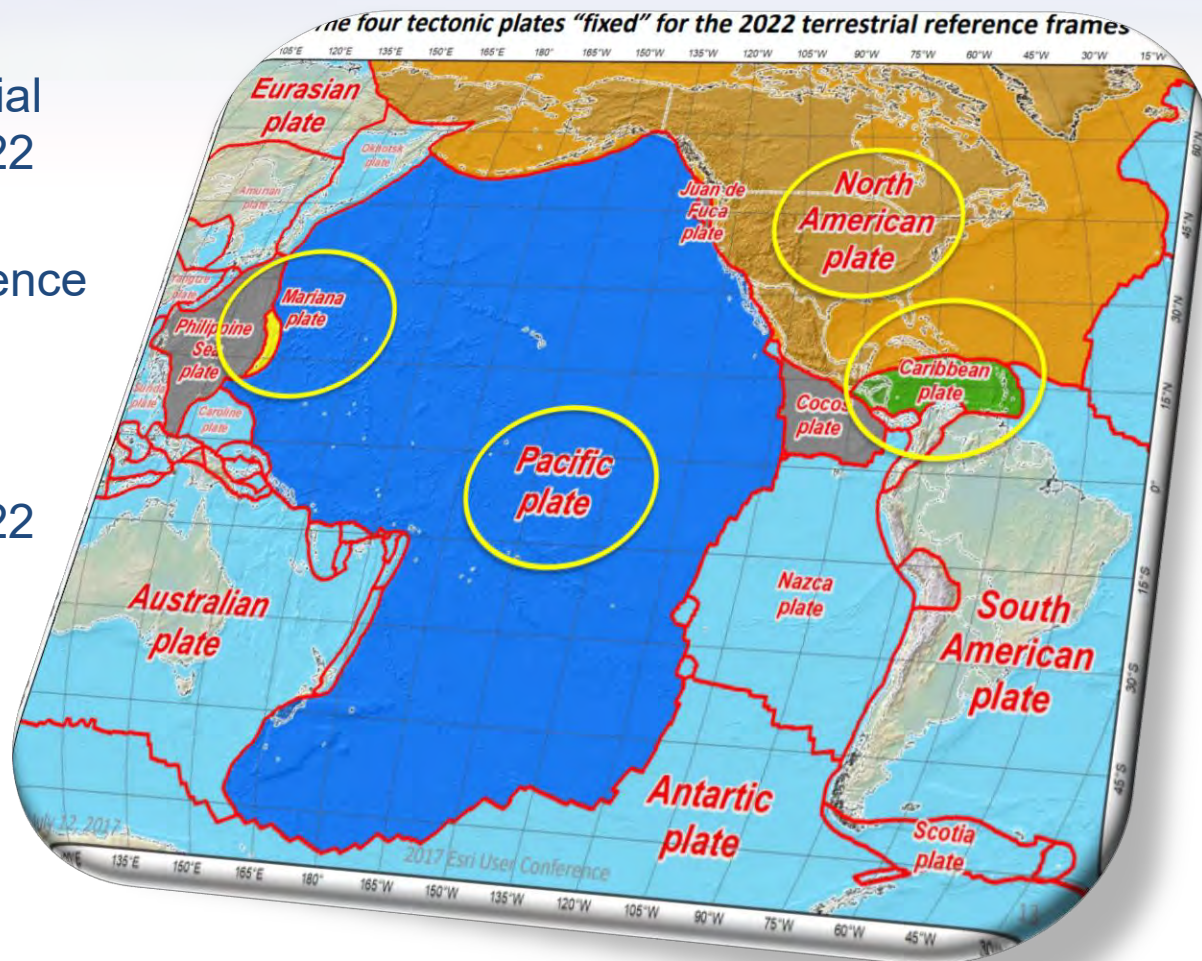
- ❖ **“Replace NAD83”** - By 2022, reduce all definitional & access-related errors in geometric reference frame to 1 cm when using ≤ 30 min of GNSS data
- ❖ **“Replace NAVD88”** - By 2022, reduce all definitional & access-related errors in orthometric heights, relative to sea level, in geopotential datum to 2 cm when using ≤ 30 min of GNSS data
- ❖ Provide tools to easily transform between new old datums



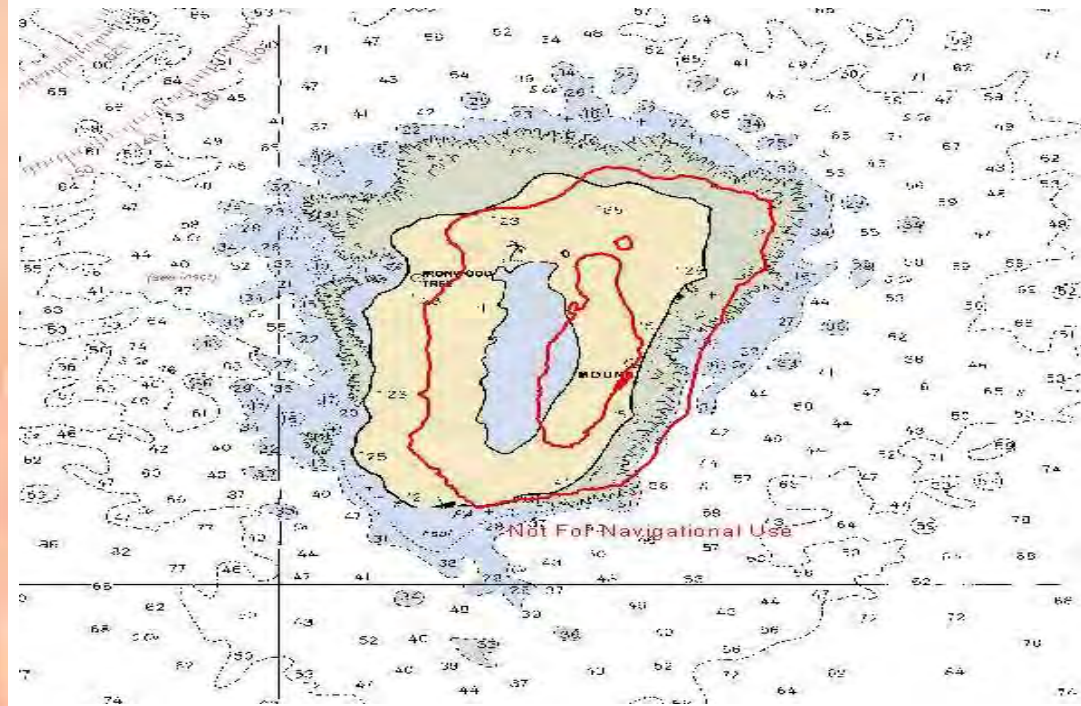
Four Tectonic Plates NGS Monitors

In 2022, the entire National Spatial Reference System (NSRS) will be modernized and will contain **four new reference frames**:

- ✓ North American Terrestrial Reference Frame of 2022 (NATRF2022)
- ✓ Pacific Terrestrial Reference Frame of 2022 (PATRF2022)
- ✓ Caribbean Terrestrial Reference Frame of 2022 (CATRF2022)
- ✓ Mariana Terrestrial Reference Frame of 2022 (MATRF2022)



All coordinates and heights will change!



Approximate Horizontal Change

Approximate Horizontal Change North American Plate

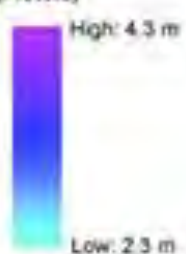
Mariana Plate
(Meters)



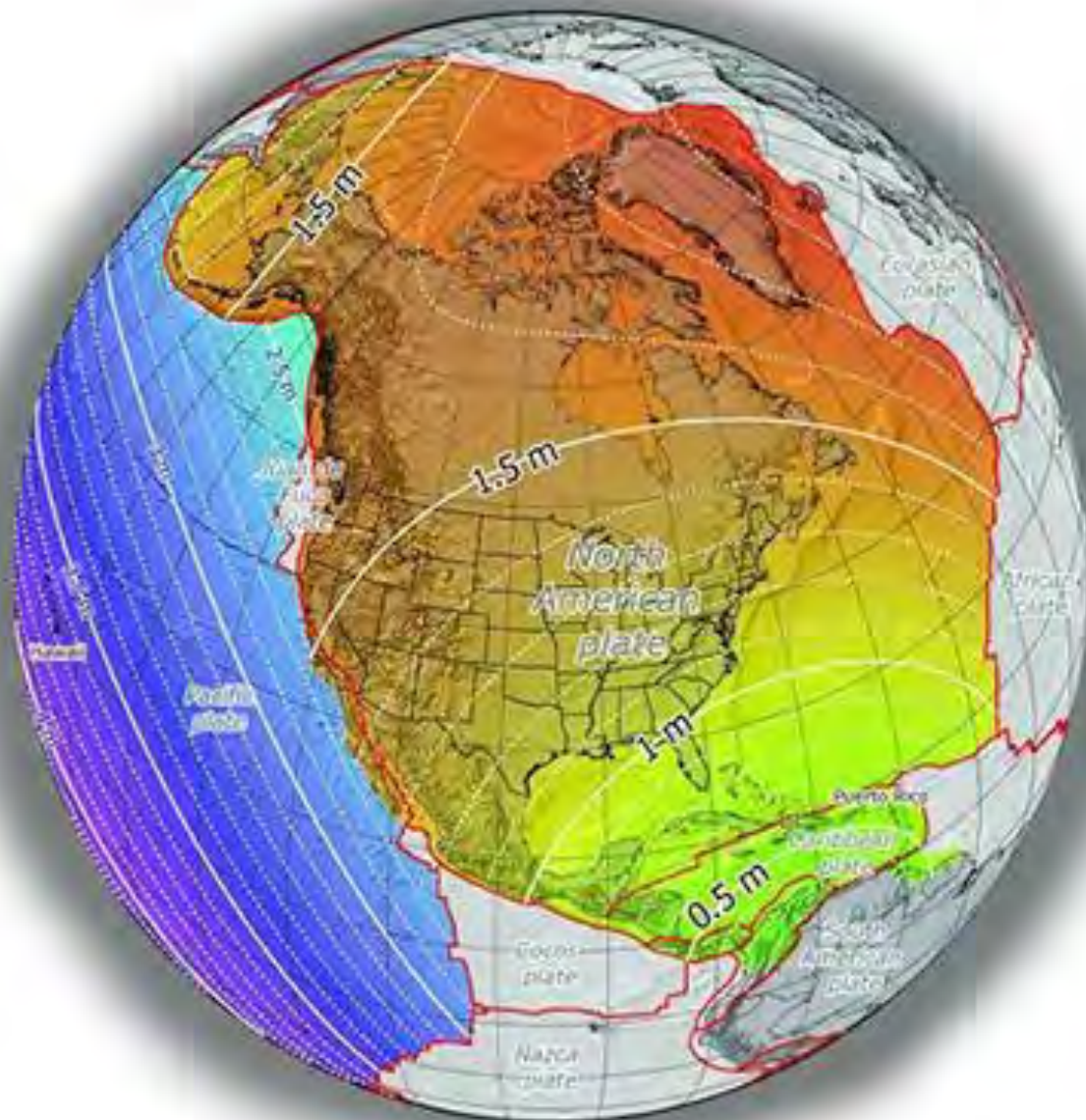
North American Plate
(Meters)



Pacific Plate
(Meters)

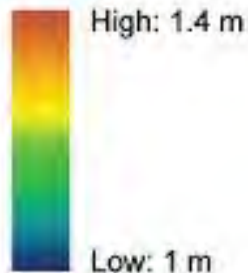


Tectonic Plate
Boundaries

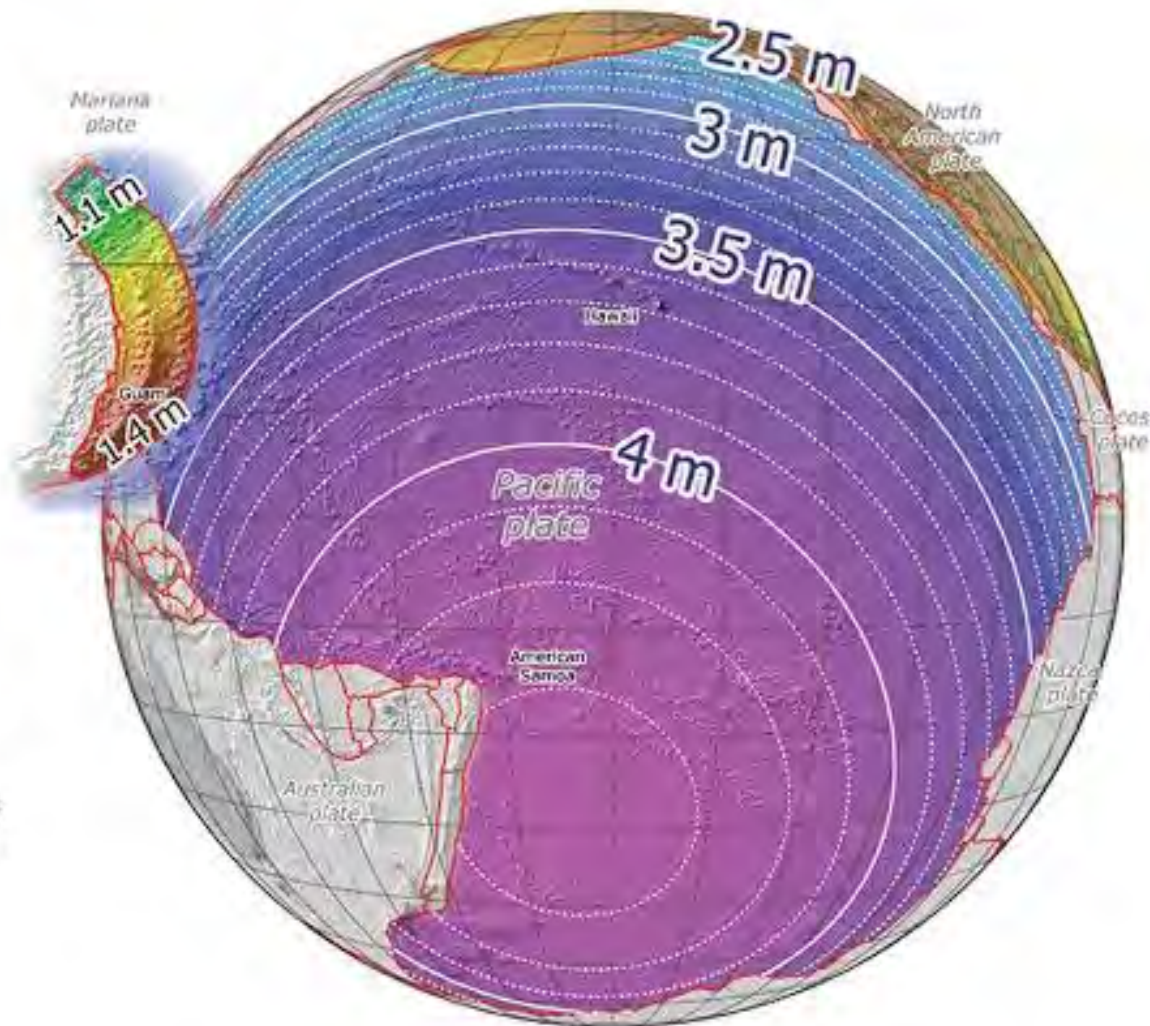


Approximate Horizontal Change Pacific Plate

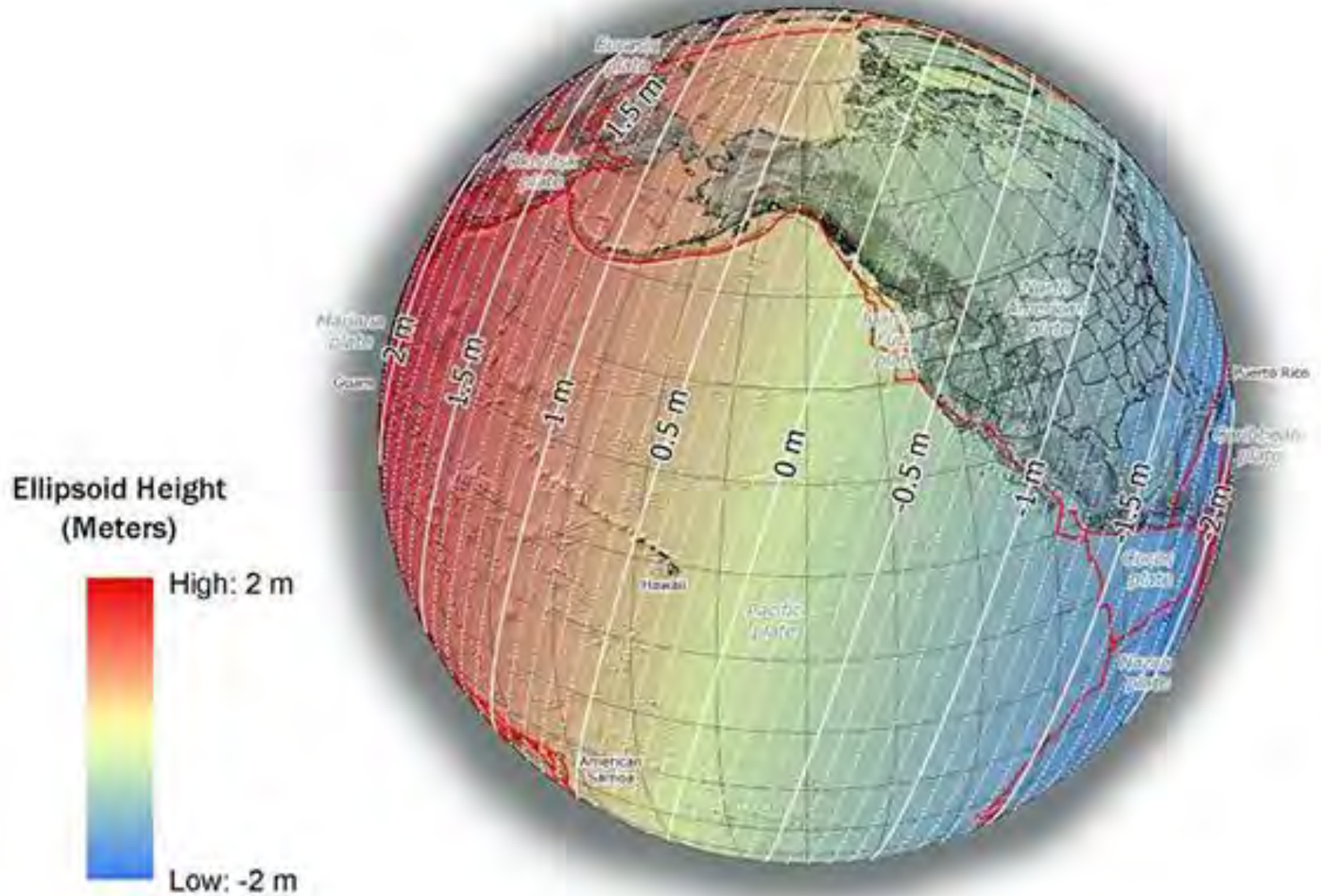
Mariana Plate
(Meters)



Pacific Plate
(Meters)



Approximate Ellipsoid Height Change



State Plane 2022

The Shape of Things to Come

Making the Earth flat again

...one zone at a time

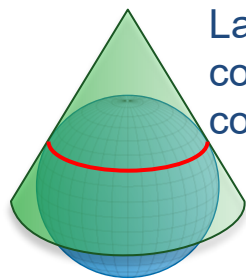
About SPCS2022

- **Statewide zones** created for **all** states
- **Default zones** created as necessary
 - To ensure **all** states and territories covered
 - Modify existing zones to meet policy

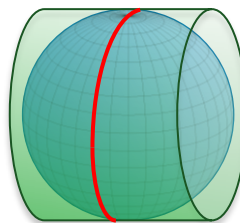
States often want statewide **and** small zones

Statewide: Single geometry required for state GIS

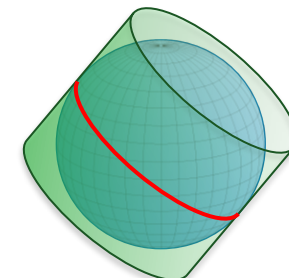
Sub-zones: Lower distortion for surveying/engineering



Lambert
conformal
conic

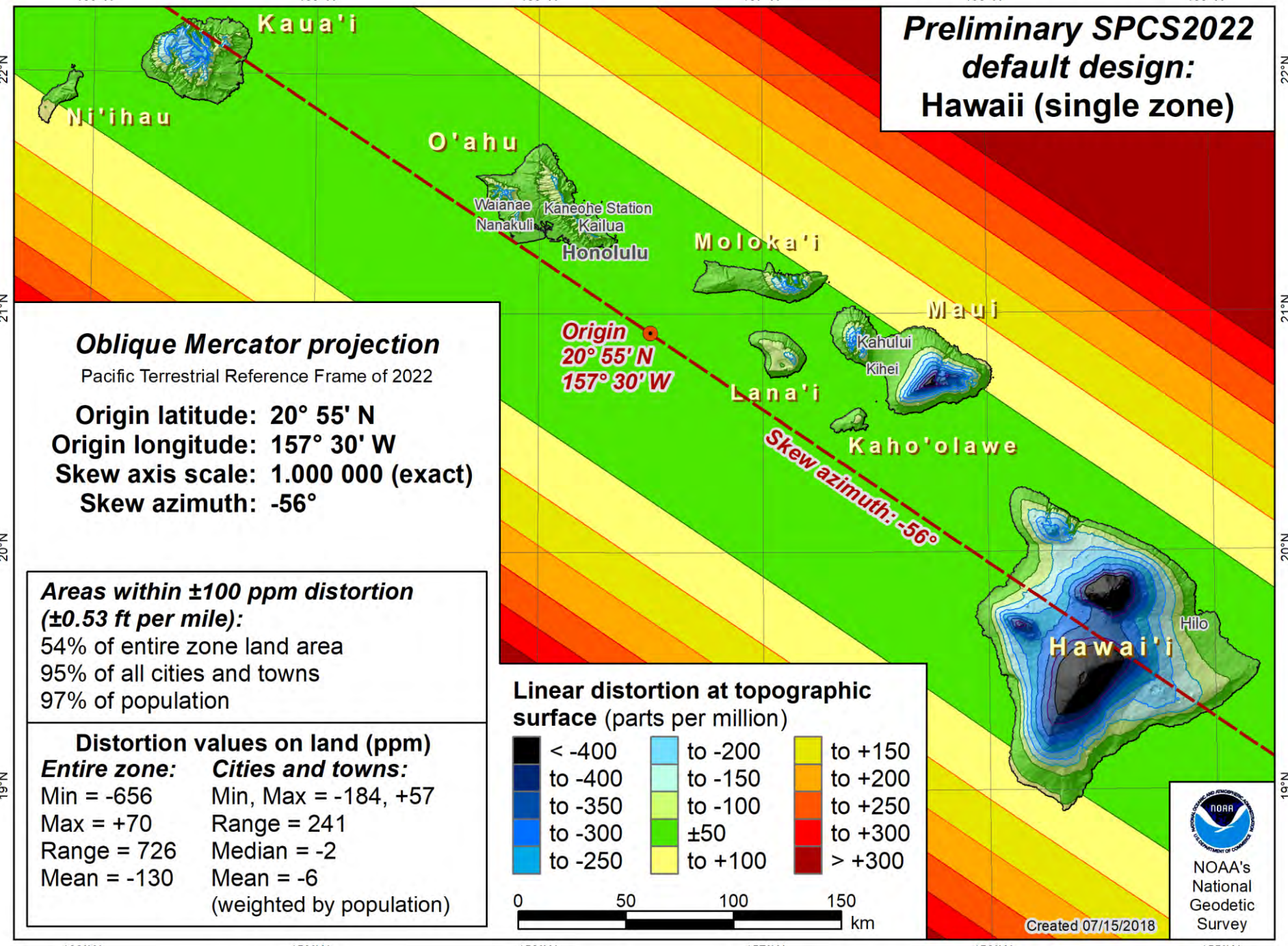


Transverse
Mercator



Oblique
Mercator

**Preliminary SPCS2022
default design:
Hawaii (single zone)**



Oblique Mercator projection

Pacific Terrestrial Reference Frame of 2022

Origin latitude: **20° 55' N**

Origin longitude: **157° 30' W**

Skew axis scale: **1.000 000 (exact)**

Skew azimuth: **-56°**

**Areas within ± 100 ppm distortion
(± 0.53 ft per mile):**

54% of entire zone land area

95% of all cities and towns

97% of population

Distortion values on land (ppm)

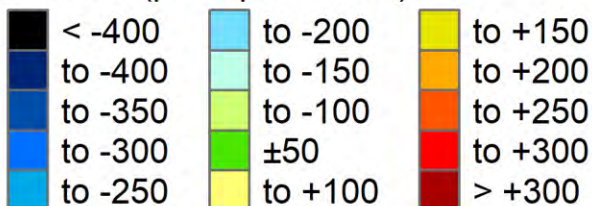
Entire zone:

Min = -656
Max = +70
Range = 726
Mean = -130

Cities and towns:

Min, Max = -184, +57
Range = 241
Median = -2
Mean = -6
(weighted by population)

**Linear distortion at topographic
surface (parts per million)**

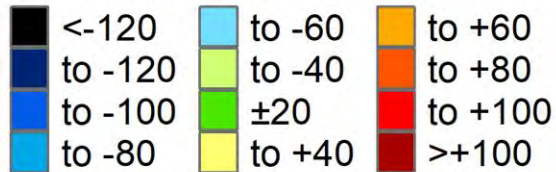


Created 07/15/2018



NOAA's
National
Geodetic
Survey

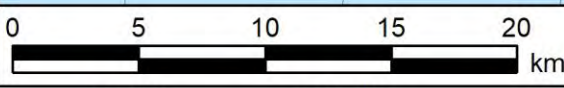
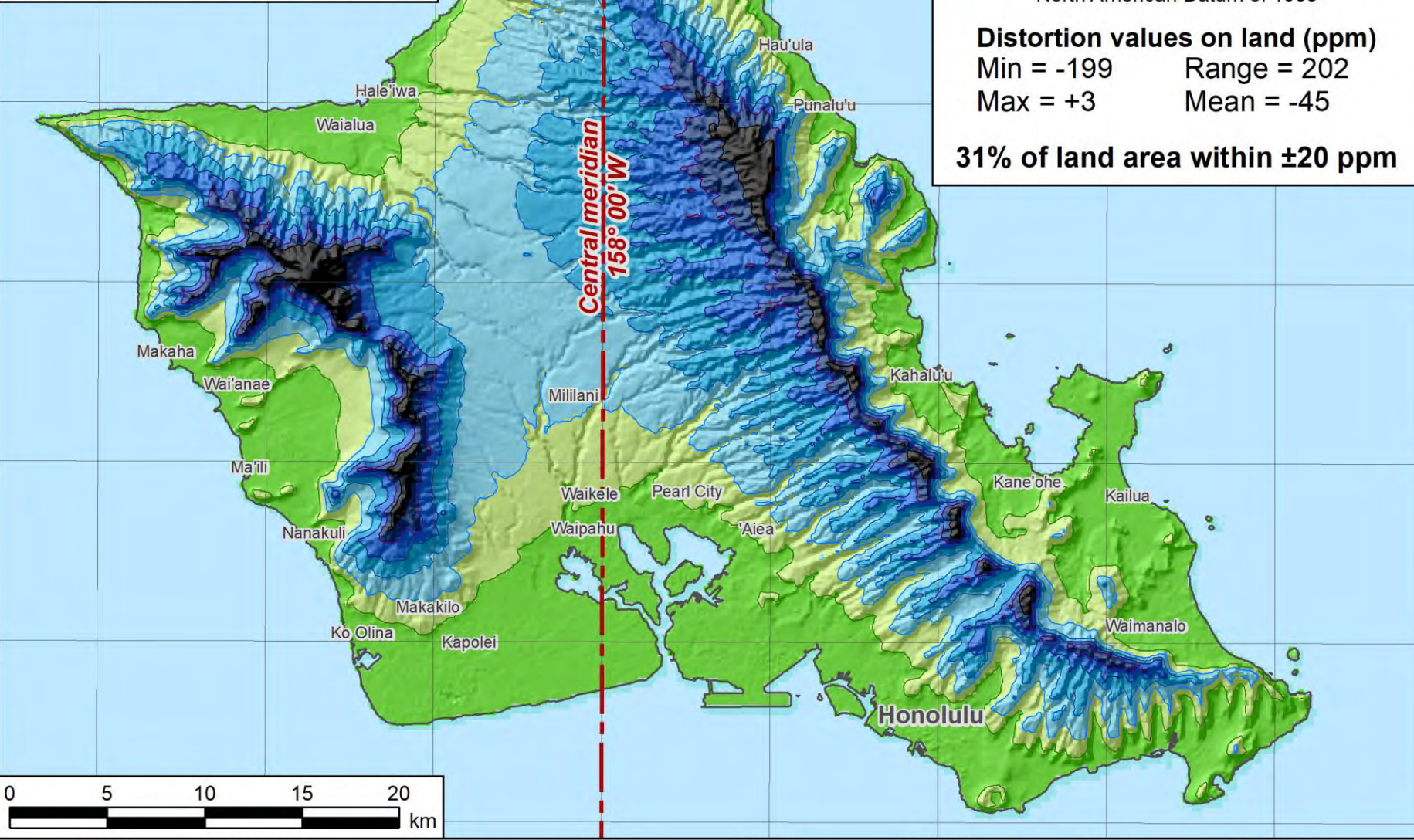
Linear distortion at topographic surface (parts per million)



Existing SPCS 83 design:
Hawaii Zone 3
Transverse Mercator projection
 North American Datum of 1983

Distortion values on land (ppm)
 Min = -199 Range = 202
 Max = +3 Mean = -45

31% of land area within ±20 ppm



Preliminary SPCS2022 statewide zone design: Hawaii (Oahu)

Oblique Mercator projection

Pacific Terrestrial Reference Frame of 2022

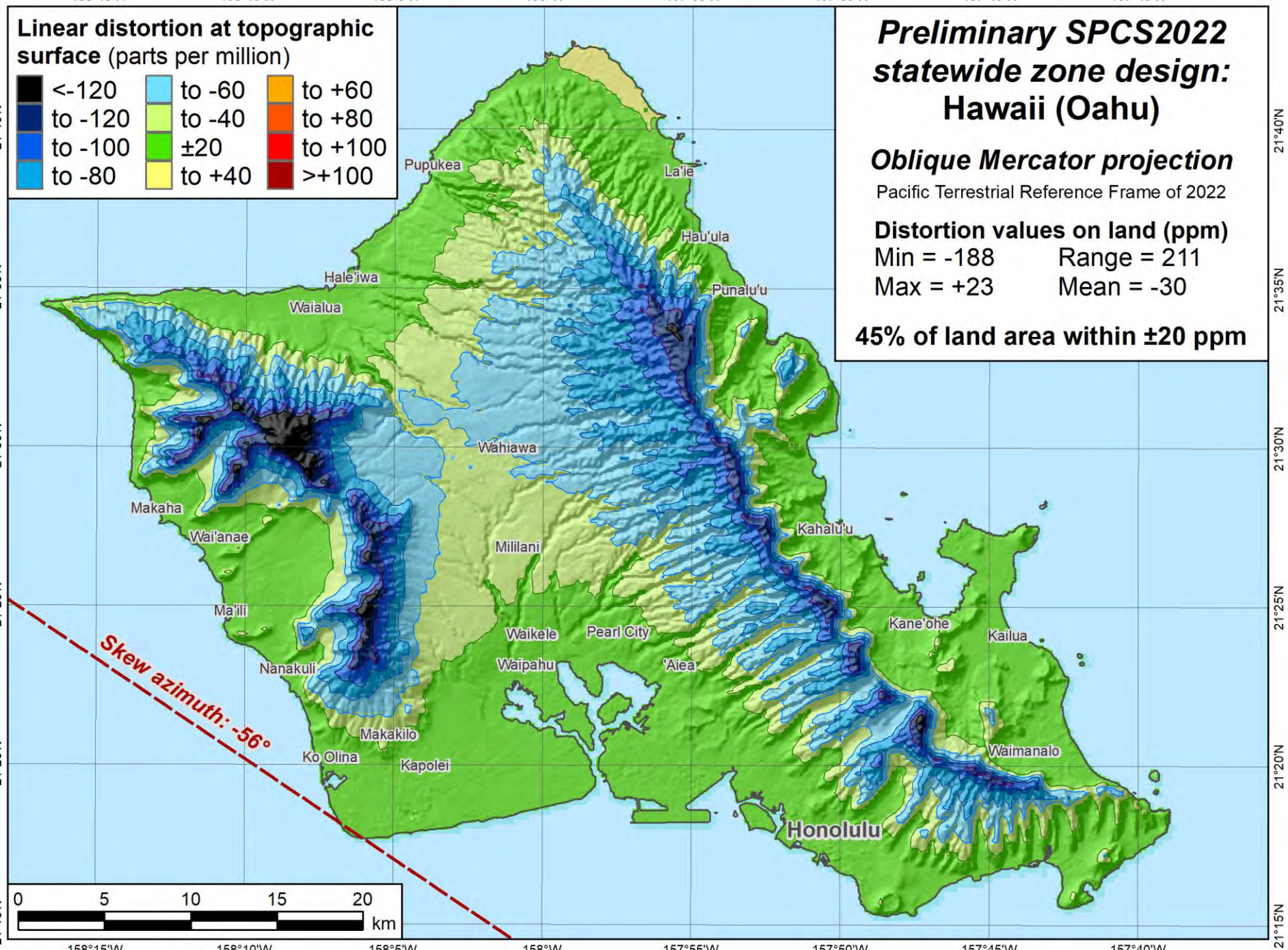
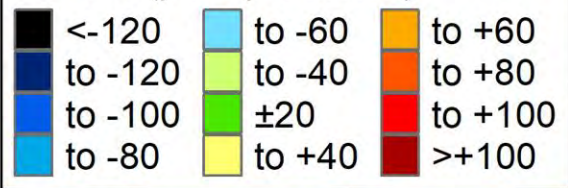
Distortion values on land (ppm)

Min = -188 Range = 211

Max = +23 Mean = -30

45% of land area within ± 20 ppm

Linear distortion at topographic surface (parts per million)



SPCS 83 shorter than SPCS2022 by 0.0563 ft, or 10.8 parts per million (ppm)

SPCS2022 longer than ground distance by 0.0001 ft (0.02 ppm)

Horizontal ground distance: 5199.8211 ft
SPCS2022: 5199.8212 ft
SPCS 83: 5199.7649 ft

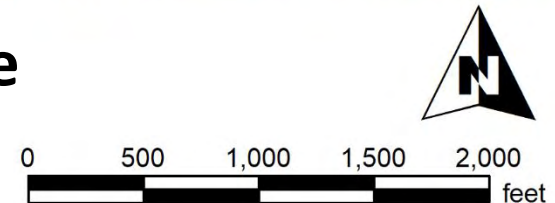
OPALA

GPS 8

HLSA Conference

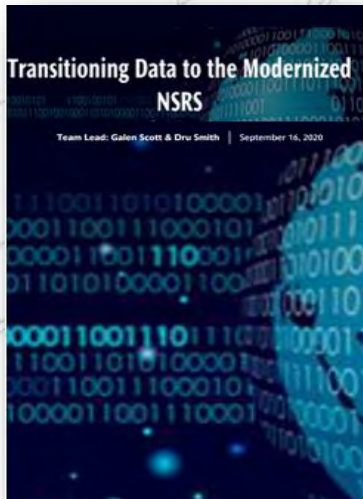
Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community

Compare grid distances: SPCS2022 statewide versus SPCS 83 Hawaii Zone 3 in Honolulu



Transitioning Existing Geospatial Data and Products to the Modernized NSRS

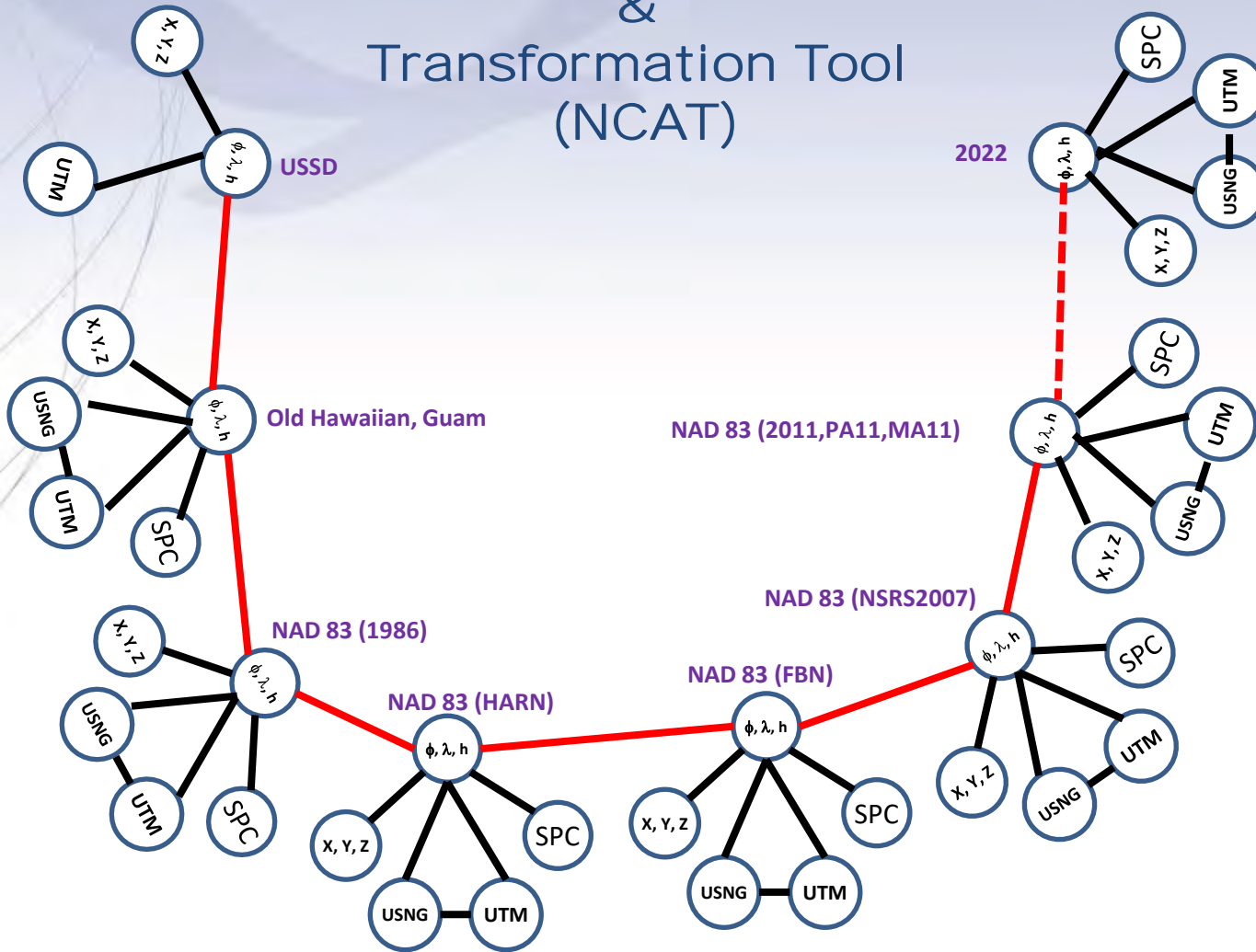
Listed in decreasing order of Accuracy, Cost, and Complexity



- 1. Resurvey**
- 2. Readjust**
- 3. Transform**

NGS will provide tools for data transformation and is working with private geospatial software vendors

NGS Coordinate Conversion & Transformation Tool (NCAT)



geodesy.noaa.gov

National Geodetic Survey
Positioning America for the Future

NGS Home | About NGS | Data & Imagery | Tools | Surveys | Science & Education | Search

Earn certificates for viewing recorded NGS webinars about geodesy, remote sensing and more.

Learn more about Webinar Certificates

NOAA's National Geodetic Survey (NGS) provides the framework for all positioning activities in the Nation. The foundational elements of latitude, longitude, elevation, and shoreline information impact a wide range of important activities.

- Process GPS Data (OPUS)
- NGS Data Explorer
- Looking for Bench Marks
- Conversion & Transformation (NCAT)
- NOAA CORS Network
- New Datums

Popular Links | **New Visitor**

Stay Informed: Subscribe

Storm Imagery
Aerial imagery aids safe navigation and captures damage to coastal areas caused by a storm.

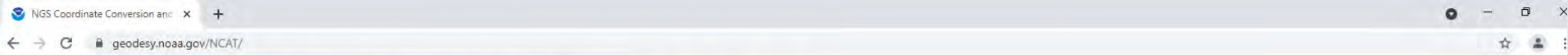
State Plane Coordinates
Large-scale conformal map projections to support surveying, engineering, and mapping activities.

Antenna Calibration
GNSS antenna calibrations for specific antenna types

Geodetic Toolkit
On-line interactive computation of geodetic values.

News Bulletins
Important Updates:
• HTDP new version release
Beta Release:
• NGS Map
• OPUS Projects 5.0
• Leveling Projects Page
• Passive Mark Page
NGS Weekly

NGS Coordinate Conversion and Transformation Tool (NCAT)



NGS Coordinate Conversion and Transformation Tool (NCAT)

National Geodetic Survey

- NGS Home
- About NGS
- Data & Imagery
- Tools
- Surveys
- Science & Education

 Search

- Single Point Conversion
- Multipoint Conversion
- Web services
- Downloads
- About Conversion Tool

Convert/Transform from:

- Horizontal
- Horizontal+height
- XYZ
- Geodetic lat-long
- SPC
- UTM
- USNG

Select the type of horizontal coordinate:



Enter lat-lon in decimal degrees

Lat:

Lon:

or degrees-minutes-seconds

Lat:

Lon:

or drag map marker to a location of interest

Input reference frame (historically called 'horizontal datum')

Output reference frame (historically called 'horizontal datum')

Don't see a reference frame in the list? [Click here to learn more.](#)

SPC zone

Submit

Export Results to

Click blue bar(s) to expand/collapse

Converted Coordinate

Reference Frame:

- Lat-Lon-Height
- SPC
- UTM/USNG
- XYZ (m)

You may change the default UTM zone. The change is processed interactively once a lat-long is converted, DO NOT click the Submit button.

NCAT – Converting SPC to Lat, Long



NGS Coordinate Conversion and Transformation Tool (NCAT)

National Geodetic Survey

- NGS Home
- About NGS
- Data & Imagery
- Tools
- Surveys
- Science & Education

- Single Point Conversion
- Multipoint Conversion
- Web services
- Downloads
- Tutorial & FAQs
- About NCAT

Convert/Transform from:

- Horizontal
- Horizontal+height
- XYZ
- Geodetic lat-long
- SPC
- UTM
- USNG

Select the type of horizontal coordinate:



Northing:
 Easting:
 Units:
 SPC zone:
 Output SPC zone (optional):

Input reference frame (historically called 'horizontal datum'):
 Output reference frame (historically called 'horizontal datum'):

Don't see a reference frame in the list? Click [here](#) to learn more.

Submit

Click blue bar(s) to expand/collapse

Converted Coordinate

Reference Frame: NAD83(PA11)

Lat-Lon-Height		SPC		UTM/USNG		XYZ (m)	
Latitude	N21° 17' 03.56099" N211703.56099 21.2843224962	Zone	HI 3-5103	Zone	<input type="text" value="4"/>	X	N/A
Longitude	E202° 09' 6.06322" W1575053.93678 -157.8483157735	Northing	13,034.283 (m) 42,763.310 (usft) 42,763.396 (ift)	Northing (m)	2,354,050.814	Y	N/A
Ellipsoid Height (')	Not given	Easting	515,740.467 (m) 1,692,058.515 (usft) 1,692,061.900 (ift)	Easting (m)	619,471.004	Z	N/A
		Convergence (dms)	00 03 18.22	Convergence (dms)	00 25 05.18		
		Scale factor	0.99999306	Scale factor	0.99977638		
		Combined factor	N/A	Combined factor	N/A		
				USNG	4QFJ1947154051		

You may change the default UTM zone. The change is processed interactively once a lat-long is converted; DO NOT click the Submit button.

MAGIC ISLAND (TU1256) OLD HI SPC to NAD83(PA11)



Northing:
 Easting:
 Units:
 SPC zone:
 Output SPC zone (optional):

Input reference frame (historically called 'horizontal datum')
Don't see a reference frame in the list? Click here to learn more.

Output reference frame (historically called 'horizontal datum')

Submit

Click blue bar(s) to expand/collapse

Transformed Coordinate

Converted Coordinate

Reference Frame: NAD83(PA11)

Lat-Lon-Height		SPC		UTM/USNG		XYZ (m)	
Latitude	N21° 17' 03.56082" N211703.56082 21.2843224500	Zone	HI 3-5103	Zone	<input type="text" value="4"/>	X	N/A
Longitude	E202° 09' 6.06205" W1575053.93795 -157.8483160980	Northing	13,034.278 (m) 42,763.293 (usft) 42,763.379 (ift)	Northing (m)	2,354,050.809	Y	N/A
Ellipsoid Height (')	Not given	Easting	515,740.433 (m) 1,692,058.405 (usft) 1,692,061.789 (ift)	Easting (m)	619,470.970	Z	N/A
		Convergence (dms)	00 03 18.22	Convergence (dms)	00 25 05.18		
		Scale factor	0.99999306	Scale factor	0.99977638		
		Combined factor	N/A	Combined factor	N/A		
				USNG	4QFJ1947154051		

Difference SPC OLD HI to NAD83(PA11)
 Northing = 0.02usft
 Easting = 0.14usft

Difference UTM OLD HI to NAD83(PA11)
 Northing = 0.005m
 Easting = 0.033m

You may change the default UTM zone. The change is processed interactively once a lat-long is converted; DO NOT click the Submit button.

GPS/Orthometric ~ Levelled (LMSL)

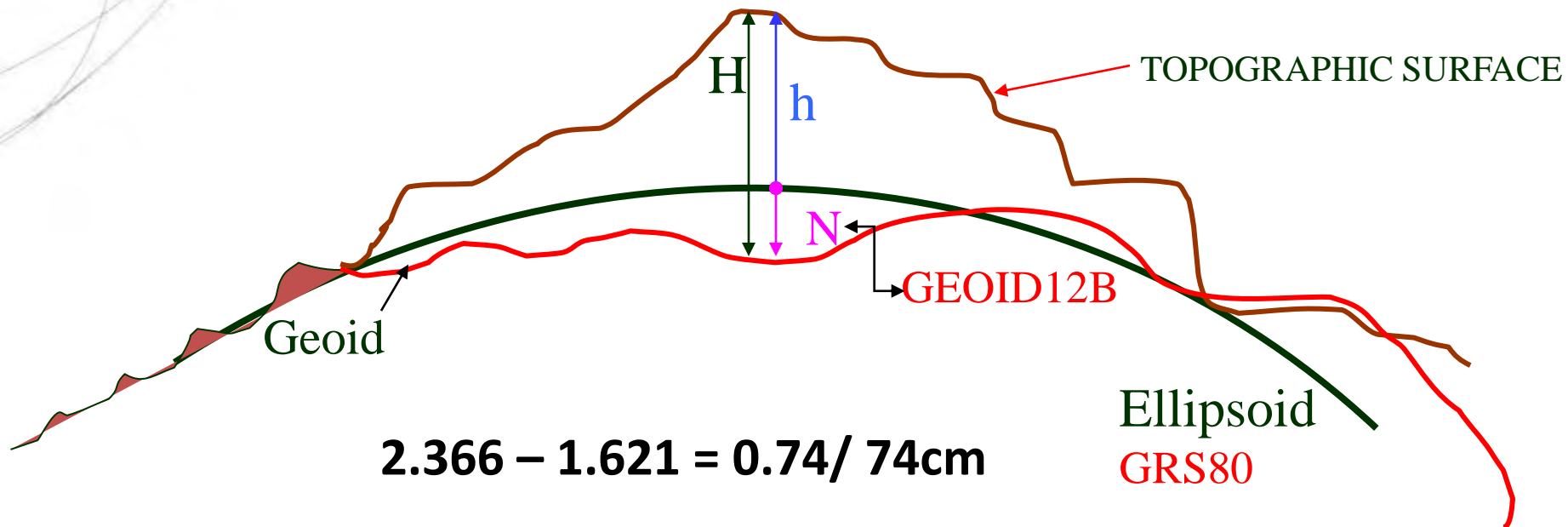
163 2340 GLO

$$H = h - N$$

h = Ellipsoidal Height (NAD 83) = 17.863m

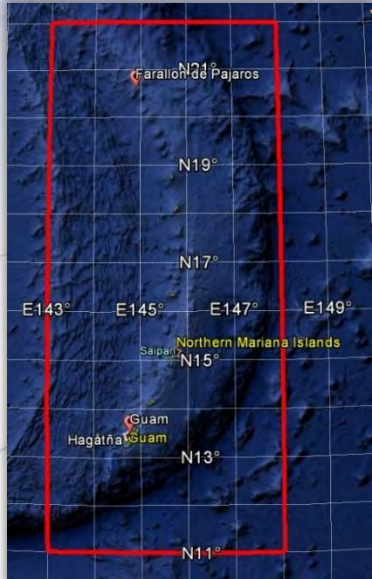
N = Geoid Height (GEOID12B) = 15.497m

H = GPS/Orthometric Height (LMSL) = 2.366m



Extent of NAPGD2022 gravimetric geoid model

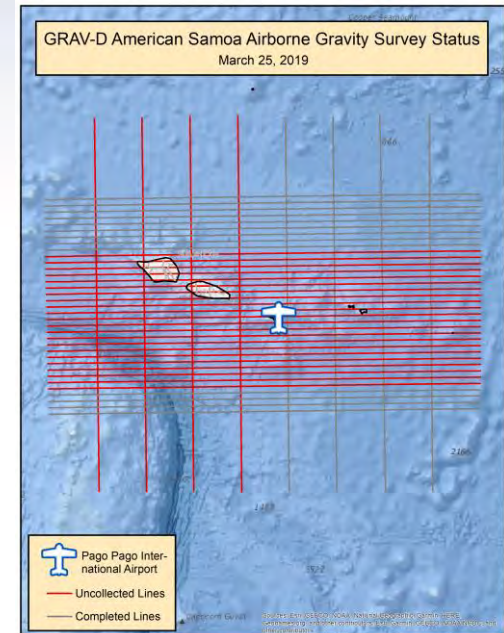
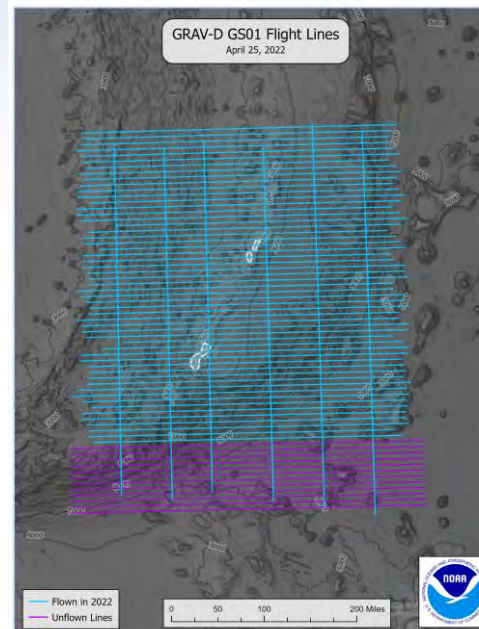
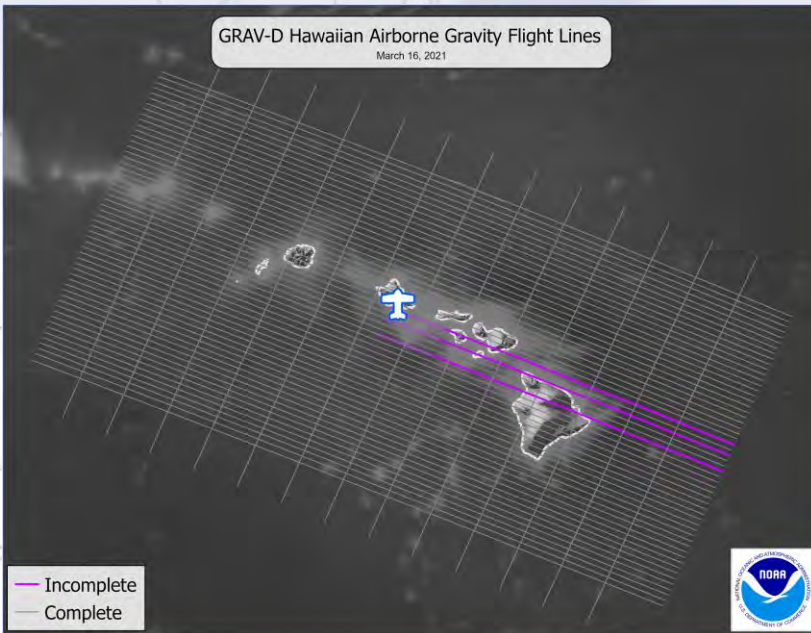
Guam and Northern Mariana Islands



American Samoa



GRAV-D in the Pacific



- Hawaiian collection is ~97% complete
- Complete American Samoa (40% Complete) in 2023 or 2024.
- Guam (82% Complete) flying as of 04/25/2022.

GPS/Orthometric ~ NAVD88

S 348

(Kansas)

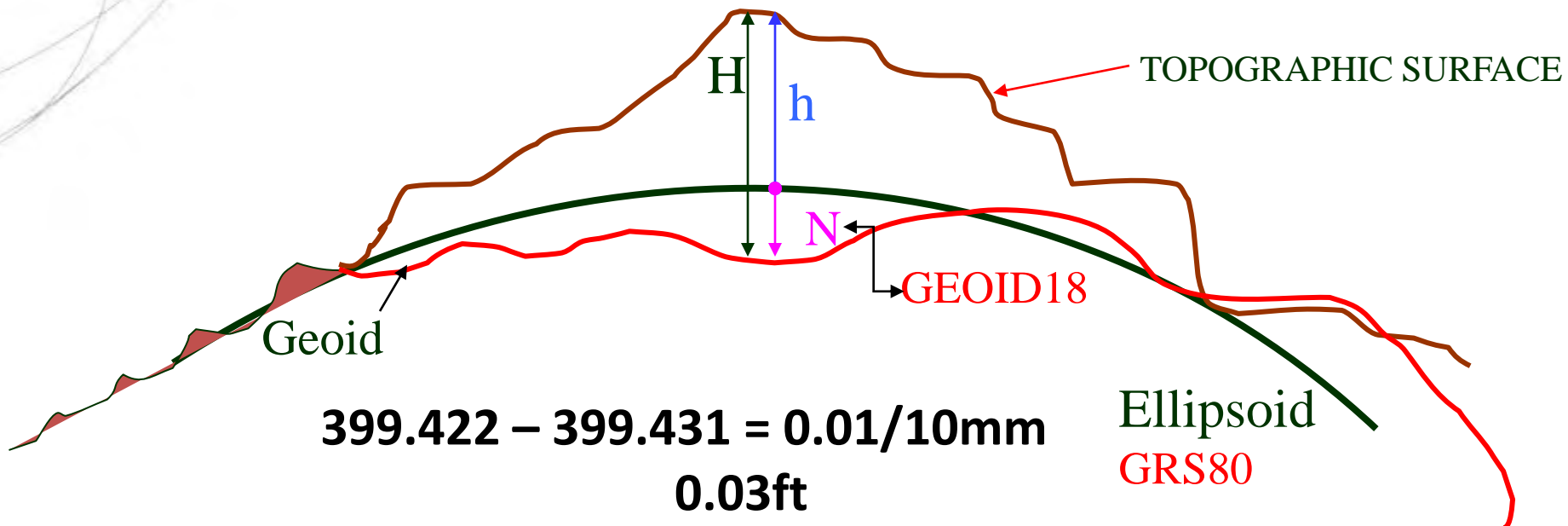
$$H = h - N$$

$h =$ Ellipsoidal Height (NAD 83) = 370.594m

$N =$ Geoid Height (GEOID18) = -28.828m

$H =$ GPS/Orthometric Height = 399.422m

NAVD88 Height = 399.431m



GEOID18 –Included of all available airborne gravity data – [GRAV-D](#)

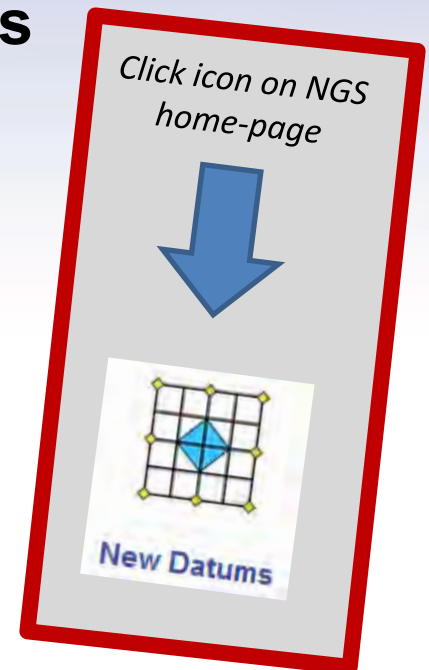
In Closing

If you do geospatial work in the United States and its territories and you work in the National Spatial Reference System, then every product you've ever made...

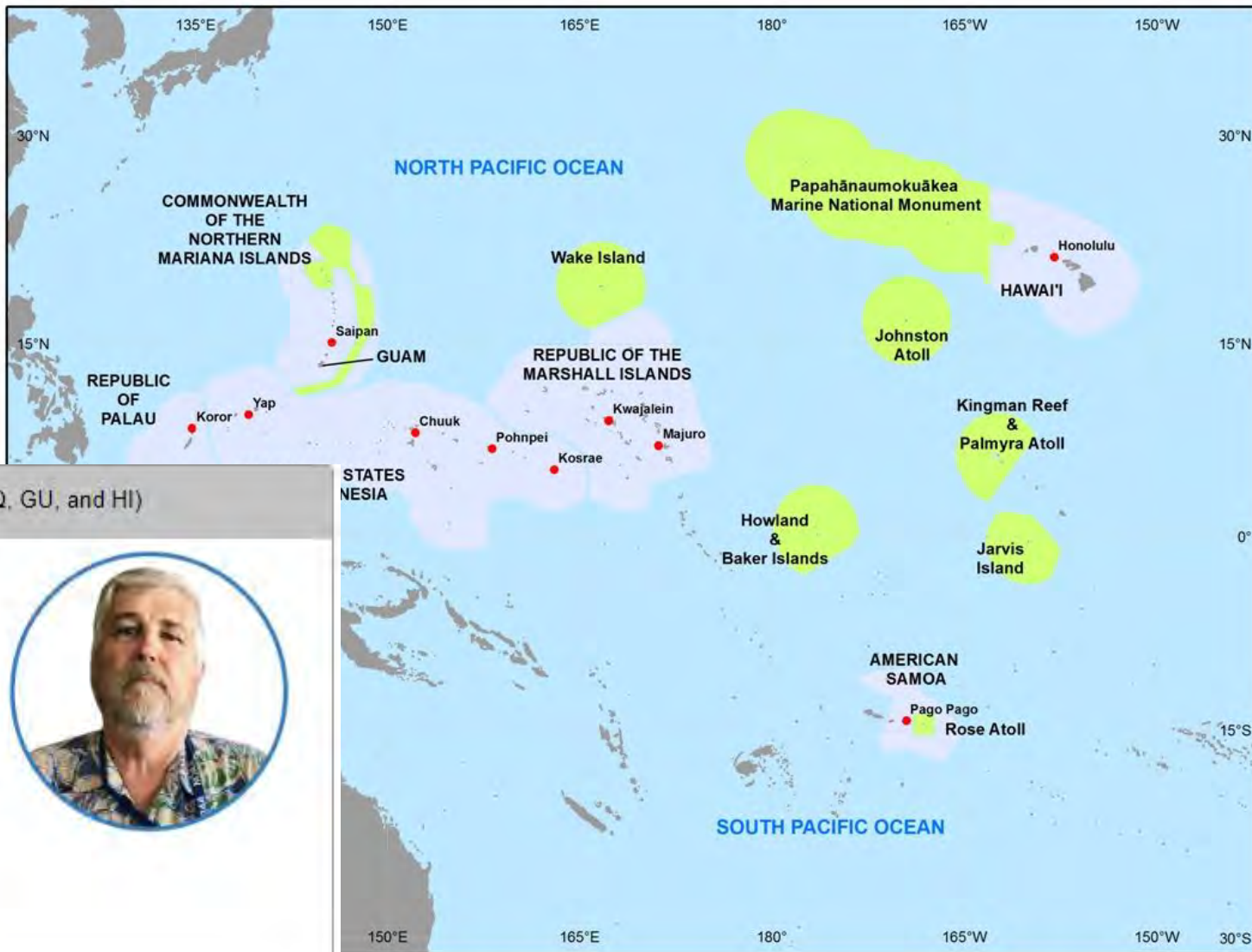
- every survey
- every map
- every lidar point cloud
- every image
- every DEM

... **WILL** need to be transformed for consistency with ***NEW*** coordinates in 2 to 3 years.

NGS will have the tools to transform your coordinates from historic datums and compute new coordinates.



A HELPING GEODESIST



Pacific (AS, CQ, GU, and HI)

Edward Carlson
NOAA Inouye Regional
Center
**NOS Pacific Services
Center**
1845 Wasp Blvd, Bldg 176
Honolulu, HI 96818
Office: (808) 725-5255
Fax: (808) 725-5260
Mobile: (808) 551-8656



Ed Carlson