Presented at the FIG Working Week 2023,
28 May - 1 June 2023 in Orlando, Florida, USA

Changes Afoot

State Plane 2022 and Retirement of the U.S. Survey Foot

FIG Working Week 2023
Orlando, Florida, USA
May 31, 2023

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SPCS2022 Project Manager
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How surveyors and engineers see the Earth…

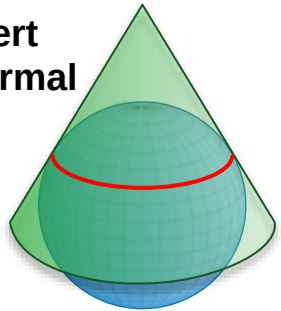
Credit: Scott Gelber, *The Atlantic*

A "flat" Earth for the future

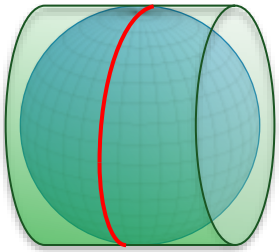
State Plane Coordinate System of 2022 (SPCS2022)

- Third generation of State Plane
  - First in 1930s, second in 1980s
  - Same 3 map projection types
  - Same ellipsoid as SPCS 83 (GRS 80)

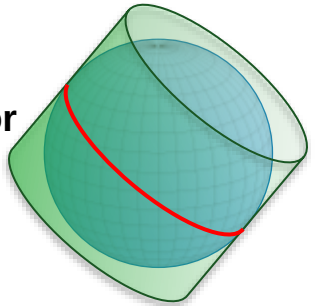
Lambert Conformal Conic



Transverse Mercator



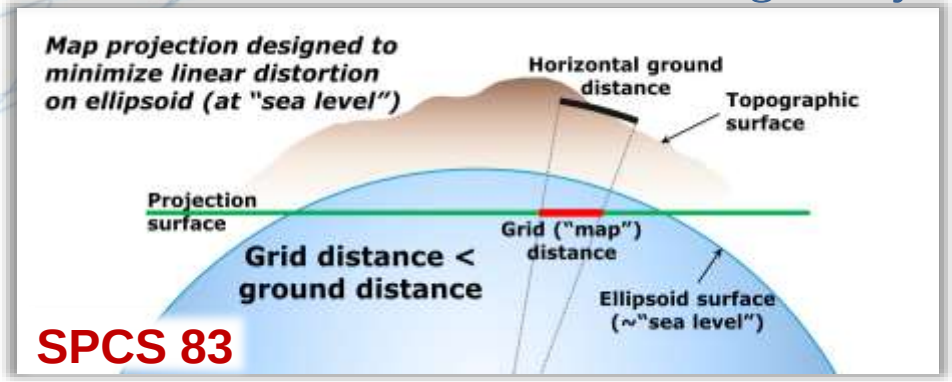
Hotine Oblique Mercator

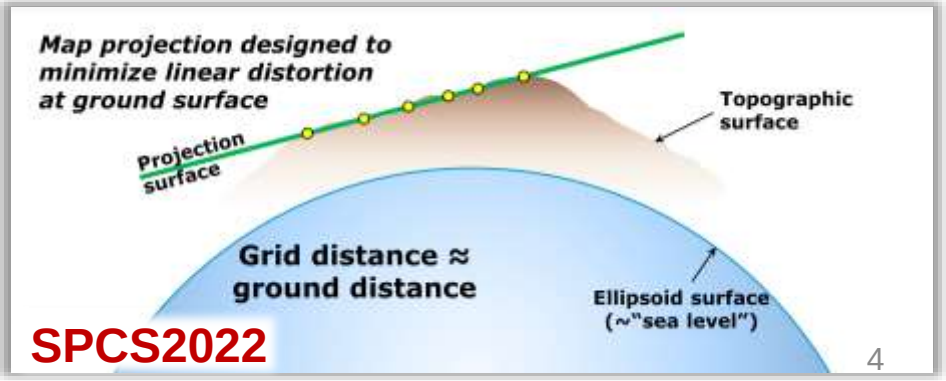


A "flat" Earth for the future

State Plane Coordinate System of 2022 (SPCS2022)

- Same as existing State Plane, ***but different…***
  - Based on new terrestrial reference frames instead of NAD 83
  - Designed to reduce linear distortion at topographic surface (i.e., reduce difference between "grid" and "ground" distances)
  - More zones, most designed by state stakeholders



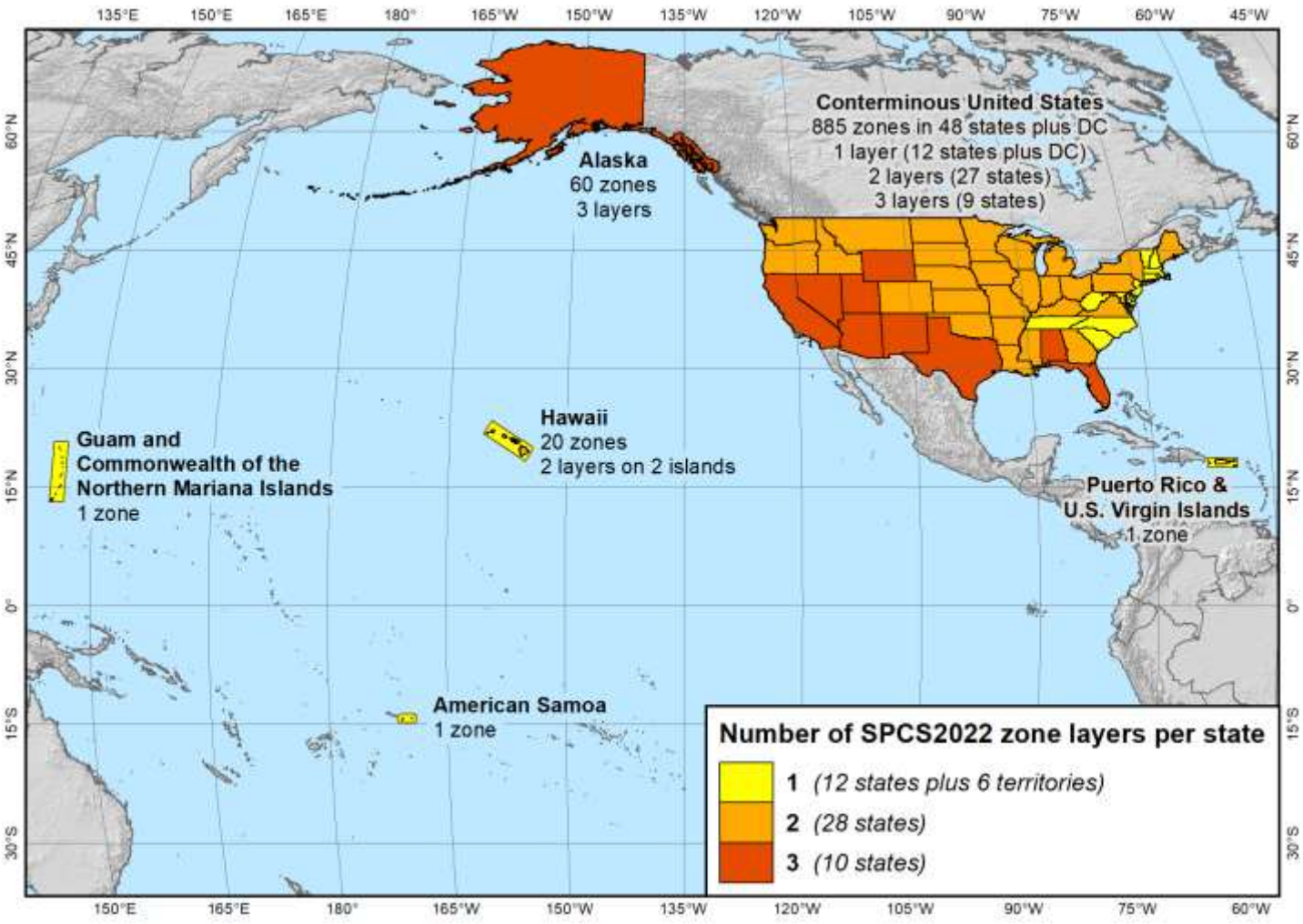


SPCS2022 zone layers

1 layer: 12 states plus 6 territories

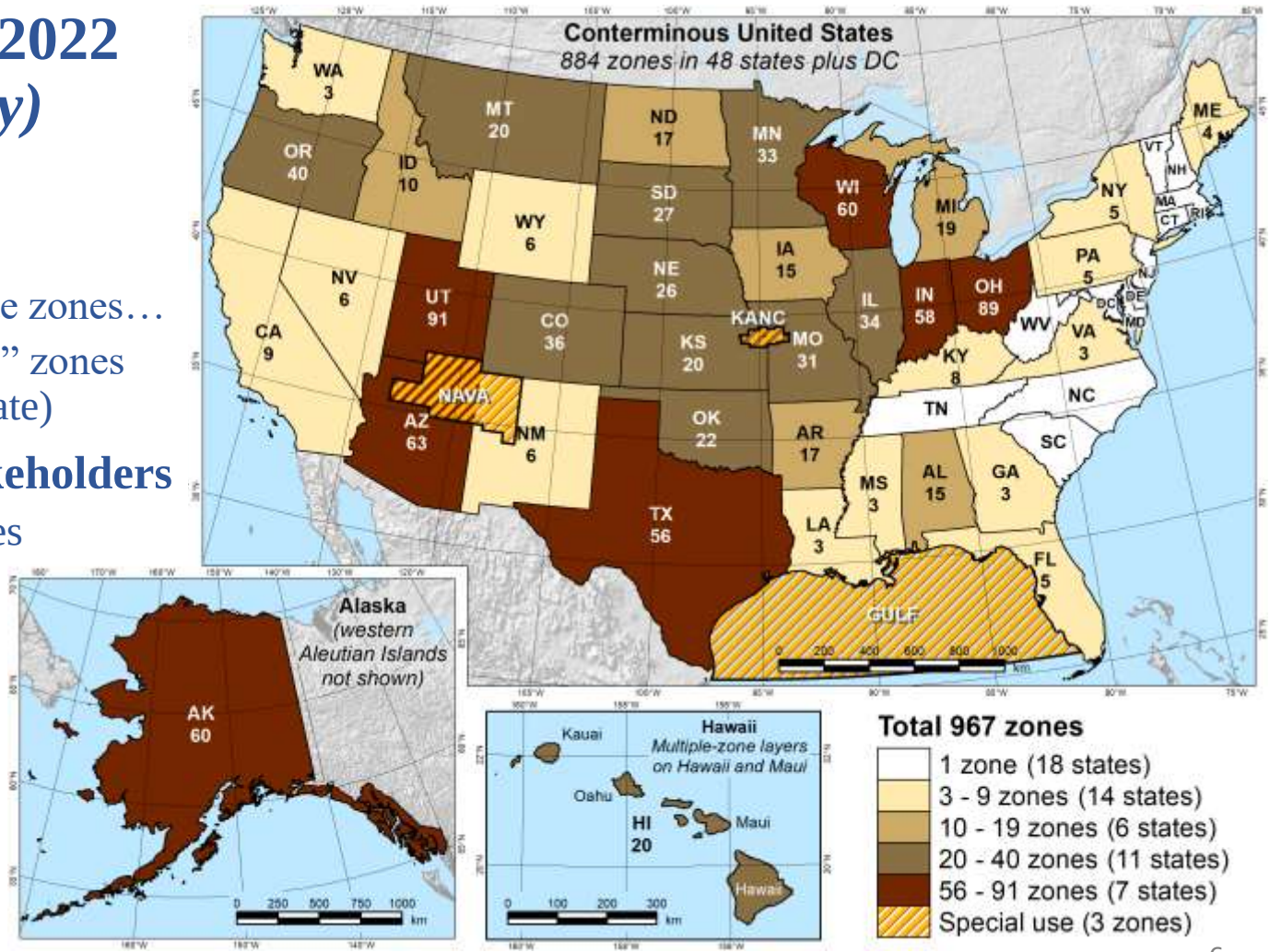
2 layers: 28 states

3 layers: 10 states



Number of SPCS2022 zones *(preliminary)*

- **Designs by NGS**
  - 165 zones
  - Includes 54 statewide zones…
  - …and 3 "special use" zones (in more than one state)
- **Designs by state stakeholders**
  - 802 zones in 28 states
- **Total = 967 zones** for 56 states and territories
- ***Compare to 125 zones in existing State Plane***



SPCS2022 linear distortion *(preliminary)*

846 zones (CONUS)

Green is ±50 ppm (±0.26 ft/mile)

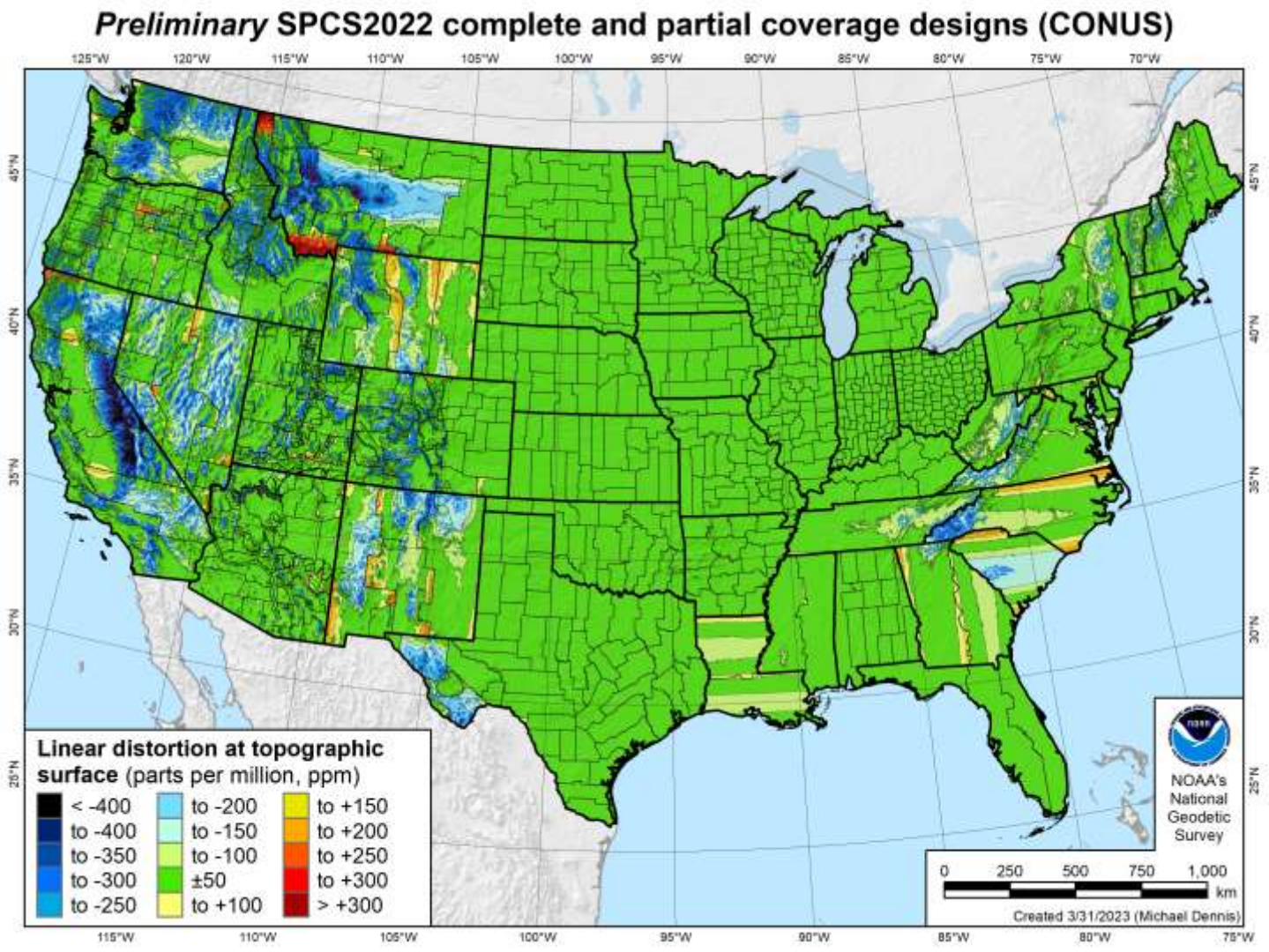
Percent within ±50 ppm:

92% population

89% cities & towns

76% total area

Mean weighted by population: **-4 ppm**



SPCS 83 linear distortion *(existing)*

106 zones (CONUS)

Green is ±50 ppm (±0.26 ft/mile)

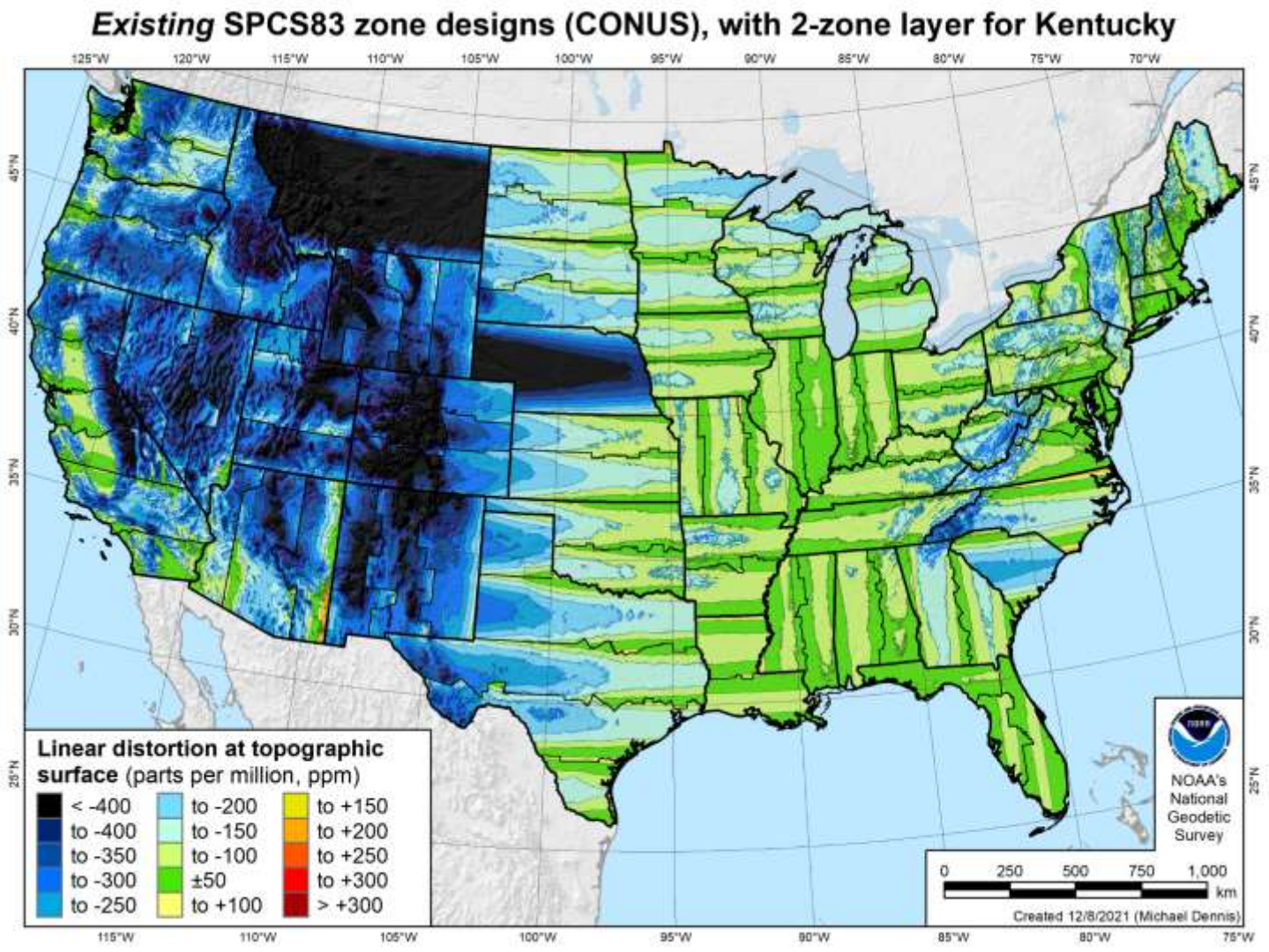
Percent within ±50 ppm:

40% population

30% cities & towns

17% total area

Mean weighted by population: **-75 ppm**



When will SPCS2022 be done?

I want it NOW!

Alpha preliminary products

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State Plane Coordinate System

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- SPCS2022 Policy
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- Maps of SPCS 83 and 27
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Have State Plane Questions?

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State Plane Coordinate System (SPCS)

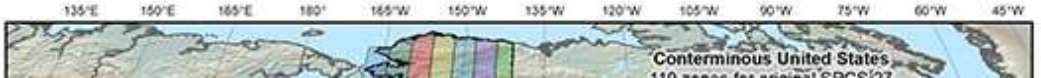
SPCS is a system of large-scale conformal map projections originally created in the 1930s to support surveying, engineering, and mapping activities throughout the U.S. and its territories. A map projection is a mathematical transformation of latitudes and longitudes on the surface of a sphere or ellipsoid representing the Earth to grid coordinates (*northing*, *easting* or *y*, *x* values) on a plane.

Since its inception, SPCS has served as a practical means for NGS customers to access to the National Spatial Reference System (NSRS). These web pages provide information on SPCS policies, the history and status of SPCS, how SPCS will change as part of the **NSRS modernization**, and converting coordinates.

The map below shows the full extents and all zones of the 1927 and 1983 versions of SPCS. View **more detailed maps** or a map depicting **SPCS 83 legislation and foot version**.

State Plane Coordinate Systems of 1927 and 1983

(click map for a higher resolution version)



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State Plane Coordinate System of 2022

- Home
- Zone Definitions and Coordinates
- Distortion Maps
- Download Maps & Data
- Learn More

Have SPCS2022 Questions or Comments?

- Give Feedback

State Plane Coordinate System of 2022 (SPCS2022)

SPCS2022 is the third generation of **SPCS**. The first version was created in the 1930s (SPCS 27) and the second in the 1980s (SPCS 83) as part of providing access to the horizontal datums current at the time of their creation. SPCS2022 will be referenced to the four 2022 Terrestrial Reference Frames that will be released as part of **NGS National Spatial Reference System (NSRS) Modernization**.

Although this is a preliminary version of SPCS2022, NGS will only make relatively minor changes going forward. The period for making requests, submitting proposals, and providing zone designs ended in 2021. In addition, changes to zone designs must be requested by recognized stakeholder groups. This is all described in the SPCS2022 **Policy** and **Procedures**. General information about SPCS, including its existing and previous versions, is available on the **SPCS website**

The maps below show that SPCS2022 has up to three zone layers in each state, and the number of zones varies greatly between states (click on the maps to get higher resolution versions). Every U.S. state and territory has a statewide zone. Most states also have a multiple-zone layer that covers the entire state, and some states also have a multiple-zone layer that covers only part of the state. In addition, there are three "special use" zones that each cover more than one state.

ALPHA Preliminary Products — State Plane Coordinate System of 2022 (SPCS2022) — National Geodetic Survey

SPCS2022 Zone Definitions and Design Status - Alpha Release - Last Updated 5/16/2023

- **Projection type abbreviations:** LC1 (Lambert Conformal Conic, one parallel); TM (Transverse Mercator); OMC (Hotine Oblique Mercator, center)
- **Terrestrial Reference Frame of 2022 (TRF2022) abbreviations:** NATRF2022 (North American TRF2022); PATRF2022 (Pacific TRF2022); MATRF2022 (Mariana TRF2022); CATRF2022 (Caribbean TRF2022)

Show 10 entries — Filter records: Texas

Zone code	Zone abbrev	Zone name	Zone type	Proj type	Origin latitude	Origin longitude east	Origin longitude west	Projection origin scale	Skew azimuth (deg)	False northing (m)	False easting (m)	False northing (ift)	False easting (ift)	Design by	Date of design change	Status	Reference frame
480001	TX	Texas	Statewide	LC1	31°12'N	260°00'E	100°00'W	0.998700		1,000,000	1,000,000	3,280,839.895	3,280,839.895	NGS	8/16/2021	Preliminary	NATRF2022
481001	TX_N	Texas North	Multizone complete	LC1	35°21'N	258°30'E	101°30'W	1.000100		800,000	200,000	2,624,671.916	656,167.979	NGS	6/11/2020	Preliminary	NATRF2022
481002	TX_NC	Texas North Central	Multizone complete	LC1	33°06'N	261°30'E	98°30'W	0.999950		800,000	500,000	2,624,671.916	1,640,419.948	NGS	6/15/2020	Preliminary	NATRF2022
481003	TX_C	Texas Central	Multizone complete	LC1	30°57'N	260°00'E	100°00'W	1.000000		800,000	700,000	2,624,671.916	2,296,587.927	NGS	2/22/2023	Preliminary	NATRF2022
481004	TX_SC	Texas South Central	Multizone complete	LC1	29°15'N	260°30'E	99°30'W	0.999970		800,000	600,000	2,624,671.916	1,968,503.937	NGS	2/22/2023	Preliminary	NATRF2022
481005	TX_S	Texas South	Multizone complete	LC1	27°00'N	261°30'E	98°30'W	0.999920		800,000	200,000	2,624,671.916	656,167.979	NGS	2/22/2023	Preliminary	NATRF2022
482001	TX_ATSC	Texas Atascosa	Multizone partial	OMC	28°30'N	261°38'E	98°22'W	1.000005	-14	300,000	405,000	984,251.969	1,328,740.157	State	7/19/2021	Preliminary	NATRF2022
482002	TX_BELL	Texas Bell	Multizone partial	OMC	31°24'N	262°21'E	97°39'W	1.000034	-36	300,000	730,000	984,251.969	2,395,013.123	State	7/19/2021	Preliminary	NATRF2022
482003	TX_BEND	Texas Big Bend	Multizone partial	TM	27°30'N	256°10'E	103°50'W	1.000222		0	1,025,000	0.000	3,362,860.892	State	7/19/2021	Preliminary	NATRF2022
482004	TX_BRAZ	Texas Brazos	Multizone partial	OMC	30°20'N	263°24'E	96°36'W	1.000005	60	300,000	1,365,000	984,251.969	4,543,963.255	State	7/19/2021	Preliminary	NATRF2022

Showing 1 to 10 of 56 entries (filtered from 967 total entries) — Previous 1 2 3 4 5 6 Next

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State Plane Coordinate System of 2022 (SPCS2022)
National Geodetic Survey

NGS Alpha Home

SPCS2022 Example Coordinates and Distortion Values - Alpha Release - Last Updated 5/16/2023

- Most example points are cities, towns, or other populated places; a small number are other identifiable features or the zone centroid (as indicated in the point name).
- Latitude and longitude are given to 9 arc-seconds (0.0025 degree) and ellipsoidal heights are given to 1 meter, and all of these exact values were used to compute SPCS2022 coordinates, distortion, and convergence.
- Linear distortion is given in parts per million (ppm) and is equal to the combined factor minus 1.

Show 10 entries

Filter records: Texas

Zone name	Zone type	Point name	Latitude	Longitude east	Longitude west	Latitude (deg)	Longitude east (deg)	Longitude west (deg)	Ellipsoid height (m)	Northing (m)	Easting (m)	Northing (ift)	Easting (ift)	Point scale factor	Combined factor	Distortion (ppm)	Convergence angle
Texas	Statewide	Houston	29°45'45"N	264°38'15"E	95°21'45"W	29.7625	264.6375	-95.3625	-18	850,220.713	1,447,942.004	2,789,438.035	4,750,465.892	0.999011264	0.999014088	-985.912	+2°24'08.46"
Texas North	Multizone complete	Amarillo	35°13'12"N	258°10'12"E	101°49'48"W	35.2200	258.1700	-101.8300	1091	785,625.655	169,952.730	2,577,511.991	557,587.697	1.000102561	0.999931327	-68.673	-0°11'27.34"
Texas North Central	Multizone complete	Dallas	32°46'57"N	263°11'42"E	96°48'18"W	32.7825	263.1950	-96.8050	101	766,072.348	658,778.287	2,513,360.722	2,161,346.086	0.999965262	0.999949405	-50.595	+0°55'32.31"
Texas Central	Multizone complete	Austin	30°15'54"N	262°15'27"E	97°44'33"W	30.2650	262.2575	-97.7425	122	726,258.281	917,237.278	2,382,737.142	3,009,308.655	1.000070946	1.000051786	51.786	+1°09'39.63"
Texas South Central	Multizone complete	Houston	29°45'45"N	264°38'15"E	95°21'45"W	29.7625	264.6375	-95.3625	-18	863,865.792	1,000,060.064	2,834,205.354	3,281,102.572	1.000009869	1.000012696	12.696	+2°01'18.01"
Texas South	Multizone complete	Corpus Christi	27°48'00"N	262°36'18"E	97°23'42"W	27.8000	262.6050	-97.3950	-25	889,120.367	308,890.359	2,917,061.572	1,013,419.813	1.000017195	1.000021122	21.122	+0°30'05.97"
Texas Atascosa	Multizone partial	Pleasanton	28°57'54"N	261°31'21"E	98°28'39"W	28.9650	261.5225	-98.4775	84	351,541.850	394,196.692	1,153,352.526	1,293,296.234	1.000005048	0.999991854	-8.146	-0°03'11.54"
Texas Bell	Multizone partial	Killeen	31°06'54"N	262°16'21"E	97°43'39"W	31.1150	262.2725	-97.7275	224	268,402.368	722,607.085	880,585.197	2,370,758.153	1.000041433	1.000006257	6.257	-0°02'23.44"
Texas Big Bend	Multizone partial	Alpine	30°21'27"N	256°20'24"E	103°39'36"W	30.3575	256.3400	-103.6600	1342	316,793.248	1,041,667.731	1,039,347.927	3,417,545.049	1.000225425	1.000014669	14.669	+0°05'15.37"
Texas Brazos	Multizone partial	College Station	30°37'39"N	263°40'03"E	96°19'57"W	30.6275	263.6675	-96.3325	75	332,641.943	1,410,646.477	1,091,344.957	4,628,105.240	1.000007942	0.999996164	-3.836	+0°08'06.96"

Showing 1 to 10 of 50 entries (Filtered from 267 total entries)

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NGS Coordinate Conversion and Transformation Tool (NCAT)

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NCAT2022(Alpha): Enables preliminary State Plane Coordinate System of 2022 (SPCS2022). Transformation of reference frames is not available at this time for the 2022 Terrestrial Reference Frames (TRFs). ITRF2020 is a proxy for the 2022 TRFs.

Convert/Transform from: ○ Horizontal ◉ Horizontal+height ○ XYZ (Cartesian geocentric)

Select the type of horizontal coordinate: ◉ Geodetic lat-long ○ SPC (State Plane) ○ UTM ○ USNG

Select a height ◉ Ellipsoidal ○ Orthometric

Enter lat-lon in decimal degrees

Lat 30.2650000000

Lon 262.2575000000

or degrees-minutes-seconds

Lat N 30-15-54.00000

Lon W 097-44-33.00000

or drag map marker to a location of interest

Ellipsoid Height 122.000

Units of height Meters

NAD83 coordinates can be used as input to this alpha tool. However, the output coordinates will differ horizontally from actual SPCS2022 by up to a few meters, depending on location. The convergence will usually be the same but may differ by ±0.01', and the scale factor will always be the same to the precision given. If NAD 83 ellipsoid heights are used, the linear distortion and combined factor will differ from SPCS2022 values by a small amount, within ±0.3 parts per million (ppm). NAD83 coordinates at epoch 2010.0 can be transformed to ITRF2020 epoch 2020.0 using the NGS **Horizontal Time-Dependent Positioning (HTDP)** *tool*

Input reference frame (historically called 'horizontal datum') ITRF2020 (epoch 2020.0)

Output reference frame (historically called 'horizontal datum') ITRF2020 (epoch 2020.0)

Don't see a reference frame in the list?
Click **here** *to learn more.*

SPC zone TX C-481003 (Multizone complete)

Ellipsoid Height 122.000

Units of height Meters

NAD83 coordinates can be used as input to this alpha tool. However, the output coordinates will differ horizontally from actual SPCS2022 by up to a few meters, depending on location. The convergence will usually be the same but may differ by ±0.01°, and the scale factor will always be the same to the precision given. If NAD 83 ellipsoid heights are used, the linear distortion and combined factor will differ from SPCS2022 values by a small amount, within ±0.3 parts per million (ppm). NAD83 coordinates at epoch 2010.0 can be transformed to ITRF2020 epoch 2020.0 using the NGS **Horizontal Time-Dependent Positioning (HTDP)** *tool*

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Output reference frame (historically called 'horizontal datum') ITRF2020 (epoch 2020.0)

Don't see a reference frame in the list?
Click **here** *to learn more.*

SPC zone TX C-481003 (Multizone complete)

Submit

Click blue bar(s) to expand/collapse

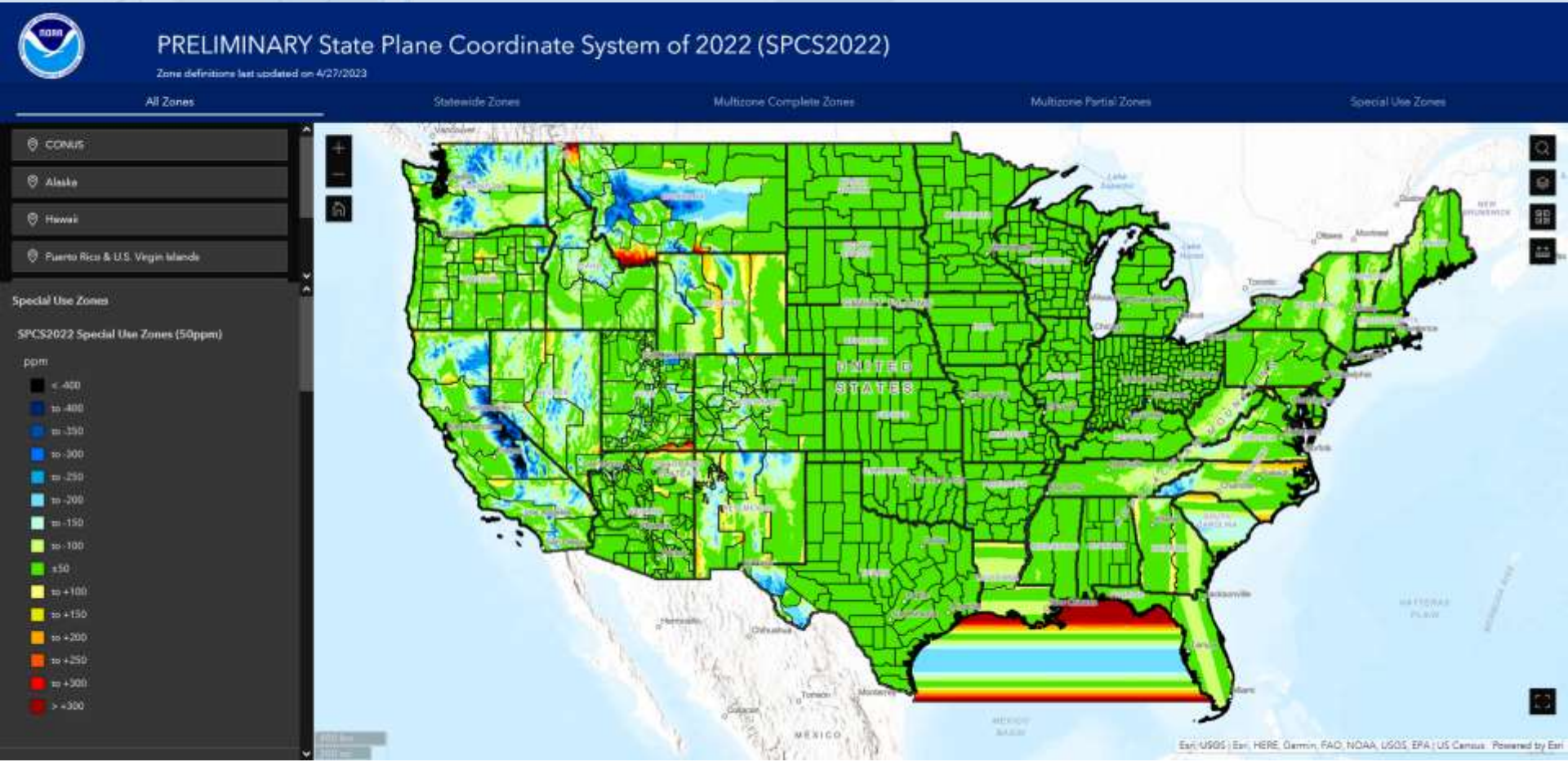
Converted Coordinate

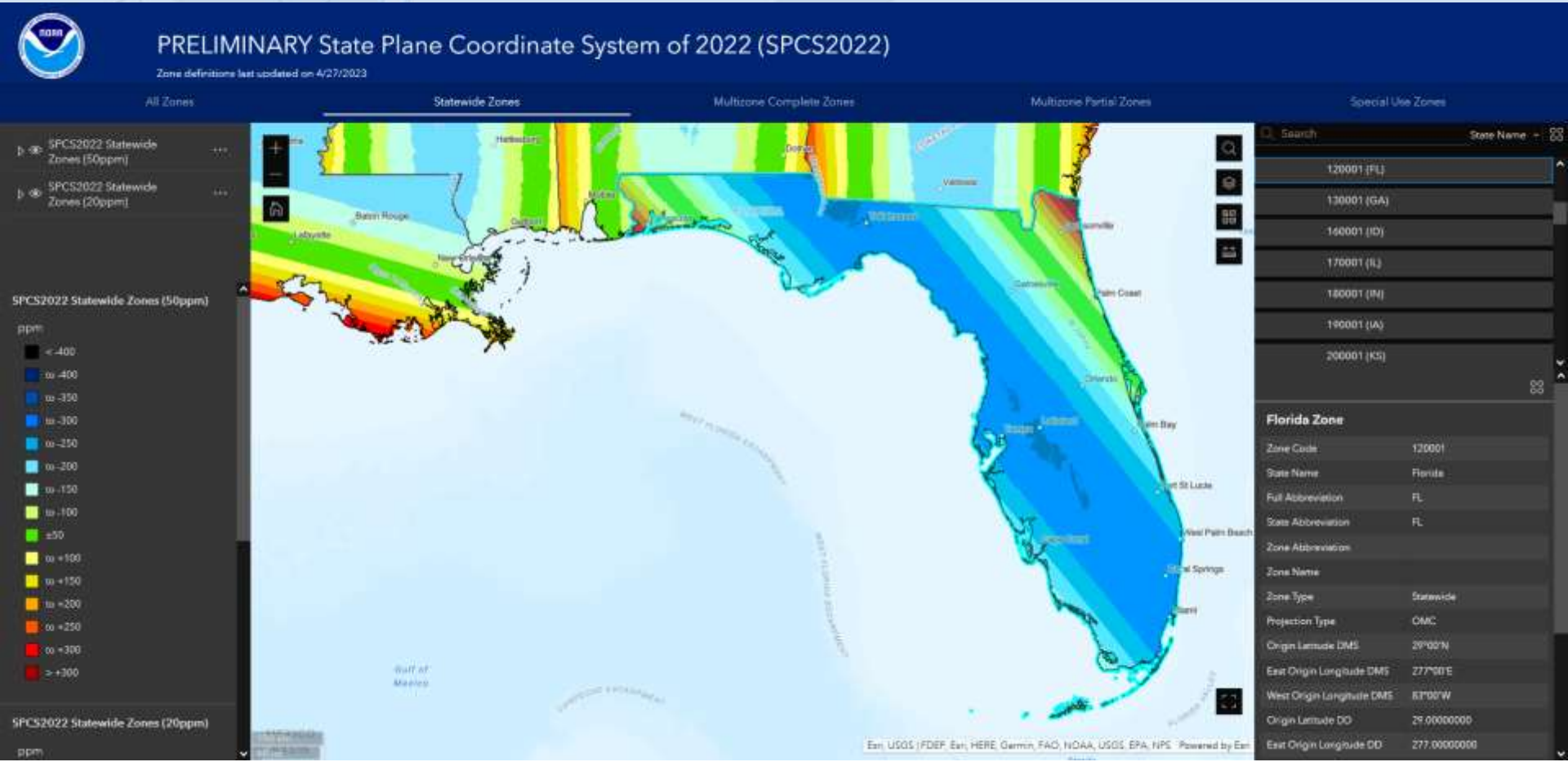
Reference Frame:ITRF2020 (epoch 2020.0)

Lat-Lon-Height		SPC		UTM/USNG		XYZ	
Latitude	N30° 15' 54.00000" N301554.00000 30.2650000000	Zone	TX C-481003 (Multizone complete)	Zone	14	X	-742,800.965 m
Longitude	E262° 15' 27.00000" W0974433.00000 -97.7425000000	Northing	726,258.281 m 2,382,737.144 ft	Northing	3,348,819.186 m	Y	-5,463,350.339 m
Ellipsoid Height (m)	122.000	Easting	917,237.278 m 3,009,308.654 ft	Easting	620,964.247 m	Z	3,195,841.952 m
		Convergence	+01° 09' 39.63"	Convergence	00° 38' 01.89"		
		Scale factor	1.000070946	Scale factor	0.999780519		
		Combined factor	1.000051785	Combined factor	0.999761364		
		Distortion	+51.785 ppm	USNG	14RPU2096448819		

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

Customize Export


PRELIMINARY State Plane Coordinate System of 2022 (SPCS2022)
Zone definitions last updated on 4/27/2023
All Zones
Statewide Zones
Multizone Complete Zones
Multizone Partial Zones
Special Use Zones
CONUS
Alaska
Hawaii
Puerto Rico & U.S. Virgin Islands
Special Use Zones
SPCS2022 Special Use Zones (50ppm)
ppm
< -400
to -400
to -350
to -300
to -250
to -200
to -150
to -100
±50
to +100
to +150
to +200
to +250
to +300
> +300
UNITED STATES
MEXICO
Esri, USGS | Esri, HERE, Garmin, FAO, NOAA, USGS, EPA | US Census | Powered by Esri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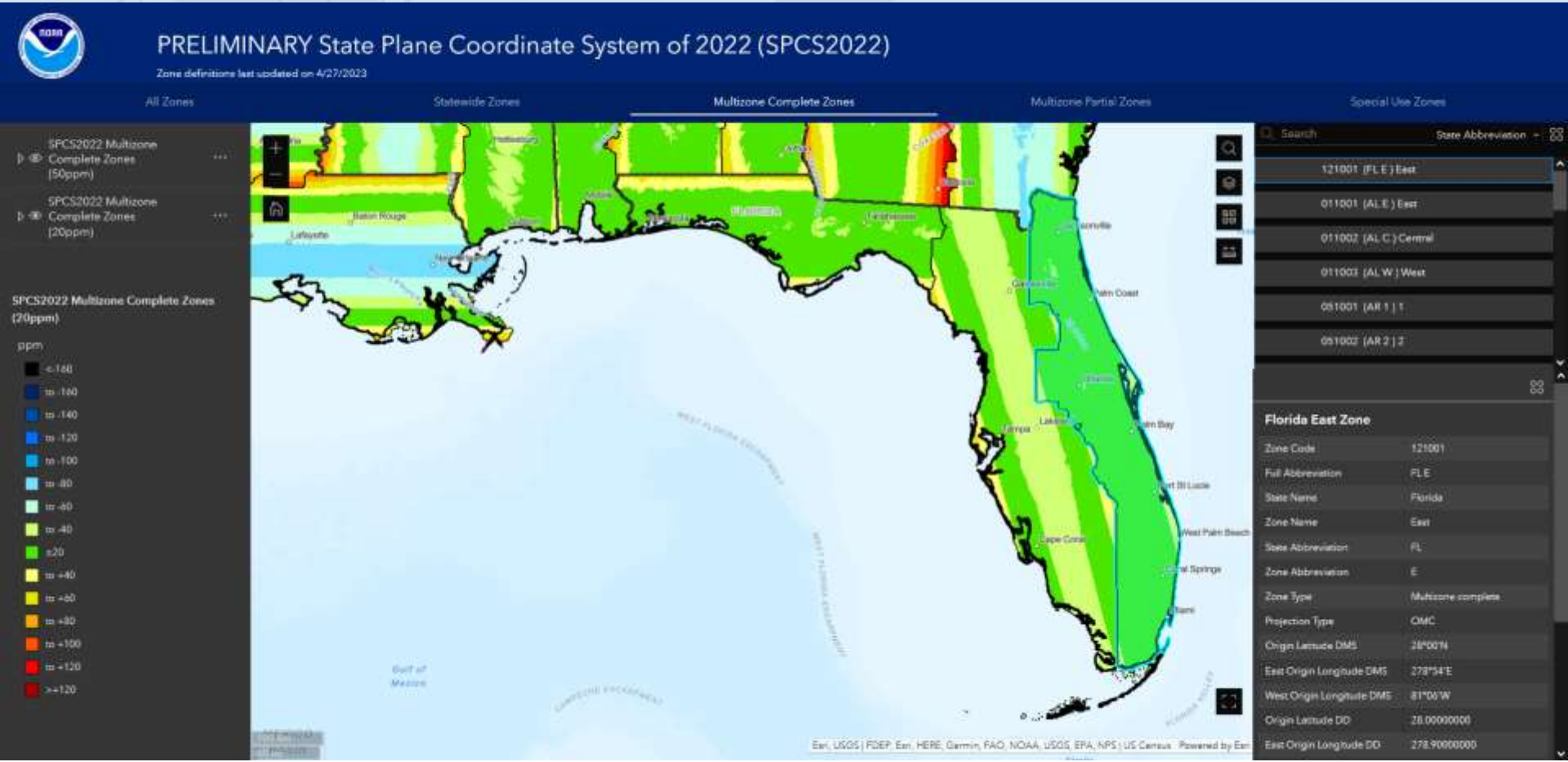
SPCS2022 Statewide Zones (50ppm)
SPCS2022 Statewide Zones (20ppm)
SPCS2022 Statewide Zones (50ppm)
ppm
SPCS2022 Statewide Zones (20ppm)
ppm
Search
State Name
120001 (FL)
130001 (GA)
140001 (ID)
170001 (IL)
180001 (IN)
190001 (IA)
200001 (KS)
Florida Zone
Zone Code 120001
State Name Florida
Full Abbreviation FL
State Abbreviation FL
Zone Abbreviation
Zone Name
Zone Type Statewide
Projection Type OMC
Origin Latitude DMS 25°00'N
East Origin Longitude DMS 277°00'E
West Origin Longitude DMS 83°00'W
Origin Latitude DD 25.00000000
East Origin Longitude DD 277.00000000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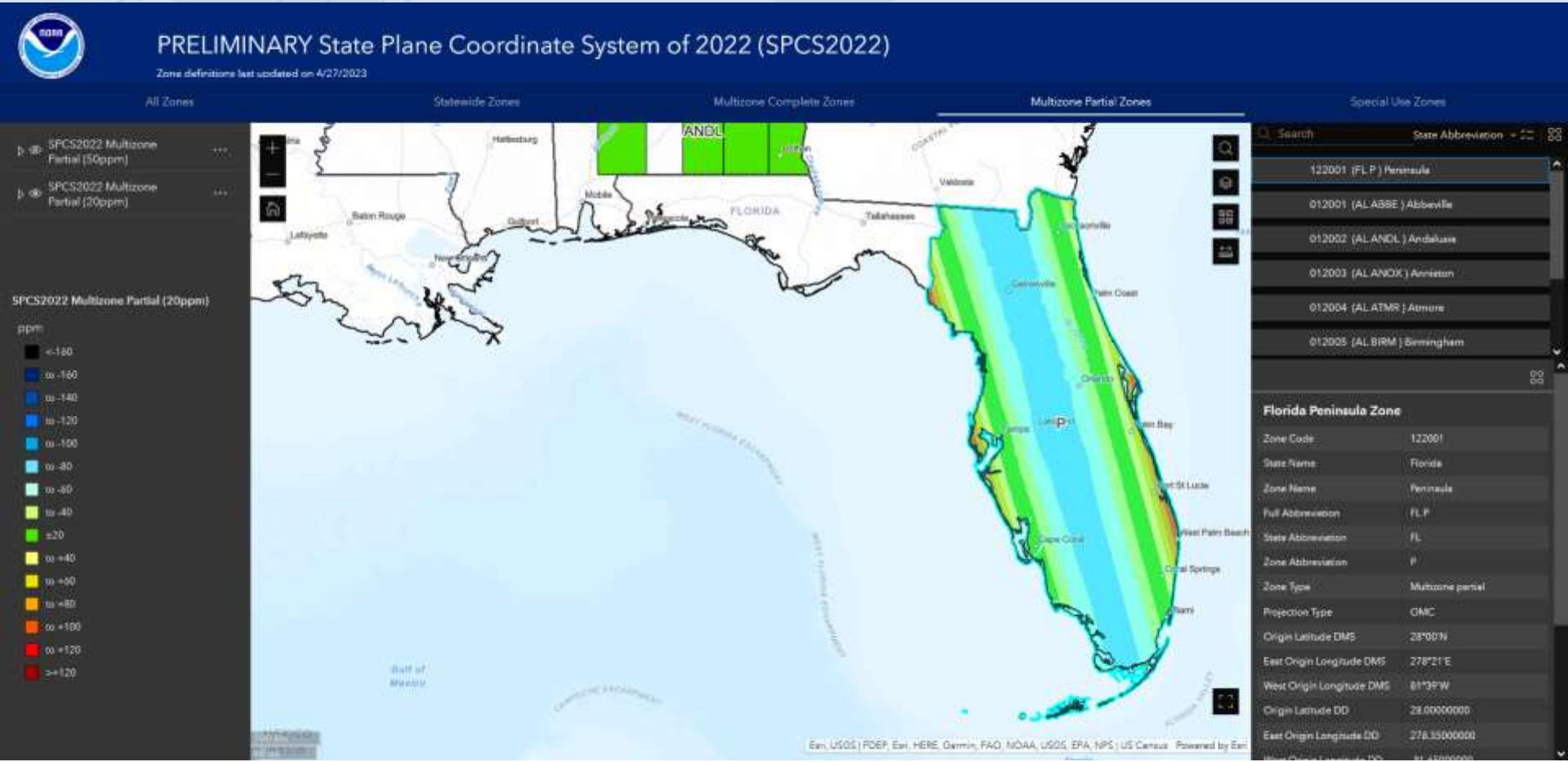
Multizone Complete Zones
Multizone Partial Zones
Special Use Zones
SPCS2022 Multizone Complete Zones (50ppm)
SPCS2022 Multizone Complete Zones (20ppm)
SPCS2022 Multizone Complete Zones (20ppm)
ppm
Search
State Abbreviation
121001 (FL E) East
011001 (AL E) East
011002 (AL C) Central
011003 (AL W) West
051001 (AR 1) 1
051002 (AR 2) 2
Florida East Zone
Zone Code 121001
Full Abbreviation FL E
State Name Florida
Zone Name East
State Abbreviation FL
Zone Abbreviation E
Zone Type Multizone complete
Projection Type OMC
Origin Latitude DMS 24°00'N
East Origin Longitude DMS 278°54'E
West Origin Longitude DMS 81°06'W
Origin Latitude DD 24.00000000
East Origin Longitude DD 278.90000000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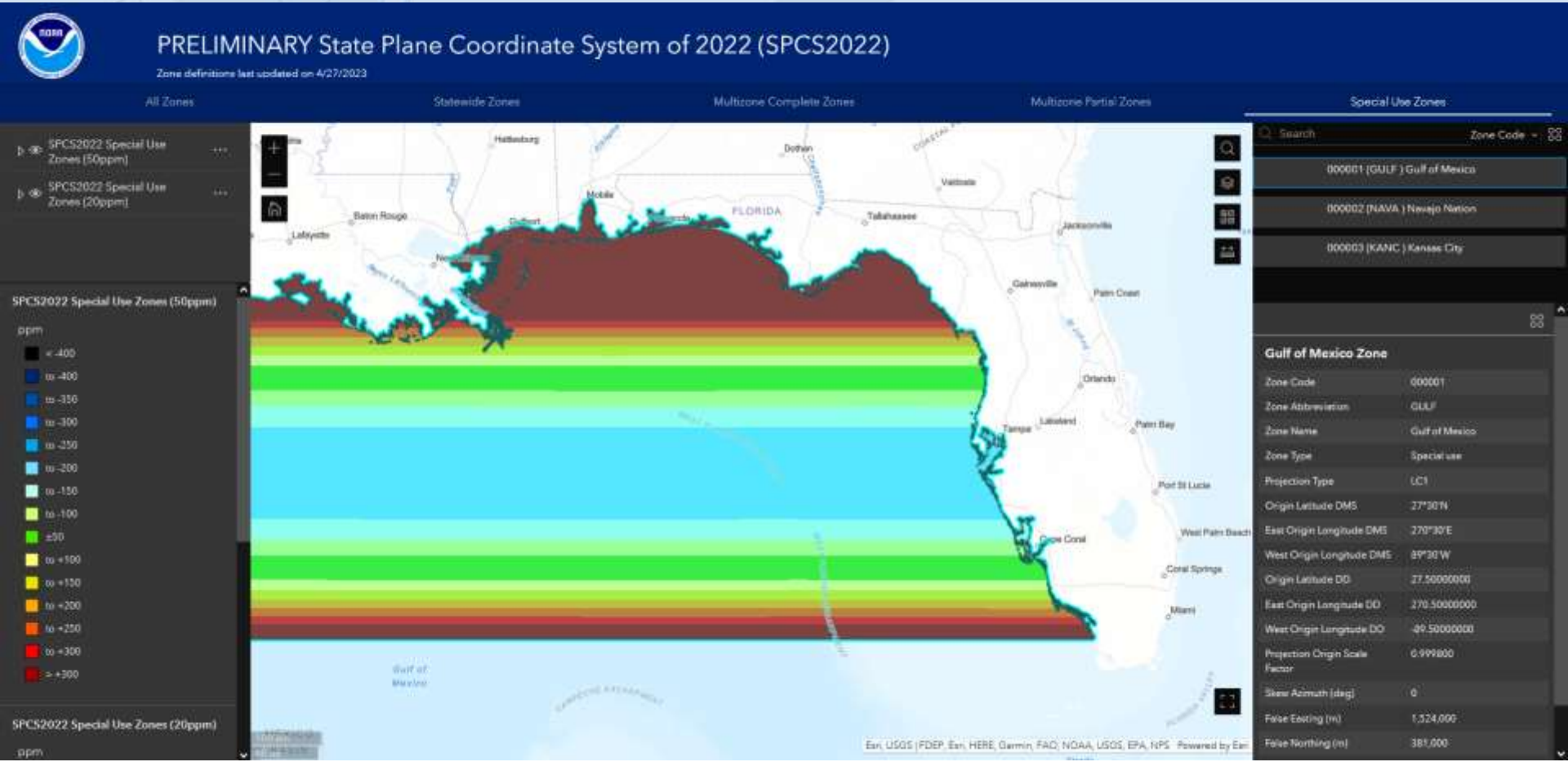
Multizone Partial Zones
Special Use Zones
SPCS2022 Multizone Partial (50ppm)
SPCS2022 Multizone Partial (20ppm)
SPCS2022 Multizone Partial (20ppm)
ppm
<-180
-160
-140
-120
-100
-80
-60
-40
±20
+40
+60
+80
+100
+120
>+120
Search
State Abbreviation
122001 (FL P) Peninsula
012001 (AL ABBE) Abbeville
012002 (AL ANDL) Andalusia
012003 (AL ANOX) Anniston
012004 (AL ATMR) Atmore
012005 (AL BIRM) Birmingham
Florida Peninsula Zone
Zone Code 122001
State Name Florida
Zone Name Peninsula
Full Abbreviation FL P
State Abbreviation FL
Zone Abbreviation P
Zone Type Multizone partial
Projection Type OMC
Origin Latitude DMS 28°00'N
East Origin Longitude DMS 278°21'E
West Origin Longitude DMS 81°39'W
Origin Latitude DD 28.00000000
East Origin Longitude DD 278.35000000
ANDL
FLORIDA
Tallahassee
Jacksonville
Orlando
Tampa
Miami
Esri, USGS | FDEP, Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, NPS | US Census Powered by Esri


PRELIMINARY State Plane Coordinate System of 2022 (SPCS2022)
Zone definitions last updated on 4/27/2023
All Zones
Statewide Zones
Multizone Complete Zones
Multizone Partial Zones
Special Use Zones
SPCS2022 Special Use Zones (50ppm)
SPCS2022 Special Use Zones (20ppm)
SPCS2022 Special Use Zones (50ppm)
ppm
SPCS2022 Special Use Zones (20ppm)
ppm
Search
Zone Code
000001 (GULF) Gulf of Mexico
000002 (NAVA) Navajo Nation
000003 (KANC) Kansas City
Gulf of Mexico Zone
Zone Code 000001
Zone Abbreviation GULF
Zone Name Gulf of Mexico
Zone Type Special use
Projection Type LC1
Origin Latitude DMS 27°30'N
East Origin Longitude DMS 270°30'E
West Origin Longitude DMS 89°30'W
Origin Latitude DD 27.50000000
East Origin Longitude DD 270.50000000
West Origin Longitude DD -89.50000000
Projection Origin Scale Factor 0.999800
Skew Azimuth (deg) 0
False Easting (m) 1,524,000
False Northing (m) 381,000
FLORIDA
Mobile
Baton Rouge
Tallahassee
Jacksonville
Gainesville
Palm Coast
Orlando
Tampa
Lakeland
Palm Bay
Port St Lucie
West Palm Beach
Coral Springs
Miami
Gulf of Mexico
Esri, USGS | FDEP, Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, NPS Powered by Esri

A tale of two feet

Two versions of the "foot" in U.S.

"Old" U.S. survey foot
(adopted 1893)

1 ft = 1200/3937 m
(0.3048006096… m)

→

"New" international foot
(adopted 1959)

1 ft = 0.3048 m *exactly*

Differ by
2 parts per million (ppm) or
~0.01 ft (~1/8 inch) per mile

A ***real*** problem with ***real*** costs
(especially for State Plane of the NSRS)

Horizontal error when mixing up feet…

SPCS 83 Nevada East Zone

End of an era for the U.S. survey foot

- **U.S. survey foot has been "deprecated" (retired)**
  - Not supported for SPCS2022 (or any part of modernized NSRS)
  - Only international foot will be supported by NGS
- **Effective December 31, 2022**
  - But will support U.S. survey foot for legacy products (e.g., existing State Plane)

***However,* NGS will *NOT* support NAD 83 after NSRS Modernization rollout**

NGS will always support U.S. survey foot for SPCS 83 and 27

Thank you.

Requiem for the U.S. survey foot

- Per final determination Federal Register Notice issued Oct 5, 2020
- Collaborative action by National Institute of Science and Technology (NIST) and NGS
- Describes public comments received, along with the plan, resources, training, and other information for an ***orderly transition with minimum disruption***

FEDERAL REGISTER
The Daily Journal of the United States Government

Notice

Deprecation of the United States (U.S.) Survey Foot

A Notice by the National Institute of Standards and Technology and the National Oceanic and Atmospheric Administration on 10/05/2020

PUBLISHED DOCUMENT

AGENCY:

The National Institute of Standards and Technology and National Geodetic Survey (NGS), National Ocean Service (NOS), National Oceanic and Atmospheric Administration (NOAA), Department of Commerce (DOC).

ACTION:

Notice; final determination.

Start Printed Page 62599

SUMMARY:

The National Institute of Standards and Technology (NIST) and the National Geodetic Survey (NGS), National Ocean Service (NOS), National Oceanic and Atmospheric Administration (NOAA), have taken collaborative action to provide national uniformity in the measurement of length. This notice announces the final decision to deprecate use of the "U.S. survey foot" on December 31, 2022. Beginning on January 1, 2023, the U.S. survey foot should not be used and will be superseded by the "international foot" definition (*i.e.*, 1 foot = 0.3048 meter exactly) in all applications. The international foot is currently used throughout

DOCUMENT DETAILS

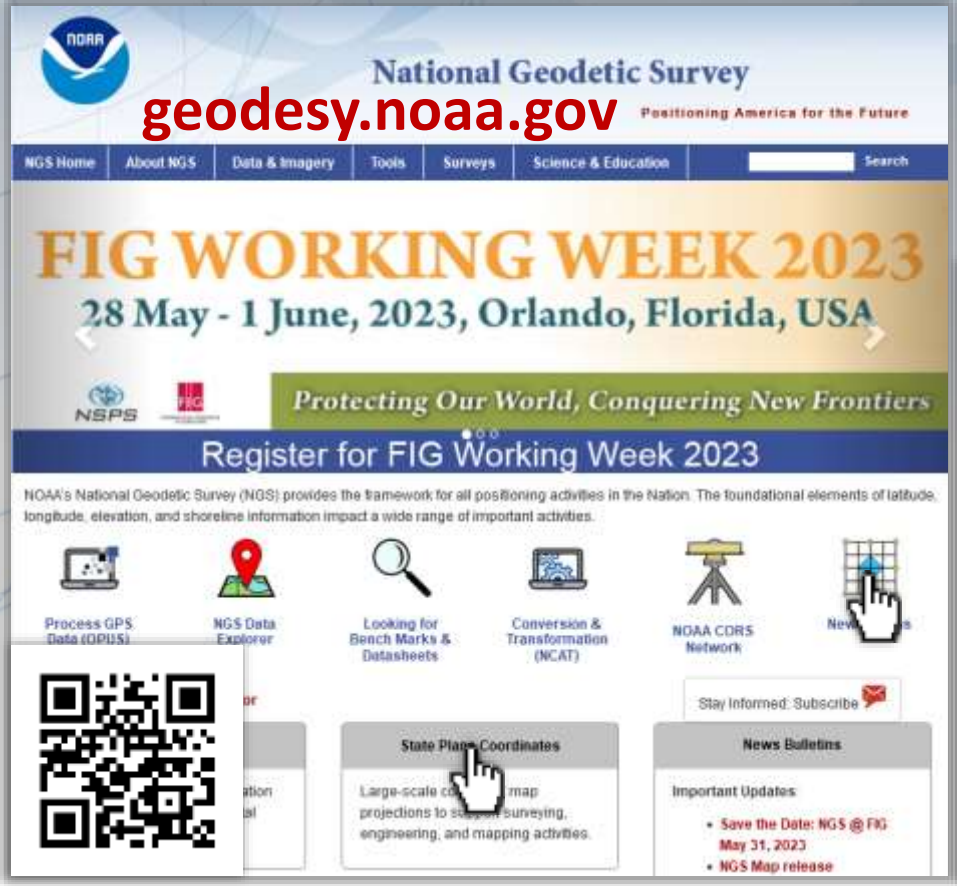
Printed version:
PDF

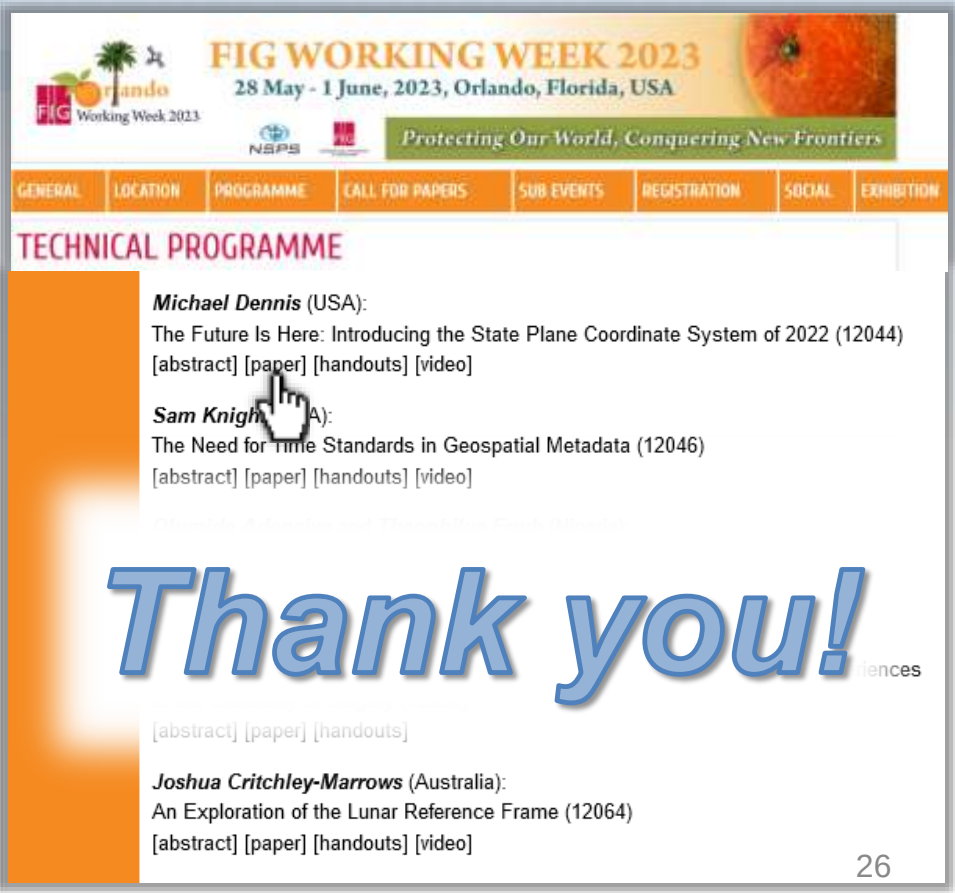
Publication Date:
10/05/2020

Agencies:
National Institute of Standards and Technology
National Oceanic and Atmospheric Administration

Dates:
Use of the U.S. survey foot will be

Where to learn more…





Thank you!