



DEPARTMENT OF COMMERCE

National Institute of Standards and Technology

National Oceanic and Atmospheric Administration

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

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.

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 Beginning on January 1, 2023, the U.S. survey foot should not be used and will be superseded by the “international foot” definition (i.e., 1 foot = 0.3048 meter exactly) in all applications.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 the U.S. for a large majority of applications and is typically referred to as simply the “foot.” Over time this terminology will become more prevalent in land surveying and mapping communities. Either the term “foot” or “international foot” may be used, as required for clarity in technical applications. This notice describes public comments received, along with the plan, resources, training, and other activities provided by NIST and NOAA to assist those affected by this transition.

DATES: Use of the U.S. survey foot will be deprecated on December 31, 2022.

ADDRESSES: All comments submitted in response to the October 17, 2019, *Federal Register* notice request for public comment may be accessed at [https:// www.regulations.gov](https://www.regulations.gov), docket number NIST–2019–0003, under the “Enhanced Content” section of the *Federal Register* web

page for that notice. Additional U.S. survey foot deprecation resources are available at <https://www.nist.gov/pml/us-surveyfoot>.

FOR FURTHER INFORMATION CONTACT:

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Technical and historical information on usage of the foot: Michael Dennis, 240-533-9611, Michael.Dennis@noaa.gov.

SUPPLEMENTARY INFORMATION:

Notice of Final Determination

On October 17, 2019, NIST and NOAA published a notice titled “Deprecation of the United States (U.S.) Survey Foot” in the *Federal Register* (84 FR 55562). In that notice, NIST and NOAA announced the initial decision to deprecate the U.S. survey foot and to require that its use be discontinued for all applications in the United States, including surveying, mapping, and engineering. The intent of this action is to provide national uniformity of length measurement in an orderly fashion with minimum disruption, correcting a measurement dilemma that has persisted for over 60 years. A notice announcing a 90-day extension of the review and analysis period to address public comments was published in the *Federal Register* (85 FR 41560) on July 10, 2020, and further indicated that the final determination would be published by September 28, 2020.

After December 31, 2022, any data derived from or published as a result of surveying, mapping, or any other activity within the U.S. that is expressed in terms of feet should only be based on the definition of one foot being equal to 0.3048 meter (exactly). This definition was named the “international foot” in the 1959 *Federal Register* notice (24 FR 5348) that officially changed the foot definition for the U.S. In 1959, the other foot definition was named the “U.S. survey foot,” with the mandate that it be used only for geodetic surveying, and that it be replaced by the international foot definition.

With this notice, the mandate to replace the U.S. survey foot with the international foot definition for all applications has been achieved, and after December 31, 2022, there will be only one

approved definition of the foot in the U.S. The preferred term is simply the “foot,” which is the name currently used for most applications. When needed to avoid confusion with the U.S. survey foot, use of the term “international foot” is an acceptable synonym for “foot.”

The date of December 31, 2022, was selected to accompany the modernization of the National Spatial Reference System (NSRS) by NOAA’s National Geodetic Survey (NGS). The reason for associating the deprecation of the U.S. survey foot with the modernization of the NSRS is that the biggest impact of the uniform adoption of the international foot will be for users of the NSRS, due to very large coordinate values currently given in U.S. survey feet in many areas of the U.S. Impacts related to the change to international feet will be minimized if a transition occurs concurrently with others changes in the NSRS. More details on the relationship between the NSRS and deprecating the U.S. survey foot were provided in the previous notices, and are discussed further later in this notice. This approach provides ample time for the surveying and mapping community to plan for and implement related changes.

Modernization of the NSRS was originally planned to occur in 2022. However, operational, workforce, and other issues have arisen causing NGS to re-evaluate the timing of implementation (see <https://geodesy.noaa.gov/datums/newdatums/delayed-release.shtml> for details). Despite the possibility of delay of the modernization of the NSRS beyond 2022, the planned date of December 31, 2022, for deprecation of the U.S. survey foot will not change and is independent from the NSRS modernization timeline. A benefit of retaining the original date for the deprecation of the U.S. survey foot is that it will ensure that it will occur prior to the rollout of the modernized NSRS. The difference in timelines will have no effect on users of the existing NSRS, because NGS will continue to support the U.S. survey foot for components of the NSRS where it is used now and in the past. In other words, as explained below, to minimize disruption in the use of U.S. survey foot for existing NSRS coordinate systems, the change will apply only to the modernized NSRS.

Comments Received

In the October 17, 2019, notice, NIST and NOAA requested comments from all interested persons on the announced changes by December 2, 2019. Seventy-two comments were received in response to that notice. The comments received, and this final determination, are available online

at the “Regulations.gov” website (<http://www.regulations.gov>) within Docket No. NIST-2019-0003. The purpose of the solicitation was to announce the initial decision to deprecate the U.S. survey foot and seek public comments to identify unforeseen issues and facilitate a smooth transition to a single definition of the foot. In response, many opinions were expressed in support or opposition. Those comments are summarized here.

Because the solicitation did not directly ask for comments in support of or in opposition to the planned change, an opinion regarding support or opposition was not provided in all of the comments. Of the 72 responses received, 64 (89 percent) offered such an opinion. Thirty-four of those 64 comments (53 percent) expressed support for universal adoption of the international foot. Twenty-one (33 percent) expressed a desire to retain the U.S. survey foot, either for surveying and mapping exclusively, or to replace the international foot for all applications. Nine (14 percent) preferred eliminating both definitions of the foot and instead adopting the meter as the length measurement unit used in surveying and mapping. Additional public feedback from sources outside this public comment process, but related to NGS U.S. survey foot outreach activities planned as part of this action, were received from a much larger number of people and generally followed the trends described later in this section.

Only four comments were anonymous. Of the 68 commenters who provided their names, 28 also identified one or more organization affiliation. These consisted of at least one state or county government agency in ten states, six professional or business associations, one university, and 13 private companies.

1. Comments in support of deprecation

The comments received included statements of support from representatives of state government agencies in eight states (i.e., Arizona, Iowa, Idaho, Kentucky, Maine, Michigan, Pennsylvania, and Washington). No state government expressed opposition to the deprecation of the U.S. survey foot.

The remainder of supportive comments were from individuals, mostly surveyors, who agreed that the U.S. survey foot should be discontinued. About half of these individuals identified either their employer or the organization they represented. The overall theme that emerged from public

comments was that discontinuing use of the U.S. survey foot enhances the value and benefit of national uniformity and minimizes opportunities for confusion and unnecessary costs to the users, states, and professionals in the surveying, mapping, and engineering fields. The following comment excerpts exemplify the reasons for supporting the change.

The elimination of the U.S. survey foot is past due, and the best time to implement this change is now, during development of the State Plane Coordinate System of 2022 (SPCS2022) as part of the NSRS modernization. For example:

“We badly need to get rid of this confusing dual definition of feet and join with the other five countries (or at least those that have not fully converted to metric yet) in that 1959 decision to have a single, common definition of the yard [and foot] and pound--the sooner, the better. Let's not allow survey feet as an option for SPCS2022 output, so as to avoid dragging this out years into the future.”

“The U.S. survey foot should be eliminated. Hard to convert to meters and back. A standard international foot will be easier to deal with. With the change in datums in 2022 it is the perfect time to eliminate it. Here in Michigan we use the international foot and it works fine except that some federal agencies report their state plane coordinates in U.S. survey feet. End the confusion I say.”

“Having the country using only one definition of the foot for survey and mapping not only makes good sense, it will [eliminate] the possibility of the unintended error [that] currently happens due to the dual foot definitions. The timing of a single foot standard coinciding with the 2022 readjustment is prudent and well planned.”

According to the U.S. Bureau of Labor Statistics, a large majority of surveyors are employed in the “Architectural, Engineering, and Related Services” industry, which includes international, national, regional, and small firms. A substantial number also work for government agencies and in the construction sector. Many surveyors are licensed in more than one state, and large projects often include surveyors and other geospatial professionals from multiple states. The ability to

efficiently work in multiple states and across borders increases the scope of revenue. The benefits of having a single definition for the foot for all states are anticipated to outweigh the inconveniences associated with this change. For example:

“I am in strong agreement with this decision. Having worked for a consultant with offices in both U.S. and International foot states, this created real headaches when staff from different offices were working on the same projects.”

“For many years I worked in multiple states and it was clear that many surveyors did not know with which definition of the foot they were working. The confusion was not always evident until there were blunders related to construction elements. These can be costly. I agree with the proposal and say good riddance to the ratio.”

“No one need look any further than the infamous Mars Climate Orbiter failure to understand why this action is vital to eliminating confusion brought about by having multiple choices between systems of measure. While the probe failure resulted from inadvertent confusion between two systems (metric vs U.S.), this issue is even more insidious given once there is an awareness for making a unit conversion the process is further complicated by the ambiguity created when multiple conversion factors are present (International foot vs. U.S. Survey foot in this case). To allow this condition to persist when it is no longer necessary would be considered intentional neglect by any objective standard.”

Many small businesses in the United States will benefit from this change. Although surveyors and other geospatial professionals work for organizations that vary greatly in size, many are independent contractors or consultants who work for small firms or are self-employed. The National Federation of Independent Businesses (NFIB), an advocate of small and independent American business owners, expressed support for the change:

“NFIB [National Federation of Independent Business] is an incorporated nonprofit association with about 300,000 small and independent business members across America.

NFIB protects and advances the ability of Americans to own, operate, and grow their businesses and, in particular, ensures that the governments of the United States and the fifty states hear the voice of small business as they formulate public policies. Many businesses, including small businesses, depend upon accurate weights and measures in their commerce... The move to a "foot" with a single length everywhere and for all purposes in the U.S. will facilitate commerce, public safety, and national defense.”

2. Comments providing examples of errors and costs

Public comments highlighted significant errors and costs that have resulted from two definitions of the foot in use within the surveying and mapping community. Several comments addressed examples based on their professional experiences:

“I am employed by a commercial contractor working on a government project in which there was confusion about 3 years ago when a simulation program noticeably deviated from real data because one used survey feet and the other used international feet. The time lost to track down the deviation was significant.”

“A roadway alignment is surveyed in international feet using a low distortion projection and laid onto a global image under the assumption the survey is the U.S. foot definition. Locally all alignment points fit well vs. record distance and bearings. However, when cast onto the global image map the roadway alignment is 12 feet north and 45 feet east of the roadway on the image. The roadway construction plans that use global aerial images as a background cannot be completed until the surveyed line work is in coincidence with the global image.”

“I one hundred percent support the deprecation of the U.S. Survey Foot as a unit of measure. Having two "feet" has cost my company and countless others untold amounts of lost time due to errors and confusion associated with two separate definitions of the foot.”

Because multiple comments disclosed generic examples of errors and the resulting negative impacts during the notice process, NGS took action to seek additional examples from the

stakeholder community to further explore the risk. The action consisted of poll questions asked during webinars and providing an email address specifically for input (NGS.Feedback@noaa.gov). A summary of these additional findings is available on the U.S. survey foot website (<https://www.nist.gov/pml/us-surveyfoot>). Multiple organizations and individual surveyors expressed to NGS that they are hesitant to disclose specific projects and the resulting errors because of liability concerns.

For example, one comment included an image from engineering plans showing both definitions of the foot, with the State Plane coordinates in U.S. survey feet redacted, so that it was not possible to determine its actual location. NGS took additional action to clarify this submission, which was further described in subsequent email correspondence:

“[The image is from a] facility drawing for an industrial plant, where the plant coordinates are in international feet yet the State Plane coordinates of the same points on the same plans were in U.S. survey feet. And yet the plant coordinates are forced to be identical to the State Plane coordinates at one location, where the State Plane easting was over 2,600,000 sft, which causes more than 5 feet of positional error.”

3. Comments dealing with legacy infrastructure and data

Comments highlighted that this measurement unit change is like past changes that dealt with legacy infrastructure and data. With planning and retention of unit conversion factors, as published by NIST, the outcome will be successful. For example:

“Many of our older records and plans will not be impacted by using one definition over another because their projection basis is not global but local and many times completely unknown and irrelevant. There will always be legacy records that use [the] U.S. foot just as there are legacy records that use the chain unit, rod, perch, etc. Those who deal with various units of measure will handle the conversions just as they do now if needed.”

“Ending the use of the U.S. Survey Foot for state plane coordinate systems is long overdue. Definitions and conversion factors need to be clear and concise without ambiguity.”

“The argument some make that deeds from U.S. foot states would need to be translated into international foot distances is weak -- there's only 0.01 ft difference in one mile between the two! How many surveyors who make this claim are accounting for the different accuracy/precision of equipment when the original deeds were surveyed or the various measurement errors present in all equipment?”

“I favor the elimination of the Survey foot. I would note that since 1983 USCGS (now NGS) has allowed states to designate whether they use the Survey or International foot in surveying and use in their State Plane Coordinate Systems. The two feet, so close in value, cause a lot of confusion.”

4. *Comments regarding use of the term “international foot” versus “foot”*

Of the 17 public comments that expressed an opinion on the name of the foot after deprecation, 14 favored retaining “international” as part of the name, rather than simply calling it the “foot.” In all cases, the reason was to avoid confusion between the types of foot, both for legacy and future applications. For example:

“Due to all of the historical data held by Federal, State and local government agencies as well as private firms, I feel it will be a mistake to refer to the International Foot as simply Foot. There is already a problem with GIS professionals as well as surveyors not documenting datums and units for projects adequately. By removing the reminder of which foot new data is presented in, it opens up the possibility of further confusion.”

“I believe to avoid confusion that upon deprecating the use of the term U.S. Survey Foot that we go on to use the terminology of International Foot. My reason is people reference the U.S. survey foot as a foot. I think that the use of International Foot will signify a change is being made. I work with legal descriptions in a state that adopted the U.S. Survey Foot and will have to change. If we don't differentiate there will be confusion. My fear is that simply saying you are adopting the foot will not resonate and may lead some to believe that they can continue to use the U.S. Survey Foot. Over time the international foot will be

referred to as a foot again but for technical purposes I think that the differentiation is important. At a minimum officially stating the U.S. Survey Foot will be superseded by the international foot will work. People will casually reference it as a foot anyway.”

“To use a term such as "the foot" is inconsistent with efforts to minimize ambiguities in Surveying documents. If there is more than one version of something, then which version is being referred to should be made clear.”

5. Comments supporting use of the metric system

The initial request for public comment noted that states currently have the option to select the International System of Units (SI), commonly known as the metric system, option for surveying and mapping; NGS adopted the metric system in 1977 (54 FR 25318). Although the notice did not request public input regarding state adoption of the metric option for surveying and mapping, several comments expressed this preference. For example:

“Rather than deprecating the U.S. Survey foot, I would rather see the United States deprecate the use of the foot altogether for survey measurements and adopt the meter as the unit of measure.”

“The native measurement unit used by modern land surveying equipment is the meter. Additional software is required to deal with our two archaic units of measurement. On December 31, 2022 the foot, in all of its iterations, should be relegated to legacy status.”

6. Comments opposing deprecation

A minority of public comments expressed opposition to the change and identified several concerns that will be addressed in the deprecation process. The two primary reasons given for supporting retention of the U.S. survey foot were that a large amount of legacy data and records in that unit already exist, and that a majority of states have legislated or otherwise adopted it for surveying.

Some opposing comments cited erroneous or misleading information, or made claims for which no supporting evidence was provided, such as conflating the change with conversion to the metric

system; stating that the U.S. survey foot has always been used for defining boundaries in the U.S.; that adopting the international foot would jeopardize rights to real property; that the change would be a financial burden; and that it creates a problem where none exists.

All comments opposed to the change were from individuals, except for one trade association, the International Association of Oil and Gas Producers (IOGP). The IOGP represents 83 member organizations that include energy corporations and related associations. Writing on behalf of its U.S. members, IOGP advocated to instead adopt the U.S. survey foot nationwide, because of its widespread current and historic use in the surveying community.

Considered collectively, the opposing comments recommended to instead pursue one of the following three alternatives: 1) keep the current approach, where each state chooses its preferred definition of the foot; 2) adopt the U.S. survey foot for all geospatial applications, and the international foot for everything else; and 3) deprecate the international foot and use the U.S. survey foot for everything. These alternatives, together with the reasons given for opposing adoption of the international foot, are addressed later in this notice.

Supplemental Feedback

During planned outreach efforts, described in the October 17, 2019, notice, additional stakeholder feedback was received. NGS presented two webinars on deprecating the U.S. survey foot. The first was on April 25, 2019, “Fate of the U.S. Survey Foot after 2022: A Conversation with NGS,” and the second was on December 12, 2019, “Putting the Best ‘Foot’ Forward: Ending the Era of the U.S. Survey Foot.” Both webinars were recorded and are available for download (https://geodesy.noaa.gov/web/science_edu/webinar_series/2019-webinars.shtml), together with the companion slides. The webinars provided an overview of the history of the survey foot, discussed examples of problems encountered, summarized the public comments received in response to the previous *Federal Register* notice, and discussed charting a path forward as part of modernizing the NSRS.

Significant feedback occurred during the two NGS webinar events, which were attended by nearly 1,400 unique participants from every state, the District of Columbia, Puerto Rico, Guam, and

Canada. Webinar polls reinforced the public comments obtained through the notice process. Figures 1 through 4 summarize feedback from the public comment process, webinar participants, and emails sent directly to NGS and NIST (with the number from each source given in the figures). Figure 1 reveals that about twice as many of the 540 respondents (63 versus 33 percent) have experienced problems due to the existence of the two definitions of the foot. This is a striking result that illustrates the impact of this problem.

In terms of solving the foot confusion problem, Figure 2 shows that a much larger proportion (58 percent of 730 respondents) prefer adopting the international foot, compared to 20 percent in favor of keeping the U.S. survey foot, which is slightly less than the number who prefer using meters (22 percent).

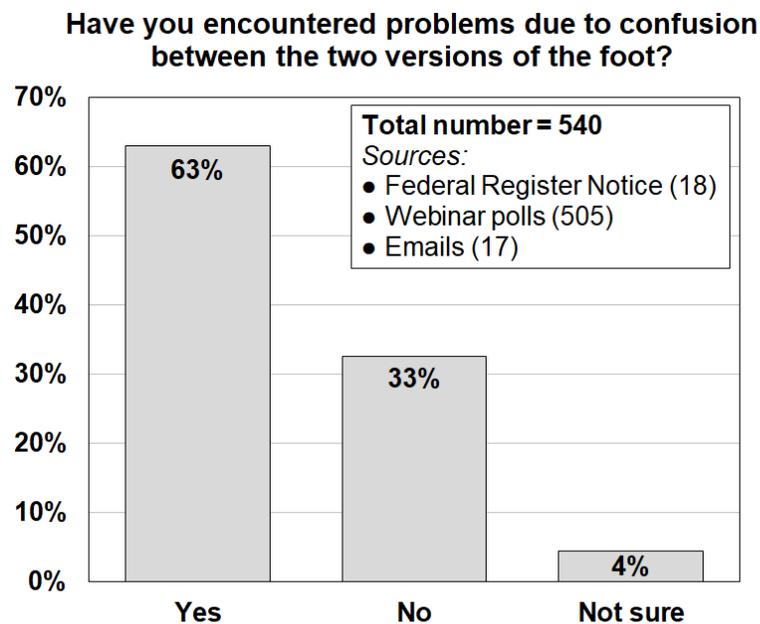


Figure 1. Feedback indicates many have experienced some negative impact from the use of two definitions for the foot.

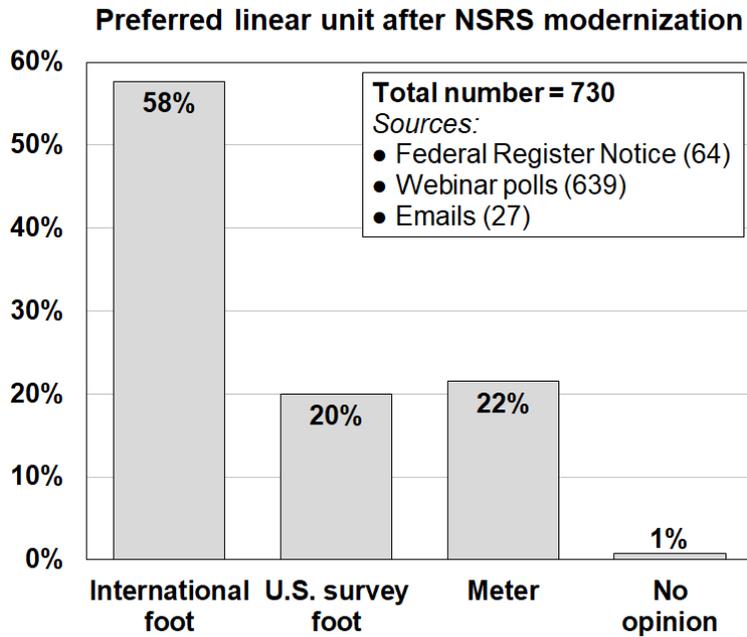


Figure 2. Feedback supports adoption of the international foot after the NSRS modernization is implemented.

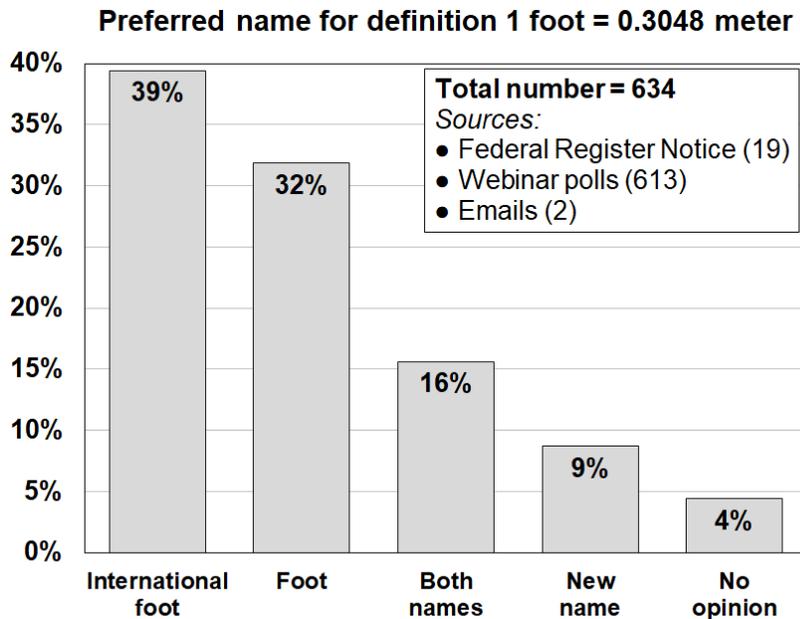


Figure 3. Feedback reinforces that use of the term international foot is strongly supported.

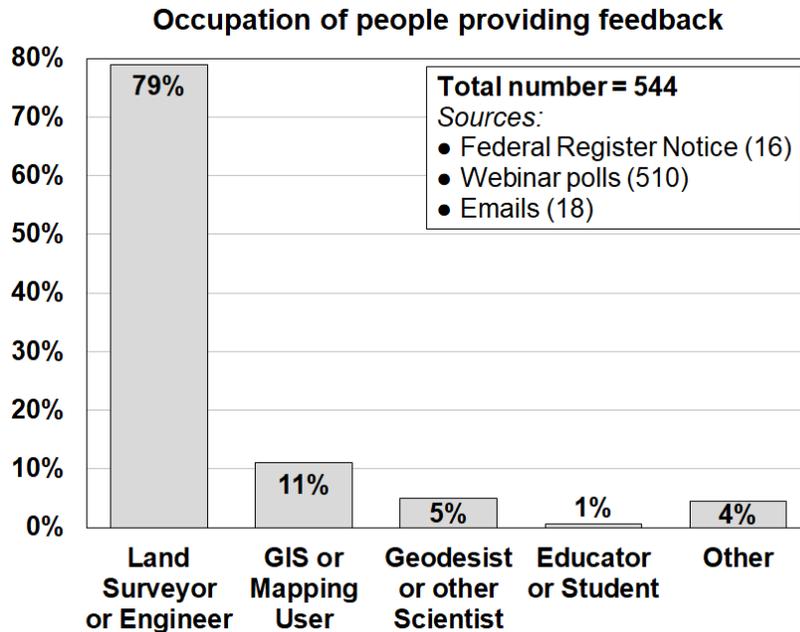


Figure 4. Land Surveyors and engineers were well represented in the process.

When respondents were asked which name they prefer for the foot after deprecation, 39 percent of the 634 respondents preferred retaining the name “international foot” as shown in Figure 3, rather than just “foot” (32 percent), or allowing the use of both names (16 percent). Only a small proportion (9 percent) felt that an entirely new name should be used. Combining the preference for the name “foot” and allowing both names represents 48 percent of the responses. There is nonetheless a large number who prefer keeping the modifier “international.”

Preference for the name “international foot” in the future is explained to a large extent by Figure 4, which summarizes the occupations of the people providing feedback. A large majority are in the category of “land surveyor or engineer” (79 percent of 544 respondents), with the next largest group in the “GIS or mapping user” category (11 percent). Land surveyors, civil engineers, mappers, and geographic information system (GIS) professionals are typically familiar with the existence of these two definitions of the foot.

The high representation of engineers, GIS professionals, mappers, and especially surveyors also helps explain the large proportion of respondents who have experienced problems with the two

definitions of the foot, as shown in Figure 1. This illustrates that NGS outreach webinar participants were highly representative of the stakeholder community.

The primary objective of seeking public comment was to get input on the process of implementing the change, not whether to make the change. To that end, valuable feedback was received regarding continued use of the name “international foot” after deprecation, rather than simply the “foot.” This input made a difference and was incorporated into the final determination. Considering all feedback received, a significant majority of commenters and webinar participants support deprecation of the U.S. survey foot and its replacement with the international foot definition. This is a noteworthy result because a majority of states currently use the U.S. survey foot for surveying and mapping. Receiving strong support for deprecating the U.S. survey foot reinforces the importance of undertaking this process.

National and State Action Supporting U.S. Survey Foot Deprecation

Surveyors are by far the most affected by a change in the foot definition, so obtaining support and input from national surveying organizations was an important part of the deprecation process. The National Society of Professional Surveyors (NSPS) and the Utility Engineering and Surveying Institute (UESI) of the American Society of Civil Engineers (ASCE) are nationwide organizations with a robust presence in the surveying profession.

Although these organizations did not provide input during the public comment period, they subsequently stated support for adopting the international foot definition for all applications throughout the United States (<https://www.nist.gov/pml/us-surveyfoot>). NSPS has 15,000 members and is affiliated with state surveying associations in every state, the District of Columbia, and Puerto Rico. UESI is an institute of 3,300 members within ASCE (with a total of 150,000 members). The UESI President expressed that:

“UESI believes that having a single definition for the foot will reduce confusion in surveying engineering projects, especially projects that make use of coordinates with large values (e.g., the State Plane Coordinate System). Deprecating the U.S. survey foot will

minimize costly mistakes that have occurred over the decades due to the confusion of having two definitions for the foot.”

The American Association for Geodetic Surveying (AAGS) is a national surveying organization with 150 members that provided input through the public comment process. AAGS took a neutral stance and did not endorse either definition of the foot but instead endorsed use of the meter.

Because many states have specified the U.S. survey foot for surveying applications in statute, it is noteworthy that two such states have already adopted the international foot in new legislation: Kentucky and Washington. For both states, the legislation went into effect this year (2020). The early and proactive action by these states has prepared them to switch to the international foot definition when the NSRS modernization goes into effect.

Counterpoints to Feedback Expressing Opposition

As discussed in the comments section of this notice, some of the public responses to the October 17, 2019, notice opposed deprecating the U.S. survey foot. Mitigating actions and supporting explanations are summarized below that address the concerns expressed in the opposing comments. More details are available on the NIST U.S. survey foot website (<https://www.nist.gov/pml/us-surveyfoot>).

1. *Association of the change with NSRS modernization.* To minimize disruption in the use of U.S. survey feet for existing NSRS coordinate systems, the change will apply only to the modernized NSRS. This will help with management of the large body of existing data and applications based on U.S. survey feet, because only the international foot definition will be available after modernization. Therefore, knowing the coordinate system will implicitly identify the type of foot. Although implementation of NSRS modernization will likely occur after the deprecation date of December 31, 2022, the difference in timelines will have no effect on use of the U.S. survey foot for the existing NSRS, as described in the next item.
2. *Continued support of the U.S. survey foot for historical and legacy applications.* Support for the U.S. survey foot will be maintained in NGS products and services where its use is

already defined, most notably for existing and previous versions of State Plane. Such tools will help users of legacy datasets, as described in the previous item.

3. *Uniformity for all users of the U.S. customary system.* Although surveyors in most states use the U.S. survey foot, they represent a small proportion of usage within the U.S. As announced in 1959 (24 FR 5348), the international foot definition is required for all other users of the U.S. customary system of measurement. Adopting a single definition of the foot will ensure consistency for all applications, as intended in the 1959 notice and required for uniform standards of measure.
4. *Reduction in errors.* A uniform nationwide definition of the foot will reduce errors due to accidental usage of the wrong foot definition. Numerous examples of such errors were provided during the outreach conducted for this notice, and about twice as many respondents said it has caused them problems than said it has not (see Figure 1). Operating with two definitions of the foot leads to a systematic overhead cost that never ends because of the ever-present risk for mistakes. Over time, deprecation of the U.S. survey foot will reduce costs in this field of measurement.
5. *No evidence of negative effects for real property.* Some feedback included claims that deprecating the U.S. survey foot would increase costs and mistakes in performing boundary surveys and would burden the conveyance and enjoyment of real property. However, no evidence was provided in support of this claim. In contrast, six states changed from the U.S. survey foot to the international foot in the late 1980s and early 1990s. None provided evidence, anecdotal or otherwise, of any such negative impacts. This is expected, since the 2 parts per million difference in length (approximately 0.01 foot per mile) is too small to be of practical consequence for the vast majority of boundary determinations.
6. *This change is not comparable to adoption of the metric system (SI).* Some responses cited previous purportedly unsuccessful and disruptive attempts to migrate to SI as a reason not to pursue this change, but this analogy is weak. Universal adoption of the international foot definition is not a change in the unit of measure. Other than for surveying, the international foot is already in use for nearly all applications where the U.S. customary system of measurement is used. This change is instead a long overdue standardization of the foot through deprecation of an older definition used only for a specific application, as intended in the 1959 notice.

Some of the comments expressing opposition to the change included proposals for one of three alternatives to deprecating the U.S. survey foot, each of which is addressed below.

1. *Define the NSRS only using the metric system (SI) and allow each state to choose its preferred foot definition.* This alternative is a continuation of what is already being done, which has clearly led to confusion and errors and is at odds with the objective of uniform standards.
2. *Adopt the U.S. survey foot nationwide for all geospatial applications, and the international foot for everything else.* This alternative was also proposed in a 1988 notice (53 FR 27213) but never adopted. In addition to conflicting with the intent of uniform standards, this alternative would be extremely difficult, and perhaps impossible, to apply in practice. It would require that data and activities be classified as to whether they are “geospatial,” which is a problematic and subjective task, given the ambiguity of such categorization in many instances. This problem is compounded for data and activities that change over time, or that are integrated together such that some parts are classified as geospatial and some are not. The task of classification itself would place a burden (cost) on participants and increase risk due to errors, disagreements, and inconsistencies.
3. *Deprecate the international foot and instead use the U.S. survey foot for everything.* This alternative is not viable because the international foot definition is the long-established standard for the foot (since 1959). In addition, the international foot is well established and in widespread use within the U.S. economy by a large majority of the population.

Transition Best Practices and Change Management Planning

Because the U.S. survey foot is specified for surveying activities in statute for most states, an important part of the implementation process is updating statutes. NSPS, AAGS, and NGS have collaborated to create template legislation to aid state adoption and transition to the international foot. State government stakeholders are encouraged to review and customize the language, as needed. These legislative resources are available online, including statutory text that has already been proposed or enacted by states (<https://www.ngs.noaa.gov/datums/newdatums/GetPrepared.shtml>).

In researching and developing the U.S. survey foot deprecation action plan, no government or professional organization reported initiating plans or establishing working groups specifically to address deprecation of the U.S. survey foot. However, many groups have organized groups to prepare for the NSRS modernization, especially at the state level. These groups typically consist of state departments of transportation, GIS or cartographer offices, professional surveying societies, universities, and other geospatial groups. There has also been considerable activity among national organizations and federal agencies (as illustrated by the example in the following paragraph). From the perspective of these various groups, adoption of the international foot is but one relatively small part of the many changes that will occur with NSRS modernization. Therefore, they are bundling multiple technical issues together as a single change management task.

The activities underway throughout the U.S. in planning for NSRS modernization are too numerous to report here. As an example, NGS solicited input for development of SPCS2022. Formal requests and proposals regarding SPCS2022 were received from about 200 different stakeholder groups in 41 states, and additional requests were received from several federal agencies (e.g., U.S. Geological Survey, National Park Service, U.S. Bureau of Reclamation) and an American Indian tribe (the Navajo Nation). Importantly, these requests and proposals directly reference current NGS Policy, which states that only the international foot will be supported for SPCS2022 (and all other components of the modernized NSRS). Therefore, all of the organizations providing these submittals are also taking action on deprecation of the U.S. survey foot, since it is an explicit part of NSRS modernization. This demonstrates a high level of national engagement, which bodes well for a smooth transition to the international foot as part of implementing the modernized NSRS.

Planning for the change early will minimize unnecessary cost and reduce complications and uncertainty. One factor reducing the uncertainty is the fact that this change has already occurred in six “early adopter” states (i.e., Arizona, Michigan, Montana, North Dakota, Oregon, and South Carolina). These states made the change from the U.S. survey foot to the international foot in the late 1980s and early 1990s. As with the future change described in this notice, this previous one was associated with a change in the NSRS, and for the same reason: to minimize disruption by

combining the changes. NGS and NIST have contacted these states to identify problems encountered, best practices, and lessons learned as part of that transition.

Based on the state responses received so far, the change was efficiently managed in the same manner as recommended now, by combining the change in the foot definition with the change of the NSRS. Statute changes were also enacted by the “early adopter” states to specify the international foot. However, ongoing problems with the wrong definition of the foot being used were reported, usually by surveyors from other states still using the U.S. survey foot. The fact that such problems continued to occur reinforces the need to uniformly adopt this change. As more feedback is received, it will be added to the U.S. survey foot website (<https://www.nist.gov/pml/us-surveyfoot>).

A significant part of the input received concerned the name to use for the foot after deprecation. The October 17, 2019, notice stated that the international foot definition would be referred to as simply the “foot.” A large proportion of feedback preferred retaining the name “international feet” (see Figure 3 and the associated discussion). However, a somewhat larger proportion preferred either “foot” or both names. In addition, the NSPS Directors voted to use the term “foot,” and UESI also implied that the term “foot” was acceptable. Finally, a large majority of people in the U.S. only use the term “foot” for the international foot, in both casual and technical contexts, with most being unaware that the U.S. survey foot definition exists.

Nonetheless, it is completely understandable that many surveyors prefer to retain the name “international foot,” since they must deal with both definitions of the foot even after deprecation and implementation of the modernized NSRS. Although the use of the U.S. survey foot will diminish over time, it will be present for the foreseeable future because of legacy data and records, and with it the risk for confusion. For that reason, NIST and NOAA recommend continued use of the term “international foot” in situations where such ambiguity is possible.

States may choose the measurement unit for mapping (metric or “foot”) appropriate for their needs. Since the publication of the October 17, 2019, notice, two states (i.e., Kentucky and Washington) have specified the international foot definition for SPCS2022 and related surveying activities.

Kentucky continues to use the term “international foot” in its new statute, together with the numerical definition. In part, this is because the statute also includes the U.S. survey foot, since it is associated with State Plane prior to SPCS2022. In contrast, the new Washington statute makes no mention of prior State Plane and does not include the word “international.” Instead it says, “[w]hen the values are expressed in feet, one foot equals 0.3048 meters, must be used as the standard foot” The language in the Washington statute is similar to the previously mentioned template legislation, which says, “[w]hen the values are expressed in feet, a definition of 1 foot = 0.3048 meter exactly must be used.” As these examples show, the wording and terminology used in legislation will depend on each state’s specific situation and preferences. The paramount objective should be to avoid ambiguity and achieve national uniformity.

Implementation Summary and Actions

NIST and NOAA will implement deprecation of the U.S. survey foot as described in the October 17, 2019, notice. The change will enter into force on December 31, 2022. This decision will allow adoption of a single, uniform definition of the foot for all applications throughout the United States. Uniformity in measurement will increase efficiency and reduce errors that occur when two nearly identical definitions of the foot are in current use. As shown by the public comments received, such problems are both common and costly. Moreover, a significant majority of input expressed approval of this change, and most of the input was received from the groups most affected (i.e., surveyors and engineers). In addition, NIST and NOAA note that the benefits of the change outweigh the temporary inconveniences, such as the existence of a large amount of data and records in U.S. survey feet, and the current dominance of its use in the surveying profession. These concerns will be mitigated by the actions described in this notice. Other concerns were based in misconceptions or lacked supporting evidence, as discussed previously.

In keeping with the terms of this notice, the U.S. survey foot will not be supported by NGS in the modernized NSRS, including for SPCS2022, elevations, or any other components of the system. Nevertheless, action will be taken by NGS to mitigate disruption caused by this change. Chief among those is that the U.S. survey foot will be maintained in NGS products and services in legacy applications, for example the computation of coordinates in States where it was specified for the

State Plane Coordinate System of 1983, and for all zones of the State Plane Coordinate System of 1927.

Although the International System of Units (SI) is the preferred measurement system for trade and commerce in the United States, U.S. trade practice may continue to use non-SI measurement units, such as the U.S. customary system of measurement. Accordingly, NIST is adopting the proposed changes regarding deprecation of the U.S. survey foot and replacement with the international foot definition for all applications of the U.S. customary system of measurement in the U.S. The relationship between SI length measurement units and the U.S. survey foot and associated non-SI units will be incorporated in the upcoming edition of NIST Special Publication (SP) 811, *Guide for the Use of the International System of Units (SI)* before December 31, 2022. The preferred measurement unit of length is the meter, and surveyors, map makers, and engineers are encouraged to adopt the SI for their work. NIST recognizes that the foot and its derivative measures are in widespread use, and therefore NIST SP 811 will provide clarifying technical guidance regarding the foot and other non-SI length measurement units.

Past editions of NIST SP 811 and other NIST publications provided relationships for several traditional linear units that were based only on the U.S. survey foot. Table 1 provides the exact foot definitions for these units. Of the units listed, only the foot itself, the mile, and the square mile also had international foot definitions in previous editions of NIST SP 811 and other NIST publications. Future editions will include international foot definitions for all of these traditional linear units.

Table 1 gives conversions to meters for both foot definitions, which are exact for the international foot and approximate for the U.S. survey foot. Although U.S. survey foot conversions are included, their use should be avoided after December 31, 2022, other than for historic and legacy applications.

The foot-based units in Table 1 have traditionally been used for land measurement and surveying, except for the cable's length and fathom (used for water depth). Maintaining these exact foot relationships to the international foot definition is essential, because at least some of these units

are still widely used in surveying practice (such as the acre and chain), and that usage will continue as long as the foot is used. In addition, these units have also been computed using the international foot since the late 1980s in those areas where the international foot was adopted. For these traditional measures, the difference between the two types of feet is usually of negligible consequence in most practical applications. For example, the greatest precision typically used for the chain in modern land surveying practice is three decimal places (or 0.1 link), and at that level of significance both definitions of the foot give the same value. Similarly, the difference in area for 1 acre is only 0.000 004 acre (about 0.17 ft² or 25 square inches) for the two definitions of the foot. Nonetheless, from a metrological perspective, documenting the formal definitions based on the international foot is essential to avoid ambiguity, hence their inclusion in this notice and future editions of NIST SP 811.

Table 1. Exact relationships for units of measure based on the foot, including exact conversions to meters for the international foot and approximate conversions to meters for the U.S. survey foot, as will be published in the 2020 edition of NIST SP 811, *Guide for the Use of the International System of Units (SI)*. Except for the mile and square mile, these units were previously only defined with the U.S. survey foot.

Units based on the foot	Unit type	Exact U.S. customary definitions based on the foot, plus other exact definitions	International foot metric equivalent (<i>exact</i>)	U.S. survey foot metric equivalent (<i>approximate</i>)
foot (ft)	length	Defined with respect to meter	0.3048 m	0.304 800 609 601 m
cable's length	length	720 ft = 120 fathoms	219.456 m	219.456 438 913 m
chain (ch)	length	66 ft = 4 rd = 100 li	20.1168 m	20.116 840 234 m
fathom	length	6 ft	1.8288 m	1.828 803 658 m
furlong (fur)	length	660 ft = 10 ch = 40 rd	201.168 m	201.168 402 337 m
league	length	15,840 ft = 3 mi	4828.032 m	4828.041 656 083 m
link (li)	length	0.66 ft = 0.01 ch	0.201 168 m	0.201 168 402 m
mile (mi) ^(a)	length	5280 ft = 8 fur = 80 ch = 320 rd	1609.344 m	1609.347 218 694 m
rod (rd), pole, perch	length	16.5 ft = 0.25 ch	5.0292 m	5.029 210 058 m
acre (ac)	area	43,560 ft ² = 10 ch ² = 160 rd ²	4046.856 422 4 m ²	4046.872 609 874 m ²

square mile (mi ²)	area	27,878,400 ft ² = 640 ac	2 589 988.110 336 m ²	2 589 998.470 319 521 m ²
acre-foot	volume	43,560 ft ³	1233.481 837 547 52 m ³	1233.489 238 468 149 m ³

(a) Also referred to as the “statute mile.” Although historically defined using the U.S. survey foot, the statute mile can be defined using either definition of the foot, as is the case for all other units listed in this table. However, use of definitions based on the U.S. survey foot should be avoided after December 31, 2022 except for historic and legacy applications.

Recommendations to Facilitate the Change

NIST and NOAA make the following recommendations to facilitate the orderly transition to a uniform adoption of the definition 1 foot = 0.3048 meter exactly for all applications in the United States:

- *Begin the process now.* States, other government agencies, businesses, private and public organizations, and all others potentially impacted by this change should take immediate steps to begin planning for the transition. Early action is important, since some changes can be time intensive, such as enacting state legislation or updating software, training materials and relevant procedures.
- *Use nationally developed template resources for updating state statutes.* NSPS, AAGS, and NGS have collaborated to create template legislation to aid state adoption and transition to the international foot. Template legislation and examples of actual statutes are available for download at <https://geodesy.noaa.gov/datums/newdatums/GetPrepared.shtml>. State government stakeholders are encouraged to review and customize the language in this template and these examples, as needed.
- *Consult the current edition of NIST SP 811 for updating software and publications.* NIST SP 811 is the authoritative source for exact and appropriate unit conversion factors. As part of preparing for implementation of this change, software developers and others who perform conversions should consult and use the current edition of NIST SP 811 to ensure the correct definitions are being used.

- *Use the foot name most appropriate to your needs.* Confusion may occur when comparing modern measurements with historical records that use legacy terminology, or any other situation where it can be unclear as to which definition of the foot was used. To minimize such ambiguity and prevent misunderstandings, NIST and NOAA recommend using the term “international foot” or specifically identifying the metric conversion of 1 foot = 0.3048 m exactly.
- *Always document the units used for quantitative work.* Complete and correct documentation of measurement units is an essential part of any quantitative work. It is particularly important for situations where confusion can occur, such as between the U.S. survey and international foot definitions.
- *Use consistent abbreviations for the types of foot.* Following deprecation, the standard lowercase abbreviation “ft” will refer to the international foot definition by default. Likewise, the abbreviations in Table 1 for all units derived from the foot will also be based on the international foot definition. Although absence of a prefix indicates an international foot definition, situations will occur where an abbreviation that clearly identifies the foot definition is necessary to avoid confusion, such as in surveying and mapping. In such cases, the abbreviation for the international foot definition should be preceded by a lower case “i” as “ift” to ensure clarity. The abbreviation for the U.S. survey foot should *always* be preceded by a lower case “s” as “sft” for all applications. For abbreviation of units derived from the U.S. survey foot, the “s” prefix should be used as needed to avoid confusion, for example “smi” for mile, “sch” for chain, and “sac” for acre. However, this may not be necessary if the type of foot is obvious from the context or is otherwise clearly documented.
- *Avoid use of the terms “Imperial” or “British” to describe the U.S. customary system.* In common parlance, the terms “Imperial” or “British” are often used to represent the traditional units used within the U.S; however, because there are significant differences between many of these traditional measurement systems, NIST recommends use of the term “U.S. customary system of measurement” to describe the collection of non-SI measurement units currently used in the U.S. This parlance is frequently incorrectly employed in software, on websites, and in publications. To further eliminate this common misunderstanding between U.S. customary measurement units and British and Imperial units, additional explanation of the differences are provided in NIST Handbook (HB) 44,

“Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices,” Appendix B, “Units and Systems of Measurement” (<https://www.nist.gov/pml/weights-and-measures/publications/nist-handbooks/other-nist-handbooks/other-nist-handbooks-2-2>).

Implementing these recommendations, together with other mitigating actions being taken by NIST and NOAA, will facilitate the smooth transition and nationwide adoption of the international foot with minimal disruption. Additional resources providing greater detail about the history of the foot, problems encountered by having two definitions of the foot, and the benefits of making this change are available on the NIST U.S. survey foot website (<https://www.nist.gov/pml/us-surveyfoot>).

Authority: 15 U.S.C. 272(b) & (c).

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[FR Doc. 2020-21902 Filed: 10/2/2020 8:45 am; Publication Date: 10/5/2020]