



The Measure of All Things After 2022

Ending the Era of the U.S. Survey Foot

Utility Engineering and Surveying
Institute • Texas Chapter
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A tale of two feet



Two versions of “foot” in current use:

“Old” U.S. survey foot → “New” international foot

1 ft = 0.3048006096... m

1 ft = 0.3048 m *exactly*

Differ by
2 parts per million (ppm)
or ~1 ft per 100 miles

A real problem with *real* costs

A tale of two feet



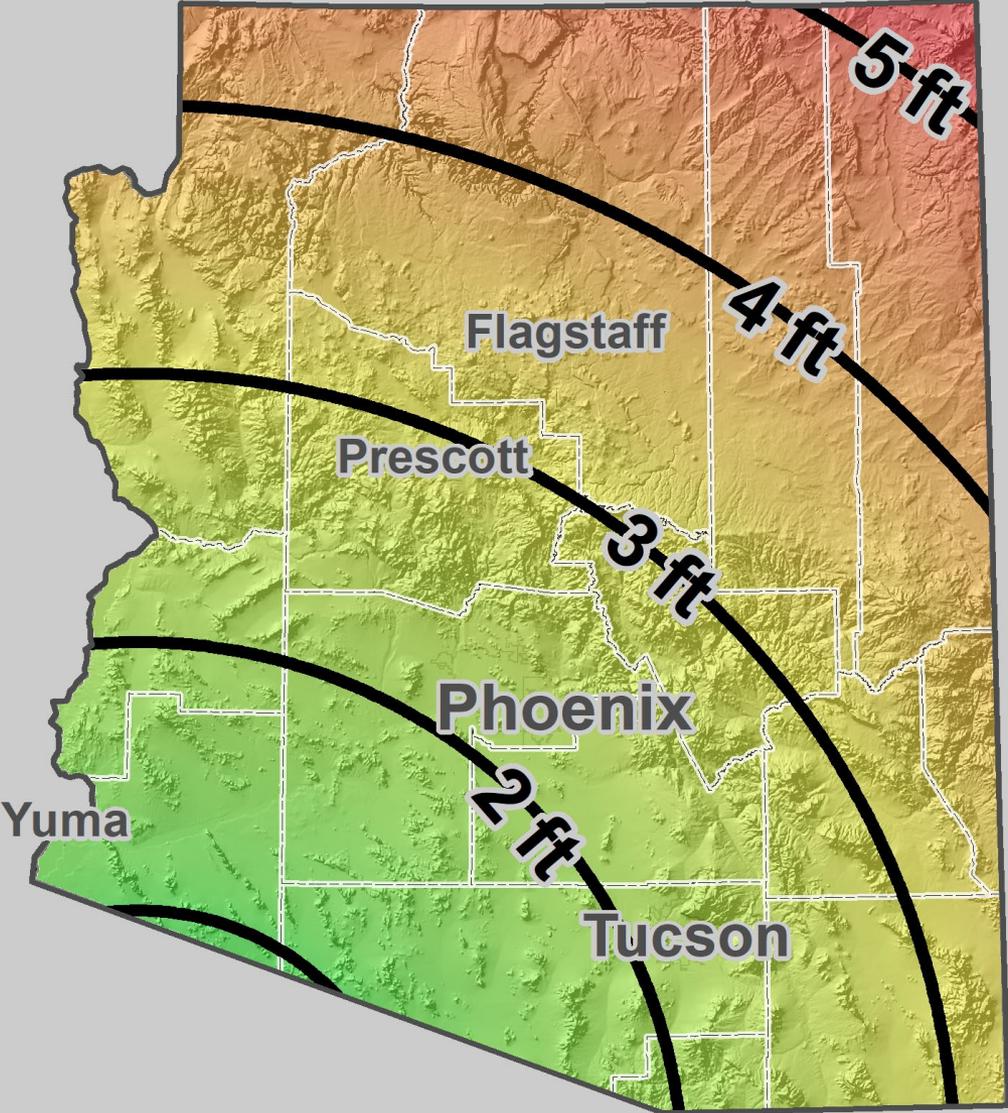
Who uses U.S. survey feet?

- Surveyors in most (*not all*) states
- But it impacts *everyone*

It is a major issue for the ***National Spatial Reference System*** (NSRS), especially ***State Plane coordinates*** (and other projected coordinate systems)

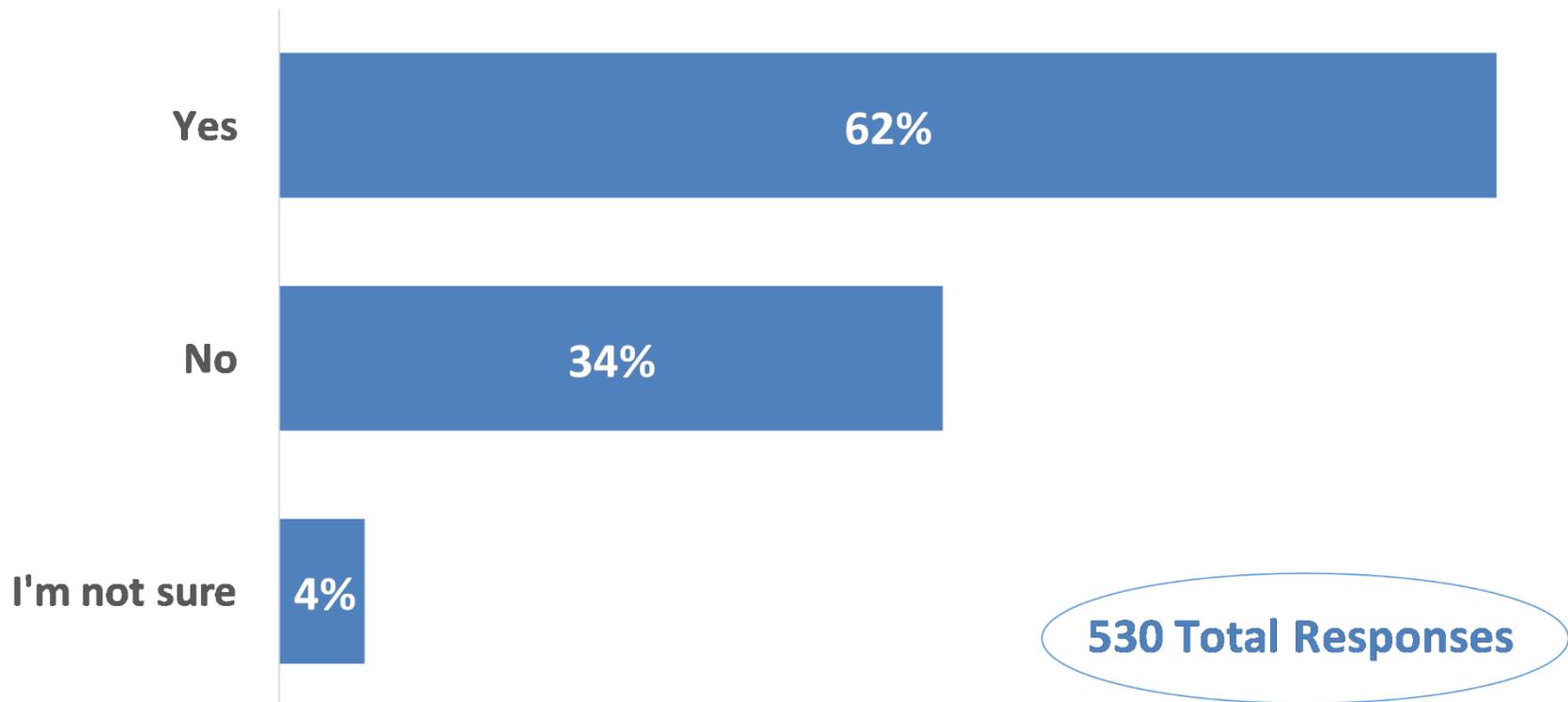
Horizontal difference in coordinates due to difference between international and US survey foot

SPCS 83 AZ Central



Poll question from NGS webinar

Has confusion between the international and U.S. survey foot ever created problems for you in your work?



How did we get in this mess?

Who is responsible for standards?

Today:

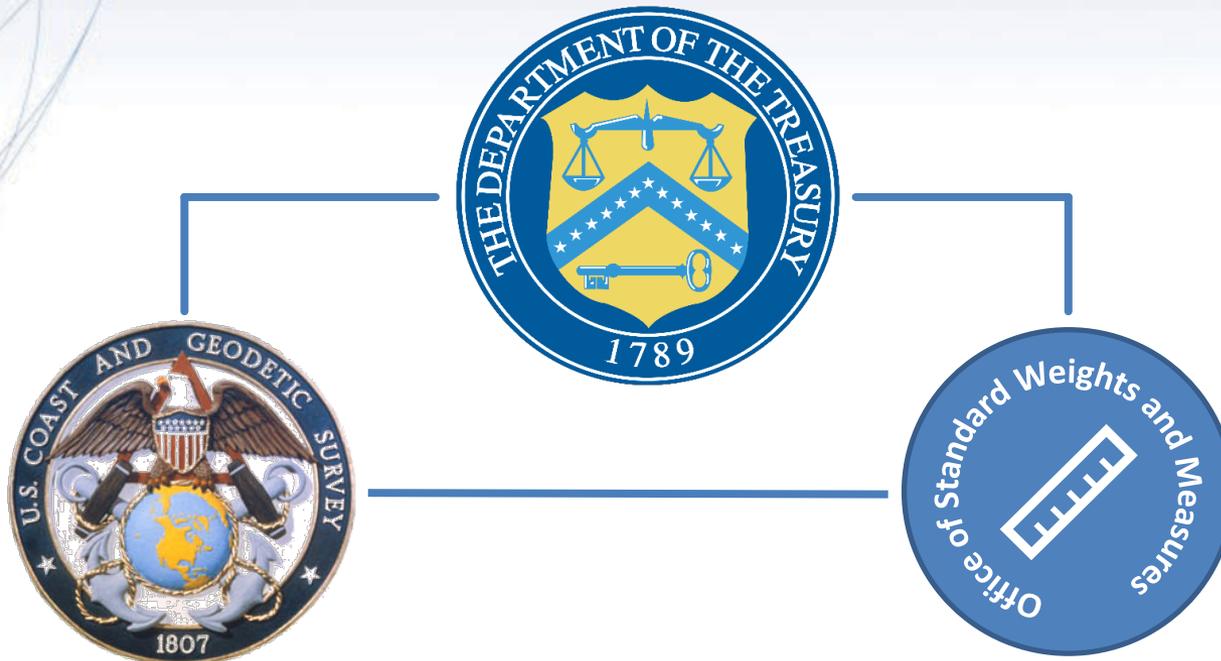
National Institute of Standards and Technology



Who is responsible for standards?

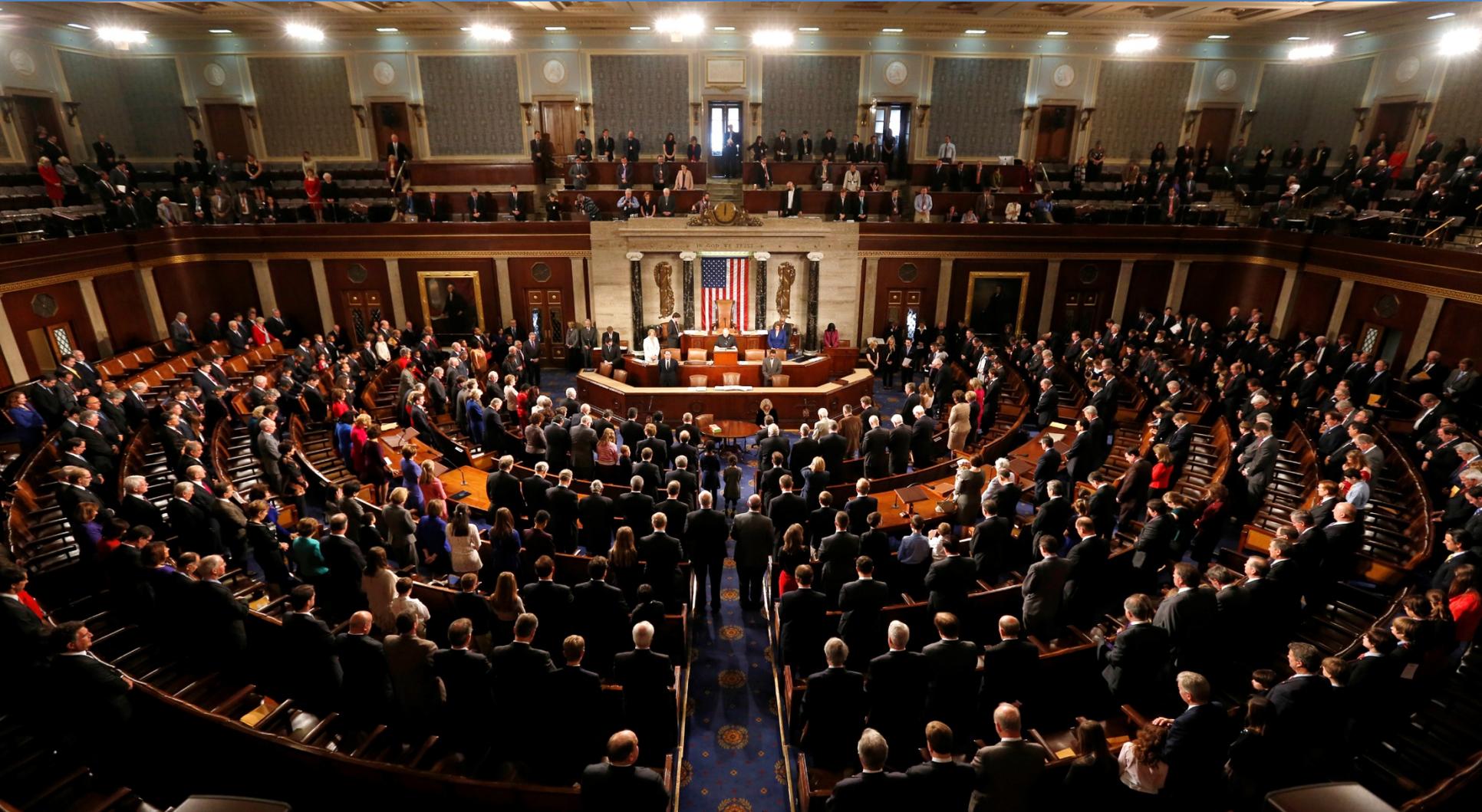
Before 1901:

U.S. Coast and Geodetic Survey



Superintendent of C&GS also Superintendent of Office of Standard Weights & Measures

Congress is the Authority



Congress is the Authority

Per the U.S. Constitution
(Article I, Section 8, Clause 5)

*“The Congress shall have
Power ... To coin Money ...
and fix the Standard
of Weights and Measures”*

Why? To avoid the “toothbrush problem”

The trouble with standards...

Standards are like toothbrushes. Everyone agrees they are desirable...

***Without uniformity,
standards are useless***

... but nobody wants to use someone else's

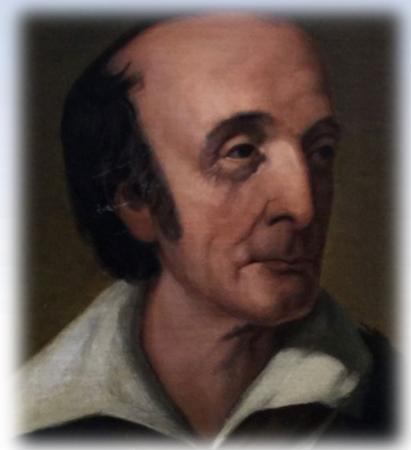
An epic tale and impressive cast



George Washington



Thomas Jefferson



Ferdinand Hassler



Thomas Mendenhall



John Quincy Adams

Surveyors

Weights & Measures: the early years

**Articles of
Confederation**

1781

**Washington:
First messages
to Congress**

1790

“Weights and Measures may be ranked among the necessities of life to every individual of human society.”

1789

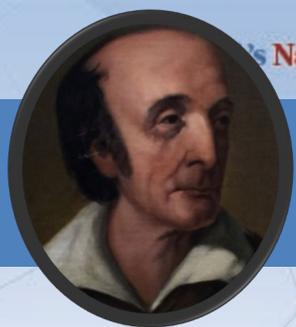
U.S. Constitution

*Article I, Section 8,
Clause 5
Congress to “...fix
Standard of Weights
and Measures”*

**Jefferson:
Proposes a
decimal
system**

1821

**Adams:
Report on
Weights and
Measures**



Hassler and the Empire

0.000 073 foot
(0.022 mm)
shorter than
Troughton
scale (24 ppm)

**Brings
Troughton scale
from England**

**Submits report
to Congress**

**Congress Joint
Resolution for
uniform
standards**



1815

1830

1832

1834

1836

1855

*“Exact” copy
of British
Imperial
Yard*

**Directed to
resolve weight
and measure
issues**

***In England:
British
Imperial Yard
destroyed in a
fire!***

**New Imperial
Yard made:
U.S. receives
2 copies**
*Bronze Yard No. 11
becomes official U.S.
standard*

Going metric, in fits and starts

Congress legalizes use of metric system

1866

Different length!
Bronze Yard No. 11 travels to England

1875

US Signs "Treaty of the Meter"

Bronze Yard No. 11 travels to England, again

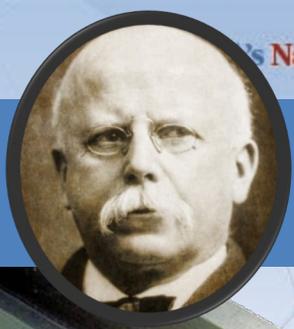
1888

Different length - again!

1890

Standard Meters Nos. 21 and 27 sent from France





Out of chaos, *order*

1893

The Mendenhall Order

Thomas Mendenhall
*Superintendent C&GS and Office of
Weights & Measures (1889-1894)*



The U.S. officially became metric

- ✓ Embraced meter
- ✓ Abandoned British Imperial Yard
- ✓ Declared foot defined by meter:

$$1 \text{ foot} = 1200/3937 \text{ meter}$$

- ✓ Provided tables of conversions
e.g., Gunter's chain = 20.1168 m

66 fth EXACTLY
65.999868 sft

A new foot for a new century

1 foot = 0.3048 meter *exactly* (1 yard = 0.9144 m)

National Bureau
of Standards
created

1901

New foot
definition
adopted by NASA
predecessor

1952

Adopted as
“new” foot for
entire U.S.
(and world)

1959

New foot
definition
adopted by ANSI
predecessor

*With one
little
exception...*

Federal Register *temporary* exception 1959

This should have happened in 1989

The foot unit defined by this equation shall be referred to as the **U.S. Survey Foot** and it shall continue to be used, for the purpose given herein, **until such a time as it becomes desirable and expedient to readjust the basic geodetic survey networks in the United States, after which the ratio of a yard, equal to 0.9144 meter, shall apply.**"

Signed by NBS and C&GS directors, approved by Commerce Secretary, June 25, 1959

https://geodesy.noaa.gov/PUBS_LIB/FedRegister/FRdoc59-5442.pdf

More Federal Register Notices

International vs. U.S. Survey Foot

Surveying and mapping only (pending analysis, never resolved)

Proposed permanent use of U.S. Survey Foot

Restatement that metric used for U.S.

1975

1977

1988

1989

1990

NGS goes entirely metric (for NAD 83)

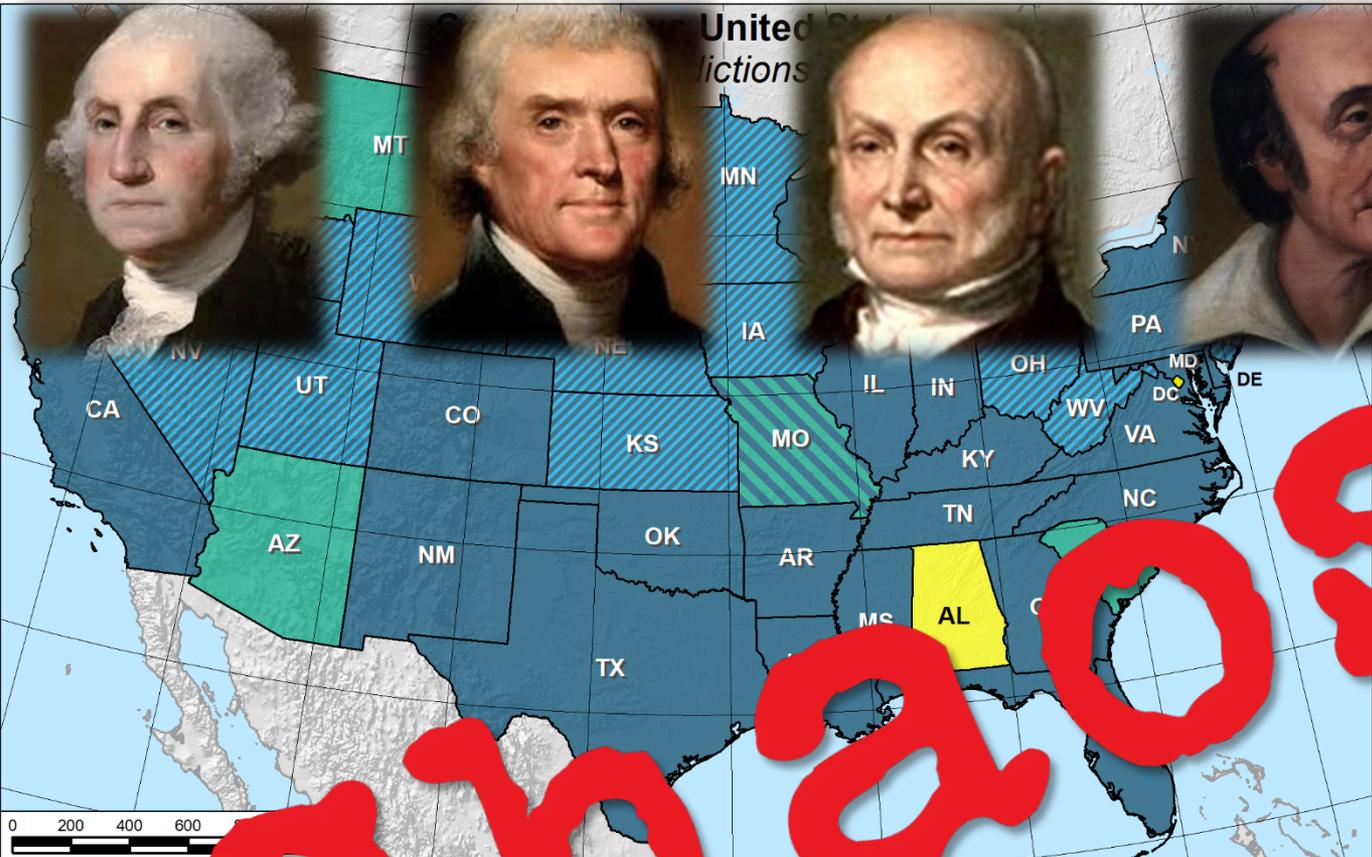
NAD 83 announced

- *International foot used for “engineering”*
- *U.S. survey foot used for “mapping and land measurement”*

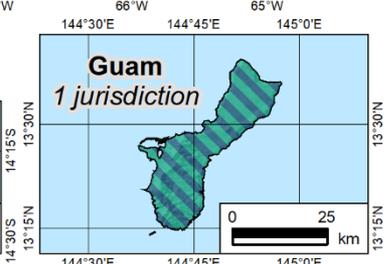
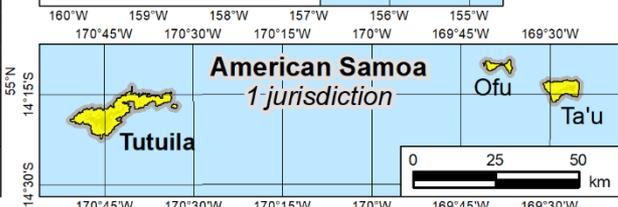
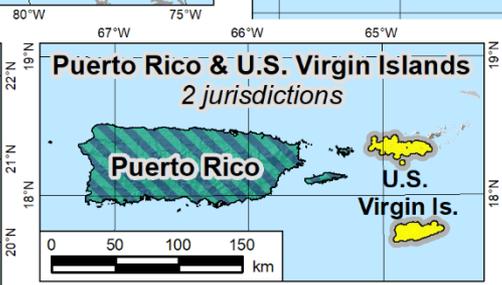
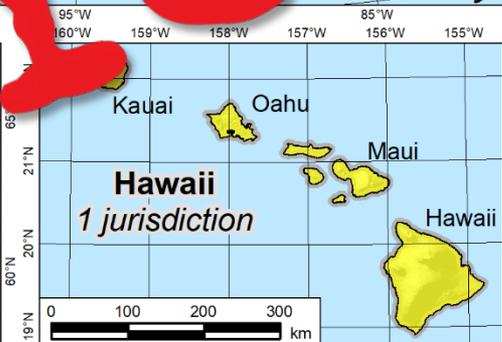
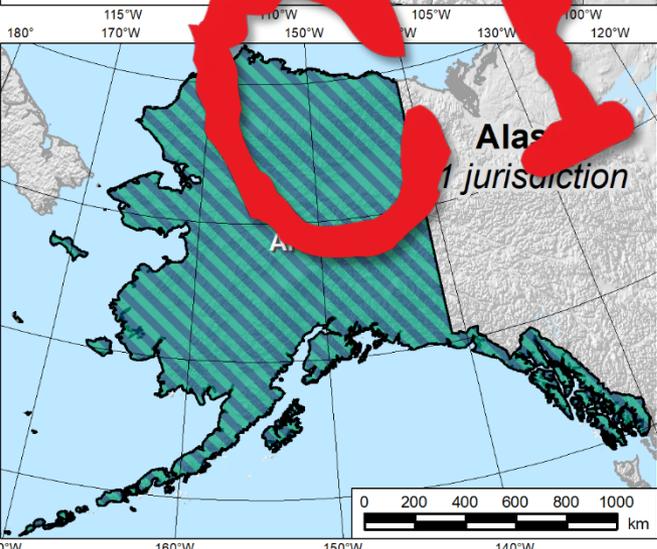


United States Jurisdictions

State Plane Coordinate System



us for 5
 SPCS 8
 foot spe
 SPCS 8
 spe
 S 8
 specified by FRN* (12)
 SPCS 83 legislation; foot type
 not specified (4)
 No SPCS 83 legislation; foot type
 not specified (6)
 Register
 ce



CNMA's!

Out of order, *chaos*

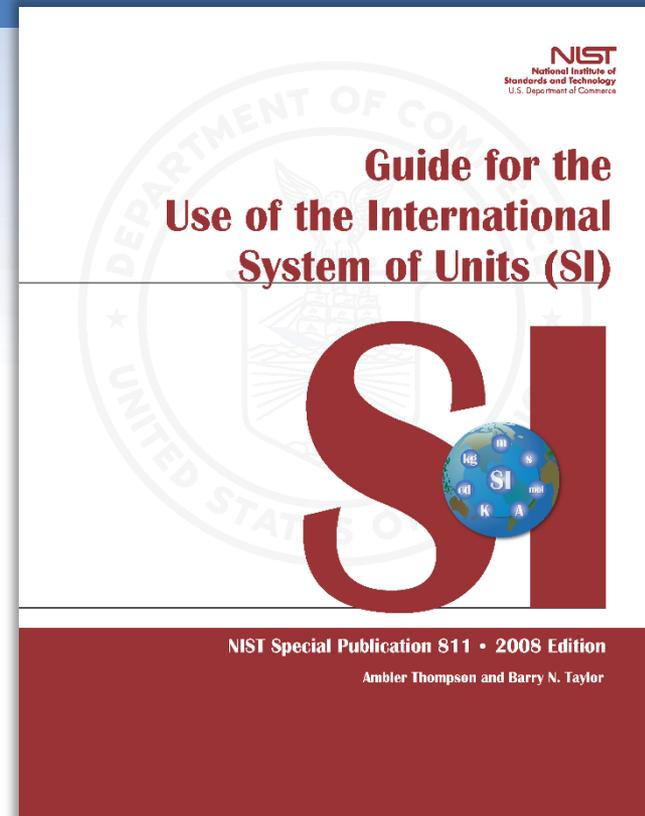
A foot still in limbo

2008. NIST “Guide to the Use of the SI”

- U.S. survey foot still used
 - but never officially permanently adopted
- Perpetuates 1975 FRN ideas about the two feet:

- International ft used for *engineering*
- U.S. ft used for *mapping & land measurement*

At odds with very idea of “standards”



Why make the change and what are the choices?

Why make the change?

- **That was original intent (*over 60 years ago!*)**
- **Two “feet” is inefficient and causes confusion**
 - Leads to errors that cost money
 - Absurd to have “same” unit that differs by 2 ppm
 - Defeats purpose of having a length standard
- **Only recognized in *part* of U.S. for *some* things**
- **NGS software can support backward-compatibility**
- ***Now is the time***
 - Many other changes will be made for modernized NSRS
 - Change in foot trivial compared to other changes
 - Otherwise U.S. survey foot problems will never go away

Why make the change?

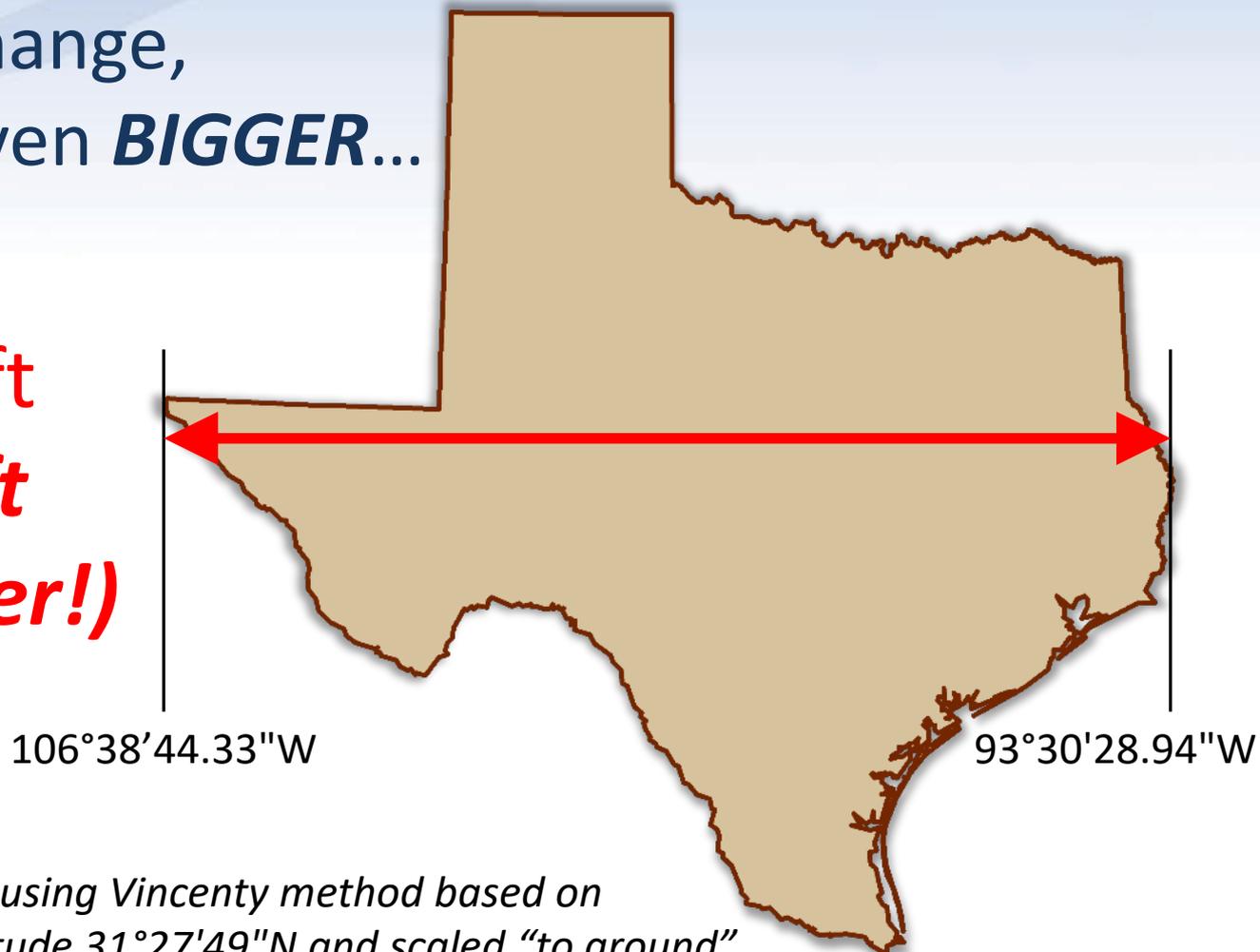
Texas is a ***BIG*** state...



Why make the change?

But with the change,
Texas will be even **BIGGER...**

4,094,309 sft
4,094,317 ift
(8 feet longer!)



Geodetic distance calculated using Vincenty method based on GRS 80 ellipsoid at mean latitude $31^{\circ}27'49''\text{N}$ and scaled "to ground" using radius of curvature in the prime vertical with mean ellipsoid height of 560 m.

What are the choices?

- **Do nothing** (i.e., NGS stays “metric” only)
 - States choose whatever foot they want
 - But feet will creep back into NGS products & services
- **Officially adopt U.S. survey foot for specific things**
 - U.S. survey foot for surveying and mapping
 - International foot for engineering (and everything else)
- **Use international foot for everything**
 - Support only foot = 0.3048 meter, period
- **Use U.S. survey foot for everything** (highly unlikely)
- **Go entirely metric** (*good luck with that!*)

Arguments for keeping “old” foot

- **Used for existing records and data**
 - Circular argument because issue never goes away
 - Such logic means old foot will always be retained
 - That’s how we got into this mess in the first place
- **Most states use U.S. survey foot already**
 - Would perpetuate problem by keeping both types of feet
 - But most economic activity uses international foot, by far
- **Old foot in state legislation**
 - But statute is usually tied to SPCS 83
 - *New statute for 2022 could break that connection*
- **Necessary to convey real property**
 - Yet six states with new foot somehow convey property...

Coordinates, distances, and area

- Foot issue is a **coordinate** problem
- Deeds are concerned with **distances**
- Bigger issues with distances than type of foot
 - *U.S. survey vs. int'l foot:*
 $\pm 2 \text{ ppm} = \pm 0.01 \text{ ft per mile} = \pm 1/8 \text{ inch per mile}$
- Can get “distances” from coordinates, but...
 - Scale of projected distance varies along line
 - What about horizontal “ground” distances?
 - What is a horizontal “ground” distance, anyway?

Coordinates, distances, and area

- Boundary surveys are not accurate (or precise) to ± 2 ppm
- ***If same surveyor measures same parcel twice with same equipment, will not get same distances or area within ± 2 ppm***
 - Doesn't matter whether parcel is 1 or 1,000 acres
 - Difference is 25 square inches per acre (5 in \times 5 in)
 - That's 0.000 004 acre per acre, ***more or less***

Arguments for keeping “old” foot

- **Used for existing records and data**
 - Circular argument because issue never goes away
 - Such logic means old foot will always be retained
 - That’s how we got into this mess in the first place
- **Most states use U.S. survey foot already**
 - Would perpetuate problem by keeping both types of feet
 - But most economic activity uses international foot, by far
- **Old foot in state legislation**
 - But statute is usually tied to NAD 83
 - *New statute for 2022 could break that connection*
- **Necessary to convey real property...**
 - Yet six states have new foot somehow convey property
- **The old foot has a better name...**

What's in a name?



- **U.S. survey vs. international foot**
 - “U.S. survey” sounds patriotic, surveyor-centric
 - “International” has faint whiff of socialism, New World Order
- **Idea: Drop word “international”**
 - Instead call it the:

***American
Freedom
Foot***



The one, true “foot”

- **In the future, simply call it the “foot”...?**
 - No modifier, since only one foot after 2022
 - 1 foot = 0.3048 meter, *period*
- **When someone says, the “Rock”**
 - You know exactly what they mean
- ***But still possibility for confusion...***



Two names for a single foot?

- **Continue using “international” modifier after 2022**
 - Allow both names going forward
 - Highly recommended if it helps clarify
- **However, keep following in mind:**
 - Only new foot supported in modernized NSRS after 2022
 - Vast majority of people unaware of the two feet
 - Over time “international” modifier will fade away
 - Many applications already use just “foot”
 - E.g., AutoDesk, Esri, hand calculators, online converters

Why not just go metric?

- **Good news:** you **CAN** “go metric”!
 - Legalized by Congress for commerce in 1866
 - All you have to do is convince your clients...
- But to work, **everything** must be metric
 - Every. Thing.
 - **More good news:** gas will be cheaper!

3	.	2	4	⁹
REGULAR				

vs.

0	.	8	5	⁹
REGULAR				

Where would you buy gas?

Putting the “best” foot forward

- **U.S. survey foot will be retired**
 - Not supported for SPCS2022 (or any part of modernized NSRS)
 - Only international foot will be supported
- **Effective December 31, 2022**
 - Independent of NSRS modernization
 - But U.S. survey foot will still be supported for legacy products (e.g., “old” State Plane)
- **Official action has been taken...**



Federal Register Notice (Oct 5, 2020)



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

(Note: this image is hyperlinked to the Federal Register page)

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 62699

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

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 deprecated on December 31, 2022.

Document Type:
Notice

Document Citation:
85 FR 62698

Final determination:
Describes public comments received, along with the plan, resources, training, and other information for an orderly transition

Additional information and resources

NIST

Search NIST



Menu

Physical Measurement Laboratory

U.S. SURVEY FOOT**www.nist.gov/pml/us-surveyfoot**

FRN Citations +

Frequently Asked
Questions (FAQs)

Resources

Revised Unit Conversion
FactorsTraining/Outreach Events
Calendar

PUTTING THE BEST “FOOT” FORWARD: ENDING THE ERA OF THE U.S. SURVEY FOOT (1959 TO 2022)

Since 1893, the legal definition of the foot in the United States has been based on the meter. The definition adopted at that time was the one specified by Congress in 1866, as 1 foot = 1200/3937 meter *exactly* (or 1 foot = 0.304 800 6 meter *approximately*). In 1959, the relationship of the foot to the meter was officially refined as 1 foot = 0.304 8 meter *exactly*. This change was made to support United States industry and international trade. It resolved a long-standing discrepancy with the definition used by different organizations within the United States and in other countries.

The 1959 redefinition of the foot was legally binding and intended for the entire United States. But a single exception *temporarily* allowed continued use of the previous definition of the foot, exclusively for geodetic surveying. To distinguish between these two versions of the foot, the new one was named the “international foot” and the old one the “U.S. survey foot.” It was furthermore *mandated* that the U.S. survey foot be replaced by the international foot upon readjustment of the geodetic control networks of the United States. Although such a readjustment was completed in 1986, use of the U.S. survey foot persisted. This situation has led to confusion and errors that continue to this day, and it is at odds with the intent of uniform standards.

To resolve problems due to simultaneous use of two nearly identical versions of the foot, collaborative action is being taken by the National Institute of Standards and Technology (NIST) and the National Geodetic Survey (NGS), National Ocean Service (NOS), National Oceanic and Atmospheric Administration (NOAA). With the goal of providing national uniformity in the measurement of length, the U.S. survey foot will be phased out as part of the modernization of the National Spatial Reference System (NSRS). From this point forward, the international foot will be simply called the foot. A [Federal Register Notice \(FRN\)](#) has been issued to solicit public comment to ensure that this change is made in an orderly fashion with minimal disruption.

New definitions for old units

Unit of measure based on feet	“U.S. survey foot” (approximate)	“foot” (exact)
foot (ft)	0.304 800 609 601... m	0.3048 m
mile (mi)	1609.347 218 694... m	1609.344 m
chain (ch)	20.116 840 234... m	
link (li)	0.201 168 402... m	
rod (rd), pole, perch	5.029 210 058... m	
furlong (fur)	201.168 402 337... m	
fathom	1.828 803 658... m	
acre (ac)	4046.872 609 874... m ²	

New definitions for old units

Unit of measure based on feet	“U.S. survey foot” (approximate)	“foot” (exact)
foot (ft)	0.304 800 609 601... m	0.3048 m
mile (mi)	1609.347 218 694... m	1609.344 m
chain (ch)	20.116 840 234... m	20.1168 m
link (li)	0.201 168 402... m	0.201 168 m
rod (rd), pole, perch	5.029 210 058... m	5.0292 m
furlong (fur)	201.168 402 337... m	201.168 m
fathom	1.828 803 658... m	1.8288 m
acre (ac)	4046.872 609 874... m ²	4046.856 422 4 m²

What about NSRS Modernization?

- **Deprecation effective Dec 31, 2022**
 - NSRS modernization will happen later
- **For users of *existing* NSRS:**
 - Deprecation will have no effect
 - U.S. survey foot will still be supported
 - ***Difference in dates will NOT create a problem***
- **Will give more time to make the transition**

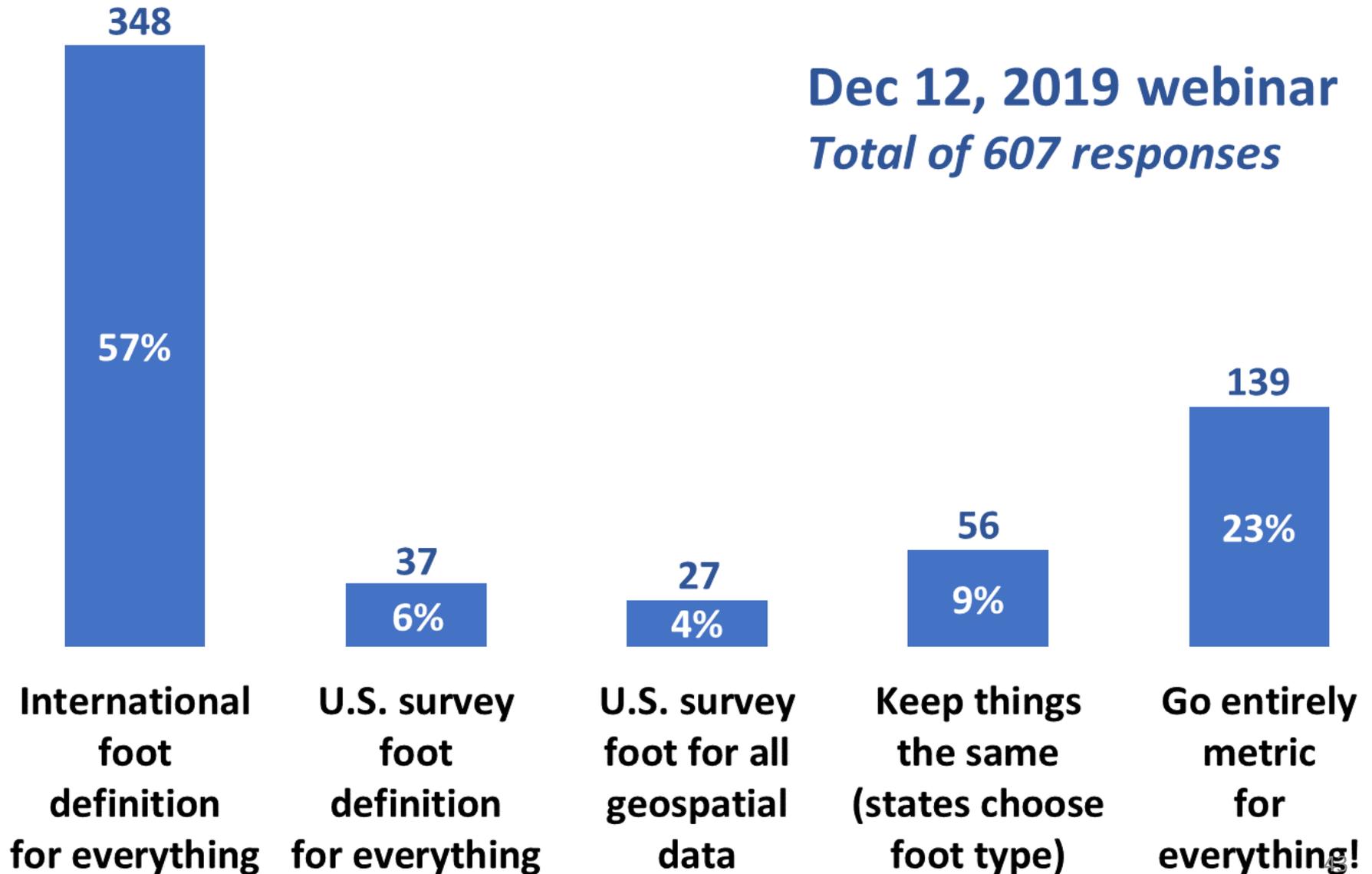
U.S. survey foot will **ALWAYS** be supported by NGS for State Plane Coordinate Systems of 1983 and 1927

Taking a stand for standards

- **The foot problem created for convenience**
 - Intended as *temporary*, for geodetic work *only*
 - Boundary surveys were *not* considered
- **Keeping U.S. survey foot is an “anti-standard”**
 - U.S. survey foot currently in standards “limbo”
 - Single definition efficient, clean, and *right thing to do*
- **Issued “order” to adopt single foot = 0.3048 m**
 - That’s what it took to fix mess in 1893
 - A long overdue solution
 - Within authority of federal government...
...but prefer to persuade rather than coerce

Which option best describes your opinion on what should be done about the foot after 2022?

Dec 12, 2019 webinar
Total of 607 responses



In closing...

- **NGS created problem, will help fix it**
 - Fully support backward compatibility
 - Will make simple and painless as possible
 - Foot change minor compared to other 2022 changes
- **This is about the *future***
 - Remember our heroes and their hard-won victories...

