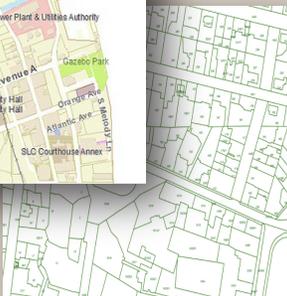

REPORT CARD ON THE U.S. NATIONAL SPATIAL DATA INFRASTRUCTURE

December, 2018

Addresses



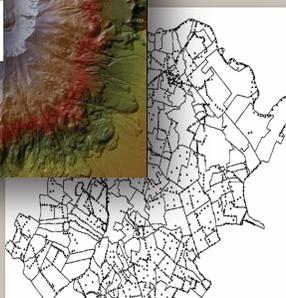
Cadastrals



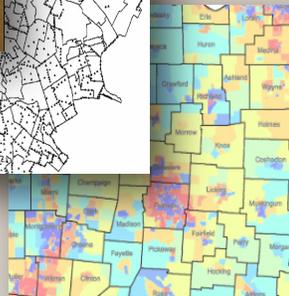
Elevation



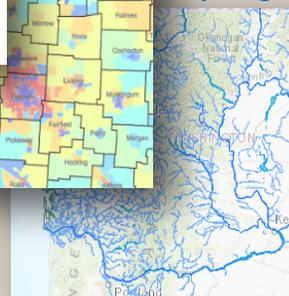
Geodetic Control



Governmental Units



Hydrography



Orthoimagery



Transportation



COALITION OF GEOSPATIAL ORGANIZATIONS

- American Society of Civil Engineers (ASCE)
- American Society for Photogrammetry and Remote Sensing (ASPRS)
- American Association of Geographers (AAG)
- Cartography and Geographic Information Society (CaGIS)
- Geographic Information Systems Certification Institute (GISCI)
- International Association of Assessing Officers (IAAO)
- Management Association for Private Photogrammetric Surveyors (MAPPS)
- National Society of Professional Surveyors (NSPS)
- National States Geographic Information Council (NSGIC)
- United States Geospatial Intelligence Foundation (USGIF)
- University Consortium for Geographic Information Science (UCGIS)
- Urban and Regional Information Systems Association (URISA)

FOREWORD

The Coalition of Geospatial Organizations (COGO) recognizes the individual contributions of all Federal, state, regional, tribal, and local government agencies that have worked in concert with the private and academic sectors to develop the National Spatial Data Infrastructure (NSDI) as it exists today. This work has spanned entire careers, and COGO applauds the sincerity of their efforts and the value of their contributions.

However, without the proper guidance, authority, or resources to do this important work, the Federal government has not been able to realize the NSDI Framework concepts that were first laid out in Executive Order 12906 in 1994. Without a strong National infrastructure, Federal, state, regional, tribal and local government agencies cannot together build the NSDI as it was originally envisioned.

COGO commissioned twenty-four content area Experts to develop this second Report Card for the NSDI. These Experts, drawn from the twelve member organizations of COGO focused on the NSDI Framework to grade National efforts, and candidly point to some of the shortcomings of those efforts. The twelve member organizations of COGO are shown at right (see also Appendix A). COGO offers its profound appreciation for the volunteer work completed by these Experts.

The COGO Member Organizations represent approximately 170,000 individual geospatial practitioners. Together, they are delivering this assessment to help Congress, the Administration, Federal agency executives, and others understand the shortcomings of the NSDI. The Member Organizations want to continue to engage Congress, Federal agencies, and the Federal Geographic Data Committee (FGDC) to discuss and identify common sense improvements that will lead to a more robust National Spatial Data Infrastructure.

COGO initiated this report card in June of 2017. The eight framework theme assessments were completed over the next twelve months. Five of the assessments were completed by December of 2017; the other three by June of 2018. From July to December of 2018 various parts of the report card were reviewed by the FGDC, members of the report card steering committee, and the twelve COGO member organizations. The result is that the assessments completed in 2017 cite resources available in 2017, while the later assessments cite more recent resources available in 2018.

COGO Member Organizations

American Society of Civil Engineers (ASCE)

American Society for Photogrammetry and Remote Sensing (ASPRS)

American Association of Geographers (AAG)

Cartography and Geographic Information Society (CaGIS)

GIS Certification Institute (GISCI)

International Association of Assessing Officers (IAAO)

Management Association for Private Photogrammetric Surveyors (MAPPS)

National Society for Professional Surveyors (NSPS)

National States Geographic Information Council (NSGIC)

University Consortium for Geographic Information Science (UCGIS)

United States Geospatial Intelligence Foundation (USGIF)

Urban and Regional Information Systems Association (URISA)

For more information on COGO, please see <http://www.COGO.pro/>

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Elevation Data Theme

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Hydrography Data Theme

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Orthoimagery Data Theme

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Roberta Lenczowski

Transportation Data Theme

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EXECUTIVE SUMMARY

Executive Order 12906 (April 11, 1994), stated that *“In consultation with State, local, and tribal governments and within 9 months of the date of this order, the FGDC shall submit a plan and schedule to OMB for completing the initial implementation of a national digital geospatial data framework (“framework”) by January 2000 and for establishing a process of ongoing data maintenance.”* Subsequent to Executive Order 12906, Framework projects have pursued, but not achieved, the concept of using “best available” locally-produced data sources.

The Federal government jump-started many of the innovations and collaborations that created the current geospatial environment. However, as noted in the 2009 National Geospatial Advisory Committee (NGAC) report *“The Changing Geospatial Landscape,”* the Federal government is no longer the dominant data producer. Federal providers of geographic information cannot continue to think of themselves as players separate from the community of private sector, state, local, tribal, and other stakeholders. The NGAC Report further stated:

- The detailed street maps that support Web-based mapping applications and in-car navigation systems can be traced to the innovations made by the Census Bureau approximately forty years ago.
- Nearly all the data, technology and applications we see today can be traced to innovative policies and government practices of the past. As such we require similar innovative policies now to keep pace with this remarkable sea change. In many cases these stakeholders have embraced technology and processes which have rapidly outpaced anything the federal government can provide. At a minimum, what is needed is a commitment to improved spatial data, recognition of the place of multiple stakeholders in this brave new world, and coordinated investment.
- The relative shifts in data production from the federal government to the private sector

and state and local government call for new forms of partnership. Furthermore, the hodgepodge of existing data sharing agreements are stifling productivity and are a serious impediment to use, even in times of emergency. There is an urgent need to reexamine the relationships between data providers and users to establish a fair and equitable geospatial data marketplace that serves the full range of applications.

In 2015, the Coalition of Geospatial Organizations (COGO) published the first COGO Report Card of the U.S. National Geospatial Data Infrastructure. The expert panel that conducted the first assessment offered the following recommendations:

- The concept of the Framework needs to be reaffirmed;
- A new model for framework data needs to be adopted, and must acknowledge the importance of local partners;
- The Federal Geographic Data Committee (FGDC) needs to emphasize that the Framework is part of its Strategic Plan, and that it will work in collaboration with non-federal and non-governmental partners to build an effective NSDI Framework.

In 2017, the FGDC released the National Spatial Data Infrastructure Framework, recognizing the changing role of the U.S. government in the development and integration of geospatial data that comprise the NSDI. In response to this changing role, the FGDC has implemented the Geospatial Platform, has established the Geospatial Interoperability Reference Architecture, and has developed the National Geospatial Data Asset (NGDA) portfolio management system that includes the Maturity Life-cycle of the NGDA data themes, as well as the eight Framework Themes that are assessed for this 2nd COGO Report Card.

The process utilized by COGO for the development of this 2nd Report Card differs from the process used for the 2015 Report Card in several

significant ways. For this Report Card COGO recruited a broader group of 24 content experts from the twelve COGO Member Organizations to conduct the assessments, engaged members of the FGDC throughout the assessment process, employed quantitative metrics that were used to evaluate the data framework themes, and assessed the Address Data Theme as an additional eighth framework theme. ***The primary goals of this evaluation are (1) to continue to bring attention to the need for current and accurate geospatial data for the United States, and (2) to engage the FGDC in a more collaborative assessment process.***

This evaluation examines the status of the eight Framework Data Themes that serve as the backbone required by users to conduct most mapping and geospatial analysis tasks. The overall view of the 24 assessment experts is that progress has been made toward a more integrated and accessible NSDI. The following are two observations expressed in the eight Framework Data Theme assessments in this report card:

- ***The FGDC has made significant progress in the NSDI since the publication of the 1st COGO Report Card.***
- ***The FGDC is employing a more consultative and cooperative approach to understand successes and shortcomings of the NSDI.***

To realize a more fully integrative and robust NSDI, the following recommendations are interspersed throughout the eight assessments:

- ***Identify sufficient funding to meet future needs of NSDI for all Framework Data Themes.***
- ***Develop Strategic and Implementation Plans for each Framework Data Theme.***
- ***Develop partnership agreements with States, Tribal governments, and local governments to facilitate continuous exchange of data.***
- ***Facilitate assessment of all stakeholder needs for Framework Data.***
- ***Develop processes and procedures for integrating Framework Data across all governmental levels.***

The overall grade assigned to the comprehensive NSDI Framework is B-.

The importance of geospatial technologies is demonstrated by our universal dependence on web maps, GPS navigation, and location-based systems. To support a myriad of decisions every day, citizens and public officials require online access to basic information about the location of streets, buildings, services, and environmental features.

The clear objective of the NSDI is to create a dependable utility that provides accurate, consistent, and current data to all users. The goals of the program are to:

- Reduce duplication of effort among agencies.
- Improve the quality of data and reduce costs for the acquisition of geographic information.
- Make geographic data more accessible to the public.
- Increase the benefits of using available data.
- Establish key partnerships with states, counties, cities, tribal nations, academia, and the private sector to increase the availability of geographic data.

The NSDI includes a number of connected components, including the technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve the utilization of geospatial data. As indicated in the first COGO report card, the cornerstone of the program is a common digital base map that would aggregate the best representations of fundamental data from all levels of government. These Framework data layers are intended to serve as the unified foundation upon which all other geographic information can be created and shared. By maintaining a standardized, high-quality series of Framework Data, the NSDI will provide access to reliable, current data from all of the above partners, not just Federal agencies. This will minimize duplication of effort and promote the use of the most complete and reliable information.

National Spatial Data Infrastructure (NSDI) Report Card

The Framework data layers included in this assessment include:

- *Address*
- *Cadastral*
- *Elevation*
- *Geodetic Control*
- *Governmental Units*
- *Hydrography*
- *Orthoimagery*
- *Transportation*

The status of these eight data layers is the focus of this second Report Card. This report reflects how well the NSDI is meeting its goals. The content experts that prepared this Report Card conducted both a qualitative and quantitative evaluation of the NSDI and its Framework data layers.

This assessment suggests that the governmental agencies charged with the stewardship of the eight Framework data layers face obstacles in terms of both authority and, more importantly, **funding**. The NSDI was designed to func-

tion within all levels of government. Often in today's environment the most accurate and current geospatial data are routinely collected by local government. Therefore, a successful NSDI demands that these high resolution data become part of the Framework. It is also imperative to recognize that the most consistent, nationwide information about roads and land records exist in proprietary databases that Federal agencies lease from commercial firms. These commercial data cannot become part of the NSDI due to licensing restrictions.

We are reminded, however, that the original vision and the greatest potential value of the NSDI Framework have not yet been fulfilled. While multiple datasets for each of the themes can be accessed through the National Geospatial Platform, definitive sets of nationally consistent, fully integrated, and reliable data do not exist for the entire nation. At a minimum, the Report Card suggests a compelling need for a thorough assessment of user needs and requirements for a modern data system.

REPORT CARD GRADES

The average grade for the eight Framework Data Themes is B-. Note that this is a national, overall assessment of the NSDI's ability to meet future geospatial data needs. The rationale for these grade assignments can be found in the remainder of this report.

PROGRESS REPORT: National Spatial Data Infrastructure (NSDI)

Theme	Custodian	Grade in 2015	Grade in 2018
ADDRESS DATA	CENSUS & DOT	N/A	B+
CADASTRAL DATA	DOI	D+	C-
ELEVATION DATA	DOI	C+	B-
GEODETTIC CONTROL DATA	DOC	B+	A-
GOVERNMENT UNITS DATA	DOC	C	A-
HYDROGRAPHY DATA	DOI	C	B-
ORTHOIMAGERY DATA	DOI & USDA	C+	B-
TRANSPORTATION DATA	DOT	D	C
OVERALL GRADE		C	B-

INTRODUCTION

The Coalition of Geospatial Organizations (COGO) serves as a forum for twelve non-profit member organizations and five advisory organizations concerned with national geospatial issues (see Appendix A). Collectively, COGO represents approximately 170,000 individual geospatial practitioners in the United States. The mission of COGO is to provide a forum for organizations concerned with national geospatial issues that improves communications among the member organizations, that provides educational information on relevant issues for their respective memberships, that aligns and strengthens COGO's respective policy agendas, and that facilitates development of strategies to address national issues.

In support of its mission, in 2013 COGO commissioned a Report Card on the National Spatial Data Infrastructure (NSDI) to focus attention on the overall condition of the NSDI and seven of its data themes. A similar type of Report Card assessment is conducted every four years by the American Society of Civil Engineers (ASCE), and is highly regarded as an effective way to monitor infrastructure improvements and deficits. COGO's first NSDI Report Card, researched over a two-year period was produced by an appointed panel of seven experts, led by former Wyoming Governor Jim Geringer. Published in February 2015, it highlighted both valuable strengths and considerable shortcomings within the NSDI and its data themes. Both the Federal Geographic Data Committee (FGDC) and COGO member organizations considered that it was a worthwhile assessment, while also acknowledging that it was an initial attempt through an unfamiliar process. Overall, the Report Card served its purpose to raise awareness of current NSDI inadequacies, and to foster discussions between COGO and federal agencies whose lead roles in NSDI development and curation had been evaluated.

Having a NSDI in place that lives up to its potential will be a positive benefit to the United States and to every COGO member organization, and public taxpayers. COGO is committed to having

the NSDI Report Card be as helpful a product as it can be, and its development workflow be fair and transparent, while not overly taxing any of the individual volunteers who dedicate themselves to its research and production. Thus in 2016 COGO agreed to develop a second Report Card, aiming at a potential 3-year return interval. The constructive criticism provided to COGO following the first Report Card was carefully and thoughtfully considered to ensure this 2018 assessment would be as robust, valid, and current as it could be.

The primary goal of this second evaluation continues to be raising attention about the need for current and accurate geospatial data for the United States. As was the case for the first Report Card, no cost estimates for completing the NSDI or for bringing the framework to a specified level have been estimated or included. However, a secondary goal in this second round was to engage the FGDC in a more collaborative assessment process. Hence there are three important ways in which this second Report Card differs from the first.

To begin, there was interest in broadening the base of experts involved in theme assessment. With this iteration, a group of 24 content experts were recruited from among the twelve COGO member organizations to evaluate the eight data themes included in this report. Each theme was evaluated by a team of at least two experts, some as many as four experts (see Appendix A).

Secondly, an important and valid criticism that emerged from the first Report Card process is that the FGDC had not been adequately involved in the development of assessment metrics or in the assessment process. To remedy this, members from COGO began discussions with members of the FGDC in summer 2016, and the two groups have continued to have regular exchanges. This allowed the FGDC to share key information with the content experts about the NGDA Portfolio Management Process, and to illustrate the Geospatial Platform Performance Dashboard and the Lifecycle Maturity Assessment. In addition to this, the FGDC provided 18 contacts from eight different federal agencies to serve as

National Spatial Data Infrastructure (NSDI) Report Card

resource people for each of the eight assessment teams (see Appendix A). Each assessment team interfaced with their respective resource people to ask questions, and to share preliminary assessments and receive feedback.

Lastly, the assessment metrics themselves have been modified. The qualitative metrics used in the first Report Card lacked measures that were sufficiently objective. In this second iteration, the original qualitative measures have been combined with quantitative metrics that have been developed for each individual data theme.

BACKGROUND

Calls for coordinated approaches to manage the survey and mapping data of the United States have long been part of the nation's history. In 1906, President Roosevelt signed an Executive Order (EO) establishing the U.S. Geographic Board that was to advise on projects, take measures to avoid duplication, and improve the standardization of maps. Over the next 84 years, numerous other Orders and Circulars were issued with related intentions. In 1990, the 1953 OMB Circular A-16 was revised to create the FGDC to "coordinate surveying, mapping and related spatial data activities and to promote the coordinated development, use, sharing and dissemination of surveying, mapping and related data across the Federal Government." A major objective of the Revised Circular was the eventual "development of a national digital spatial information resource with the involvement of Federal, state, and local governments and the private sector." A secondary objective identified the key need for criteria and standards that would enable the sharing and efficient transfer of spatial data between producers and users.

The 1990s was a time of significant forward movement in the development of the United States as an information society, and a linked recognition that an information society depended on spatial data and information. The National Research Council's Mapping Science Committee issued reports in 1993, 1994, and 1995 that addressed the concepts, needs, and potential contents of an NSDI, stating in one of its reports that

"The NSDI should be the means to assemble geographic information that describes the arrangement and attributes of features and phenomena of the Earth." The 1993 NRC Report, "Toward a Coordinated Spatial Data Infrastructure for the Nation," suggested that an ad hoc NSDI already existed but was in need of substantial formalization. Two specific goals and related actions were recommended: "first, to make the existing NSDI more coherent and coordinated; and second, to position the U.S. more competitively in the growing and increasingly international geospatial data and technology arena."

Apart from helping to define the NSDI, the NRC Mapping Science Committee Reports also specified four principles to guide its development:

- Data should be widely available.
- Accessing spatial data should be easy.
- The NSDI should be flexible and not dependent on current technology, data, or organizational structures.
- The NSDI should be a foundation to foster new applications, services, and industries.

The NRC Reports laid important groundwork for further federal action. On April 11, 1994, President Clinton issued EO 12906 that charged the FGDC to lead and coordinate the development of the NSDI. The EO broadly defined the NSDI as "the technology, policies, standards, and human resources necessary to acquire, process, store, distribute and improve utilization of geospatial data," language that came directly from the 1993 NRC Report. FGDC was given nine months to consult with state, local, and tribal governments to prepare a plan for the initial implementation of a national digital geospatial data framework, which itself was to be completed by January 2000.

THE CURRENT NSDI

The concept of the NSDI has evolved since the 1990s but much of the original vision of the NRC Reports and EO 12906 remains. Central is the understanding that geographic information promotes economic development, improves stew-

National Spatial Data Infrastructure (NSDI) Report Card

ardship of natural resources, and protects the environment. Coordination is another key tenet, with Clinton's EO stating that the FGDC "shall develop, to the extent permitted by law, strategies for maximizing cooperative participatory efforts with State, local, and tribal governments, the private sector, and other nonfederal organizations to share costs and improve efficiencies of acquiring geospatial data consistent with this order." Today, it is understood that the NSDI must be:

- A geographic resource for both the present and the future.
- A foundation for helping the public and private sectors use geospatial data for better decision making.
- A resource for many people and organizations working together towards common goals.
- A collection of current and accurate geospatial data available for local, state, national, and global use.
- An infrastructure for geospatial applications and services.
- A flexible resource that changes as technology, business requirements, and user needs change.

Infrastructures can be physical or cyber-based systems with sets of interconnected elements needed to carry out the operations of society, a single enterprise, or a group of enterprises. Like our transportation, banking, and financial infrastructures, a spatial data infrastructure such as the NSDI is an interconnected system designed to facilitate a state of cooperation and connectivity. This enables government, businesses, private institutions, and citizens to share and use spatial information and services to meet their basic operational needs. Thus, the purpose of the NSDI is to:

- Reduce duplication of effort among agencies;
- Improve quality and reduce costs related to geographic information;
- Make geographic data more accessible to the public;

- Increase the benefits of using available data; and
- Establish key partnerships with states, counties, cities, tribal nations, academia, and the private sector to increase the availability of geographic data.

To achieve its purposes, the NSDI is understood to include the "technologies, policies, organizations and people necessary to promote cost-effective production, ready availability, and greater utilization of high quality geospatial data among a variety of sectors, disciplines and communities" (DOI 2003). It should provide a common structure of practices and relationships among data producers and users to facilitate data sharing and use, as well as new ways to access, share, and use geographic data. As it has matured, it is increasingly understood that the NSDI must be comprised of multiple and connected elements including:

- Clearinghouses, catalogues, and portals for discovery and access;
- Metadata or information that captures the basic characteristics of data or information technology resources;
- Framework data (a reliable and standardized source of commonly used data);
- Thematic data developed and used for particular business requirements;
- Standards for geospatial data and technology—developed through voluntary, consensus-based processes to promote interoperability and effective sharing and use;
- Collaborative partnerships between the private sector, academia, and state, local, and tribal governments to efficiently and cost-effectively collect, integrate, maintain, disseminate, and preserve spatial data, building on local data wherever possible; and
- Public policies that promote greater public access to government data, data sharing, privacy protection, simplified and unified business processes, and reduced duplication of data collection and government services.

STANDARDS

Standards are a core element of the NSDI as are key to interoperability and effective sharing and usage geospatial data and technology. This Report Card will reference a variety of existing standards that have been endorsed by different standards development organizations, but each is important in providing a level of conformity and consistency. For example:

- FGDC-endorsed standards are required for use by Federal agencies;
- American National Standards Institute (ANSI) standards are required for use in the U.S. marketplace; and
- the International Organization for Standardization (ISO) develops international standards for products, services, and systems to ensure quality, safety, and efficiency; and to facilitate international trade.

Standards from any of these organizations - as well as technology standards and specifications from organizations such as the Open Geospatial Consortium (OGC) - may be appropriate for use by an organization. Standards may also move from national or governmental approval to international approval. A key part of the standards development and maintenance process of these recognized organizations is the periodic review of adopted standards. Reviews are conducted to determine if standards meet current user needs and are up to date with accepted practices and technology. Good management practices call for standards to be checked to ensure they are current prior to being promoted for use in major new NSDI initiatives.

THE FGDC AND THE PORTFOLIO MANAGEMENT APPROACH

To manage the NSDI and other federal geospatial resources with all of their complexity requires a tremendous amount of coordination and structure. In the mid-1990s, the FGDC adopted a Framework Approach that placed emphasis on 1) the most commonly used themes of geospatial

data; 2) procedures, technology, and guidelines that provide for integration, sharing, and use of these data; and 3) institutional relationships and business practices that encourage the acquisition, maintenance and use of data. In this way, the Framework incorporated all elements of the NSDI and progress on the Framework was illustrative of overall NSDI coordination and advancement. The NSDI Framework remains important to the continued development of the interconnected system that enables government at all levels, businesses, private institutions, and citizens to share and use spatial information and services to meet their basic operational needs.

The FGDC's Strategic Plan for the NSDI was adopted to update and modernize the strategic direction of Federal geospatial programs. The Strategic Plan sets priorities and describes the actions that the FGDC community will take, in collaboration with partners, to develop and maintain the NSDI. The three goals of the NSDI are to:

- Develop Capabilities for National Shared Services.
- Ensure Accountability and Effective Development and Management of Federal Geospatial Resources.
- Convene Leadership of the National Geospatial Community.

Each of these goals is highly relevant to the successful development of NSDI data themes as a resource for the entire geospatial community, though the plan otherwise lacks a focus on this core NSDI capability. One element for the NSDI in the FGDC Strategic Plan is the development and tracking of Performance Measures for each of the goals and objectives, something that had been absent from the Framework Approach. Such measures should facilitate implementation of the strategic plan as well as facilitate future external assessments such as this Report Card.

Meanwhile, the FGDC has also begun using a Portfolio Management Approach for its geospatial data, in accordance with the OMB Circular A-16 Supplemental Guidance. This business approach identifies Federal datasets

National Spatial Data Infrastructure (NSDI) Report Card

that could be considered National Geospatial Data Assets (NGDA). Assets of this type support mission goals of multiple federal agencies; are statutorily mandated; or support national or Presidential priorities as expressed by Executive Order or by the OMB. Framework data are not specifically identified as such in the Portfolio but are part of the construct of 16 Themes identified in the NGDA Portfolio.

The FGDC's 2014-2016 Strategic Plan and Portfolio Management approach appears to have diminished Federal emphasis on the Framework as a national resource and on the importance of state, local, tribal and private data as frequently comprising the best geospatial data available for use.

THE NSDI FRAMEWORK THEMES ASSESSED

Assessing the status of the entire NSDI would require significant funding and cooperation from all Federal agencies and is beyond the scope of a COGO initiative. However, focusing on eight framework data themes that are recognized as the backbone of the NSDI is appropriate and feasible. The importance of these data themes as fundamental building blocks of the NSDI has been recognized since the issuance of EO 12906. The Strategic Plans have focused upon data, as one component within the three goals of the 2005 NSDI Future Directions Initiative. Seven of the Themes are ones that COGO had included in its 2015 Report Card, and they are selected again for this assessment. The Address Data Theme is an additional eighth theme.

Importantly, these same data are often in high demand by businesses and agencies for their operations and systems. Data are often collected by multiple organizations within a particular level of government, or between levels of government, resulting duplication of effort. Companies or organizations that cannot access the right data, or afford the costs of data collection and production, will simply use outdated or unreliable data, resulting in inaccurate information

and less effective decision making. This COGO Report Card is intended to help address the need for accessible, accurate spatial data. Such data could be provided efficiently from a reliable and standardized source for the eight most commonly needed and used spatial data themes

The NSDI Framework has the following eight designated themes of data. Two of these themes, Elevation and Cadastral, each contains two sub-parts.

ADDRESS DATA THEME

Custodians: Census and DOT

The Address Theme consists of the data elements, attributes, and metadata that specify a fixed geographic location by reference to a thoroughfare or landmark, or specify a point of postal delivery, or both.

CADASTRAL DATA THEME

Custodians: DOI-BLM (land) & BOEM (offshore)

Cadastral information refers to property interests. Cadastral data represent the geographic extent of the past, current, and future rights and interests in real property. It is the spatial information necessary to describe the geographic extent, and the rights and interests in property includes surveys, legal description reference systems, and parcel-by-parcel surveys and descriptions. The offshore cadastre is the land management system used on the Outer Continental Shelf. It extends from the baseline to the extent of United States jurisdiction. Existing coverage is currently limited to the conterminous United States and portions of Alaska. The maximum extent of United States jurisdiction is not yet mathematically calculated.

ELEVATION DATA THEME

Custodians: DOI-USGS (terrestrial), & DOC-NOAA (water)

Elevation data provide information about terrain. Elevation refers to a spatially referenced vertical position above or below a datum surface. The Framework includes the elevations of land surfaces as well as the depths below water surfaces (bathymetry).

National Spatial Data Infrastructure (NSDI) Report Card

GEODETIC CONTROL DATA THEME

Custodian: DOC-NOAA

Geodetic control provides a common reference system for establishing the coordinate positions of all geographic data. It also provides the means for tying all geographic features to common, nationally-used horizontal and vertical coordinate systems.

GOVERNMENTAL UNITS DATA THEME

Custodian: DOC-Census

Governmental Units include boundary data of the nation, states and statistically equivalent areas, counties and statistically equivalent areas, incorporated places and consolidated cities, functioning and legal minor civil divisions, Federal and state recognized American Indian reservations and trust lands, and Alaska Native regional corporations.

HYDROGRAPHY DATA THEME

Custodian: DOI-USGS

Hydrography data include surface water features such as lakes and ponds, streams and rivers, canals, oceans, and shorelines. Each of these features has the attributes of a name and a feature identification code.

ORTHOIMAGERY DATA THEME

Custodians: USDA-FSA (leaf-on) & DOI-USGS (leaf-off)

Orthoimages are positionally correct images of the Earth. An orthoimage is a georeferenced image prepared from an aerial photograph or other remotely sensed data from which displacements of images caused by sensor orientation and terrain relief have been removed.

TRANSPORTATION DATA THEME

Custodian: DOT-BTS

Transportation data include the following major common features of transportation networks and facilities: roads, trails, railroads, waterways, airports, ports, bridges, and tunnels.

ASSESSMENT METHODOLOGY

CRITERIA

The following general criteria developed and used in the first report card assessment were used in this second assessment. These assessment criteria are modeled on the assessment criteria used by the ASCE Report Card for America's Infrastructure. These criteria are used in the following eight sections for each of the individual Framework data themes. Each assessment has additional objective metrics, particular to that assessment, that were considered in the evaluations. These objective metrics are outlined in each Framework Theme assessment.

CAPACITY

The Framework's ability to meet current and future demands:

CONDITION

The existing or near-term condition of the Framework themes as an integrated whole.

FUNDING

The funding capability of the Framework.

FUTURE NEED

Whether future-funding prospects will be able to meet the need.

OPERATION AND MAINTENANCE

The ability of key lead organizations to develop and maintain the Framework and to adopt new technology, procedures, and standards.

PUBLIC USE

The Framework's ability to provide data resources that meet the everyday needs of organizations.

RESILIENCE

The ability of the geospatial community to participate in development of the Framework and to contribute to its sustainability as a long-term asset of value for the nation.

GRADING SYSTEM

The following explains the grading system that was used in this 2018 report card, as well as the 2015 report card:

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A = FIT FOR THE FUTURE

The data theme is generally in excellent condition and meets the needs for the present and the future. Few geographic areas of the nation require attention. Standards for data and assured public access are met. Specific data are identified as Framework and are integrated for use consistently across the United States. Data identified as Framework are also in a standards-based form that can be readily incorporated into an integrated Framework data network across the United States. Users are able to easily identify, integrate, and use data from this theme in a wide variety of applications.

B = ADEQUATE FOR NOW

The data theme is in good to excellent condition, but some geographic areas of the nation require attention for significant deficiencies. A substantial majority of the theme data that have been designated as Framework follow appropriate standards and are available. Data identified as Framework is integrated for use consistently across the United States and can be incorporated into an integrated Framework data network with minimum work by users. Users are able to find, integrate, and use data for a majority of U.S. locations.

C = REQUIRES ATTENTION

The data theme is in fair to good condition, but it requires attention for many geographic areas of the nation. Standards for this data theme exist and are used for most of the data that are designated as Framework. Users have some difficulty finding, integrating, and using data, and a consistent integrated network for this theme is not in place across the United States. Significant effort will be required to incorporate data identified as Framework into an integrated Framework data network. Some locations in the U.S. are missing Framework data for this theme.

D = AT RISK

The data theme is in poor to fair condition and mostly below the goals envisioned for the NSDI. A large portion of the data for this theme have not been developed sufficiently to make them accessible, or are unable to be integrated with other data from this theme. Standards exist for

data designated as Framework for this theme, but the standards are not being consistently used among data providers and developers. For many locations, data are not useful without significant work by the user and cannot be integrated into a network for consistent use across the United States.

F = UNFIT FOR PURPOSE

The data for this theme is in an unacceptable condition and provides little to no value to users. Standards for the data theme do not exist or are not being used by most of the users, providers, or data developers. Most of the data cannot be found or used in applications at national or local levels and cannot be integrated into either a network for the theme or an integrated Framework data network for use across the United States.

I. ADDRESS DATA THEME

EXECUTIVE SUMMARY

The Address Theme is the newest element of the National Spatial Data Infrastructure, approved in 2016. As such this evaluation provides an initial view of the Theme, and identifies opportunities for the further development of the theme's foundational documents (Strategic Plan, Implementation Plan), and looks at the initial efforts on Standards and the development of a National Address Database (NAD), both of which were started well in advance of the actual establishment of the Theme itself.

At present, the Theme is off to a good start, but it also appears that it would be beneficial if the Theme stakeholders reviewed the results of the initial US Department of Transportation pilots, and then completed work on the Strategic and Implementation Plans for the theme. The NAD project should complete a comprehensive plan for the development, operation, organization, funding and on-going maintenance of the NAD, to help ensure its success. It is clear that without a permanent, dedicated funding source and budget, it will be difficult for the NAD to be sustained.

THEME GRADE: B+
ADEQUATE FOR NOW

I. DESCRIPTION OF THE FRAMEWORK

A. An Introduction to the Theme

The Address Theme was added to the National Spatial Data Infrastructure in August, 2016. Over the past 10 years, many stakeholders in the NSDI have recommended adding addresses to the NSDI given their ubiquitous nature, and widespread use by local, state and federal governments. Existing national address databases are limited, and many of the more complete data sets are subject to legal restrictions and cannot be used by the public (for example, Census's Master Address File, the IRS's and Social Security databases of taxpayers and Social Security card holders, and the U.S.P.S. DSF file based on privacy issues,)

Development of a complete and open address database for the entire United States is a daunting exercise. By law, address assignment is pri-

marily a function of local government, either a municipal (city, town, village, township, etc.) or county government. However, there are exceptions to this, including land held by Native American nations, state and federal governments, and certain other entities. This arrangement means that there are somewhere between 20,000 and 30,000 different agencies that assign and maintain address information within the United States.

Further, addresses themselves are not subject to national or state-imposed standards for assignment. Each local jurisdiction creates its own set of rules for the assignment of address numbers and street names. In general, these rules are followed, but over time, various anomalies are created. Often the addressing rules and system are poorly documented and understood. Assignment of addresses and street names is generally a task within the processes of land subdivision, property development, and/or permit issuance for individual buildings and structures.

The assignment and maintenance of addresses at the local level results in considerable variation in the quality, completeness, accuracy and currency of address data. Additionally, methods for storage of this information range from paper maps and documents to highly sophisticated relational databases and digital mapping systems. Even within the digital systems, variations in data schemas, field naming conventions, and levels of normalization lead to difficulties in sharing and aggregating data from multiple jurisdictions into a single database.

B. The Theme Definition

The Address Theme consists of the data elements, attributes, and metadata that specify a fixed geographic location by reference to a thoroughfare or landmark, or specify a point of postal delivery, or both. The address theme does not include information about occupants or addressees nor does it include the attribute information about any features that may be specified by an address point. The address theme may include linkages to these feature attributes and other location reference methods.

C. Lead Agency and Current Activities

Census and Department of Transportation (DOT) jointly share this Theme Lead. They have formed a subcommittee to develop a definition, strategic plan and implementation plan. Monthly meetings have been held since the fall of 2016 shortly after the Theme was added to the NSDI by the FGDC.

D. Collaboration and Partnerships

The Address Theme Subcommittee has invited numerous members of the geospatial data community, along with many federal agencies to participate in the development of the definition and strategic plan. URISA, NSGIC, and NENA participate through representatives as external resources. Several State GIS/Address coordinators are also regular external members of the committee, and a few local government representatives also attend. URISA's representatives include the original authors of the FGDC Address Standard.

E. Standards

The FGDC United States Thoroughfare, Landmark and Postal Address Data Standard (FGDC-STD-016-2011) is currently being updated. This Standard was originally endorsed in 2011, and has been adopted at the Federal level, and by some state and local environments.

A profile of this standard outlines a basic scheme at the international level (19160-1:2015). An update is currently underway. Two other profiles have been developed for the FGDC Standard: 1) a profile for conformance with the United States Postal Service Publication 28, which provides guidance for placing an address on a mail piece (letter or parcel), and 2) the Civic Location Data Exchange Format (CLDXF) standard developed by the National Emergency Number Association. The CLDXF standard is for addresses contained within an emergency (E-911) call record. It is dependent on a full address repository that meets the FGDC standard. This means that address data using the FGDC Standard is quality tested, and formatted for exchange using the XML protocol contained in the standard.

F. Estimate of Theme Completeness

Theme Elements:

- 1) Definition: Complete
- 2) Supporting subcommittee: Complete
- 3) Strategic Plan: Not yet complete, scheduled for 2018
- 4) Business Requirements Analysis: In progress through a Subcommittee sub-group.
- 5) Implementation Plan: No formal plan in place yet. Development of the National Address Database (NAD) is seen as the primary goal of initial implementation, and activities are underway. The U.S. DOT has done some pilot projects. However, the business requirements for the NAD are still being developed. Pilots have informed the process by indicating what data are available. State governments have submitted data. The NAD content was initially developed by DOT as a result of the Pilot study. Census is currently leading the Address Content Subgroup of the Address Subcommittee to re-evaluate and

make new recommendations on NAD content. The NAD was made publicly available in April 2018 at <https://www.transportation.gov/nad>.

6) Data sets: Data is still being continuously developed at local level. Address assignment and maintenance of addresses is a local government function. Aggregation to state and federal level is in early stages. Some Federal agencies, notably Census, U.S. Postal Service, Social Security, and some others have extensive address lists, used for their business purposes. No systematic evaluation of the quality or completeness of these lists has been made.

At this point, beyond the development of the NAD, there is no specific strategic or implementation plan for Address Theme development. However the development of a strategic plan has been identified as a goal.

G. Accessibility of data

Data accessibility varies widely, and is governed by a variety of laws and regulations.

Federal Level: Census addresses are restricted to Census use only by Title 13 of the U.S. Code. Addresses held by some other agencies are considered non-public because they are contained in records linked to the names of individuals. This includes IRS, Social Security, and others. Many other agencies, including HUD, FEMA, Homeland Security, FBI, Education, Consumer Finance Protection Bureau, and others have address data that is generally considered for internal use only. The Postal Service does make some lists of its customers' addresses available for a fee.

State Level: States have some address data, collected from local governments who are the address authorities. In the last 10 years, various programs, including Broadband Access, and NG-911 have prompted states to assemble state-level address data. Some of these data have contributed to pilots for the NAD. NSGIC has been working to survey this information.

City/County Level: Cities and Counties are the originators of addresses across the United States. However, the management of address data varies widely. Virtually all jurisdictions have addresses for residential property and commercial, industrial and public uses. These are used for numerous purposes in local governments ranging from emergency dispatch, to property assessment, utility services, voting, schools, business licenses, building permits, public health and many others. Data are often scattered among the individual departments responsible for different functions, and lists vary widely in terms of completeness, quality and the manner of storage. Sharing of data among the internal agencies of a single municipality or county is often difficult, and address data may not be held in a manner that permits easy public access. This includes addresses recorded only on paper or Mylar (hard-copy) maps, in spreadsheets or even text files, and within proprietary applications used for specific business purposes (such as Computer Aided Dispatching, Permitting, Computer Assisted Mass Appraisal (CAMA)), and asset management systems. Billing systems for utilities, taxes and fees also often contain addresses, but are not optimized or organized to make address data accessible.

Some local governments have developed separate, complete and accessible address repositories that contain all known addresses within the jurisdiction. These are usually contained within relational databases linked to GISs that can provide both tabular and graphic representations of the addresses along with other information (such as feature types, metadata, etc.) for public consumption.

Tribal: Many of the tribal governments have been working to develop basic addressing systems for the lands they control. However, as noted in the NAD Pilot Project Findings Report, acquisition of data from Tribal Nations and Councils is likely to be somewhat problematic.

Private Sector: Numerous private companies, both in the parcel delivery industry (e.g., FedEx, UPS, mailing vendors, etc.) and navigation industry (e.g., Tom-Tom, Google Maps, Apple

Maps, Navteq, etc.) maintain proprietary databases of addresses. There are private sector companies that acquire address data from numerous government and non-government sources, collate the results, and provide subscription-based services for profit. These are not generally available in bulk to the public, but individual address ranges, or numbers appear on digital maps through browser or mobile interfaces. Other private sector companies with significant address data include utility companies (electrical, natural gas, water, telephone/cable/internet providers, etc.). Again, these are proprietary customer databases, and are not available to the public.

H. Authority, Governance, and Management of the Theme.

The Census Bureau and the Department of Transportation jointly administer the Theme. There is an active Theme Subcommittee consisting of interested Federal agencies (NTIS, Education, Homeland Security, HUD, NPS, FBI, Dept. of Justice, BLS, Dept. of Labor, OMB, Social Security, USPS, Consumer Finance Protection Bureau, Dept. of Energy, FEMA, USGS, and others) and participants from professional associations, state and local government agencies and private sector companies. The Address Subcommittee has formed an Address Workflow Subgroup to identify and recommend potential workflows for development and maintenance of Address Theme data. The Subcommittee has also formed an Address Content Subgroup to re-evaluate the minimum address content and other possible tiers of desired or optimum content for inclusion in the NAD.

II. NAD STATUS

As previously discussed, the development of the NAD is the primary implementation strategy for the address theme. The initial conceptualization of the NAD occurred beginning in 2013 following the adoption of the FGDC Standard. Both Census and the Department of Transportation (DOT) held workshops on the potential methods, costs, and strategies for development of a NAD. State, local, private sector, and Federal agencies were included in these workshops.

DOT began collecting data sets from state governments in 2015 as part of a pilot to test various assumptions about data [1]. The report lays out a simple schema for address data in Appendix 5, partly based on the FGDC Standard, and partly (for at least 2 elements, Place Name, and Sub-address) on the CLDXF Standard.

Data were initially collected from Arizona, Arkansas, and Boone County, MO. Other states also submitted some address data for use in testing including Virginia, New Jersey, Washington, DC, Utah, and subsets of data for selected counties in both Ohio and Missouri. At the present time, DOT reports that data have been received from 20 states with 3 more pending. Two additional states have reported having complete data sets, but that those data sets are not publicly available. Of the data received from the 20 states, Arizona, Colorado and Maryland withheld data from Counties that refused to participate in the NAD. Missouri has only provided partial data. There has not been a determination of how often this data will be updated. **Figure 1** illustrates the status of the data in the NAD for the United States [2].

At present, the NAD is being developed in partnership with the States, and it is expected that there will be data from all states that are willing to enter the partnership by the end of 2018. DOT is assisting the partner states in developing Extract-Transform-Load (E-T-L) protocols to transform local data into the NAD Schema. These will be made available through Github.

III. NAD ASSESSMENT AND DISCUSSION

A. What are the business requirements that are driving a National Address Database?

The NAD working groups are preparing a report based on the Federal users Requirements workshop that was held in 2017. However, it should be noted that there has not been any formal, systematic investigation of the needs for a national address data set at the State, regional, tribal or local government levels [3]. Assuming that

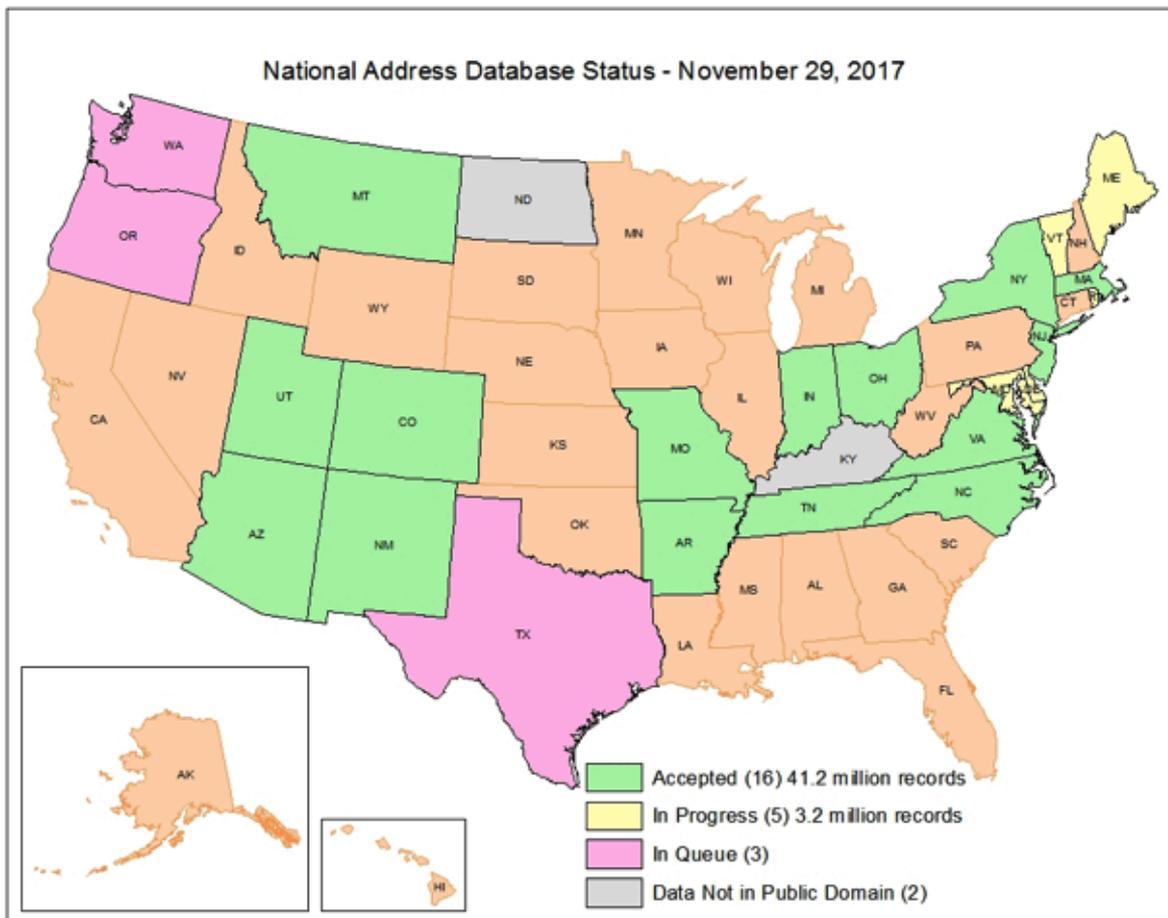


Figure 1. National Address Database Status

the cooperation and participation of these other levels of government is desirable, we would recommend further study of how the business needs of these agencies can be supported or met by the NAD. Further it will be important to incorporate additional data fields or views of the data that are identified as critical attributes of the addresses to support all levels of users.

B. How is the effort towards a NAD being conducted, and does it recognize and incorporate known business needs?

The NAD effort has focused largely on collecting available data from State governments along with a few local governments. Further activities by the Address Theme leads and Address subcommittee include workflow processes for the NAD, user requirements workshop for Federal agencies, and discussion with some commercial vendors, associations such as NSGIC and NENA about what the NAD should be. The current

direction is to see what data are available, and to extract a sense of functional requirements from that.

Given the somewhat fragmented state of address data, largely due to its origin at the local level, and the lack of formal standards for address data until the last few years, this approach does not ask some important questions: what would agencies at all levels of government, and the private sector, like to be able to do with address data if it were standardized, and widely and publicly available? A simple list of all addresses in the United States (including territories, etc.) with geographic coordinates is useful, but without attributes that define how these address data can be used, it's unlikely that it's potential value will be realized. Further, until a maintenance process is defined, and the tools developed, keeping these data current and accurate will be a very difficult task. The Census Bureau is currently

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leading the Address Content Subgroup of the Address Subcommittee to re-evaluate and make new recommendations on NAD content.

C. What are the business needs at each level of government (local, state, tribal, federal, territorial)?

This is still in the process of definition. A workshop was held in February 2017 to identify Federal Requirements. A report of this workshop was completed in January, 2018 and is available via fgdc.gov, the address theme community page.

D. What is the mechanism of participation for locals, states, tribal governments, territories, and the Federal government?

At present, all have been invited to participate in the Subcommittee meetings, and to provide input. Participation is voluntary. A number of states, and a few local governments have offered to participate by providing existing data. These data are being aggregated into a single repository by the DOT. The very simple data schema in use is partially consistent with the FGDC Standard, and also uses some elements found in the CLDXF Standard (which does not have a data schema). Most of the optional attributes that

contribute to quality control, record-level metadata, and feature description/ identification, as well as relationships among addresses, were not included in the pilot schemes used for the NAD. While represented in the scheme, it is not clear at this time what additional data may be identified as required, recommended, desirable, or optional; what additional attribute data are available but not being collected (or volunteered), or what is the quality and completeness levels of the data provided.

There is no current study of how to finance the NAD on a long-term basis, or how to encourage or ensure or require the participation of the states or local governments.

E. What is known about the current condition of address data at each level?

At the Federal level, most of the major address stakeholders are well known. However, no study has been made to review the current condition of the data (quality, timeliness, accuracy). At the State level, NSGIC provided a survey in 2015 of states, who self-reported their address data. This information is summarized in **Tables 1 and 2**. This survey is in the process of being updated

Table 1. NSGIC 2015 Geospatial Maturity Assessment Question 23 (about completeness of statewide address points)

Level of Completeness	Have No Program	0%	1-25%	26-49%	50-74%	75-95%	96-100%
Number of States	13	7	1	1	2	11	16

Table 2. NSGIC Geospatial Maturity Assessment 2015 Question 24 (About Statewide Address Point Database)

	Yes	No	N/A	No Response
Program in place to collect from locals	23	6	1	23
Designated Data steward	29	2	0	23
Data is publicly accessible w/o restriction	19	11	1	22
Data layer available on public web mapping service	19	11	1	22

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As of this time, we do not have information about how the data will be collected nor how it will be stored, or made accessible in an ongoing manner. Without clear answers on these questions, it is difficult to predict the success of a NAD. Pilots are being undertaken, but as yet the governance and maintenance procedures for the NAD have not been identified. These are critical to the maintenance of quality in the data themselves.

IV. RECOMMENDATIONS

The following recommendations are consistent with the factors and outcomes noted in the NAD Pilot Projects Findings Report, the NSGIC Geospatial Maturity Analysis, and discussions with local, state and federal officials who create, manage and maintain address data. There is a:

- 1) Need to complete the Theme Strategic and Implementation Plans.
- 2) Need to focus on state and local business requirements for NAD before investing too heavily in assembling of data. Adjustment of data schema may be required.
- 3) Need to develop methodology for data collection, aggregation, and quality assurance.
- 4) Need to develop methodology and workflow for update processes.
- 5) Need to identify costs at each level for support of the NAD (data creation, data aggregation, data maintenance, data publication, overall administration)
- 6) Need to identify sources of funding for all costs.
- 7) Need to identify the agency responsible for the maintenance of the NAD. Census is not a likely candidate, in spite of their considerable experience in working with address data on a national level, due to the restrictions placed on the agency under the privacy requirements of U.S. Code Title 13.
- 8) Need to develop partnership agreements with States, tribal governments, local governments, and others to insure continuous exchange of data.

9) Need to identify and implement educational materials, training courses, and other information resources to assist participants in delivering quality data to NAD at a minimal expenditure of time and cost.

10) Need to identify other activities that promote good address practices, uses, and integration with other types of geospatial and tabular data in Federal, Tribal, State and local governments, and in the private sector. This may include training, tools, and collaboration on best practices that can be shared among the stakeholders.

References

- [1] Department of Transportation, National Address Database Pilot Project Findings Report, 9/20/2016.
- [2] Source: Steve Lewis, US DOT, co-Chair of Address Theme Subcommittee, provided this map on November 30, 2017. Used with permission.
- [3] While the NGAC report discusses local requirements, they are couched in terms of what the Federal government's agencies require local governments to provide in the way of address data. No analysis of how address data is used locally is included in the report. The NSGIC 2014 review of the needs of local, state and federal government agencies for address data lists a number of different uses that locals have (assessment, NG-911, voter registration, schools, permits, utilities, etc.), but there is no description of what data might be needed as a part of an address record, beyond the address string itself, and the coordinate position, to support those needs. More work on this area is clearly necessary to justify the costs of implementing the NAD and maintaining it.

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II. CADASTRAL DATA THEME

EXECUTIVE SUMMARY

The 2015 NSDI report card assigned a D+ grade for the cadastral data theme. In the three year span since, measurable progress has occurred that warrants an upgrade to C-. A comprehensive parcel database covering public and private lands still does not exist. However, on the public side marked improvement has occurred with other components of the cadastral framework. These components along with improvements at local and state levels give reason for hope and a justification for grade improvement. The 2015 assessment remarked that perhaps the cadastral data theme should be considered for removal from the framework layers and be re-addressed as a separate significant issue. However, future improvements in the cadastral theme are best served by its continued inclusion as an NSDI framework theme. The geospatial community at large must continue to advocate for the need to improve the cadastral theme.

THEME GRADE: C-
REQUIRES ATTENTION

I. DESCRIPTION OF THE FRAMEWORK

A. An Introduction to the Theme

Property ownership has been at the heart of American Democracy from the beginning, and remains a fundamental part of how local government is able to function and support community needs. The local property tax continues to be a primary source of local government funding, with property parcels and their records management remaining a mostly local responsibility. This tax becomes an annual lightning rod of interest for obvious reasons. County Courthouses and Land Offices have always been open to the public too, because it was important to assure whoever wanted to examine the records to check that assessments were fair across a community, sharing the load so that everyone participated in financially supporting common community needs. Roads, schools, and public safety being the common top items funded by local property taxes.

It was deemed so important that these records be above reproach, that it was typical to have a checks and balances system where multiple elected officials participated in managing the annual assessment rolls of property ownership. Annual certification was a serious official undertaking with consequences for errors or omissions. As these records management tasks have been automated, the checks and balances aren't as obvious, but statutes and regulations are still in place to audit for completion, correctness and fairness. A key component in local property assessment is the annual taxpayer review and protest processes, requiring that local property records remain open and accessible to the public.

Local municipalities and utilities are also daily users of property information to manage their operations and assets in a community. Though it isn't yet common everywhere for parcel level data to be shared directly with local entities, digital mapping along with web services and records management systems are improving the opportunity to share current parcel information

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across these jurisdictional and business boundaries. Ideally, a local parcel management system would become as robust as the multi-purpose cadastre as envisioned since the 1970s. Recognizing that parcels and property information is a valuable resource beyond merely assessment functions, there is a growing recognition that parcel level information is a fundamental underpinning of information for communities in our locally-focused democracy. Viewing, analyzing and comparing the information in this theme is undeniably critical to the democratic process of ensuring fair and equitable taxation.

Paying for Your Schooling and Much More

The assessor is recognized as the authoritative source for land records data for both government agencies and the private sector (IAAO, 2015). Property or cadastral data is shared with financial, insurance and real estate agencies for modeling markets or other means of manipulation. Non-assessment functions of government agencies may also rely on cadastral data for property taxation and local funding sources may provide a locational means for distribution of school funding or other budgeted special social programs. These data along with other supplemental data sources may be utilized to assess the impact they have on a particular geographical area.

Cadastral maps are essential for local governments to efficiently and effectively identify, list, and value property for property tax purposes. Location identification attributes such as address or parcel identification provides a unique identifier for joining additional data collected by the assessor and to visualize geographical relationships. Cadastral maps also provide efficiency in understanding proximity to other phenomena, and are utilized within other government entities such as planning, engineering, and environmental management. A national data system would allow for the standardization of data sources to compare and contrast locational impacts on both government and non-government phenomena. To sum it up appropriately, municipal and county government rely heavily on the revenue generated from property assessment and that function is driven by parcel data.

According to a 2017 National Center for Education Statistics report, forty-five percent of elementary and secondary public school revenues across the US were from local sources, with only nine percent coming from the federal government. In some states, the reliance on local revenues, namely the local property tax, is much greater. For example, the local property tax accounts for more than fifty percent of revenue for public schools in Nebraska and Illinois, with the national average being thirty-six percent. Here, the local property tax provides funding for budget items like teacher salaries, building and equipment maintenance, and projects such as building new schools. Although not all states fund their schools in exactly the same manner, the responsibility of K-12 education falls upon the states, with many heavily relying on the local property tax to fill in the gaps. The importance of the local property tax is particularly apparent when considering the public school enrollment rate is expected to increase up to forty percent in some areas. This means that public schools across the US will need to rely on a consistent and reliable source of funding, the kind that is provided by the local property tax. The majority of public education funding comes from local sources.

A Geographic Measure of the U.S. Economy

Today we live in an information and data driven society. Whether for an industrial prospect asking questions on a state level, or a small community dealing with a commercial developer, we need information now. The old adage “Knowledge is Power” has never been more true in our world of split second decision-making and fast paced business development. Every expansion, relocation, or new start-up factors in real estate location. The quicker an economic development prospect can be handed information the more likely that community will get to the next level in the economic development process. The ability to respond rapidly with high quality information may make the difference in whether a prospect chooses to locate in a community, bringing jobs and commerce, or whether that community is passed over for the next community who has their information resources readily available.

Cadastral information is the currency driving those decisions.

The necessities of site characteristics such as power, water and transportation access are typical items used in site selection or expansion, however other factors at play, including administrative boundaries such as taxing districts and the configuration of the individual tax parcel itself, frames many business decisions. Real estate parcel data effectively becomes a digital billboard allowing expansion, relocation, and site selection decision makers to preview what communities have to offer.

It is indisputable that no other component of the nation's geospatial framework is more closely linked to the economic prosperity of the United States. Out of all of the themes of the National Spatial Data Infrastructure a real estate parcel is the only one immediately measurable by a sales price. No other framework theme measures the geography that is bought or sold. Considering commercial real estate alone from the *Economic Impacts of Commercial Real Estate, 2017 Edition* highlights include:

- Commercial real estate development supported 6.25 million American jobs in 2016 (a measure of both new and existing jobs).
- Commercial real estate development contributed \$864 billion to U.S. GDP.
- Commercial real estate development generated \$264.4 billion in salaries and wages.
- There were 410.1 million square feet of commercial real estate space built in 2016, with capacity to house 1.1 million new workers.

For all these reasons cited above, the lack of a standardized, comprehensive and accessible view of the nation's real estate is recognized as harmful. Property ownership was a fundamental underpinning of the U.S. democracy from the beginning, indeed a prerequisite to participate as a voter until 1856, when North Carolina was the last state to remove property ownership as a requirement to vote.

Parcels of property are bought and sold, representing a major economic contributor to local

economies. The majority of parcels are a locally originated and managed theme. The value of these lands is the source of local public education serving our national interest. This theme maps the unit of geography closely tied to more jobs and economic prosperity than any other. It is regrettable our nation has not yet fully developed the theme that is an official record of public and private rights and interests in its vast lands.

B. The Theme Definition

The cadastral theme is defined as, past, current, and future rights and interests in real property including the spatial information necessary to describe geographic extents. Rights and interests are benefits or enjoyment in real property that can be conveyed, transferred, or otherwise allocated to another for economic remuneration. Rights and interests are recorded in land record documents. The spatial information necessary to describe geographic extents includes surveys and legal description frameworks such as the Public Land Survey System, as well as parcel-by-parcel surveys and descriptions. However, it does not include Federal government or military facilities.

C. Lead Agency and Current Activities

The Bureau of Land Management (BLM) is the lead agency for the cadastral theme. BLM and the FGDC Cadastral Subcommittee provide government-wide leadership for cadastral data coordination that is carried out under the policy guidance and oversight of the Federal Geographic Data Committee.

Under the National Geospatial Data Asset (NGDA) program's concept of shared portfolio management, the FGDC created a comprehensive listing of cadastral elements under federal authority. This guides BLM's stewardship by identifying 21 different cadastral data sets (**Table 1**) managed by nine different agencies: the Bureau of Land Management, the Bureau of Ocean Energy Management, the Army Corps of Engineers, the Department of Defense, the Bureau of Indian Affairs, the National Parks Service, the Fish and Wildlife Service, the Forest Service, and the USGS.

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Table 1. BLM Dataset Stewardship

Cadastral Theme NGDA Datasets	NGDA Agency
Administrative Boundaries of National Park System	DOI-NPS
Army Military Land Tracts (AMLT)	DOD-USACE
BIA Indian Lands Dataset (Indian Lands of the United States)	DOI-BIA
BLM National Public Land Survey System Polygons	DOI-BLM
BLM National Surface Management Agency Area Polygons	DOI-BLM
BLM National Surface Management Agency Special Public Purpose Withdrawal Area Polygons	DOI-BLM
BLM National Surface Management Agency Withdrawal Area Polygons	DOI-BLM
Department of Defense Land Parcels and Sites	DOD-AT&L
FS National Forest Dataset (US Forest Service Proclaimed Forests)	USDA-USFS
FWS Interest	DOI-FWS
Outer Continental Shelf Active Renewable Energy Leases	DOI-BOEM
Outer Continental Shelf Lease Blocks - Alaska Region NAD83	DOI-BOEM
Outer Continental Shelf Lease Blocks - Atlantic Region NAD83	DOI-BOEM
Outer Continental Shelf Lease Blocks - Gulf of Mexico Region NAD27	DOI-BOEM
Outer Continental Shelf Lease Blocks - Pacific Region - West Coast NAD83	DOI-BOEM
Outer Continental Shelf Official Protraction Diagrams - Alaska Region NAD 83	DOI-BOEM
Outer Continental Shelf Official Protraction Diagrams - Atlantic Region NAD 83	DOI-BOEM
Outer Continental Shelf Official Protraction Diagrams - Pacific Region - West Coast NAD 83	DOI-BOEM
Outer Continental Shelf Official Protraction Diagrams And Lease Maps - Gulf Of Mexico Region NAD27	DOI-BOEM
Outer Continental Shelf Block Aliquots - Atlantic Region NAD83	DOI-BOEM
Protected Areas Database of the United States (PAD-US)	DOI-USGS

Absent from all of the federal structure, is any component representing the rights and interest of privately held lands. The lack of understanding by those interested in a national fabric of parcel data lament the federal government has not been successful in the objective of building a national theme. The opposite circumstance may also be true. Federal lands along with state lands are exempt from the real estate assessment process so there may be instances where the state and federal real property assets are not mapped in the local databases because they contribute limited value to the local government function of assessment.

The area where BLM has exercised its authority best, is in the role of standards development. That leadership has been essential in the progress of the cadastral framework.

D. Collaboration and Partnerships

As reported in the Report Card on the National Spatial Data Infrastructure (2015):

“The Federal Lands Workgroup, which includes representatives from USFS, BLM, NPS, FWS, Census, USGS, BOEM, BIA, BOR, and DoD....is focused on the development and maintenance of a parcel-level federal lands geodatabase that can be used to meet common federal agency needs.”

Towards that goal, the Federal Lands Workgroup (FLWG) has made significant progress. Building on the USGS Protected Area Database (PAD-US), the FLWG defined feature classes and data translation protocols for compiling all federal-level land management data directly into PAD-US. This has been a huge task. PAD-US

National Spatial Data Infrastructure (NSDI) Report Card

now contains 3 billion land and water acres managed by more than 15,000 agencies (Federal, State, and NGOs) in over 150,000 separate parks and protected areas in the United States and its territories. The PAD-US development team manages all of the data in ArcGIS in a file geodatabase, which categorizes fee and private lands, designation areas, easements, and marine protected areas. It is currently updated on an annual basis.

While the PAD-US database does not meet all of the NSDI recommended requirements for federal parcels, it does provide a solution for federal agencies that utilize Geographic Information System (GIS) technology and manage land and/or submerged lands. The PAD-US geodatabase model can be revised to accommodate federal parcels that do not specifically share the “protected” designation. The geodatabase model also accommodates non-federal data, and the participation of non-federal partners in this effort addresses the recommendation stated in the report card that “local stewards” be involved.

As reported in the report card, the Bureau of Ocean Energy Management (BOEM) maintains the offshore cadastre. The Official Protraction Diagram and the Supplemental Official Block Diagram are the primary mapping products that reflect the offshore cadastre. Not mentioned in the report card is the fact that BOEM generates and maintains two official offshore boundaries: the Submerged Lands Act boundary (which divides Federal and State ownership of submerged lands and waters) and the Section 8(g) Revenue Zone boundary, which defines the zone whereby revenues derived from energy development projects are shared between coastal states and the Federal Government. In 2014, BOEM began the development of the Boundary Delineation System to support a transition from antiquated non-GIS mapping tools to a graphic user interface (GUI). The new data model has been designed to service all areas of the United States including its territories and possessions. The data model utilizes multiple geodatabases to store the offshore cadastre (block and boundary) data. The geodatabases are based on individual zones of the Universal Transverse Mercator

projection. Storing the data in geodatabases, which is a common GIS format, ensures that the data can be imported and exported between the Boundary Delineation System and the non-spatial BOEM Technical Information Management System, as well as other GIS applications and/or report systems. A total of forty-two (42) geodatabases will be constructed to accurately map all Outer Continental Shelf areas of the United States. Cadastral data for the Atlantic, Pacific, and Alaska Regions has already been successfully imported into the Boundary Delineation System geodatabases. The BOEM now has the databases and tools needed to efficiently generate accurate offshore boundaries, and a map production system that will quickly provide the products required for energy development on the Outer Continental Shelf.

E. Standards

The Cadastral Subcommittee was one of the first FGDC subcommittees to create and publish a data content standard for a Framework data theme. This standard was the Cadastral Data Content Standard for the National Spatial Data Infrastructure, FGDC-STD-003-2008. The approved 2008 standard is available at: <http://nationalcad.org/download/cadastral-data-content-standard-ver-1-4.pdf>

According to the Cadastral Subcommittee:

“The Cadastral Data Content Standard is intended to support the automation and integration of publicly available land records information. It is intended to be useable by all levels of government and the private sector. The standard contains the standardization of entities and objects related to cadastral information including survey measurements, transactions related to interests in land, general property descriptions, and boundary and corner evidence data. Any or all of these applications are intended to be supported by the standard. The standard is not intended to reflect an implementation design.” (FGDC, 2008)

In addition to the cadastral content standard the sub-committee supports a Cadastral Reference Document revised in 2012 <http://nationalcad.org>.

National Spatial Data Infrastructure (NSDI) Report Card

[org/download/CadastralNSDIReferenceDocument.pdf](#). This work is pivotal because it set the context for a core of cadastral content, specifically framed as a publication standard. By recognizing a set of minimum content criteria it provided a target for state and local entities to aim toward.

The International Association of Assessing Officers (IAAO) has the greatest influence over local government in assessment. They foster education, technical standards, consulting services and many other resources for the property valuation and tax policy community. They adopted the “Standard on Digital Cadastral Maps and Parcel Identifiers-2015” http://www.iaao.org/media/standards/Standard_Digital_Cadastral_Maps_2015.pdf. This standard provides specific guidance to local government on many aspects of parcel map conversion, best practices, and specifically data content. While this is not a federal standard its influence is significant over the local cadastral data producers.

IAAO standards are consistent with the Cadastral Sub-Committee concept of a core data set by suggesting that local Assessors should try to capture this information and make this core data set available. This is how IAAO framed the status:

“It is important to recognize that publication data are not the same as operation and maintenance data or production data. Production data are structured to optimize maintenance processes, are integrated with internal agency operations, and contain much more detail than publication data. Publication data are a subset of the more complete production data and are intended to be integrated across jurisdictional boundaries and be presented in a consistent and standard form nationally. To the extent that assessors consistently capture and make available parcel core data, this goal will be attainable.”

The Cadastral Sub-committee work on the publication core standard and IAAO voicing a similar position in 2015 for local stakeholders paves the way for states to execute on the roll-up concept for integration, publication and wider access to all. These developments also support the merit for raising the grade of the cadastral theme.

F. Estimate of Theme Completeness

From the 2015 report card, “It is estimated that there are approximately 150 million parcels that define the privately owned property in the United States and another 8 to 10 million that represent public lands. Surveys conducted by the FGDC Cadastral Subcommittee suggest that about 123 million or 82% of the private parcels are “GIS ready.” Since Federal lands constitute about 650 million acres or about 28% of the land area, there are only about 55% of the U.S. land areas with parcels that are “GIS ready.” In addition, the National States Geographic Information Council (NSGIC) GMA estimated that 17 states have no program for developing statewide parcel data.”

So what has changed? The 2017 total parcel count for the U.S. is estimated at 151,500,000. The total parcel count has grown by roughly one million, which illustrates that a national cadastral layer will require continual maintenance. This component of the theme may achieve complete geographic coverage but will always remain in a state of continual maintenance. This point makes a compelling argument that parcels combined with address points are the most dynamically changing components of national geospatial data assets. The 2017 NSGIC GMA result show 11 states with no program for developing or maintaining parcel data. Twenty-four states reported having a systematic program in place to collect this data from local government, 25 having a state designated steward for this layer, 14 have the data publicly accessible without restriction, 21 have the data available on a public web mapping service, and 24 report the data is available in a standardized format.

The counties where digital parcel data exists represent a total parcel count of 146,372,780 parcels, which equates to 97% of parcels in counties where GIS data has been developed. That figure is up from 82% in the 2015 assessment. This is not to say that 97% of parcels in the U.S. are mapped, but are located in counties where they are GIS ready and likely to be mapped.

Additionally, the 2015 report noted that Core-

National Spatial Data Infrastructure (NSDI) Report Card

Logic, one of the leading commercial suppliers of parcel data at that time could supply parcel data covering 2,658 counties, accounting for 140.8 million parcels, 137.1 million of which are actual parcel boundaries. Fast-Forward to 2017 and those figures have risen to 3,092 counties, 151.4 million parcels nationwide, and 144.6 million respectively. This growth parallels the increase in the public sector supply chain.

G. Accessibility of data

With over 50% of the parcels in the nation that are maintained by local governments now not only in digital form, but being ‘rolled up’ into statewide databases, it seems appropriate to revisit the mechanics by which the federal government might access local property information.

At a recent gathering of the NSGIC member states provide an annual report of major accomplishments they want to highlight for their peers, and attendees. The reports focus on strategic activities where the state has invested significant time and resources. The following nine states released this news:

- Alabama’s Department of Revenue is coordinating with the State GeoHub to pull together statewide parcels.
- Iowa is working toward a statewide aggregated parcel service. Next steps would be a public facing version.
- North Carolina just completed a semi-annual, statewide refresh cycle for parcels covering 100 North Carolina counties.
- Massachusetts approves statewide structure & process requirements for local parcel data rolled up to the state GIS Office.
- Missouri reporting they are developing a method for acquiring a statewide parcel layer for use by state government.
- Texas announces they are beginning a statewide land parcel and address database.
- Vermont announces the establishment of a statewide parcel data program, staffed by one full time employee, and cooperative support from six state agencies.

- Washington State completes streamlined development of statewide parcel layer coordinated with counties.
- Wisconsin says they just released version three of their statewide parcel file.

These states join many others already engaged in rolling up and aggregating parcel data to then be published for consumption through State GIS data clearinghouses. Assuming this trend will continue, there are numerous advantages of using these data rather than harvesting local government working files accessible on the internet. Indeed this work isn’t complete, but the trend has progressed rather quickly over the last two years, and may be a more reliable resource for a number of reasons.

States are rolling up local property data to serve some state functions more efficiently than dealing directly with each local assessment office that is maintaining property data, so they too have similar criteria to what the National Academy of Science, Mapping Science Committee identified as guiding principles for NSDI development:

1) Data should be widely available. These statewide roll ups will often be in a form of an annual ‘certified’ assessment roll of all the properties in a state. States will be looking to normalize the local data, perhaps a distilled version as well that isn’t just for assessment and taxation purposes.

2) Accessing spatial data should be easy. There are often state standards for local assessment data to follow, and as data are received the state aggregators will also need to somehow normalize the various schemas so that it is more readily used for state functions that cross jurisdictional lines. Rather than duplicate that effort at a federal agency level, it would be advisable to use these statewide spatial databases that have been through some level of authenticity, normalization, and even certification. Even though not current daily, if indeed that level of need existed, the only way is to work directly with the local jurisdictions to assure the federal need is getting correct and complete data at that point in time.

3) The NSDI should be flexible and not dependent on current technology, data, or organizational structures. The processes that states would be using in their aggregation of local data are independent activities in each state at this point. There are also many interested parties that have interest in seeing the above criteria followed to assure continuing access to this valuable data for local, regional, multi-state as well as federal needs. The organizational structures that would be the steward of this periodically rolled-up database are just being identified, but a common theme is that it is an abridged version of the public property record for a wide range of public, government and commercial users. Indeed though, only dealing with 50 entities rather than 3,000 to 4,000 to acquire this piece of the NSDI would seem preferable from a data quality perspective as well as being more efficient.

4) The NSDI should be a foundation to foster new applications, services and industries. Integrating cadastral data normalized into a single, authoritative source used by others at a local, regional and state level for various governmental functions has many current and future benefits. To date there has been substantial progress in direct accessibility of these data at the local level. With 3,223 jurisdictions reporting, 2,058 indicate they have some form of parcel data viewer online, with 747 having a form of parcel data download available, and 1,979 counties having some level of parcel data available via a REST service endpoint. Add to this picture the status of statewide parcel aggregation reported at 2017 NSGIC Fall Conference (see above), it is apparent that there has been substantial improvements since 2014, which can be expected to continue, especially with respect to accessibility. Overall accessibility of the theme has improved.

H. Authority, Governance, and Management of the Theme.

Governance for this strategic asset is federated much like other aspects of the framework. At the federal level under the FGDC structure the BLM has the responsibility for this theme. The

BLM has used its role to establish standards, and has improved the skeleton of the cadastral theme through their leadership on the Public Land Survey System. However, they do not have funding appropriations from Congress for state and local data, or authority over state or local entities that are charged with the stewardship of the cadastral theme at the primary transaction level.

The transaction level of this theme — the buying, selling and subdividing of the private lands is governed at the local level. This is where the picture of the complete parcel data rests. The nation's system of land tenure is recorded at that local level for the public good by the recorders of deeds, and then mapped for discovery and equitable valuation by the Assessors who perform the ad valorem assessment process. The other level of governance over the theme is at the state level where the state has a regulatory role in the oversight of the ad valorem process.

Typically the state provides some guidance that may include standards on the content and structure of information associated with real estate records used in the assessment process. There are only a few examples where the state led parcel map conversion. The local processes of assessment have remained at the local level, but map conversion took place at the state level. Montana, Tennessee and Maryland represent examples of this state driven conversion and maintenance process.

A single authority governing all the components of the cadastral theme across the nation might be ideal. However, this structure simply does not fit the reality of the federated system that is in place.

This assessment recommends that the state roll-up initiatives outlined earlier be taken into consideration as a valuable improvement in the integration of cadastral data. It is further recommended that the state organizations that are leading these efforts be contacted, and that effort be extended to the benefit of both the state aggregators, stewards and the lead federal agencies.

II. CADASTRAL DATABASE ASSESSMENT

Incremental progress has occurred, yet there remains no national program to create a sustainable and equitable funding program for the development and maintenance of parcel data. This framework category requires attention because there are significant geographic areas of the nation lacking local parcel data. These areas have not made the leap to convert the paper based tax maps to a digital structure of polygons representing the tax parcels. It is also worth noting that many existing digital local government cadastral data sets need to be upgraded because they are not sufficiently accurate, complete or current. Despite numerous uses of local cadastral data by the federal government there is no recognizable federal incentive that tips the balance for local parcel conversion. Thus, in order for the nation to achieve substantial progress for this theme at this point in time, state and local leaders must continue to finance their efforts without federal funding.

While users can find PLSS, federal lands and protected areas through portals assembled by the BLM, the Federal Lands Working Group, and other users cannot find a single point of aggregation, distribution or viewing of both public and private lands. A consistent integrated network for this theme is not in place across the U.S. To be fair, there are many pieces of foundational activity that assist state and local government parcel conversion. The Bureau of Land Management (BLM) has facilitated and (or) completed the standardization of the Public Land Survey System (PLSS) for all 30 PLSS States in fiscal year 2016. Fifteen States saw significant updates and enhancement in 2016. The Cadastral Subcommittee of the FGDC has a Strategic Plan in place to continue improvements that will enhance the theme for both public and private lands:

https://cms.geoplatform.gov/sites/default/files/a16cadastre/Cadastral_Strategic_Plan_Final_April_2017.pdf

Part of the strategic plan suggests that federal

agencies do not have the authority to collect or maintain parcel data on privately managed lands. While this may be true, many federal agencies need a comprehensive view of the cadastral fabric. Such a comprehensive view would have facilitated the emergency response of FEMA, NOAA and HUD following the disastrous season of hurricanes that have damaged substantial portions of Florida, Texas and Puerto Rico. Each agency has processes that would have been enhanced if local parcel data were consistently and widely available.

The federal strategic plan is aiming for an inventory of available parcel data and hopes to facilitate state efforts to aggregate and standardize data for non-federal lands. One of their objectives is to complete a parcel data web service standard. Web services can be used to provide authoritative data from local data producers to map services. These steps can shine a light on the remaining areas of the nation where conversion must occur. A catalog of parcel web services will provide quick access to the data when and where it exists. The desire of all stakeholders to improve on this theme is unquestionable but the will, and resources require attention.

Another major step forward includes the nation's progress for the nation's interests along the oceans. The Official Offshore Cadastre, generated and maintained by BOEM, is a comprehensive spatial data infrastructure whereby rights, restrictions and responsibilities in the marine environment can be assessed, administered and managed. The offshore cadastre includes the lease block grids and various offshore boundaries, which provide the base for nearly all of the BOEM offshore maps and leasing processes. It also gives BOEM the means to define, describe, analyze, and account for every acre/hectare of federal offshore submerged lands. In 2016 - 2017, the offshore cadastre was transferred from a tabular (non-spatial) database to geodatabases, which are used in a GIS format. BOEM also recently completed the first official maps reflecting the federal waters offshore of Hawaii.

III. RECOMMENDATIONS

The lack of comprehensive national cadastral database remains a significant impediment. There are still many areas of the nation lacking adequate cadastral data representing private lands. The previous report card highlighted a significant national issue associated with the mortgage crisis of 2008 and 2009. It went on to describe how cadastral data might have been used as a barometer on predatory lending practices. The lack of complete parcel data did not allow for analysis that could have predicted the financial collapse of the mortgage market. Congress responded with the Dodd-Frank Act. It modified the Home Mortgage Disclosure Act (HMDA). Congress authorized the Consumer Financial Protection Bureau (CFPB) for regulatory rule writing that could potentially modify the data collected under HMDA. Congress required the CFPB to gather higher resolution data and to ensure there was a unique identifier, with discretion to add what they deemed appropriate. Congress wrote in the law, “(H) as the Bureau may determine to be appropriate, the parcel number that corresponds to the real property pledged or proposed to be pledged as collateral;” It’s apparent the Congress intended for the reporting to have a unique identifier for property, and not necessarily a geographic polygon.

In reading the final rules adopted by the CFPB, property addresses were used rather than a parcel number. The rules highlighted some key issues that represent some technical challenges associated with a national parcel database. Commenters noted that collecting postal address, while imperfect, is the best available option because it is less burdensome to report than reporting a local parcel number that uniquely identifies most properties. Commenters also noted the current absence of a national universal parcel numbering system. A few commenters representing specific geospatial vendors recommended collecting both postal address and local parcel information. They explained that this would allow the Bureau, using both the reported address and local parcel information, to establish a national parcel database with mapping capabilities. Some of these commenters noted that col-

lecting this information would also facilitate the creation of a national parcel numbering system.

In the period between 2015 and 2017 there have been 308 Federal Disaster Declarations recorded by the Federal Emergency Management Agency. It is certain the response and recovery activities for many of these disasters would have benefited from access to a cross-jurisdictional view of parcel information. Undoubtedly this would also be true for mitigation activities as well, and it’s reasonable to ask yet again why, when such important matters are at stake would our nation not have a complete view of the parcel fabric?

Finally, in regards to impact there is the loss of economic opportunity for those areas where the cadastral data doesn’t exist or is inadequate. Those areas are at a competitive disadvantage in the areas of community and economic development work that fuels job growth, and prosperity for local economies.

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III. ELEVATION DATA THEME

EXECUTIVE SUMMARY

This committee assigned a grade of B- for the Elevation Theme. Nation-wide medium and low resolution topographic elevation data are available for public download and dissemination through The USGS National Map. High resolution 3D elevation is publicly available for a majority of the populated and coastal areas within the United States. While work continues to assure baseline high resolution elevation data for the remainder of the Country, additional efforts are required to procure data in the western US. Bathymetric data of U.S. Coastal areas and the Great Lakes is also available for use by mariners, and is rapidly collected after large storm events for recovery efforts and maritime navigation assistance. The grade of B- recognizes excellent progress and leadership while highlighting that gaps in high- resolution topographic coverage remain and adequate future funding is in question.

THEME GRADE: B-
ADEQUATE FOR NOW
(HOWEVER STILL REQUIRES ATTENTION)

I. DESCRIPTION OF THE FRAMEWORK

A. An introduction to the Theme

High quality elevation data are critical to flood risk management, infrastructure management, resource management, conservation, energy, agriculture, emergency response, and many other nationally significant applications.



Figure 1. 2014 Landslide, Steelhead Haven, Washington

On March 22, 2014 a large landslide buried about 40 homes and other structures, blocking State Route 530 and resulting in 43 fatalities in the community of Steelhead Haven near Oso, Washington, receiving national media attention (<https://www.usgs.gov/news/revisiting-oso-landslide>) and rejuvenating national interest in high resolution elevation data. Mud flows ravaged Southern California in early 2018, causing at least \$177 million in property damage, at least 20 fatalities, and 163 injuries. These and similar

natural disasters highlight the critical importance of high quality public elevation data (<https://www.gislounge.com/LiDAR-used-help-natural-disaster-mapping-management/>).

Significant work has been done to better leverage budgets, to better coordinate data collection efforts, and to better collaborate across various levels of government. The result has been a substantial increase in density, accessibility, and usability of public elevation data as compared to the previous report card.

A large volume of elevation metadata can

be accessed through the United States Inter-agency Elevation Inventory (USIEI), located at <https://coast.noaa.gov/inventory/>. This comprehensive, nationwide listing of data sets identifies elevation data available from all major Federal agencies including USGS, NOAA, United States Department of Agriculture (USDA), Federal Emergency Management Agency (FEMA), and the United States Army Corps of Engineers (USACE), as well as several state and regional agencies that have chosen to share their data.

NEEA Study

The USGS 3D Elevation Program (3DEP) initiative is based on the results of the National Enhanced Elevation Assessment (NEEA) Study, which was completed in 2012. The NEEA Study clearly documented the need for national high resolution elevation data, indicating that enhanced elevation data can generate \$13 billion in new benefits annually for 602 mission critical activities. Realizing this benefit required significantly better data than was currently available. The benefits apply to flood risk management, agriculture, water supply, homeland security, renewable energy, aviation safety, and other areas. The USGS and NOAA are currently immersed in the 3D Nation Requirements and Benefits Study, a follow-on study to guide the next generation of 3DEP investment and elevation products and services.

3D Nation

Elevation data have been unified by the vision of a 3D Nation, “from the tops of the mountains, to the depths of the seas, to include our inland rivers and lakes.” Leadership is provided by the 3D Nation Elevation Subcommittee, formed by FGDC in 2015. This subcommittee is led by the United States Geological Survey (USGS) for topography and National Oceanic and Atmospheric Administration (NOAA) for bathymetry. The concept of 3D Nation serves as a unifying structure for all national elevation efforts, and provides a consistent set of standards and objectives for an authoritative foundation to support national needs.

Currently the National Oceanic and Atmospheric

Administration (NOAA) and the United States Geological Survey (USGS) are conducting a follow-on study to the NEEA Study entitled ‘3D Nation Requirements and Benefits Study’ (hereafter called the 3D Nation Study) which is scheduled to be completed in 2019 (<https://my.usgs.gov/confluence/display/3DNationStudy/3D+Nation+Requirements+and+Benefits+Study>). The purpose of the 3D nation study is to understand inland, nearshore and offshore bathymetric data requirements and benefits, to plan for the next round of 3DEP after completion of nationwide coverage—next gen of 3DEP products and services, and to gather technology-agnostic user information to be able to assess new technologies. More information can be found at the web site <https://communities.geoplatform.gov/ngda-elevation/3d-nation-study/>.

The 3D Nation Study continues the practice of program development and government investment based on a set of requirements and benefits defined by the stake-holder community. The study is articulated as an objective in the FGDC Elevation Theme Strategic Plan: A draft of the plan can be downloaded from: https://communities.geoplatform.gov/ngda-elevation/wp-content/uploads/2018/04/Elevation_Theme_Strategic_Plan20160926.pdf.

2018 COGO Elevation Survey

In an effort to represent its constituents in this report card more effectively, the 12 COGO member organizations issued a survey in April 2018 to its members (hereafter called the Elevation Survey) to evaluate members’ perception of the state of public elevation data. The results of that survey have been incorporated into this report and disseminated to the Elevation Theme lead agencies. Summary results of the Elevation Survey are included at the end of this assessment.

B. The Theme Definition

Elevation data provide height position of a horizontal location on the earth’s surface, typically relative to sea level. Elevation normally describes bare earth positions but may also describe the top surface of buildings, vegetation structure, or submerged objects.

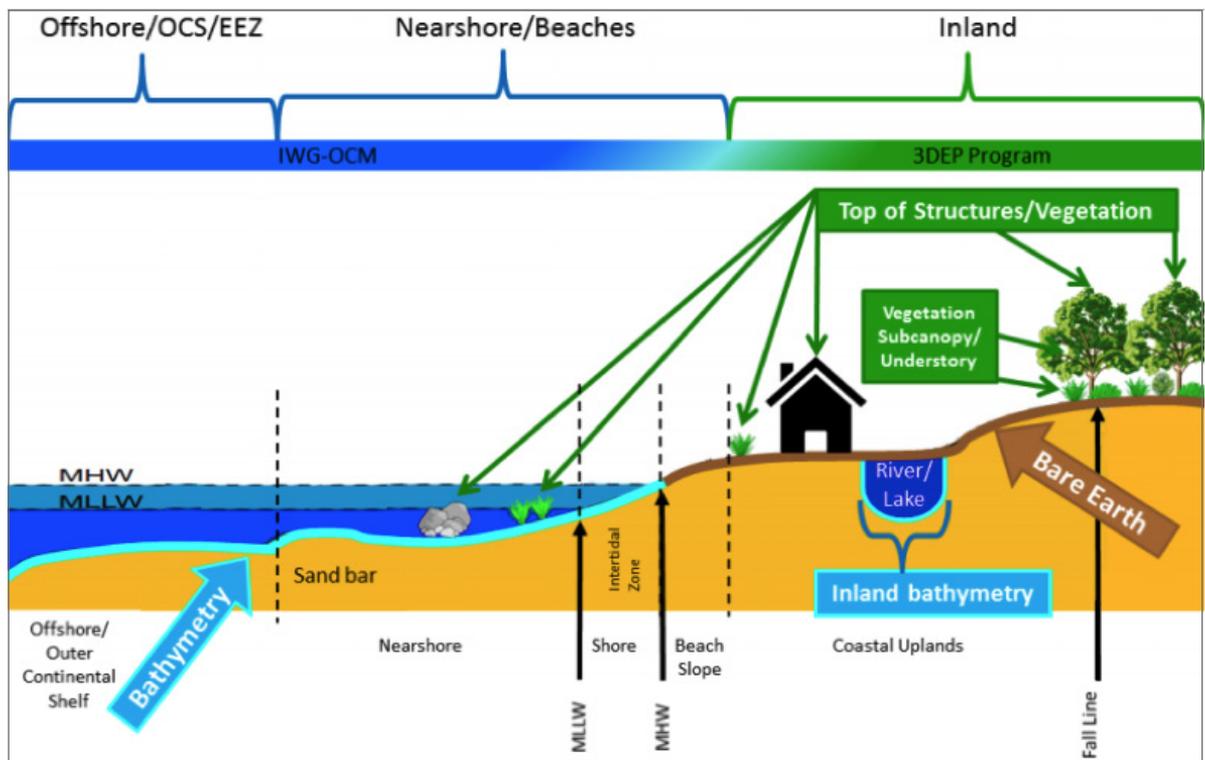


Figure 2. https://communities.geoplatform.gov/ngda-elevation/wp-content/uploads/2017/11/3DEP_IWGOCM_3DDDataRequirementsGraphic_3_27_17-e1529625743552-768x482.png

Elevation data can be formatted as a three-dimensional array, or as a continuous surface such as a raster, a triangulated irregular network, or as contours. Elevation data may also be represented in other derivative forms such as slope, aspect, ridge and drainage lines, and shaded relief maps. The Framework includes the elevations of land surfaces (topography) and the depths below water surfaces (bathymetry) (**Figure 2**).

Terrestrial Topography

United States Elevation Data have historically been represented as contour lines and bare earth digital elevation models (DEMs) in The National Map (<https://nationalmap.gov/>). For over 15 years, the elevation layer of The National Map was the National Elevation Dataset (NED), providing seamless coverage of the conterminous United States at 1/3 or 1-arc-second resolution (approx. 10 or 30 meters) and coverage of Alaska at 2-arc-second resolution (approx. 60 meters).

The DEMs comprising the NED remain widely used, but their coarse resolution renders them

unsuitable for many applications including aircraft and autonomous vehicle navigation, land surveying, construction, precision agriculture, and topographic mapping. In addition, NED water bodies are flattened for aesthetic appeal, with no bathymetric coverage for hydrologic modeling except at the largest scales and are therefore unsuitable for applications such as watercraft navigation, flood modeling, and hydrologic design.

The 3D Elevation Program (3DEP; <https://nationalmap.gov/3DEP/>) was developed to address this need for higher resolution elevation data (**Figure 3**). The legacy NED has been renamed and incorporated into The National Map, alongside high resolution 3DEP products now available for some regions (https://nationalmap.gov/3DEP/3dep_prodavailability.html). The 3DEP strategic plan is available here: <https://pubs.usgs.gov/circ/1399/pdf/circ1399.pdf>.

With 3DEP fully operational beginning in 2016, light detection and ranging (LiDAR) and interferometric synthetic aperture radar (IfSAR) data



Figure 3. 3DEP collaborators.

(in Alaska) are now the primary collection methods for elevation data. These technologies also provide opportunities for measuring, mapping and monitoring not only the bare earth surface, but above ground features as well. As a result, USGS provides the classified LiDAR point clouds and digital elevation models (DEMs), or in Alaska IfSAR data over every area where data have been acquired for 3DEP. Contours derived from these elevation data are also used in the US Topo digital topographic maps (<https://national-map.gov/ustopo/index.html>).

Three bare earth DEM layers in 3DEP are nationally seamless and are distributed in geographic coordinates at 1/3, 1, and 2 arc-seconds. Two high resolution layers over the conterminous U.S., 1/9 arc-second and 1-meter, are seamless within projects but not across projects. The 1-meter bare earth DEM data set is derived from the current high resolution 3DEP data and continues to grow as new data are acquired. IfSAR acquisition in Alaska is 98% complete in support of a state-wide 5-meter DEM. Alaska is partially covered by a 5-meter DEM that will eventually become the highest-resolution elevation data set over the entire state. Each of the seamless bare

earth DEM layers are derived from the highest quality DEMs available for any geographic location within the conterminous United States, Alaska, Hawaii, Puerto Rico, U.S. territorial islands, Mexico and Canada. The extent of geographic coverage varies by layer.

Bathymetry

The term “bathymetry” originally referred to the ocean’s depth relative to sea level, although it has come to mean “submarine topography,” meaning the depths and shapes of underwater terrain. In the same way that topographic maps represent the three dimensional features of overland terrain, bathymetric maps illustrate the submerged terrain.

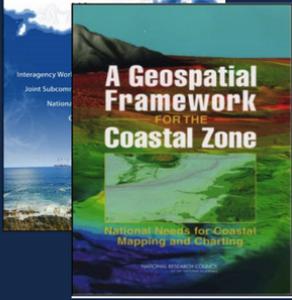
Bathymetry provides the primary spatial component of the science of hydrography. In combination with the characteristics of tides, currents, weather, and the chemical properties of the water itself, hydrography supports the Nation’s great dependence on safe navigation and maritime commerce, and our understanding of and resilience to flood risks and sea level rise. Bathymetric mapping is typically conducted through acoustic [sonar] mapping, with satel-

**The Interagency Working Group
on Ocean and Coastal Mapping (IWG-OCM)**

WHO:

- NOAA
- USGS
- USACE
- NAVO
- BOEM
- NSF
- NGA
- USCG
- EPA
- FEMA
- NASA
- USDA

▪ and other appropriate Federal agencies involved in ocean and coastal mapping.



**A Geospatial Framework
FOR THE
Coastal Zone**

National Needs for Coastal Mapping and Charting

- Co-chaired by NOAA, USGS, and USACE
- Charged with facilitating “the coordination of ocean and coastal mapping activities and avoid[ing] duplicating mapping activities...”

Figure 4. Interagency Working Group on Ocean and Coastal Mapping

with the coordination of ocean and coastal mapping activities, and is co-chaired by NOAA, USGS, and USACE. The IWG-OCM coordinates and collaborates on bathymetric data acquisition, end-to-end data management, and maximizing data re-use (**Figure 4**). Many IWG-OCM agency mapping products can be accessed online through NOAA’s Digital Coast website (<https://coast.noaa.gov/digitalcoast/>).

lites, aerial photogrammetry, and topobathymetric LiDAR support. Hydrographic surveys form the foundation for NOAA’s Electronic Navigation Charts (ENCs), guiding mariners much as road maps guide motorists. Bathymetry also helps the U.S. Army Corps of Engineers ensure that federal navigation channels are maintained to their authorized depths. In addition, bathymetric data can be searched through the USIEI and NOAA’s National Center for Environmental Information web sites <https://www.ngdc.noaa.gov/mgg/bathymetry/relief.html>.

NOAA ENCs and Raster Chart Products can be accessed online. Raster charts portray water depths, coastlines, dangers, aids to navigation, landmarks, bottom characteristics and other features, as well as regulatory, tide, and other information important to mariners.

Recently, bathymetry has also come to include “topobathymetric mapping” which includes the land-water interface (e.g., beaches and lagoons) that is generally too shallow, dynamic, or dangerous for ship-based acoustic acquisition of bathymetry. Topobathymetric mapping is typically conducted through specialized blue-green LiDAR sensors and aerial photogrammetry. The Interagency Working Group on Ocean and Coastal Mapping (IWG-OCM) has been charged

C. Lead Agency and Current Activities

The 2015 COGO report card noted that the FGDC lacked an elevation subcommittee and emphasized the need for unified leadership in the collection, management, and distribution of elevation data. Although historically topography and bathymetry have been considered separate and unique, in 2015 the FGDC formed the 3D Nation Elevation Subcommittee to formalize, unify, and enhance coordination of Elevation data collection in accordance with OMB Circular A-16 (https://www.fgdc.gov/policyandplanning/a-16/index_html).

The elevation theme has two theme leads: USGS is the lead agency for terrestrial topography and inland bathymetry through the 3DEP, and NOAA is the lead agency for offshore bathymetry through the IWG-OCM. Additional member agencies of the two programs include:

- Bureau of Land Management
- Department of Homeland Security
- Department of Transportation
- Environmental Protection Agency
- Federal Aviation Administration
- Federal Communications Commission
- Federal Emergency Management Agency
- US Forest Service
- US Fish and Wildlife

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- National Park Service
- Natural Resources Conservation Service
- Office of Surface Mining Reclamation and Enforcement
- US Department of Agriculture
- US Army Corps of Engineers
- American Association of State Geologists
- National States Geographic Information Council
- National Aeronautics and Space Administration
- National Science Foundation

The goal of the 3D Nation Elevation Subcommittee of the FGDC is to continually improve the national elevation mapping foundation by coordinating the topographic, coastal, and bathymetric mapping activities across the Federal government. Further detail about the group's mission and goals can be found in its charter at: <https://www.fgdc.gov/organization/working-groups-subcommittees/3dne-sc/3d-nation-elevation-sc-charter-sc-approved-10-30.pdf>.

D. Collaboration and Partnerships

3DEP is a partnership program which garners financial support from federal, state, local and non-government organizations. Federal members of the 3DEP Working Group (Figure 3) actively collaborate on annual acquisitions designed to satisfy overlapping mission requirements and further advance the goal of nationwide high density 3D topographic data. 3DEP issues an annual Broad Agency Announcement (BAA) which provides detailed information on how all stake-holders may partner with the USGS and other Federal agencies to acquire high-quality 3D Elevation data. Information on the annual BAA is available through the 3DEP Website: <https://www.usgs.gov/core-science-systems/ngp/3dep/broad-agency-announcements> and through [fbo.gov](https://www.fbo.gov) and [grants.gov](https://www.grants.gov). Applicants may contribute funds toward a LiDAR data acquisition activity via the USGS managed Geospatial Products and Services Contracts (GPSC) or they may request 3DEP funds toward a LiDAR data acquisition activity where the requesting partner is the acquiring authority. Federal agencies, state and local governments, tribes, academic institutions and the private sector are eligible to submit proposals. Since 2015, over 200 distinct

partners have contributed to 3DEP projects. The number of partners will continue to grow.

E. Standards

The USGS standards and specifications define the requirements to ensure that all products and data prepared by the USGS under the National Geospatial Program are consistent in accuracy, structure, format, style, and content. National Geospatial Program Standards and Specifications are easily available through the National Map website (<https://nationalmap.gov/standards/>). The website also contains Digital Product, Digital Data, Printed Map standards as well as other standards and instructions. All are easily downloaded.

Standards for Terrestrial Mapping LiDAR have evolved significantly thanks to the leadership provided by the American Society for Photogrammetry and Remote Sensing (ASPRS) and the USGS. ASPRS supplies geospatial accuracy standards (<https://www.asprs.org/news-resources/asprs-positional-accuracy-standards-for-digital-geospatial-data>) and industry standard file formats (<https://www.asprs.org/divisions-committees/LiDAR-division/laser-las-file-format-exchange-activities>). Guidance towards a nationally consistent LiDAR dataset is provided in the USGS 2018 LiDAR Base Specification (v 1.3, <https://pubs.er.usgs.gov/publication/tm11B4>), developed in collaboration with ASPRS for consistency with the geospatial accuracy standards. These specifications are widely used throughout the international mapping industry, even for projects outside the scope of 3D Nation.

Bathymetric mapping standards are easily accessible through National Oceanic and Atmospheric Administration (NOAA) websites. The standards provide for: horizontal and vertical position uncertainty; tides and water levels requirements; coverage and resolution requirements for multibeam, singlebeam, side scan, and LiDAR data; features and required field reporting. The website also contains information on field procedures and links to additional resources to the International Hydrographic Organization, Current Year Survey Plans (Story Map) and Future

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Survey Plans. Standards and specifications are designed to be compatible with and complementary to the USGS and ASPRS standards.

NOAA Office of the Coast Survey Hydrographic Survey, Specifications and Deliverables are available at <https://nauticalcharts.noaa.gov/publications/standards-and-requirements.html>. Standards for elevation data (Geospatial Metadata Guidelines) have been developed by the Federal Geodetic Data Committee (FGDC) <https://www.fgdc.gov/> as well as other US and International Organization for Standardization (ISO) <https://www.iso.org/home.html>.

Comments from the Elevation Survey respondents:

- 3DEP and its associated standards, contracting vehicle, and collaboration with Federal, State, local, and private partners are a shining example of successful leadership provided by a Federal agency.
- Publication of the LiDAR Base Specification is one of the most significant contributions to the mapping industry that USGS has made in the past decade.
- Addition and refinement of horizontal accuracy standards is necessary for the continued advancement from simple Elevation Data to a 3D Nation.
- Explicit support or quality levels for higher resolutions is needed.

F. Estimate of Theme Completeness

The 3D Elevation Program (3DEP) contracted for approximately 12% of the nation in FY 2017, including Alaska IfSAR. Approximately 98% of Alaska is available or was in progress at the end of 2017. 3DEP data has been contracted for 37% of the entire US. For 2018 the 3DEP program will have 48% of the nation mapped or under contract. The primary goal of 3DEP is to systematically collect enhanced elevation data in the form of high-quality light detection and ranging (LiDAR) data over the conterminous United States, Hawaii, and the U.S. territories, with data acquired over an 8-year period. Interferometric synthetic aperture radar (IfSAR) data

will be collected over Alaska, where cloud cover and remote locations preclude the use of LiDAR over much of the State. The USGS continues to evaluate new methods and technologies that can meet the vertical accuracy requirements of the use cases identified in the NEEA Report. While evaluating new approaches, it is imperative that the USGS not compromise the integrity of mission critical elevation data created with the well-established LiDAR and IfSAR technologies, work flows and processes.

Coverage in the western United States remains thin due to lack of non-Federal funding partners, although 100% coverage is predicted by 2033 at current funding levels. However, the proposed presidential budget for FY19 reduces the National Geospatial Program budget by approximately 24%, putting the program's mission at risk without additional outside funding partners.

In FY17, USGS and its many partners invested over \$86 million in LiDAR and IfSAR data acquisition, and the U.S. Interagency Elevation Inventory shows that about 48% of the lower 49 States and territories has LiDAR data that meet the quality levels needed. 3DEP is a "Call for Action" because no one entity can accomplish it independently. 3DEP presents a unique opportunity for collaboration between all levels of government, to leverage the services and expertise of private sector mapping firms that acquire the data, and to create jobs now and in the future. When partners work together, they can achieve efficiencies and lower costs so that 3DEP can become a reality. When 3D elevation data are available to everyone, new innovations will occur in forest resource management, alternative energy, agriculture, and other industries for years to come. (from <https://communities.geoplatform.gov/ngda-elevation/3dep-adata-acquisition/>)

Similar completion percentage estimates of bathymetric completion are unavailable and difficult to estimate in part due to the dynamic nature of coastal topography. However, significant portions of the United States coast have been mapped with topobathymetric LiDAR and acoustic mapping in the previous decade, creating a baseline data set. Rapid mapping

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responses to storm events such as Hurricanes Sandy, Irma, Katrina, and Harvey have dramatically improved prediction, response, and recovery for similar events (<https://www.usgs.gov/news/usgs-hurricane-response-met-challenges-2017-prepares-2018>) and representing an ongoing need for funding for coastal mapping.

Alaska represents a significant challenge for coastal and inland bathymetry, possessing more coastline and more lakes than the continental USA combined. Coastal bathymetry coverage remains minimal, although recent progress has been made.

Recommendations from the Elevation Survey respondents:

- More frequent updates are required in some regions. Example update intervals provided include 1 year, 3 year, 5 year, 10 year, and post-event.
- Users seem to be unaware of data becoming available in their regions of interest. It may be helpful to provide “subscribe” options for users to receive notifications when potential projects are added, contracted, and completed. Base subscriptions off of keywords, regions, and agency.
- Stake-holders in Alaska were particularly vocal about needing higher quality elevation data.

G. Accessibility of Data

Respondents to the Elevation Survey frequently expressed frustration regarding their inability to find high-resolution elevation data for their region(s). Often they knew that data probably existed or would soon exist, but they were unaware of where to find it or when it would be available.

Multiple Federal, State, university, and nonprofit entities support various portals, collaboration sites and inventories with significant overlap and often duplicated data sets. Some examples of portals, collaboration sites and inventories are:

- United States Interagency Elevation Inventory (NOAA): <https://coast.noaa.gov/inventory/>

- The National Map (USGS): <https://viewer.nationalmap.gov/basic/>
- US Federal Mapping Coordination on Seasketch (Multiple): <http://fedmap.seasketch.org>
- Flood Map Service Center (FEMA): <https://msc.fema.gov/portal>
- Geoplatform.gov (FGDC): <https://www.geoplatform.gov/>
- Data.gov (GDA): <https://www.data.gov/>
- OpenTopography (UCSD/NSF): <http://www.opentopography.org/>
- Oregon LiDAR Consortium (DOGAMI): <https://gis.dogami.oregon.gov/maps/LiDARviewer/>
- Virginia GIS Clearinghouse (VGIN): <http://vgin.maps.arcgis.com/home/index.html>
- Alaska Elevation Portal (State of Alaska): <https://elevation.alaska.gov/>
- NGS Data Explorer (NOAA): <https://www.ngs.noaa.gov/NGSDataExplorer/>
- OPUS Shared Solutions (NOAA): <https://www.ngs.noaa.gov/opusmap/>
- Bathymetric Data Viewer (NOAA/NCEI): <https://maps.ngdc.noaa.gov/viewers/bathymetry/>

Although overlap between data providers is not necessarily a bad thing, several Federal sites in particular claim to be the authoritative source of publicly-funded elevation data, further confusing users. Representatives from the subcommittee are on record saying that the USIEI is the authoritative inventory for publically available LiDAR data. This is not well understood by the public or reflected on the various web sources of public elevation data. The recent proliferation of high quality and high resolution public elevation data presents an opportunity for the 3D Nation Elevation Subcommittee to provide valuable leadership and clarity through webinars, interaction with professional and state organizations, and newsletters. Other suggestions for improvement from Elevation Survey respondents include:

- Consolidate Federal public elevation data into a single portal:
 - This should be the primary link on Elevation page of The National Map, not a related link. The current (as of July 2018) download link from The National Map is limited to 3DEP only.

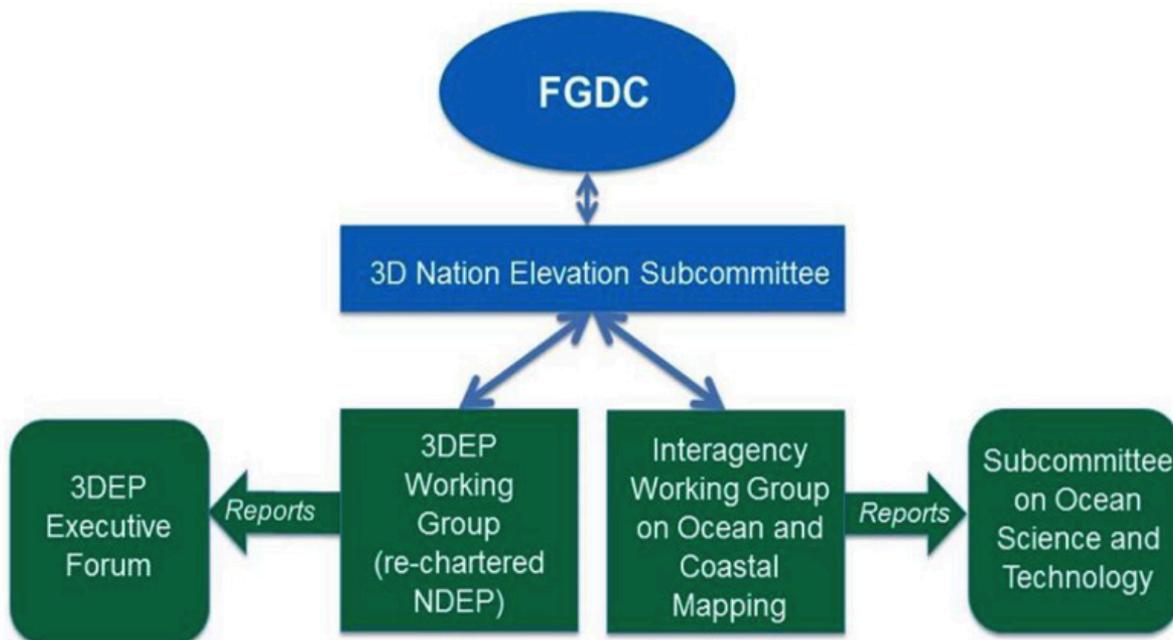


Figure 5. 3DEP governance committees and working groups.

- It is not obvious which site or sites are the authoritative source. The National Map, Data.gov, Earth Explorer, USIEI, and geoplatform.gov all come up from web searches for elevation data and claim to be the authoritative source.
- Include State-specific elevation data in the Federal portal.
- Include links to each state or region’s elevation data portal.
- Improve search engine optimization and website design to make elevation data portals easier to find:
 - Discovering elevation data portals with a web search currently requires foreknowledge of the site itself or the managing agency, which varies from state to state.
- Phase out list-based geospatial data portals (e.g., data.gov, geoplatform.gov) and incorporate them into interactive web maps.
- Elevation Survey indicates that certain sectors (such as land survey) still possess a lack of public awareness of 3DEP, the NED’s phase-out, and especially the USIEI.

H. Authority, Governance, and Management of the Theme.

3DEP Governance is through Committees and Working Groups (**Figure 5**). The 3DEP Executive Forum’s purpose is to facilitate executive dialog and collaboration on strategies to implement and sustain 3DEP for the benefit of its Federal stake-holders and the broader community. The Alaska Mapping Executive Committee is chaired by the DOI Assistant Secretary for Water and Science and is building up the Federal investment and partnering with the State to complete statewide data coverage. 3DEP Working Group formerly known as the National Digital Elevation Program (NDEP), is the operational coordination group for terrestrial elevation data. The Interagency Working Group on Ocean and Coastal Mapping (IWG-OCM) is the operational coordination group for bathymetric elevation. It reports to the Subcommittee on Ocean Science and Technology.

3DEP presents a unique opportunity for collaboration between all levels of government, to leverage the services and expertise of private sector mapping firms that acquire the data. The 3D Elevation Program and the Interagency Working Group on Ocean and Coastal Mapping have established a system to share information about areas of interest, proposed and planned elevation projects. Planned and potential Federal projects

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as well as State and Local areas of interest are available at the NOAA sponsored Seasketch site: <http://fedmap.seasketch.org>. All Federal agency and stake-holder areas of interest will be made available for viewing through this site to enable comparison and facilitate discussion with other 3DEP and IWG-OCM stake-holders. This mapping site is comprehensive, showing areas of interest, proposed, planned, in-work, and completed elevation and related projects.

The lead agencies have provided effective leadership, and along with their partners, have made considerable progress. Collaborative approaches have enabled the use of Federal and state appropriated funds to expand the availability and use of elevation data.

Digital Coast Act S.B S.110 Passed Senate on 05/25/2017. This bill requires the National Oceanic and Atmospheric Administration (NOAA) to establish a constituent-driven Digital Coast program. This program currently exists under NOAA to provide data, tools, and training that communities use to manage their coastal resources. The program must: (1) provide an online resource that integrates geospatial data, decision-support tools, training, and best practices to address coastal management issues and needs, and to enhance resilient communities, ecosystem values, and coastal economic growth and development; and (2) provide for the documentation, dissemination, and archiving of the data. An identical bill was introduced in the House as H.R.4062 and is unfortunately currently being held. Passage of the bill would enhance capacities to manage coastal regions. With the advent of sea level rise, access to vertical data along coastal regions is imperative to manage resources and the health and safety of coastal inhabitants

NOAA must focus on filling data needs and gaps for critical coastal management issues and support continued improvement in existing efforts to coordinate the acquisition and integration of key data sets needed for coastal management, and other purposes. NOAA may: (1) enter into financial agreements and collect fees to carry out the program; (2) enter into contracts with private

sector entities as may be necessary to collect, process, and provide remote sensing and other geospatial data and products.

II. ELEVATION DATABASE ASSESSMENT

CAPACITY

The Framework's ability to meet current and future demands:

The Elevation Framework has significant capacity through public and private partnerships. The Broad Agency Announcement (BAA) has resulted in 119 proposals funded and continues to grow in partners from different federal, state, regional, local, private and non-profit participants. The required infrastructure is in place to meet the 3D Nation objectives, so long as funding needs are met.

CONDITION

The existing or near-term condition of the Framework themes as an integrated whole:

The interagency collaboration system that was put in place to share information about areas of interest, proposed and planned elevation projects by the 3D Elevation Program and the Interagency Working Group on Ocean and Coastal Mapping have minimized duplicate mapping and contributed towards collaboration to integrate terrestrial and coastal mapping. However, it is unclear how the 3D Elevation Program integrates with offshore bathymetric mapping, which is maintained by NOAA's Office of Coast Survey. The following are two perspectives gleaned from the Elevation Survey respondents:

- Smooth transitions to the new 2022 vertical reference frame will be extremely important for stake-holders.
- Respondents were generally unfamiliar with the existence of the Framework as an entity.

FUNDING

The funding capability of the Framework:

3DEP reports that coverage is approximately halfway to the program objective. However,

the proposed FY19 presidential budget reduces the National Geospatial Program budget by approximately \$16M compared to FY18, from \$66.9M to \$50.9M. A fully funded and implemented 3DEP would provide more than \$690 million annually in new benefits to government entities, the private sector, and citizens. Given that the western United States is dominated by federal lands, the second half of 3DEP coverage will likely need significant federal funding and a reduction would significantly erode 3DEP's ability to realize its objectives. It should be noted that the 3DEP stake-holders are maximizing their reduced budgets by actively collaborating to create elevation data that has the maximum benefit. Sometimes this may be done at the risk of not acquiring data in areas having lower interest/priority.

FUTURE NEED

Whether future-funding prospects will be able to meet the need:

Elevation Survey respondents expressed a voracious appetite for high resolution elevation data. Although some applications and use cases require more recent and dense data than is practical for 3DEP as a whole, most respondents indicated that the quality level provided by 3DEP and IWG-OCM is sufficient as a high quality baseline dataset. This important endeavor requires reasonable future funding to continue to enhance publically available elevation data for use by both the private and public sectors.

The 3D Nation Study currently being prepared by NOAA and USGS is scheduled to be completed in 2019. This study will formally obtain input from elevation data stake-holders to be used to prioritize and direct investments that will best serve user needs.

On June 20, 2018, the 3DEP Coalition sent a letter to Dr. James F. Reilly II the Director of the US Geological Survey. The letter stated the Coalition's support of the 3DEP Elevation Program, highlighted the cost benefit ratio of the program and noted the USGS previously stated budget to achieve nationwide coverage on the 8 year cycle originally conceived by the USGS.

<https://www.docdroid.net/t0HmVi8/coalition-letter-supporting-3dep-to-usgs-director-reilly-6-20-2018.pdf>

OPERATION AND MAINTENANCE

The ability of key lead organizations to develop and maintain the Framework and to adopt new technology, procedures, and standards:

The leadership provided by the 3D Nation Elevation Subcommittee and its members has thus far proven to be responsive, innovative, and competent. The 3DEP program in particular was recognized with the 2018 Outstanding Enterprise Achievement Award by LiDAR Magazine at the 2018 International LiDAR Mapping Forum. Their cooperation and collaboration with ASPRS to develop and promote national standards is exemplary.

PUBLIC USE

The Framework's ability to provide data resources that meet the everyday needs of organizations and the general public, and to provide data resources that meet the need to respond to public safety incidents, natural disasters, and other emergencies:

Although significant amounts of high quality elevation data for the Nation are available, there is a perception within some of the user community that more elevation data are available than what is publicly available. Improvements to the transparency and accessibility for Elevation Data for users should significantly improve this assessment category.

Direct quotes from the COGO Elevation Survey include:

- "More LiDAR data that have been flown but is not necessarily being shared with the public..."
- "The highly successful 3DEP program has produced elevation data for approximately 50% of the USA. We just need to continue this important mission to complete the country. This will become a reality if existing and more agencies support 3DEP."

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RESILIENCE

The ability of the geospatial community to participate in development of the Framework and to contribute to its sustainability as a long-term asset of value for the nation:

The Broad Agency Announcement (BAA) for the 3D Elevation Program (3DEP) provides detailed information on how to partner with the USGS and other Federal agencies to acquire new or existing high-quality 3D Elevation data. Additionally, ASPRS, NOAA, and USGS utilize a rigorous review process to solicit public feedback on standards and specifications. Both Lead Agencies appear to be open to stake-holder feedback.

III. OVERALL GRADE OF ELEVATION THEME

This committee assigned a grade of B- for the Elevation Theme. The high resolution elevation data where it exists is in good to excellent condition. Users are able to find, integrate and use elevation data which is publicly available for a majority of the populated and coastal areas within the United States. However, some areas have yet to be covered with baseline high resolution elevation data, particularly in the western United States and Alaska. Bathymetric data of U.S. Coastal areas and the Great Lakes is also available for use by mariners, and is rapidly collected after large storm events for recovery efforts and maritime navigation assistance.

This report is a culmination of efforts from the geospatial community representing government, academic and provide sector stake-holders. As such, continuing to develop the Elevation Data Theme requires a tightly coordinate effort amongst the stake-holder with the USGS continuing its leadership of 3DEP. Based the feedback from all sectors the following action items may be considered to promote improving and creating a dynamic Elevation Theme across the nation:

1. Celebrate and publicize the success of 3DEP creating more support for its continued funding. Accomplishing this in a coordinated manner

is imperative in 2019/2020 as agency budgets continue to be reduced. The USGS must coordinate with all sectors defining specific goals and responsibilities to advance to collection completion in this budget cutting environment. For example, the private sector who can advocate and educate on Capitol Hill for increasing, not reducing funding based on the return on investment of 3DEP. Specific goals for all levels of government and the academic community should also be defined.

2. Address the data accessibility and claims of duplicate authoritative sources. This should help eliminate confusion within the user community, and a perception of federal agencies creating redundant data.

3. Strongly encourage all government funded elevation projects to conform to the industry accepted 3DEP standards and specifications. This would foster a more timely and complete acquisition of the LiDAR data over the nation .

The grade of B- recognizes excellent progress and leadership while highlighting that gaps in topographic coverage remain and adequate future funding is in question.

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2018 COGO Elevation Survey Results

Q1: What kinds of PUBLIC elevation data do you use? (select all applicable)
644 responses, N = 647

ANSWER CHOICES	%	N
Published benchmarks	51.09%	329
Active geodetic networks (e.g., OPUS/CORS, RTNs, etc)	43.63%	281
Raster grids (e.g., USGS National Map DEMs, which includes the National Elevation Dataset or NED)	72.20%	465
Point cloud datasets (e.g., topographic and/or bathymetric LiDAR)	58.23%	375
Contour maps (e.g., USGS Topo Maps)	74.22%	478
Coastal hydrographic surveys (e.g., NOAA nautical charts and surveys, USACE dredge surveys)	22.98%	148
Inland hydrographic maps (e.g., FEMA flood maps, NHD)	54.81%	353
Other (please specify)	9.63%	62

Q2: How often do you use PUBLIC elevation data in your practice?
644 responses, N = 647

ANSWER CHOICES	%	N
Routinely (several times per week)	42.39%	273
Occasionally (every week or two)	27.17%	175
Rarely (a couple times per month)	25.78%	166
Never; I don't use elevation data at all	2.17%	14
Never; I only use elevation data that I create	2.48%	16

Q3: How frequently do you need PUBLIC elevation data updated to be useful for your applications?
644 responses, N = 647

ANSWER CHOICES	%	N
30 years	1.25%	8
10 years	12.62%	81
5 years	34.74%	223
Annually	31.46%	202
Monthly	5.14%	33
n/a; I need new data every job	2.80%	18
n/a; I don't use public elevation data	2.80%	18
Other (please specify)	9.19%	59

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*Q4: Check all sources of PUBLIC elevation data with which you are familiar:
642 responses, N= 647*

ANSWER CHOICES	%	N
National Elevation Dataset (NED)	78.97%	507
FEMA	72.43%	465
Local/Regional Elevation Portal (e.g., OLC, PSLC, county sources)	52.34%	336
NGS Datasheets	51.09%	328
3D Elevation Program (3DEP)	50.47%	324
NOAA Digital Coast	34.42%	221
NOAA vector/raster nautical charts (ENCs, RNCs)	34.27%	220
OPUS Shared Solutions	27.73%	178
NOAA National Centers for Environmental Information (formerly National Geophysical Data Center)	27.73%	178
Other (please specify)	8.72%	56

*Q5: Grade public elevation data resources based on your needs (A-F):
639 responses, N= 647*

Category*	A	B	C	D	F	N/A	N	**AVG GRADE
Capacity	4.1%	42.5%	34.3%	7.4%	1.9%	9.9%	638	B-
Condition	3.5%	35.0%	41.6%	6.6%	2.1%	11.2%	634	C+
Funding	0.8%	7.6%	34.6%	25.9%	7.4%	23.7%	633	C
Future Need	1.1%	9.0%	32.8%	29.5%	3.6%	24.0%	637	C+
Operation and Maintenance	5.2%	25.6%	34.7%	16.3%	2.0%	16.2%	637	C
Public Use	5.2%	34.8%	34.5%	13.4%	2.4%	9.8%	635	C+
Resilience	6.8%	28.3%	37.7%	9.6%	2.4%	15.3%	636	C+

***Categories Explained for Q5**

Capacity: The ability of public elevation data to meet current and future demands.

Condition: The existing or near-term condition of public elevation data as an integrated whole.

Funding: The funding capability of public elevation data.

Future Need: Whether future-funding prospects for public elevation data will be able to meet the need.

Operation and Maintenance: The ability of key lead organizations to develop and maintain the public elevation data and to adopt new technology, procedures, and standards.

Public Use: The ability to provide public elevation data resources that meet the everyday needs of organizations and the general public, and to provide data resources that meet the need to respond to public safety incidents, natural disasters, and other emergencies.

Resilience: The ability of the geospatial community to participate in development of public elevation data and to contribute to its sustainability as a long-term asset of value for the nation.

****Grades Explained for Q5**

A = FIT FOR THE FUTURE: The Framework is generally in excellent condition and meets capacity needs for the future. Few themes require attention. Standards for data and assured public access are met, and all themes form an integrated data network across the United States. Users are able to easily identify, integrate, and use Framework data from all themes.

B = ADEQUATE FOR NOW: The Framework is in good to excellent condition, but some themes require attention for significant deficiencies. Users are able to find, integrate, and use data from a majority of themes in

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Grades Explained for Q5 (continued)

C = REQUIRES ATTENTION: The Framework is in fair to good condition, but requires attention for most themes of data. Users have some difficulty in finding, integrating, and using data in general, and some locations in the U.S. are missing data for individual themes.

D = AT RISK: The Framework is in poor to fair condition and mostly below the goals envisioned for the NSDI. Large portions of the data themes have not been developed sufficiently to make them accessible or able to be integrated with other Framework data. Data for many locations is not useful without significant work by the user.

F = UNFIT FOR PURPOSE: The Framework infrastructure is in unacceptable condition and provides little to no value to users. Most of the data cannot be found or used in applications at national or local levels.

<i>Q6: How prepared do you feel for the new vertical datum, NAPGD2022?</i> 639 responses, N= 647		
ANSWER CHOICES	%	N
Very prepared	8.14%	52
Waiting on the state to provide direction	15.34%	98
Still a lot to learn	51.02%	326
What new datum?	25.51%	163

<i>Q7: Type of firm-agency you work for: (select one)</i> 642 responses, N= 647		
ANSWER CHOICES	%	N
Federal	8.72%	56
State	12.77%	82
Regional (County, etc)	17.45%	112
Local (City, etc)	15.58%	100
Private	37.38%	240
Education	8.10%	52

<i>Q8: Primary relationship with elevation data: (select one)</i> 642 responses, N= 647		
ANSWER CHOICES	%	N
User	81.15%	521
Producer	11.99%	77
Maintainer	6.85%	44

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Q9: Type of work for firm/agency: (check all that apply)
Answered: 643 out of 647

ANSWER CHOICES	%	N
GIS	92.5%	595
Architecture/Engineering/Construction	31.7%	204
Aerial Mapping	31.6%	203
Topographic Surveying	31.3%	201
Boundary Surveying	25.5%	164
Hydrography	22.9%	147
Researcher	19.4%	125
Educator	14.5%	93
Policy	14.5%	93
Bathymetric Surveying	10.9%	70
Hardware/Software Developer	9.2%	59

Q10: COGO affiliation(s): (check all that apply)
589 responses, N= 647

ANSWER CHOICES	%	N
American Planning Association (APA)	5.9%	35
American Society for Photogrammetry and Remote Sensing (ASPRS)	21.2%	125
American Society of Civil Engineers (ASCE)	11.9%	70
Association of American Geographers (AAG)	17.0%	100
Cartography and Geographic Information Society (CAGIS)	6.5%	38
Geographic and Land Information Society (GLIS)	3.1%	18
GIS Certification Institute (GISCI)	73.9%	435
International Association of Assessing Officers (IAAO)	2.6%	15
Management Association for Private Photogrammetric Surveyors (MAPPS)	7.0%	41
National Alliance for Public Safety GIS Foundation (NAPSG)	2.4%	14
National Association of Counties (NACo)	5.1%	30
National Emergency Number Association (NENA)	3.6%	21
National Society of Professional Surveyors (NSPS)	17.3%	102
National States Geographic Information Council (NSGIC)	8.3%	49
United States Geospatial Intelligence Foundation (USGIF)	3.7%	22
University Consortium for Geographic Information Science (UCGIS)	2.0%	12
Urban and Regional Information Systems Association (URISA)	37.5%	221
Western Governors Association (WGA)	1.0%	6
Other:	11.4%	67

IV. GEODETIC CONTROL THEME

EXECUTIVE SUMMARY

The 2015 NSDI Report Card assigned a grade of B+ to the Geodetic Control Theme, noting that it was adequate to meet current needs but needed improvement to meet future needs. Based on our assessment of the data available at the time of this report, the National Geodetic Survey (NGS) has provided a clear road map forward with a planned implementation of the new datum in 2022. It is anticipated that accurate and accessible geodetic data are and will continue to be available in an enhanced environment. The mission of NGS will remain the same for the foreseeable future. NGS will still define, maintain, and provide access to the National Spatial Reference System.

A grade of A- has been assigned to the NSDI Geodetic Control Data Theme

THEME GRADE: A-
NEARLY FIT FOR THE FUTURE

I. DESCRIPTION OF THE FRAMEWORK

A. An introduction to the Theme

Geodetic control provides a common reference system for establishing the coordinate positions of all geographic data. It also provides the means for tying all geographic features to common, nationally used horizontal and vertical coordinate systems.

B. The Theme Definition

Survey control points or other related data sets which are accurately tied to the National Spatial Reference System (NSRS), a common system for establishing coordinates for geospatial data that are consistent nationwide. Examples include: (1) benchmarks, (2) data from Global Navigation Satellite Systems (e.g., GPS), (3) gravity measurements, and (4) models of the earth's gravity field (geoid).

C. Lead Agency and Current Activities

NGS is the lead agency for this data theme. NGS provided information about their efforts with

this theme and is included herein. The mission of NGS will remain the same for the foreseeable future. NGS will still define, maintain, and provide access to the NSRS.

Further, outreach has already begun in a series of bilateral meetings between NGS and other federal agencies involved in geodetic applications. These include a pilot project with FEMA and recent agency-to-agency work with USGS.

Additionally, presentations are made annually to the Federal Geographic Data Committee Coordination Group and twice a year during the Federal Geodetic Control Subcommittee meetings to ensure that progress towards the new NSRS is understood by all other government agencies using geodetic control for their work. Through these meetings and liaisons, NGS is working to ensure that any specific implementation issues are addressed over the next few years.

In 2015, NGS increased the transparency of the work leading to the modernized NSRS by providing a quarterly newsletter, available to the public, called the NSRS Modernization Newsletter. Each issue reports on high-level projects,

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identifying their start, progress and completion as appropriate.

In 2018, NGS increased direct industry engagement on various topics including, but not limited to: time-dependent coordinates; transformation parameters; update cycles / change of data parameters; and reference epochs and transformation tools. A small, industry workshop was hosted in May 2018 to facilitate an exchange of information between NGS technical experts and industry counterparts. NGS also held a more widely attended June 7th webinar for industry partners to learn about the topics discussed and preliminary outcomes from this year's inaugural NSRS Modernization Industry Workshop. The webinar can be found at https://www.ngs.noaa.gov/web/science_edu/webinar_series/industry-engagement.shtml.

Data collection is primarily limited on the physical side by the vast area that must be surveyed. The Gravity for the Redefinition of the American Vertical Datum (GRAV-D) Project as a part of the NGS Gravity Program is currently planned to finish collections by late 2022 based on current funding levels. These data must be processed and incorporated into gravity field products in collaboration with the DoD's National Geospatial-Intelligence Agency (NGA). NGA will be rolling out a new global model in 2020 that will incorporate most of the GRAV-D data. NGA will continue to work with NGS to develop a more comprehensive gravity field model when all GRAV-D data have been collected. Hence, this may take NGS beyond 2022 to produce a final vertical datum. Additional collaboration is needed and largely happening between NGS and NASA for coordinating Global Navigation Satellite Systems (GNSS) infrastructure, gravity collection and products, and digital elevation models. Collaborations between NGA and NGS as well as NGS and NASA are fairly strong as all have vested interests in collaborating.

However, collaboration with other federal agencies to develop models and techniques which assist in their implementation may not be as robust. This is in large part due to turnover of personnel in other federal agencies who are

experienced in how to implement changes to geodetic infrastructure that underlie their products and services. Finally, some of our products require international collaboration. The reference frames for the Caribbean and the Pacific span regions where NGS must have additional information to properly develop a model. Hence, agreements with other countries may be required. This may involve the State Department and slow the process of development.

A final consideration is that the transformation of the modernized NSRS will account for time dependency of positions. In principle, this is a sound approach as it would better account for the motion of a point and better align observations from different periods of time for comparisons. It would help to account for how a location may have moved over time. In practice though, how well will this be implemented? NGS will develop the tools and provide training, but how readily this will be adopted by the user community is unknown. NGS will also remain ready to collaborate with the user community to implement the modernized NSRS, but NGS must account for a broad range of skills and adaptability.

NGS plans to continue to provide a remote participation/webinar option for future geospatial summits. In addition, the NGS Webinar Series invites speakers to present information related to NGS programs, projects, products and services. The webinars educate constituents about NGS activities, and provide opportunities for NGS to gather feedback from its customers. These webinars have hundreds of attendees from both the public and private sectors.

NGS expects to hold the next Geospatial Summit in Spring 2019 in Washington, DC. The three preceding Geospatial Summits were held in 2010 and 2015 and 2017. The 2010 summit was held at the NOAA Auditorium in Silver Spring, MD. The majority of the over 200 attendees were from federal agencies in 2010. In 2015, the Geospatial Summit was held at the Crystal City Hilton in Arlington, VA in collaboration with the annual conferences of the National Society of Professional Surveyors (NSPS) and the Manage-

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ment Association for Private Photogrammetric Surveyors (MAPPS). This Summit also had over 200 attendees (approximately 113 non-federal), as well as 125 webinar attendees (approximately 83 non-federal). The 2017 Geospatial Summit, was held at the Silver Spring Civic Center, in Silver Spring, MD. On hand were more than 400 attendees including NGS Geodetic Advisors, field personnel, representatives from the U.S. Army Corps of Engineers, National Society of Professional Surveyors, Federal Emergency Management Agency, and other federal, state, public, and private-sector stakeholders.

Webinars are held on the second Thursday of every month, from 2:00-3:00 p.m. eastern time. Registration is free, and video recordings are made of all webinars for later viewing. To participate in the Webinar series. NGS has the following near-term webinars planned and will continue hold monthly webinars on topics of interest to the geodetic community.

More information on past and future webinars, include recordings of past webinars, is available here: https://www.ngs.noaa.gov/web/science_edu/webinar_series/index.shtml

D. Collaboration and Partnerships

NGS also seeks to collaborate with local (governmental, commercial, and academic) partners throughout the GRAV-D project. Partners that are willing to support airborne or terrestrial surveys or to monitor local variations in the gravity field are a critical component of GRAV-D - <https://geodesy.noaa.gov/GRAV-D/>

Although this part does not discuss non-geodetic control points, such as Public Land Survey System points, local government control points, project control points for public and private projects, aerial-photo control points, and so on, it can be used as a model for effective collaboration and partnership to enhance services to users.

There are strategic opportunities between COGO and NGS specifically with support in outreach and communication efforts and feedback for stakeholder concerns. When the update to the NSRS rolls out, there will still be individuals and

groups that were unaware. As such, there may be unanticipated consequences to those groups from the new NSRS. Minimizing this impact by ensuring the broadest outreach is a significant goal for NGS. COGO members can assist by relaying communication and outreach efforts to as many stakeholders as possible. If concerns are expressed and mitigated before the roll out, then implementation of the new NSRS will be that much more successful.

The most significant obstacles in a successful rollout of the modernized NSRS include both data collection and collaboration. Data collection is primarily limited on the physical side by the vast area that must be surveyed. The Gravity for the Redefinition of the American Vertical Datum (GRAV-D) Project as a part of the NGS Gravity Program is currently planned to finish collections by late 2022 based on current funding levels. These data must be processed and incorporated into gravity field products in collaboration with the DoD's National Geospatial-Intelligence Agency (NGA). NGA will be rolling out a new global model in 2020 that will incorporate most of the GRAV-D data. NGA will continue to work with NGS to develop a more comprehensive gravity field model when all GRAV-D data have been collected. Hence, it may be beyond 2022 before a final vertical datum is released. Additional collaboration is needed and largely happening between NGS and NASA for coordinating Global Navigation Satellite Systems (GNSS) infrastructure, gravity collection and products, and digital elevation models. Collaborations between NGA and NGS as well as NGS and NASA are fairly strong as all have vested interests in collaborating.

However, collaboration with other federal agencies to develop models and techniques which assist in their implementation may not be as robust. This is in large part due to turnover of personnel in other federal agencies who are experienced in how to implement changes to geodetic infrastructure that underlie their products and services. Finally, some of the NGS products require international collaboration. The reference frames for the Caribbean and the Pacific span regions where NGS must have addi-

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NGS will work hard to help the GIS community adapt to the new NSRS by providing digital transformations under ISO 19111. These transformations will be maintained in an ISO-sponsored geodetic registry and will also be available through the NGS website as models and the underlying interpolation algorithms. The surveying community will have available the same transformations; however, the existence of paper records in legacy datums will require digitizing to upgrade. On the plus side, robust, map-grade transformations already exist in geometric coordinates and a similar set are being developed for physical height transformations. Additionally, models are being developed that will explain any expected movement over time (e.g., plate rotation) so that data collected at different epochs could be transformed to common epoch for comparison for long term projects. A robust collection campaign is in progress to obtain sufficient GPS on bench marks to improve the new realization of the reference frame with the previous. Additionally, NGS is working with its counterparts in Canada and Mexico to ensure continuity of the NSRS across the borders.

As noted above, NGS is also working with Canada and Mexico to ensure continuity over

the border as well as to facilitate any transnational activities. This is a part of the broader United Nations Global Geospatial Information Management (UN-GGIM) activities that the United States has agreed to support. UN-GGIM stipulates that nations should adopt common, international models and standards of use.

Further, one of the primary objectives of NGS has been the development of a complete educational portfolio, with ready-to-teach training units for teachers at the elementary through university level.

NGS has just completed a significant change to the NGS State Advisor structure. In October 2016, NGS transitioned from a state advisor program, covering only 24 participating states, to a new Regional Advisor Program covering the entire United States. Regional Geodetic Advisors serve as liaisons between NGS and our public, academic, and private sector constituents within their assigned regions, to ensure all territories are covered. Regional Advisors provide expert guidance to constituents who manage geospatial activities that are tied to the National Spatial Reference System (NSRS). Geodetic Advisors serve as the subject matter experts to regional geodetic issues and collaborate internally across NGS and NOAA to further the mission of the organizations. This transition to a regional program is particularly important, as NGS executes the plans to replace the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD 88) by 2022, when our Gravity for the Redefinition of the American Vertical Datum (GRAV-D) project will be completed. During this period of change, every state will need the direct support and technical assistance provided by their Regional Advisor.

Finally, it should be noted that NGS Regional Advisors interface with the state and - to some extent - local governmental organizations. NGS Regional Advisors attend professional meetings and conduct workshops and training sessions. They will continue to provide outreach and education of the planned rollout and usage of the new NSRS in 2022. They remain the robust forward presence in outreach and communication. NGS

staff also attend many meetings at the national level to ensure broader educational outreach. NGS plans to continue to provide remote access to educational materials through meetings, trainings and webinars.

NGS is engaged with multiple agencies and groups primarily through contacts in the Federal Geodetic Control Subcommittee (FGCS) but also with other federal agencies. The most direct interactions are with NASA and NGA. NASA has groups related to geometric infrastructure (GNSS sites), gravity field modeling (GRACE Follow-On), and digital elevation models. All of these are essential to NGS to update the NSRS. NASA's interest in GNSS infrastructure is to ensure that the U.S. is providing and leading scientific efforts to develop the International Terrestrial Reference Frame (ITRF). In turn, NGS is interested in using these same sites as the backbone network for defining the NSRS in the U.S. These sites will be designated as Foundation CORS (FCORS) and provide the main ties to ITRF in the U.S. NGS will also seek to work with NSF and other private groups to ensure that either by direct ownership or proxy, NGS will have a robust network of FCORS distributed around all U.S. states and territories to guarantee access to the NSRS in case voluntary contributions from regular CORS ceases for any reason. There will also necessarily be agreements made with U.S. neighbors Canada and Mexico, the Caribbean states, and countries in the Asia-Pacific region to develop coordinated models for those regions. All of this is stipulated under the tenants of the UN-GGIM agreements to adopt ITRF models and an eventual International Height Reference Frame (IHRF).

For the latter part, NGS collaborates with both NGA and NASA to develop a highly accurate geopotential datum. NGS has been steadily collecting data through GRAV-D but will be building this into a larger Gravity Program to ensure that the final products remain updated and consistent with the planned IHRF. This also has required collaboration to ensure continuity throughout the region and across international borders.

E. Standards

The FGCS of the FGDC was established to promote standards of accuracy and currentness in geodetic data financed in whole or part by Federal funds; to exchange information on technological improvements for acquiring geodetic data; to encourage the Federal and non-Federal communities to identify and adopt standards and specifications for geodetic data; and to collect and process the requirements of Federal and non-Federal organizations for geodetic data. The lead agency responsible for the coordination, management, and dissemination of geodetic data is the Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, National Geodetic Survey:

- Geographic Information Framework Data Content Standard, Part 4: Geodetic Control (2008)
- Geospatial Positioning Accuracy Standards, Part 1: Reporting Methodology (1998)
- Geospatial Positioning Accuracy Standards, Part 2: Standards for Geodetic Networks (1999)
- Geospatial Positioning Accuracy Standards, Part 3: National Standard for Spatial Data Accuracy (1998)
- Geospatial Positioning Accuracy Standards, Part 4: Architecture, Engineering, Construction, and Facilities Management (2002)
- Geospatial Positioning Accuracy Standards, Part 5: Standards for Nautical Charting Hydrographic Surveys (2005)
- Geographic information - Geodetic codes and parameters (ISO) (2010)

F. Estimate of Theme Completeness

The NSGIC GMA (Geospatial Maturity Assessment) for 2017 is shown in **Figure 1**. It can be concluded that based on this dashboard that the geodetic data theme is mostly optimized at the Federal level. The only area not fully optimized is the archive appraisal process for the data set. However, state and local geodetic data vary in maturity from one jurisdiction to the other as indicated in subsequent sections. **Figure 2** shows the status of the GRAV-D program and what remains to be collected. Green shows available data and metadata, blue shows areas where data is being processed, orange shows areas

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Geoplatform.gov Performance Dashboard - Lifecycle Maturity Assessment

Assessments: 2017

Printed: Jun 20, 2018

Themes: Geodetic Control

Agencies: All agencies

Note: 2015 and 2017 Lifecycle Maturity Assessment levels are not comparable. For more information see: <https://geoplatform.gov/ima-maturity-temporal-changes/>

Legend													
5/5	Optimized, Established	4/5	Mature, Consistent	3/5	Managed, Predictable	2/5	Transition, Transformation	1/5	Planned, Initial Development	0/5	No Activity	empty	No Data
NGDA Id	Year	Dataset	General	Define/Plan	Inventory/Evaluate	Obtain	Access	Maintain	Use/Evaluate	Archive	Overall	Theme	Agency
		Rollup	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5		
47	2017	Airborne Gravity GRAVD	5/5	5/5	5/5	5/5	5/5	5/5	5/5	3/5	5/5	Geodetic Control	DOC NOAA
48	2017	Continuously Operating Reference Stations CORS	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	Geodetic Control	DOC NOAA
49	2017	Geodetic Control Information on Passive Marks	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	Geodetic Control	DOC NOAA
50	2017	Geoid Models	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	Geodetic Control	DOC NOAA

Figure 1. Chart of geodetic control theme maturity assessment (2017)

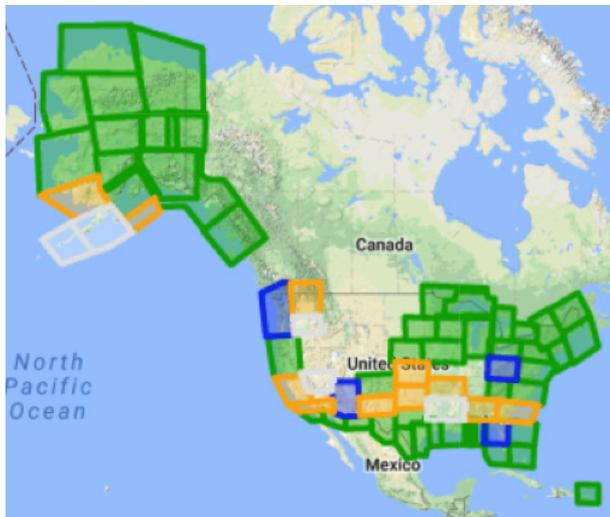


Figure 2. Status of GRAV-D program

where data collection is underway, and white shows areas where data collection is planned (https://www.ngs.noaa.gov/GRAV-D/data_products.shtml). Figure 3 illustrates the dichotomy of CORS coverage across the United States.

G. Accessibility of data

NGS products and services are available from the NOAA website at www.geodesy.noaa.gov, as well as from the NSDI Clearinghouse and other government portals. In their GMA responses, 26

states reported that geodetic control data were publicly available without restriction and 3 indicated that they were not. In addition, 19 states said that these data were available through a public state-maintained web mapping service.

H. Authority, Governance, and Management of the Theme.

NGS is an agency within NOAA. NOAA is part of the Department of Commerce. NGS provides the framework for all positioning activities in the Nation. The foundational elements of latitude, longitude, elevation, shoreline information impact a wide range of important activities. The NGS, our Nation's first civilian scientific agency, was established by President Thomas Jefferson in 1807 as the Survey of the Coast. Its mission was, and still is, to survey the U.S. coastline and create nautical charts of the coast to help increase maritime safety. As the nation grew westward surveys of the U.S. interior began. In 1878 the agency was given a new name, the U.S. Coast and Geodetic Survey (USC&GS), which it maintained until 1970. In 1970 a reorganization created the National Oceanic and Atmospheric Administration (NOAA) and the National Ocean Service (NOS) was created as a line office of NOAA. To acknowledge the geodetic portion of

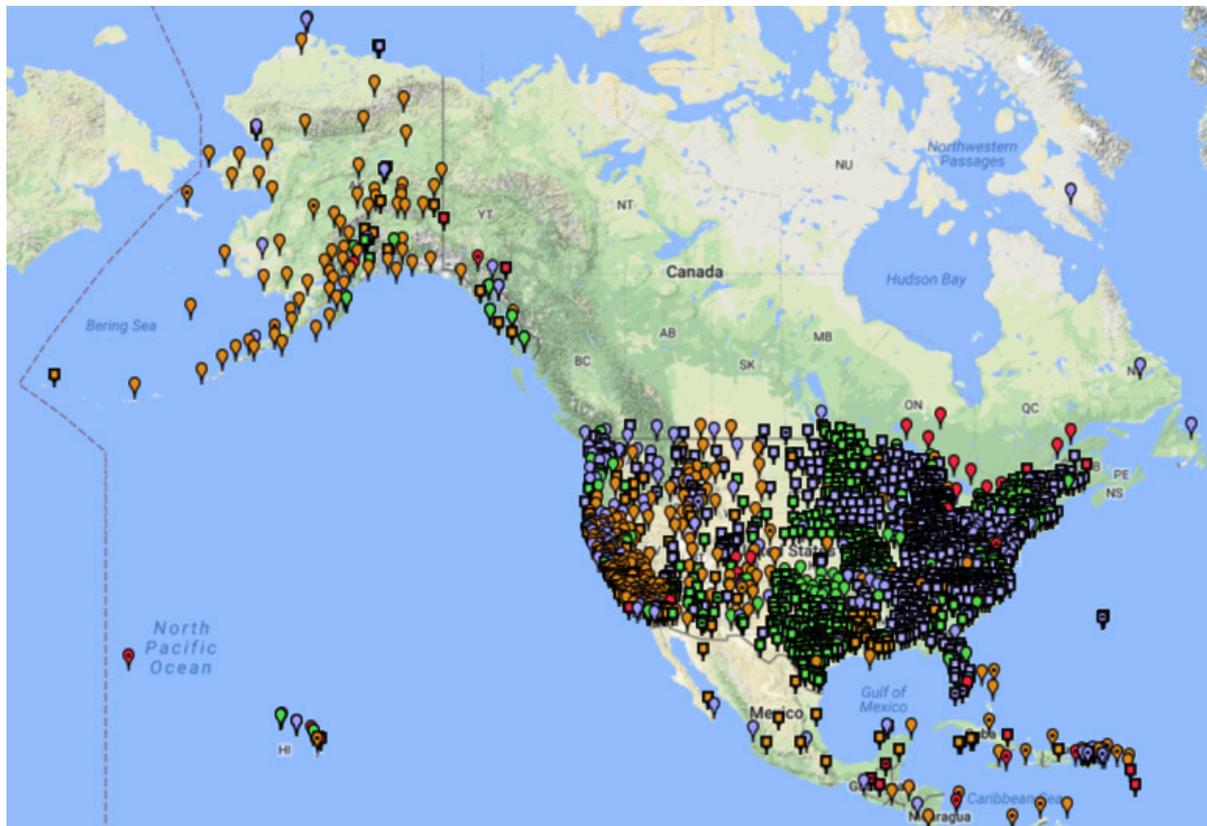


Figure 3. Source is NGS, 2017 (https://www.ngs.noaa.gov/CORS_Map/)

NOAA mission, the part of NOS responsible for geodetic functions was named the National Geodetic Survey.

network of the nation can serve as a secondary method of access to the NSRS and as a partial backup to GPS should any threats arise.

II. GEODETIC CONTROL ASSESSMENT

CAPACITY

The Framework's capacity to meet current and future demands:

NGS's strategic plan calls for extremely accurate positioning, with a strong reliance upon the use of GNSS. This reliance upon GNSS, with a heavy leaning toward GPS for at least 5 more years, means that any threat to GPS is a threat to the NGS mission. Other GNSS constellations could eventually serve as a backup to GPS, though the goal would be to use all GNSS constellations interoperably first, only relying on them independently as backups to one another as threats arise. Further, the passive control

CONDITION

The existing or near-term condition of the Framework themes as an integrated whole:

Modernization of the National Spatial Reference System (NSRS) is on track for completion per the NGS Strategic Plan. The National Geodetic Survey (NGS) has finalized certain key decisions in replacement of the three NAD83 reference frames, and in the replacement of various vertical datums of the National Spatial Reference System. Four plate-fixed terrestrial reference frames are being implemented. These Reference Frames are North American Terrestrial Reference Frame of 2022 (NATRF2022), Pacific Terrestrial Reference Frame of 2022 (PATRF2022), Marianna Terrestrial Reference Frame of 2022 (MATRF2022), and Caribbean Terrestrial Reference Frame of 2022 (CATRF2022).

FUNDING

The funding capability of the Framework:

Current funding levels must be maintained to complete the Gravity for the Redefinition of the American Vertical Datum (GRAV-D) Project as a part of the NGS Gravity Program by 2022. Any reduction in funding may cause delays in the development and implementation of the datum.

FUTURE NEED

Whether future-funding prospects will be able to meet the need:

The NSDI Report Card of 2015 noted that the geodetic control theme was adequate to meet the then current needs but needed improvement to meet future needs. Based on the data available at the time of this report, NGS has provided a clear road map forward with the contemplated implementation of the new datum in 2022. It is anticipated that accurate and accessible geodetic data are and will continue to be available in an enhanced environment.

OPERATION AND MAINTENANCE

The ability of key lead organizations to develop and maintain the Framework and to adopt new technology, procedures, and standards:

NGS is updating the NSRS to a more easily maintained and accessed model that meets the future needs of federal, state and local governments as well as private organizations. The current paradigm of accessing passive control is costly to maintain and is inconsistent with international plans for updates that have been adopted by the U.S. through participation in UN-GGIM. The aim is to provide an accessible NSRS via easily obtained GNSS, processed online, and closely tied to other physical heights and gravity field products. All of these would then have velocity models to describe the expected changes over time. This should account for physical changes that make the old datums obsolete, such as subsidence in Louisiana or glacial isostatic adjustment in the Great Lakes region. It further avoids having to maintain a million bench marks that would have to be revisited often to ensure their integrity and accuracy.

PUBLIC USE

The Framework's ability to provide data resources that meet the everyday needs of organizations and the general public, and to provide data resources that meet the need to respond to public safety incidents, natural disasters, and other emergencies:

Continued outreach and education are planned through more geospatial summits, webinars, presentations at conferences (scientific and professional), publication of papers in scientific and trade journals, and industry-specific meetings. A major focus of this effort will be through NGS Regional Advisors who are at the forefront of interactions with state, county and private institutions. However, NGS is also actively engaged with other government agencies through activities within the Federal Geodetic Control Subcommittee (FGCS) and Federal Geographic Data Committee (FGDC).

RESILIENCE

The ability of the geospatial community to participate in development of the Framework and to contribute to its sustainability as a long-term asset of value for the nation:

NGS will help the GIS community adapt to the new NSRS by providing digital transformations under ISO 19111. These transformations will be maintained in an ISO-sponsored geodetic registry and will also be available through the NGS website as models and the underlying interpolation algorithms. The surveying community will have available the same transformations; however, the existence of paper records in legacy datums will require digitizing to upgrade. On the plus side, robust, map-grade transformations already exist in geometric coordinates and a similar set is being developed for physical height transformations. Additionally, models are being developed that will explain any expected movement over time (e.g., plate rotation) so that data collected at different epochs could be transformed to common epoch for comparison for long term projects. A robust collection campaign is in progress to obtain sufficient GPS on bench marks to improve the new realization of the reference frame

III. ASSESSMENT CATEGORIES SPECIFIC TO GEODETIC CONTROL

In this section we include an assessment of CORS Coverage, OPUS-RS Ellipsoid Height 1-Hour Data Coverage, Passive Control Coverage, Passive Control Maintenance and RTN Service on a state by state level.

A. CORS COVERAGE: The CORS coverage of each state’s total surface area (including federal, non-federal, and water bodies) is assessed using NGS CORS data and the USDA-NRCS National Resources Inventory data.. Only operational NGS CORS stations within each state were evaluated. Some states have agreements with neighboring states to access CORS stations beyond state limits, which was not evaluated. NGS guidelines suggest that new CORS be located no closer than 70 km (~43 miles) from an existing CORS. This indicates a coterminous coverage of half this distance (21.5 miles). The resultant surface area coverage is 1450 square miles, which is considered an average indicator of sufficiency for this assessment. **Table 1** illustrates the rubric was used to determine a grade for CORS Coverage (grades by state for each assessment category are shown in **Table 6**):

Table 1.

Grade	Square Miles of Coverage
A	<500
B	1000
C	1450
D	3500
F	5000+

B. OPUS-RS ELLIPSOID HEIGHT 1-HOUR DATA COVERAGE: Subjective graphical assessment of the availability and coverage of rapid static processing of 1-hour ellipsoid height data was conducted using the NGS OPUS Map: https://www.ngs.noaa.gov/OPUSI/Plots/Gmap/OPUSRS_sigmap.shtml. Compared to horizontal positioning, ellipsoid height positioning is the best indicator of position integrity. For instance,

high accuracy GPS ellipsoid heights will always generate high accuracy GPS horizontal positioning whereas high accuracy horizontal positioning will not always generate high accuracy GPS ellipsoid heights. Rapid-static processing of OPUS solutions is an indicator of efficiency and ability to meet future needs. **Table 2** illustrates the rubric was used to determine a grade for OPUS-RS Coverage.

Table 2.

Grade	Coverage
A	100%
B	98%
C	95%
D	80%
F	70%

C. PASSIVE CONTROL COVERAGE: The passive control coverage of each state’s non-federal developed and rural surface area (excluding water bodies) was assessed using NGS CORS data and the USDA-NRCS National Resources Inventory data. Passive control is critical to the NSRS modernization efforts. The coverage of passive control throughout each state is a good measure of ability to support modernization efforts. Constraining the passive control coverage to the non-federal developed and rural surface area (excluding water bodies) is an indicator of public availability and use. **Table 3** illustrates the rubric was used to determine a grade for passive control coverage.

Table 3

Grade	Square Miles of Coverage
A	<2
B	10
C	20
D	30
F	40+

D. PASSIVE CONTROL MAINTENANCE: The percentage of passive control recovered, monumented, or first observed since 1995, as indicated in the NGS control database was

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assessed. Alternative databases were not evaluated. Regular maintenance and recovery of passive control indicates deliberate effort to keep passive control networks fresh and available. This is an indicator of how attentive states are in maintaining their passive control system. It is recognized that there is no requirement to use NGS database for passive control maintenance, but access to other sources was not available at the time of this report. **Table 4** illustrates the rubric was used to determine a grade for passive control maintenance.

Table 4

Grade	Percentage
A	80%
B	70%
C	60%
D	50%
F	40%

E. RTN SERVICE: The availability and cost of a RTN service was assessed. The pervasiveness of RTNs continues to enable GPS users with quick and reliable access to positional correction data without the use of base stations. The access and availability to GPS users is an indicator of accelerating geodetic network services. **Table 5** illustrates the rubric that was used to determine a grade for RTN service.

Table 5

Grade	RTN Service
A	Free public RTN service
B	Single baseline service
C	Fee-based RTN service
D	Private RTN
F	No RTN service

Table 6 on the next page illustrates the assigned grades by state for the five assessment categories of CORS Coverage, OPUS-RS Ellipsoid Height 1-Hour Data Coverage, Passive Control Coverage, Passive Control Maintenance and RTN Service. A final overall grade was given for each state (the last column) and for each category

(last row).

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Table 6

State	CORS Coverage Rating	OPUS-RS Coverage Rating	Passive Control Coverage Rating	Passive control maintenance Rating	RTN Service Rating	Overall Rating
Alabama	C	A	C	F	A	C
Alaska	F	F	F	F	C	F
Arizona	D	B	B	F	C	C
Arkansas	D	A	C	F	F	D
California	B	A	B	F	B	B
Colorado	D	A	C	F	C	C
Connecticut	A	A	B	F	F	C
Delaware	A	C	B	B	F	C
Florida	D	B	A	C	A	B
Georgia	D	A	C	F	C	C
Hawaii	A	F	B	F	F	D
Idaho	D	C	C	F	B	C
Illinois	D	A	B	B	F	C
Indiana	B	A	C	F	A	B
Iowa	D	A	F	F	A	C
Kansas	F	D	F	F	F	F
Kentucky	D	A	C	F	A	C
Louisiana	C	A	B	F	A	B
Maine	C	D	D	F	A	C
Maryland	B	A	A	D	F	C
Massachusetts	A	D	B	F	A	C
Michigan	B	A	B	B	A	B
Minnesota	C	C	B	A	A	B
Mississippi	D	A	C	F	A	C
Missouri	B	A	C	F	A	B
Montana	F	A	F	F	B	D
Nebraska	D	B	F	F	F	D
Nevada	F	C	C	F	B	D
New Hampshire	B	A	C	F	F	C
New Jersey	A	C	A	B	F	B
New Mexico	F	B	F	F	B	D
New York	B	A	B	F	A	B
North Carolina	B	B	B	C	B	B
North Dakota	F	C	F	F	C	D
Ohio	B	A	B	F	A	B
Oklahoma	D	A	F	F	C	D
Oregon	D	A	C	F	A	C
Pennsylvania	D	A	B	F	F	C
Rhode Island	A	F	A	F	F	C
South Carolina	D	B	B	A	C	B
South Dakota	F	B	C	F	C	D
Tennessee	B	A	D	F	C	C
Texas	D	B	D	F	C	D
Utah	F	A	D	F	C	D
Vermont	A	A	B	B	A	A
Virginia	C	A	B	F	F	C
Washington	D	C	B	F	C	C
West Virginia	C	A	C	F	A	C
Wisconsin	D	A	B	A	A	B
Wyoming	F	A	F	F	B	D
Average Grade	C	B	C	D	C	C

V. GOVERNMENT UNITS THEME

EXECUTIVE SUMMARY

The Governmental Units Theme has benefited greatly from the Census Bureau's stewardship and investment. Government units are an integral part of the work products at the Census Bureau, supporting economic, election, and demographic statistics and geographies. As a critical data component Census invests heavily in boundary data quality by supporting annual updates from local, state, and tribal governments, continuously striving for increased accuracy, publishing updated data sets twice a year, and offering web services. Embedding the boundary data into the Bureau's daily decision and work processes is the key to success making this theme fit for the nation for many years to come.

THEME GRADE: A-
FIT FOR THE FUTURE

I. DESCRIPTION OF THE FRAMEWORK

A. An Introduction to the Theme

Governmental units are the boundaries and names of government service and management areas at all levels of government. For the purposes of the framework scoring, governmental units are defined as:

The geopolitical divisions of the U.S. including international and tribal boundaries, states and territorial boundaries, state divisions, typically counties and their equivalents, county divisions including cities, villages towns and minor civil divisions, and election geography.

This Framework assessment on governmental units excludes statistical divisions such as those areas defined for statistical aggregation, census blocks and tracts, administrative boundaries such as those defined for internal agency resource allocation, and service areas such as emergency response zones or municipal service districts.

Governmental units are essential to describing and delineating the U.S., by defining the spatial extent of legal jurisdictions in the U.S. They define the extent of governances and laws. Cross a governmental unit boundary and many things can change such as speed limits, sales tax rate, liquor and tobacco laws, and service franchises to name a few. In a recent resurvey of the North and South Carolina state line, a business that sold gasoline and fireworks on the state line in South Carolina was found to be located in North Carolina where fireworks sales are illegal. Gas tax contributions to brownfield mitigations, sales tax, hours of operation, and employment and income taxes are all different in the two states. These are just a few of the differences in governing and laws highlighted by this one boundary resurvey.

Governmental Units provide the basic understanding about the size, shape, and organization of places in the U.S. Examples of the uses and applications for governmental units include the following:

- Governance

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- Election Management
- Area of interest or map orientation
- Navigation and search and rescue
- Addressing - both addressing authority and address search and orientation
- Real estate tax rates and collection
- Unique identification of places

A quote from the 2015 NSDI report card on Governmental Units is likely still true: “When the USGS published *The National Map Customer Requirements Findings from Interviews and Surveys* in 2009, the need for civil boundaries and Federal and Native American lands were ranked in the top ten of data requirements.”

B. The Theme Definition

In the 2015 NSDI report card, the Governmental Units theme included the following:

- Governmental Units — These data describe, by a consistent set of rules and semantic definitions, the official boundaries of Federal, state, local, and tribal governments as reported/certified to the U.S. Census Bureau by responsible officials of each government for purposes of reporting the nation’s official statistics.
- International Boundaries—International boundary data sets include both textual information to describe, and the cartographic data to depict both land and maritime international boundaries, other lines of separation, limits, zones, enclaves, exclaves, and special areas between states and dependencies.
- Marine Boundaries—Marine boundaries depict offshore waters and sea beds over which the U.S. has sovereignty and jurisdiction.

Additional definitions are provided by the Subcommittee on Cultural and Demographic Data (SCDD) include:

“A governmental unit is a geographic area with legally defined boundaries established under Federal, Tribal, State, or local law, and with the authority to elect or appoint officials and raise revenues through taxes.”

An administrative unit is a geographic area established by rule or regulation of a legislative, executive, or judicial governmental authority, a non-profit organization, or private industry for the execution of some function. A statistical unit is a geographic area defined for the collection, tabulation, and/or publication of demographic, and/or other statistical data.”

The original report card report for this theme described an expanded portfolio management approach with governmental units including administrative and statistical boundaries, encompassing 70 separate data sets. A search of data.gov (<https://catalog.data.gov/dataset>, last accessed in August 2018) using Governmental Units as a search criteria returned 3,098 data sets, the USGS National Boundary Dataset. A search of the National Geospatial Data Asset Datasets site (https://www.fgdc.gov/ngda-reports/NGDA_Datasets.html, last accessed in August 2018) returned 39 data sets for Governmental Units, and Administrative and Statistical Boundaries. This demonstrates a need to include ‘governmental units’ in federal data metadata key word.

However, statistical and administrative areas are not part of this evaluation, nor are the U.S. international boundary data sets as they are integrated into the Census Bureau’s data sets.

Election geography was not addressed specifically in the 2015 report card and is also excluded here. The concepts and applications defining and maintaining election geography are beyond the scope of this evaluation as they can have varying interpretations depending on the level of government, governing statutes, and applications or uses for the data. The appendix at the end of the governmental units assessment includes a discussion of some of the boundary issues surrounding redistricting and defining local boundaries and precincts. Election precincts will be important for the post 2020 redistricting, and a national understanding of their availability and status would be helpful to that effort. There are many state and local laws and authorities that impact the definition and aggregation of precinct data and precinct areas are not part of the Office

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of Management and Budget (OMB) Circular A-16 responsibility or definition.

Thus, with these revisions and for the purposes of this evaluation, the Governmental Units theme is defined as:

“The geopolitical divisions of the U.S. including international and tribal boundaries, states and territorial boundaries, state divisions, typically counties and their equivalents, county divisions including cities, villages towns and minor civil divisions, and election geography.”

C. Lead Agency and Current Activities

The Census Bureau is the A-16 designated lead for the Governmental Units Theme. All federal agency and federally funded applications that use Governmental Units (boundaries) should be using the Census Bureau published data as the authoritative and legal definition of these boundaries.

D. Collaboration and Partnerships

The Census Bureau has an extensive partnership and cooperation program. This is a staffed and funded program that develops agreements for data sharing, data maintenance, and in most cases annual state and local submissions of boundary updates for Governmental Units’ data sets. In addition to formalized partnership programs, the Census Bureau has many programs providing technical and application support, a fully staffed technical and administrative support call in line, and workshops, outreach and training programs. Training programs are conducted on site for the partners and include workshop materials and follow up on the use of application tools and submission requirements.

The Census Bureau co-chairs the FGDC National Boundary Group (NBG) with United States Geological Survey (USGS). While this report focuses on the Governmental Units Theme, the activities of the NBG contribute to the overall success of the national coordination for this Theme. The NBG meets regularly with conference calls and two in-person meetings every year. Meeting participants include representatives from tribal, federal, state and local agen-

cies and the private sector. This serves to keep a wide audience of stakeholders informed on boundary updates, boundary program activities, and maintenance schedules. The NBG sponsors the Federal Lands Working (FLWG) group, an active group that supports the annual publishing of the Protected Areas Database (PAD-US). PAD-US is described in greater detail in the Cadastral Theme report. The cross-theme coordination with Cadastral and Governmental Units strengthens both Themes and provides the nation with more robust geospatial data assets.

Since the 2015 report card, the Census Bureau has strengthened its connection with Cadastral data and has an active program upgrading the Census Bureau’s boundaries to align with locally sourced cadastral boundaries when the legal descriptions are coincident.

In order to ensure that the boundaries contained in TIGER are current, the Census Bureau partnered with local governments to conduct a voluntary annual Boundary and Annexation Survey (BAS), which is authorized by Section 6 of Title 13 - Census of the United States Code. The Office of Management and Budget (OMB) approves the BAS survey materials. The current valid OMB control number is OMB No. 0607-0151, and approval expires on March 31, 2019. As noted in the Federal Register:

“No other Federal agency collects these data nor is there a standard collection of this information at the State level. The Census Bureau’s BAS is a unique survey providing a standard result for use by federal, state, local, and tribal governments and by commercial, private, and public organizations.”

The BAS also provides an opportunity for participants to review the names and geographic relationships for these areas. The Census Bureau uses this information to provide a record for reporting the results of the decennial and economic censuses, and to support the Population Estimates Program and the American Community Survey.

The Census Bureau currently maintains BAS state agreements with states and continually

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works to establish new agreements with interested state governments. Two types of BAS state agreements are available to states, depending on the state authorizing legislation. The state legal authority must acknowledge the state's authority to report on behalf of local governments. Under the first type of agreement, the state reports boundary changes for all incorporated places, minor civil divisions (if applicable), and counties within its jurisdiction to the annual BAS. Under the second type of agreement, the state provides the Census Bureau with a list of local governments that reported boundary changes to the state. The Census Bureau uses this list to target those local governments for the BAS.

The Census Bureau works closely with the U.S. Bureau of Indian Affairs to ensure that the BAS reflects official boundaries for Federally-recognized American Indian reservations, off-reservation trust lands, and tribal subdivisions.

E. Standards

Governmental Units has an established FGDC DataContentStandard (FGDC-STD-014.5-2008) that is available at this link (https://www.fgdc.gov/standards/projects/framework-data-standard/GI_FrameworkDataStandard_Part5_GovernmentalUnitBoundaries.pdf). Developed in 2008, this standard specifies the exchange of governmental unit and other geographic area boundary data. The standard provides a common baseline for the semantic content of governmental unit and geographic area databases.

The Census Bureau has applied these content standards to its Master Address File (MAF)/ Topologically Integrated Geographic Encoding and Referencing (TIGER) System. In addition to TIGER's operation database the Census Bureau produces standardized geographic information system (GIS) products such as shapefiles, geodatabases, and web services. The content of the published products, as well as the product's metadata, are well documented. TIGER data files and their documentation can be found at this link (<https://www.census.gov/geo/maps-data/data/partnership.html>, last accessed 8/10/18). The partnership shape files and their documentation

can be found here (<https://www.census.gov/geo/maps-data/data/partnership.html>, last accessed 9-7-17).

The standards for governmental units at the Census Block level and above are well documented. There are no business needs for further data standards for Governmental Units beyond what the Census Bureau maintains.

F. Estimate of Theme Completeness

The Census Bureau's data sets collectively provide coverage for the U.S., States, Territories, Counties (State Divisions), County Subdivisions (incorporated and unincorporated areas), and Legislative Districts for the U.S. Congress and State legislatures. The Census Bureau has A-16 responsibility for Governmental Units and serves as a national steward for these data sets. To properly aggregate and analyze the statistics and counts from the many census surveys, maintaining a complete and accurate inventory of governmental units is essential for the Census Bureau's line of business. While the combined datasets are national in geographic coverage, the timeliness of the data is challenging due to maintenance. As an example the BAS program is national in scope and voluntary in participation. As such there are municipalities where boundary changes have occurred at the local level, and due to any number of reasons may have gone unreported, leaving the accuracy in question in certain areas.

G. Accessibility of data

The Census Bureau provides regular updates of Governmental Units GIS data for download and viewing at their web site (<https://www.census.gov/geo/maps-data/data/tiger.html>, last accessed 8-10-19). These data are provided in a variety of formats. Partnership shape files (**Figure 1**) are provided by state and by county (or equivalent) at this site (<https://www.census.gov/geo/maps-data/data/partnership.html> last accessed 8-10-18). TIGER shape files and geodatabases are provided at this website (<https://www.census.gov/geo/maps-data/data/tiger.html>, last accessed 8-10-18) (**Figure 2**). Representational State

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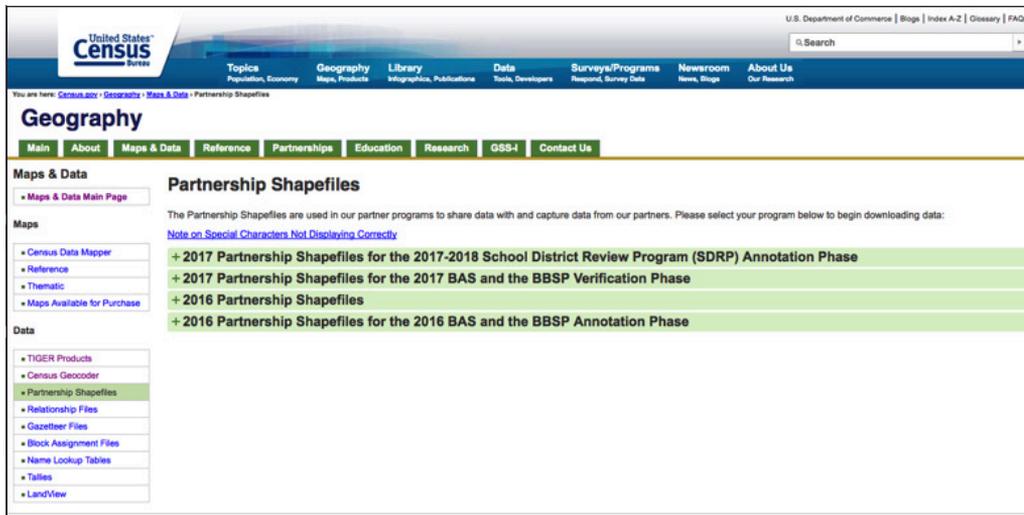


Figure 1.
Census Bureau partnership data web site.

Figure 2.
Census Bureau TIGER products web site.

TIGER Products

TIGER = Topologically Integrated Geographic Encoding and Referencing

TIGER products are spatial extracts from the Census Bureau's MAF/TIGER database, containing features such as roads, railroads, rivers, as well as legal and statistical geographic areas. The Census Bureau offers several file types and an online mapping application. Our products are:

- [TIGER/Line Shapefiles - New 2016 Shapefiles](#)
- [TIGER/Line Geodatabases](#)
- [TIGER/Line with Selected Demographic and Economic Data](#)
- [Cartographic Boundary Shapefiles](#)
- [KML - Cartographic Boundary Files](#)
- [TIGERweb](#)

25 Years and Counting

- [TIGER Story Map \(Part 1\)](#)
- [Happy 25th Anniversary, TIGER](#)

TIGER Data and Product FAQs

Which product should I use?

Product	Best For...	File Format	Type of Data	Level of Detail	Descriptive Attributes	Vintages Available
TIGER/Line Shapefiles	Most mapping projects—this is our <i>most comprehensive dataset</i> . Designed for use with GIS (geographic information systems).	Shapefiles (.shp) and database files (.dbf)	Boundaries, roads, address information, water features, and more	Full detail (not generalized)	Extensive	2006 - 2016, CD 113
TIGER Geodatabases	Useful for users needing national datasets or all major boundaries by state. Designed for use in ArcGIS. Files are extremely large.	Geodatabase (.gdb)	Boundaries, roads, address information, water features, and more	Full detail (not generalized)	Limited	2013-2016
TIGER/Line with Selected Demographic and Economic Data	Data from selected attributes from the 2010 Census, 2006-2010 through 2010-2014 ACS 5-year estimates and County Business Patterns (CBP) for selected geographies. Designed for use with GIS.	Shapefiles (.shp) and Geodatabases	Boundaries, Population Counts, Housing Unit Counts, 2010 Census Demographic Profile 1 attributes, 2006-2010 through 2010-2014 ACS 5-year estimates data profiles, CBP data.	Full detail (not generalized)	Limited	2012 CBP, 2010, 2006-2010 to 2011-2015 ACS 5-Year Estimates
Cartographic Boundary Shapefiles	Small scale (limited detail) mapping projects clipped to shoreline. Designed for thematic mapping using GIS.	Shapefiles (.shp)	Selected boundaries	Less detail (generalized)	Limited	2013-2016, 2010, 2000, 1990
KML - Cartographic Boundary Files	Viewing data or creating maps using Google Earth, Google Maps, or other platforms that use KML.	KML (.kml)	Selected boundaries	Less detail (generalized)	Limited	2013-2016
TIGERweb	Viewing spatial data online or streaming to your mapping application.	Interactive viewer. HTML data files, plus REST and WMS map services	Boundaries, roads, address information, water features, and more	Detailed	Extensive	Current, 2015 ACS, 2014 ACS, 2010 Census

TIGERweb

Home | TIGERweb Applications | WMS | REST Services | Data Files | TIGERweb Geography

Contact Us
Email us at: geo.tigerweb@census.gov
Click here to sign up for updates on TIGERweb and other Census Bureau Topics.
[TIGERweb Brochure](#)

Incorporated Places - Current/AC

GEOID	STATE	PLACE	PLACENS	BASENAME
0100124	01	00124	02403054	Abbeville
0100460	01	00460	02403063	Adamsville
0100484	01	00484	02405123	Addicks
0100676	01	00676	02405125	Albany
0100820	01	00820	02403069	Alabaster
0100988	01	00988	02403074	Albertville
0101132	01	01132	02403077	Alexander City
0101228	01	01228	02403080	Aliceville
01110	27	890100192662	010130001	Alibon
01110	27	890100197663	010166001	Alibon
01110	27	890100197663	010166001	Alibon

TIGERweb Overview

TIGERweb is a web-based system that allows users to visualize our TIGER (Topologically Integrated Geographic Encoding and Referencing database) data in several ways:

- TIGERweb and TIGERweb Decennial Applications
- TIGERweb WMS
- TIGERweb REST Services

Figure 3.
Census Bureau TIGER WEB products.

Transfer (REST) Services, Web Map Service (WMS), and web applications are also available for all TIGER Products (https://tigerweb.geo.census.gov/tigerwebmain/tigerweb_main.html, last accessed 8-10-18) (**Figure 3**).

Local precinct data are not aggregated to the national level and the availability varies by state. The Census Bureau provides data reported to them at the TIGER Products web site (<https://www.census.gov/geo/maps-data/data/tiger-line.html>, last accessed 9-7-17). Check the 2010 vintage to find the data sets with voting districts.

H. Authority, Governance, and Management of the Theme.

The Census Bureau is governed by Titles 13 and 26 (when using federal tax data) of the United States Code. These laws pertain to protection of information collected from individuals and businesses and protecting personal privacy. The Bureau is dependent on voluntary partnerships with local, State, and Federal partners to fulfill its Constitutional mandate to conduct a decennial census. In addition, the accuracy of all Census Bureau surveys, including the annual American Community Survey (ACS), is dependent on the continuous update of the MAF/TIGER Database. The continuous maintenance of this database is a major operational function of the Geography Division of the Census Bureau.

II. GOVERNMENTAL UNITS ASSESSMENT CATEGORIES

CAPACITY

The Framework's capacity to meet current and future demands:

The currently maintained Census Bureau Governmental Units inventory uniquely identifies all incorporated places, counties (and their equivalents) and states and territories of the U.S. Because this data layer is complete and well maintained, it has the capacity to meet identified business needs well into the future.

CONDITION

The existing or near-term condition of the Framework themes as an integrated whole:

The Census Bureau's Governmental Units data is integrated and matched to associated data such as roads, hydrography, and cadastral data. Additionally, the attribution including unique identifiers and names are synchronized with the Geographic Names Information System (GNIS).

FUNDING

The funding capability of the Framework:

The current funding including staffing and technical resources meet the maintenance and publication needs for the datasets of this theme. It is not possible to speculate on future funding. Census Bureau tabulation is a constitutionally mandated activity and funding should be secure, but in times of government cutbacks, hiring freezes, and resource reductions, nothing can be guaranteed.

FUTURE NEED

Whether future-funding prospects will be able to meet the need:

One of the best ways to secure future funding availability and adequacy would be for states, federal agencies, and counties to provide consolidated digital data submissions on an annual basis. The consolidated data is more efficient to maintain as fewer data sets need to be reviewed and updated. Consolidated data also reduces the number of potential conflicting data submissions. Digital update submissions reduce boundary interpretation error and are more efficiently processed. Annual submissions provide a more even workload, allowing the Census Bureau to have a sustained work force and reduces the impact on the once a decade workload.

OPERATION AND MAINTENANCE

The ability of key lead organizations to develop and maintain the Framework and to adopt new technology, procedures, and standards:

The Census Bureau has demonstrated leadership in workforce training and new technology adoption. They provide for web submissions and can accept a wide variety of data input for-

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mats, as long as essential attributes for changes are provided. The U.S. Census Bureau revisits its outreach, training, and procedures materials on a regular basis. It is important to note that the production data set from the MAF/TIGER Database has over 5 million polygons and over a billion line segments. A data set of this size is not likely to be migrated very often. The Census Bureau adapts to emerging technology by providing continuously updated access to published data sets. As resources and budgets allow, new applications and access are developed, tested, and deployed.

PUBLIC USE

The Framework's ability to provide data resources that meet the everyday needs of organizations and the general public, and to provide data resources that meet the need to respond to public safety incidents, natural disasters, and other emergencies:

The Census Bureau makes its data available on a regular schedule that can be used by any business, agency, or public need. In the hurricane and wildland fire emergency events in 2017, Census Bureau data were used extensively at all levels of government for estimating the numbers and demographics of potentially impacted populations.

RESILIENCE

The ability of the geospatial community to participate in development of the Framework and to contribute to its sustainability as a long-term asset of value for the nation:

The Census Bureau relies on authoritative boundaries for its Governmental Units data sets. Therefore, the community of contributors is limited to those jurisdictions that have the legal authority to define and verify those boundaries. It is up to the local data authorities to participate as fully as they can to assure long-term resiliency of this theme's data sets.

The Census Bureau has made significant progress since the last scorecard evaluation and has addressed the issues identified in the 2015 report card. The collaboration with Cadastral Subcommittee, further agreements with states and consolidated BAS reporting, and, hopefully, sustained funding for the future contributed to the assessment metrics.

The national governmental units data set is complete and well maintained. It incorporates partnerships with authoritative local governments, has a funded outreach and training component, and aggregates locally sourced data into a consistent standardized data set. The data are easily accessed and meet defined content and metadata standards.

Governmental Units Theme is FIT FOR THE FUTURE, Grade A-.

Framework Evaluators

Nancy von Meyer, Theme Lead, URISA
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Reviewers of Governmental Units Framework Assessment

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III. OVERALL ASSESSMENT OF GOVERNMENTAL UNITS THEME

APPENDIX

Precincts

Precincts, sometimes called election districts or voting districts, are governmental units created and maintained by state and local governments. The authority and management of these districts is not a national data theme and not under the authority of A16 or national stewardship. Census has worked with states and the National Conference of State Legislatures to provide guidance and sample legislation to support consistent voting district data.

Voting district (VTD) is a generic term adopted by the Bureau of the Census to include the wide variety of small polling areas, such as election districts, precincts, or wards, that State and local governments create for the purpose of administering elections. Some States also use groupings of these entities to define their State and local legislative districts, as well as the districts they define for election of members to the U.S. House of Representatives. In a nationwide cooperative program for the 1980 census, the Census Bureau gave States the opportunity to request use of these election precinct boundaries as the boundaries of Census enumeration districts (EDs) or, in some areas, census blocks. The Census Bureau began using the term voting districts as it began planning for the 1990 census. This chapter describes the events that led to the development of the VTD program for the 1980 and 1990 censuses, and briefly explains the operations and procedures the Census Bureau used to implement the program. (https://www.census.gov/geo/reference/gtc/gtc_vtd.html, last accessed 9-7-17)

A more complete description of the history of voting districts at census is contained in this document (<https://www2.census.gov/geo/pdfs/reference/GARM/Ch14GARM.pdf>, last accessed 9-7-17)

Voting districts are not a simple dataset. They do not form a nicely nested hierarchical structure. Shelby Johnson, State Geographic Information Officer for Arkansas, published this paper

to explain the impact of redistricting in regard to some specific legislation in Arkansas. The explanation of the impacts of voting districts and redistricting captures the complexity of local voting districts.

Redistricting Background

In Arkansas, election administrators are required to create a ballot style that is unique and distinct for each, and every unique, or distinct election polygon (district). This is how election administrators assign the correct ballot for any given voter regardless of the number of precinct splits. This is a daunting challenge because every ten years, following the decennial census, states and localities undertake redistricting.

The process of redistricting is designed to apportion roughly equal numbers of population to various election districts. The result of redistricting is that most election precincts are split or divided by two or more election districts. Redistricting can apply to the following election districts; Congress, State House and Senate, County Justice of Peace, City Wards, and School Districts. The redistricting process carves up county territory into many geographic slivers. Complicating matters is that redistricting for these boundaries is done independently of each other. The Arkansas Legislature performs redistricting for Congress. The Arkansas Board of Apportionment does redistricting for the Legislature. County Election Commissions redistrict Justice of Peace territory, and set election precincts. And finally, School Boards and cities redistrict themselves. The carving of equal portions of population for all these election boundaries independently can create slivers, and occasionally, these slivers can be very small geographic areas.

To understand the impact of how redistricting affects ballot style, the following graphics, Figure 4, 5 and 6 on the next page depict election precincts and how various election districts can split them.

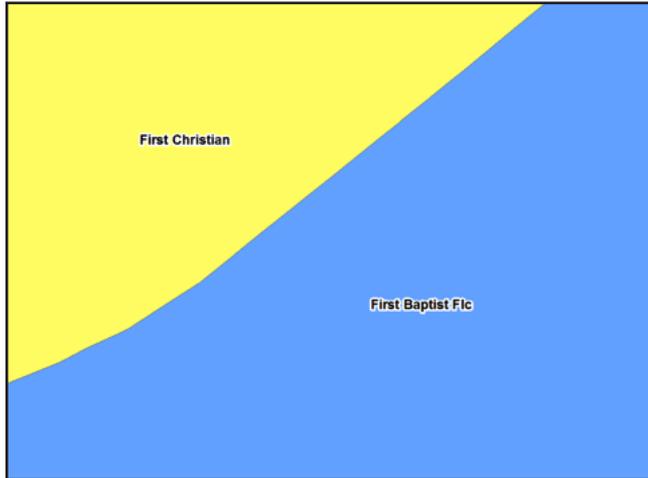


Figure 4 shows an area of Saline County that is composed of two election precincts. Interstate 30 running from southwest to northeast separates these two precincts

Figure 5 shows the boundary between House District 23 and 28, which is splitting the First Baptist Flc election precinct (shown in blue). For the area in blue In Figure 5 there must be two ballot styles for voters. Election administrators must create a ballot style for voters who can vote for the candidates of House District 23 in First Baptist Flc precinct and they must create a ballot style for voters who can vote for the candidates of House District 28 in the First Baptist Flc precinct.

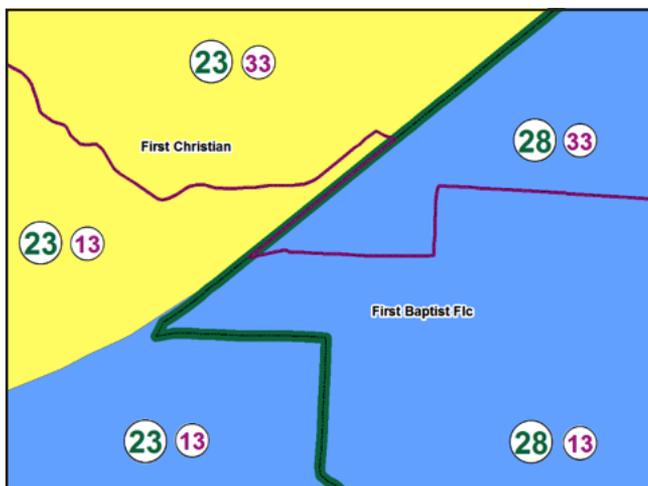


Figure 6 shows how the introduction of additional election districts complicates matters. When Senate Districts are overlaid, more ballot styles are necessary for voters to cast their ballot for candidates in Senate District 13 and 33 in the First Baptist Flc Precinct.

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The following tables show fictitious ballot styles that would be required for voters in the First Baptist Fle precinct. This process ensures fair and proper administration of elections. Voters are provided a ballot with candidates who represent the district in which the voter resides. It prevents voters from casting ballots for candidates who do not represent where the voter resides.

Redistricting can carve up County territory into many slices. The more a County is carved up the harder it is for County Clerks and election administrators to prepare for any election.

Ballot Style 1

VOTE FOR **Senate District 13**

<input type="checkbox"/>	Jeremy Hutchinson
<input type="checkbox"/>	Chuck Norris

House District 28

<input type="checkbox"/>	Kim Hammer
<input type="checkbox"/>	Bruce Lee

Ballot Style 2

VOTE FOR **Senate District 13**

<input type="checkbox"/>	Alan Clark
<input type="checkbox"/>	Arnold Schwarzenegger

House District 23

<input type="checkbox"/>	Lanny Fite
<input type="checkbox"/>	Sylvester Stallone

Ballot Style 2

VOTE FOR **Senate District 13**

<input type="checkbox"/>	Alan Clark
<input type="checkbox"/>	Arnold Schwarzenegger

House District 28

<input type="checkbox"/>	Kim Hammer
<input type="checkbox"/>	Bruce Lee

VI. HYDROGRAPHY DATA THEME

EXECUTIVE SUMMARY

The 2016 Hydrography Requirements and Benefits Study (HRBS) documented input from more than 500 organizations representing federal, state, local, and non-profit entities across the entire nation. In this report the 420 mission critical activities were identified and linked to 25 business uses with an estimated annual future total benefit of \$1.14B. HRBS is a milestone accomplishment for the Hydrography theme because it captured the requirements of organizations nationwide and provides insights and requirements for a future state hydrography theme. This assessment considered the Hydrography Requirements and Benefits Study when assigning the grade of B-.

THEME GRADE: B-
ADEQUATE FOR NOW
(NEEDS ATTENTION FOR FUTURE)

I. DESCRIPTION OF THE FRAMEWORK

A. An introduction to the Theme

The NSDI Hydrography Data Framework is based on an approach developed for the EPA and the USGS. This approach has resulted in the National Hydrography Dataset (NHD). The Hydrography Requirements and Benefits Study (USGS, 2016) is the most recent and most comprehensive study to identify the requirements and benefits from users throughout the nation.

Hydrography is important to many applications. As with other data themes, many users need hydrographic features as reference or base map data. The data have assisted with monitoring water quality and availability, agriculture, flood risk management, environmental health, land suitability, wildlife management and coastal processes, among many others.

B. The Theme Definition

The hydrography data framework is a compre-

hensive set of digital spatial data that encodes information about naturally occurring and constructed bodies of surface water (lakes, ponds, and reservoirs), paths through which water flows (canals, ditches, streams, and rivers), and related entities such as point features (springs, wells, stream gages, and dams). The information encoded about these features includes classification and other characteristics, delineation, geographic name, position and related measures, a “reach code” through which other information can be related to the NHD, and the direction of water flow. The network of reach codes delineating water flow allows users to trace movement in upstream and downstream directions. In addition to this geographic information, the data set contains metadata that supports the exchange of future updates and improvements to the data.

C. Lead Agency and Current Activities

OMB Circular A-16 designates USGS as lead federal government agency for the Hydrography Dataset. The Advisory Committee on Water Information (OMB Memorandum No. 92-01)) and FGDC created the FGDC Subcommittee on Spatial Water Data (SSWD) to assist coor-

dination of Federal and non-Federal interests in spatial water data, including (1) facilitating the exchange of information and transfer of data; (2) establishing and implementing standards for quality, content, and transferability; and (3) coordinating the identification of requirements and the collection of spatial data to minimize duplication of effort where practicable and economical.

D. Collaboration and Partnerships

The NHD and Watershed Boundary Dataset (WBD) are managed by the USGS, with collaboration, support, and cost-sharing with many other federal, state, and local entities. This includes formalized Stewardship Agreements with partners to improve the NHD and WBD locally. Stewardship Agreements are no-funds-exchanged agreements and depend largely on the dedication of state or other resources; therefore, although 38 states have agreements in place, the level of participation and data set editing activity varies across the nation.

The NHD and WBD provide a foundational structure for the Open Water Data Initiative (OWDI), an effort led by the Department of Interior to integrate fragmented water information into a national water data framework. Water-relevant data can be indexed, or addressed, to the NHD and WBD; thereby, making data sets from a multitude of sources discoverable and shareable through one common hydrography network.

The USGS communicates with partners through the monthly NHD Newsletter and conducts trainings, technical advisory meetings, technical information exchange meetings, and community of use meetings regularly. These online meetings offer an opportunity for data stewards to receive information, get assistance with technical tasks, ask questions, and provide feedback on the model. Additionally, states are assigned a dedicated Technical Point of Contact at the USGS to assist with NHD model and editing questions.

E. Standards

The FGDC has developed the Geographic Infor-

mation Framework Data Content Standard. The standard was endorsed in 2008 as FGDC-STD-014-2008, and hydrography is one of the parts of this standard. According to the standards document, the goal of the hydrography part of the Framework Data Content Standard is to provide common definitions and syntax to enable collaborative development, use, and exchange of hydrography data. The standard defines the components of networked and non-networked surface water features and supports the exchange of hydrographic feature and network information by general and expert users. The standard sets a common baseline of information content for exchange within the hydrographic community and will enhance data sharing and applications development when used with standards-based web services or file transfer.

NHD and WBD standards are well-documented and readily available online (<https://national-map.gov/standards/>). Additionally, the USGS provides a user guide, data model poster, feature catalog, feature rules, and a help video library. The Federal Standards and Procedures for WBD can be found at <https://pubs.usgs.gov/tm/11/a3/>.

G. Estimate of Theme Completeness

The NHD is complete nationwide in two seamless data sets: one based on 1:24,000-scale topographic mapping, known as the high-resolution NHD, and the other based on 1:100,000-scale topographic mapping, known as the medium-resolution NHD. Hydrography is highly dynamic and regular updates to the 1:24,000-scale data are necessary. The frequency of updates varies greatly across the nation depending largely on the activity of State Stewards and on dedicated state resources being in place.

With the data set established, efforts are underway to improve the capabilities and utility of the 1:24,000 scale NHD by building the high-resolution NHDPlus (NHDPlus HR). (Note that the NHDPlus is at a medium resolution, 1:100,000, whereas NHDPlus HR is being produced today at 1:24,000.) The NHDPlus HR provides catchment areas, flow surfaces (flow direction and flow accumulation), and value-added attributes

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that enhance network navigation, analysis, and display. The projected completion date for the NHDPlus HR beta version of NHDPlus HR for CONUS is federal FY2019; Alaska will remain to be completed. Completion of the conterminous US may extend into FY20.

The NHD is becoming available in more areas at larger scales, such as 1:5,000-scale mapping from LiDAR. These larger-scale features replace features in the high-resolution NHD, creating a data set of mixed resolutions and densities. With the availability of high-resolution imagery (e.g. NAIP) and elevation data (e.g. 3DEP), users of the NHD are increasingly expecting spatial alignment between data sets. HRBS responses express a desire for higher-resolution hydrography data and uniformity, and moving towards these expectations is an anticipated trend for the USGS and state and federal partners. One example is USGS's effort to develop integrated elevation and hydrography data sets based on high-accuracy elevation data.

G. Accessibility of Data

NHD data sets are readily available for download at 1:24,000-scale and 1:100,000-scale nationwide from the USGS. NHD data sets, including the WBD, are part of the National Map and multiple web-based map services are available. The NHDPlus (1:100,000-scale) is also available and the NHDPlus HR (1:24,000-scale) is currently in production with a number of regions available in beta form. The downloadable data, feature rules, data models, user guide, and further information are available (<https://nhd.usgs.gov/>). The NHD is also accessible through the Geoplatform.gov Dataset Search, as well as through various state-maintained websites and web mapping services.

The USGS maintains a handful of tools to assist with the use and editing of the NHD, including linear referencing, building a geometric network, viewing metadata, comparing versions, and conflation. Many user resources and documentation are readily available online.

H. Authority, Governance, and Management of the Theme

OMB Circular A-16 designates USGS as lead federal government agency for the Hydrography Dataset. With regard to the overall Water-inland theme, the Open Water Data Initiative (OWDI), led by the Department of Interior will integrate currently fragmented water information into a connected, national water data framework and leverage existing systems, infrastructure and tools to underpin innovation, modeling, data sharing, and solution development. OWDI is coordinated through the Subcommittee on Spatial Water Data (SSWD), a subcommittee of both FGDC and the Advisory Committee on Water Information (ACWI). The SSWD has been building and coordinating an active community surrounding water geospatial data, and this activity aligns well with the NGDA Water-Inland theme goals. The Water-Inland theme strategy incorporates many aspects of the OWDI, and the NGDA data sets provide a foundational structure upon which to build the OWDI. This strategy aligns the theme goals with those of the OWDI, and improves the synergy between these closely related programs. The NHD is a key component to the overall strategy.

State stewards are key partners with USGS on Hydrography. Authority, governance, and management of the hydrography framework within each state varies greatly. Commitments among all partners are key to a robust national hydrography resource.

II. HYDROGRAPHY THEME GENERAL ASSESSMENT

The Hydrography framework evaluated for this report is the NHD, one of five data sets that comprise the NGDA Waters - Inland framework theme. The Waters – Inland framework theme was established after a review of OMB Circular A-16 Supplemental Guidance in 2012. At that time, the FGDC consolidated 34 NGDA themes into 17 (**Figure 1**). As part of this action, the former Hydrography framework theme was developed into 2 themes, NGDA Waters – Oceans and Coasts and NGDA Waters – Inland framework themes.

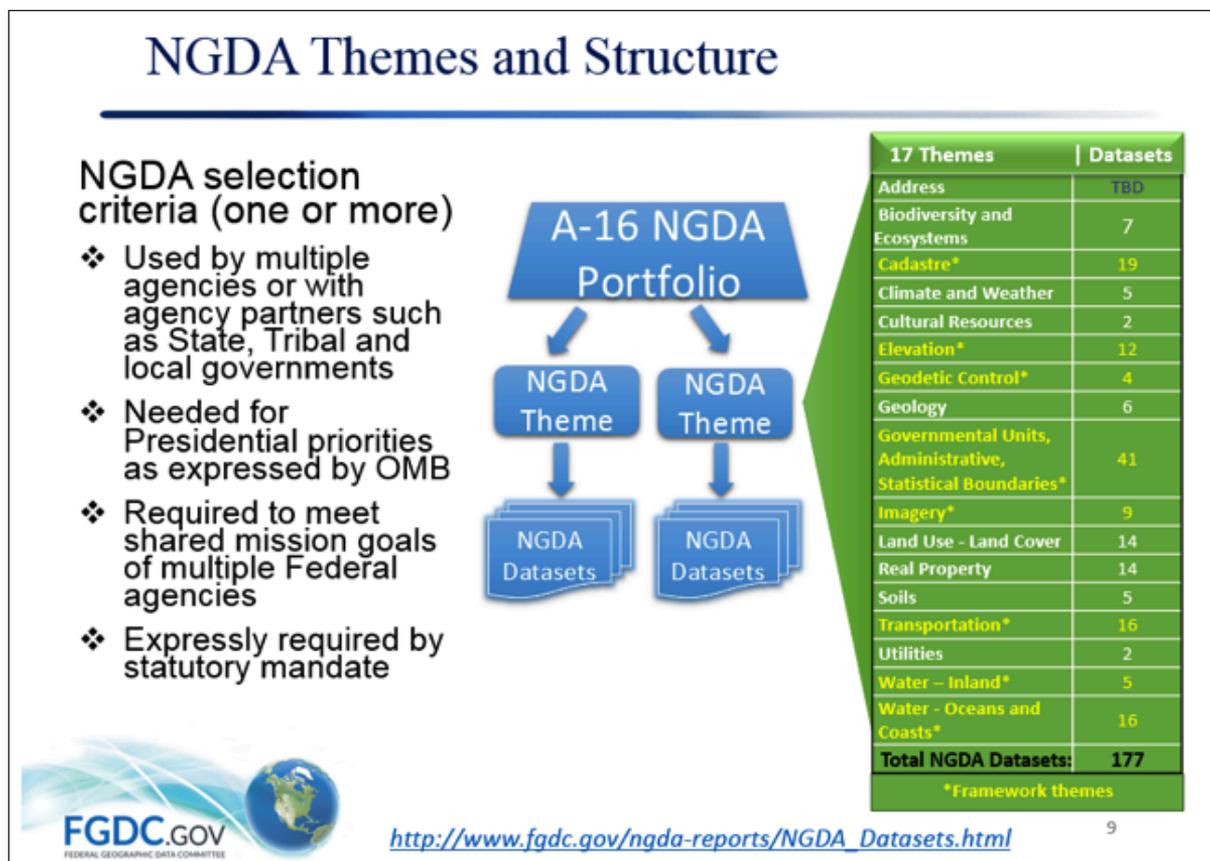


Figure 1. The NHD is one of five datasets comprising the NGDA Water -Inland Framework Theme.

Per the consolidation, the Waters –Inland framework theme consists of the following five data sets:

- National Hydrography Dataset (NHD)
- Watershed Boundary Dataset (WBD)
- National Wetlands Inventory (NWI)
- National Inventory of Dams (NID)
- National Levee Database (NLD)

Federal agency co-leads for the Waters –Inland framework theme are the U.S. Geological Survey (USGS) and the U.S. Fish and Wildlife Services (USFWS).

Important to note is that two of the five data sets listed under the Waters - Inland framework theme, NHD and WBD, are combined with Digital Elevation Models (DEM) in the creation of NHDPlus. NHDPlus is a national geospatial surface water framework developed by the U.S. EPA in partnership with U.S. Geological

Survey. NHDPlus has been in place at medium resolution (1:100,000 scale) for several years, and a high-resolution (1:24,000 scale) version called NHDPlus HR is under development and is expected to be complete for (conterminous) United States in federal fiscal year 2019. Any new local-resolution NHD content, some at 1:5,000 scale, are being incorporated into the NHD High Resolution Dataset and subsequently into the workflow for creation of NHDPlus HR. NHDPlus and NHDPlus HR is used to support water resource applications, such as inputs to the National Water Model (<http://water.noaa.gov/about/nwm>). NHD, WBD, and NHDPlus is also a topic of discussion with work underway to harmonize comparable data sets in watersheds shared along borders with Canada and Mexico.

For the review, COGO focused primarily on the National Hydrography Dataset, but the review includes consideration and correlation to other data sets (WBD) and derivative products (NHDPlus HR). This approach is most consistent with

the COGO review conducted in 2015. COGO will collaborate with FGDC and determine if future reviews should encompass all data sets for the Waters-Inland and Waters - Oceans and Coasts Framework themes.

Successful evolution of the Hydrography Dataset as a national resource is a shared responsibility of the federal theme leads and the state stewards. Program and technical aspects of both federal and state programs were considered in the review.

USGS is the federal agency theme lead for the Hydrography (NHD) Dataset. USGS forms partnerships with other federal agencies and state government stewards to maintain and enhance the Hydrography Dataset. The capacity, resources, and priorities of each partner directly impact the level of improvements, maintenance, and evolution of NHD as a nationwide resource.

A five year strategic plan for the Waters – Inland framework theme was published June 28, 2016 and is available on www.geoplatform.gov. The five data sets in the theme are all essentially complete and are considered “Optimized; Established” according to the most recent NGDA Lifecycle Maturity Assessment. The emphasis of the five-year plan, is:

- 1) To use results of the Hydrography Requirements and Benefits Study (HRBS) to assess community needs and guide future programs;
- 2) To improve and enrich the capabilities/intelligence of the datasets;
- 3) To continue building and strengthening the water data community; and
- 4) To provide discoverable, standardized and interoperable data to users.

The strategic plan details actions to address these four areas. Completion of the Hydrography Requirements and Benefits Study (HRBS <https://nationalmap.gov/HRBS.html>) was a significant achievement since publication of the previous COGO report in 2015. HRBS is a nationwide assessment of user requirements

and benefits of improved hydrography data. As part of the study, an online questionnaire was completed by more than 500 hydrography users from local, state, federal, and tribal governments, nonprofit organizations, and academia. Twenty-one federal government agencies and all fifty states participated in the study. According to HRBS, the annual benefits of the hydrography framework in the current condition is \$538M. The estimated potential future annual benefits from enhanced hydrography data as described in HRBS is an additional \$602M. A strategic action plan to maximize user needs identified in HRBS is underway.

The NHD has migrated from a very low spatial resolution resource with limited geometric content of the past to a higher resolution (1:24,000) resource available today. Strategic action taken on HRBS is likely to migrate the NHD to much more relevant local resolution content, bringing it in-line with the resolution and scale of the other framework themes (Orthoimagery, 3DEP Elevation, Cadastral). In order to realize the full benefits of HRBS, technical innovations are needed, along with additional investment of resources by all stakeholders. These opportunities and challenges are described in the strategic plan.

An organizational process to consider for evolution to an enhanced hydrography framework is to leverage the products and the model for the 3DEP program.

III. GRADE OF HYDROGRAPHY THEME

Grade for this theme is a B- : Adequate for now, but needs attention for future

Framework Evaluators

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VII. ORTHOIMAGERY DATA THEME

EXECUTIVE SUMMARY

The Orthoimagery Data Theme is a highly valued component of the Nation’s Spatial Data Infrastructure, providing a rich set of georeferenced images that have supported a wide range of stakeholders for many decades. The Theme has evolved and matured, benefiting from advances in technology as well as focused investments at both the Federal and State level. The Theme’s lead agencies, with support from the National Digital Orthoimagery Program (NDOP), have been instrumental in helping to advance the Theme. USGS, USDA, NOAA as well as State and local organizations should be commended for their efforts to archive and enable open access to their imagery assets. However, concern is growing that a lack of adequate funding for programs such as NAIP, may result in more restrictive data availability models as Federal and State agencies consider a move toward licensed imagery products. The user community should stay engaged, demanding ongoing access to non-proprietary and non-licensed imagery within the public domain.

THEME GRADE: B-
REQUIRES ATTENTION

I. DESCRIPTION OF THE FRAMEWORK

A. An Introduction to the Theme

In 2017, the FGDC released the “National Spatial Data Infrastructure Strategic Framework”

[1] that acknowledged “the role of government in the geospatial ecosystem has changed significantly since the inception of the NSDI”, noting that the “FGDC community has made significant progress over the past three years in driving activities such as the development of the National Geospatial Platform (GeoPlatform.gov), the establishment of the Geospatial Interoperability

Reference Architecture (GIRA), and the enhancement of the National Geospatial Data Asset (NGDA) portfolio management process.” The first COGO report card on the NSDI [2] released February 23, 2015 was one factor in the strategic planning sessions that FGDC hosted, influencing the development of the Theme



Figure 1. NGDA Portfolio Management Overview (<https://www.fgdc.gov/ngac/meetings/march-2017/ngda-portfolio-management-update-ngac-march-2017>).

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Implementation Plans [3]. In March of 2017, the FGDC provided the National Geospatial Advisory Community with a presentation [4] that explained the maturity factors for managing and routinely assessing the NGDA portfolio (see **Figure 1**). The implementation of this approach has substantially informed and influenced this second edition (2018) of the NSDI Report Card. Of the seventeen NGDA data themes in that portfolio, eight are characterized as Framework Themes, including imagery.

The USGS published “The National Map Customer Requirements: Findings from Interviews and Surveys” in 2009 as [Open-File Report 2009–1222](#). Orthoimagery consistently was cited as one of the top data sets needed to support geospatial activities regardless of the business activity or application level by the persons interviewed in the survey. A big volume of geospatial orthoimagery data is coming from sensors installed in different aircraft.

B. The Theme Definition

The “imagery theme” consists of georeferenced images of the Earth’s surface, which have been collected via aerial or space-based platforms in near-Earth orbit. Orthoimagery is prepared

through a geometric correction process known as orthorectification to remove image displacements due to relief and sensor characteristics, allowing orthoimages’ use as base maps for digital mapping and analyses among other uses. A digital orthoimage may be created from several images mosaicked to form a single image. The result is an aerial or satellite image with the geometric qualities of a map.

This assessment considers the NGDA Imagery Theme data sets [5] that are available in the public domain. In addition, this assessment also includes imagery collected by States. This COGO assessment excludes proprietary and licensed imagery. The imagery data sets considered are shown in **Table 1**.

C. Lead Agency and Current Activities

According to Office of Management and Budget (OMB) Supplemental Guidance – Appendix E – National Geospatial Data Assets (NGDA) Data Themes, Definitions, and Lead Agencies Updated March 24, 2017, the following Federal departments are defined as lead agencies for the Imagery Theme.

Table 1 - Imagery Theme datasets assessed by this Report

Dataset	Jurisdiction	NDOP Oversight	NGDA Dataset
Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)	Federal	Y	Y
High Resolution Orthoimagery	Federal	Y	Y
Landsat 1-5 Multispectral Scanner (1972-1992)	Federal	Y	Y
Landsat 4-5 Thematic Mapper (1982 - present)	Federal	Y	Y
Landsat 7 Enhanced Thematic Mapper Scan Line Corrector Off (ETM SLC-off) (2003-present)	Federal	Y	Y
Landsat 8 Operational Land Imager and Thermal Infrared Sensor (2013-present)	Federal	Y	Y
Moderate Resolution Imaging Spectroradiometer (MODIS) Aqua	Federal	Y	Y
Moderate Resolution Imaging Spectroradiometer (MODIS) Terra	Federal	Y	Y
National Agriculture Imagery Program (NAIP)	Federal	Y	Y
NOAA Coastal Mapping Remote Sensing Data	Federal	Y	Y
State High Resolution Orthoimagery	State	N	N

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Dept. of Agriculture, Farm Service Agency
 Primary Point of Contact: Shirley Hall USDA/
 FSA

Dept. of the Interior, U.S. Geological Survey
 Primary Point of Contact: John Cullen DOI/
 USGS/National Land Imaging

Objective 2.2.” [7]

Members of the NDOP Subcommittee (see **Table 2**) reflect key representation from the current twelve participating federal agencies and organizations. Non-profit organizations representing State, local, regional and tribal governments may be added with the consensus of NDOP Subcommittee representatives. Although non-Federal participants may engage in NDOP Subcommittee discussions and offer information and opinions, their participation is limited to a non-voting role.

For the GeoPlatform, The National Digital Orthoimagery Program (NDOP) is a subcommittee of the Federal Geographic Data Committee (FGDC). NDOP is “an activity of the U.S. Government responsible for managing and coordinating overhead imagery and applications to support the operational needs of civil government in the United States” [6].

D. Collaboration and Partnerships

According to the FGDC website, the “National Digital Orthoimagery Program (NDOP) Subcommittee is responsible for developing, promoting, and executing a national strategy for acquisition or development of orthoimagery data for Federal agencies, while creating and utilizing partnerships with State, local, Tribal, and private organizations and supports NSDI Strategic Plan

Governmental bodies and private organizations are essential to completing the orthoimagery theme requirement. To that end the NDOP confers with the National States Geographic Information Council to coordinate Federal and State agency imagery needs and establish the terms of the agreements between the subcommittee and the States. As of 2016, the national liaison offices of the USGS National Geospatial Program no longer directly support the imagery theme.

NDOP FY2017 Subcommittee Members			
US Department of Agriculture (USDA) Farm Service Agency (FSA) (Program Subcommittee Chair)	Shirley Hall	US Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS)	Tony Kimmet
US Department of Agriculture (USDA), US Forest Service (USFS)	Everett Hinkley	US Department of the Interior (DOI), US Geological Survey (USGS), Natinoal Land Imaging	Timothy Stryker (Chair), John Cullen, Ryan Longhenry
US Department of the Interior (DOI), Fish and Wildlife Service (FWS)	Brian Huberty, Ken Elsner	US Department of the Interior (DOI), US Geological Survey (USGS), National Geospatial Program	Gita Urban-Mathieux
Department of Homeland Security (DHS), Federal Emergency Management Agency (FEMA)	Paul Rooney	US Department of the Interior (DOI), Bureau of Land Management (BLM)	Matthew Bobo (Technical Subcommittee Chair), Chris Noyles
National States Geographic Information Council (NSGIC)	TBD (as of August 2018)	National Oceanic and Atmospheric Administration (NOAA)	Erik Hund
US Department of Commerce (DOC) Census Bureau	Peter Reid	US Department of the Interior (DOI), National Park Service (NPS)	Lisa Nelson
US Environmental Protection Agency (EPA)	Tim Richards		

Table 2. NDOP FY2017 Steering Committee Members [8]

E. Standards

Numerous national and international standards and protocols pertain to objects or phenomena that are directly or indirectly associated with a location(s) on the Earth. Standards help facilitate reliable, consistent access, discovery and sharing of data, metadata and services between providers and among users. The FGDC has recommitted itself to leading and participating in “the development and coordination of national and international standards applicable to the imagery geospatial community”. [9]

The FGDC Subcommittee of Base Cartographic Data (SBCD) submitted a draft Standard for Digital Orthoimagery to the FGDC Standards Working Group over two decades ago (1996). Since that time, several related efforts have successfully delivered:

- Content Standard for Remote Sensing Swath Data (1999) [10]
- Content Standards for Digital Orthoimagery by FGDC (1999) [11]
- Content Standard for Digital Geospatial Metadata: Extensions for Remote Sensing Metadata (2002) [12]
- OpenGIS® Sensor Observation Service Interface Standard, version 1.0.0 (2010) [13]
- ISO 19115 – 2: Geographic information - Metadata - Part 2: Extensions for imagery and gridded data, GeoTIFF Revision 1.0 [14]
- OGC Standards [15], with interoperability standards adopted by the geospatial community worldwide.

More recently industry trends have begun to shift from onsite geospatial data storage and processing to cloud-based services. Public entities, operating at U.S. Federal, State, municipal, and tribal levels, and private or international entities are customizing services for different users. For imagery products and services, three primary bodies (FGDC, OGC, and ISO) propose, test, and establish the standards to ensure interoperability across all users.

These trends are evident among the various programs and management systems and services

resident in the United States. All these data and services are coming from different sensors on different platforms, and are being accessed and/or converted through interoperable interfaces. These are discovered and shared through Open Geospatial Consortium (OGC) standards, such as Web Map Service (WMS), Web Feature Service (WFS), Catalog Service for the Web (WSC), WMTS (Web Mapping Tile Service), Sensor Model Language (SensorML), Sensor Planning Service (SPS), Sensor Observation Service (SOS), and others. It is important to note that the move toward licensed imagery services (e.g. Google Imagery) is also changing whether imagery is freely accessible and available to U.S. public and private users, with significant impacts to accessibility, depending upon the specifics of a vendor’s offerings.

Since the last Report Card, the Digital Object Identifier (DOI) (based on the ISO 26324 standard) has gained traction to provide a permanent and unique digital identification for images, digital or film-based. Some federal agencies, such as NASA in the Earth Observing System Data and Information System (EOSDIS), have already adopted DOI.

Rapid innovations in platform, sensor, and hosting technologies have lowered the cost of imagery acquisition and access. However, these rapid changes often outpace the ability of organizations such as FGDC, OGC, and ISO to promulgate and maintain relevant standards. Current federal and international standards for orthoimagery must be continuously evaluated and updated to ensure relevance and usability. Several organizations are developing standards focused on the use of “emerging technologies” that need to be integrated with other geospatial data and services, such as imagery collected with Unmanned Aircraft Systems (UAS), crowdsourcing platforms (e.g. social media), and other technologies. However, there is currently a lack of policies and standardization that promotes harmonization, integration, and calibration for these emerging technologies and methods.

F. Needs of Community Users

Civil agencies including NDOP [16] member

agencies have provided requirements to the USGS National Land Imaging Program, Requirements, Capabilities and Analysis (RCA) Branch, with an effort named RCA for the Earth Observations (RCA-EO), as part of the USGS/NASA Sustainable Land Imaging (SLI) Program and Landsat-9 follow-on mission formulation. While requirements were primarily collected from Landsat and other moderate resolution projects and applications, a sub-portion of these requirements included higher resolution needs as potential enhancements to current moderate resolution systems. This activity is part of a larger, ongoing effort to help optimize investments in land imaging technology and products that better meet user needs in support of Landsat and other missions and national Earth observation assessments. The effort supports the U.S. Group on Earth Observation (USGEO) national planning process, for which the USGS/NLI serves as Vice-Chair alongside NASA and NOAA. RCA-EO provides data and analyses to USGEO to help optimize Federal investments in Earth observing technology and products to better understand and address user needs across a broad range of uses and applications, both scientific and geospatial in nature. The RCA-EO is in the process of supporting other NDOP Federal Agency members to assist their organizations in defining future capabilities and user needs across this broad range of applications, including imagery collection systems.

For the NAIP, the FSA has established a requirements team as well as an inter-agency working group that assessed user needs and requirements through workshops, surveys and direct dialogue. Establishment of an inter-department-level working group is planned to identify a more effective approach to both the procurement strategy and cost-share relationships starting after FY19. In addition, FSA does gather information yearly from direct user feedback, error reports, as well as through forums such as the yearly USDA Imagery Planning Meeting and biannual NDOP meetings.

FSA also conducts a NAIP user satisfaction survey for FSA users every few years. The latest report was published in April 2014 and can be

downloaded from the FSA-APFO website [17]. The program deliverables did not change from the time of the last survey through this year; so another formal electronic survey was not instituted in 2017.

The Group on Earth Observations (GEO) [18] has defined eight Societal Benefit Areas (SBAs) which group user community requirements thematically: Disaster Resilience, Energy and Mineral Resources Management, Food Security and Sustainable Agriculture, Infrastructure and Transport Management, Public Health Surveillance, Sustainable Urban Development, Water Resources Management and Biodiversity Ecosystem Sustainability. This view of requirements for orthoimagery, similar to the independent themes of the FGDC itself, cuts across the various imagery data sets, web services and applications sponsored by NDOP member organizations, and provide another perspective for assessing need and satisfaction by functions, such as data providers, server, client, social media functions, archival, and others.

G. Estimate of Theme Completeness

To estimate the “completeness” of the Nation’s imagery, one must consider numerous factors including the business requirements behind individual NDOP agency imagery programs. The spatial, spectral, radiometric and temporal resolution requirements of individual imagery programs vary widely (e.g. NOAA Coastal Mapping vs. NAIP), uniquely determining the measure of completeness. Programs such as NAIP and Landsat have achieved high-levels of maturity [18], enabling them to acquire robust sets of imagery across the country over a period of many years (decades in the case of Landsat). As one example, **Figure 2** highlights the success of NAIP since its inception (2002). However, all imagery programs are subject to budgets pressures, and requirements volatility that can potentially impact the sustainability of NDOP agency programs.

H. Accessibility of Data

For this report, data accessibility is defined as data that can be freely downloaded, is consis-

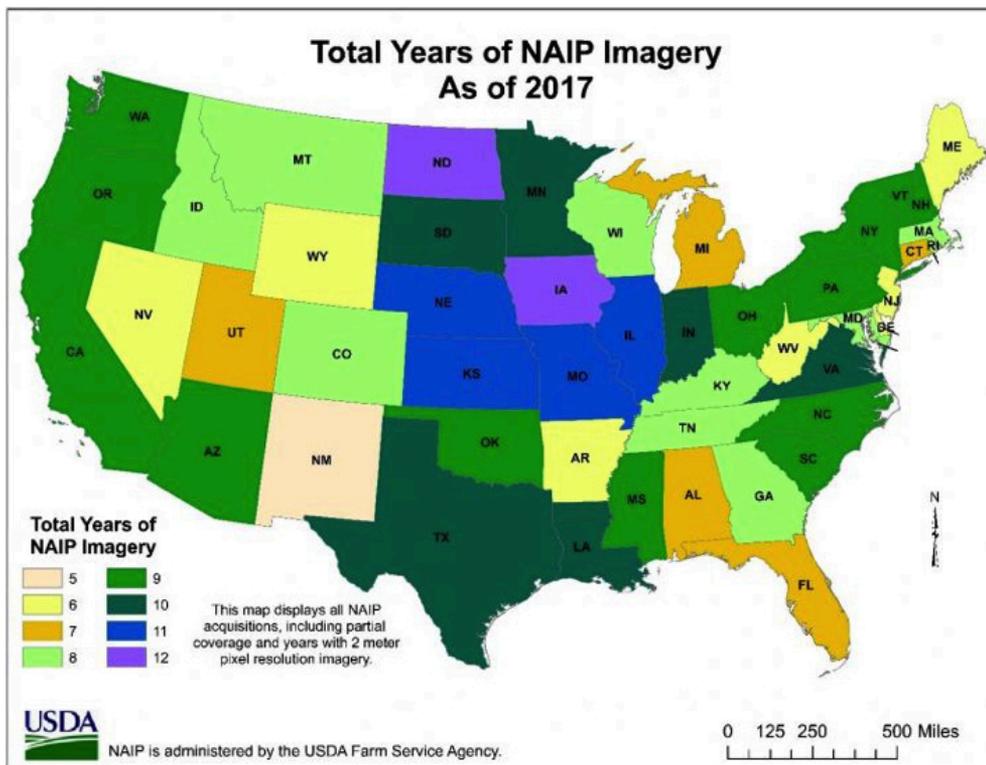


Figure 2. Years of NAIP coverage by State (2002-2017) (<https://cms.geoplatform.gov/a16imagery/NDOP>)

tent with Open Data policies, and/or available at the cost of reproduction. Metadata (information about the data) must also be readily available; without it data are unusable or easily misused.

Open and free access to imagery provides significant return on investment for taxpayers. The National Geospatial Advisory Committee (NGAC) noted that the “economic value of just one year of Landsat data far exceeds the multi-year total cost of building, launching, and managing Landsat satellites and sensors.” [18] Numerous federal organizations have websites that allow users to download and/or order imagery products. USGS, USDA, NOAA and other State and local organizations should be commended for their efforts to archive and enable access to their imagery assets.

Innovations in data collected with UAS, cloud computing, web services, and licensed imagery products are altering how imagery is procured, delivered, and consumed. This has put pressure on orthoimagery program managers to justify the cost of keeping imagery in the public domain. This set of circumstances has already led to the

elimination of public domain imagery programs in some states. For example, in Massachusetts [20] Texas [21] and Utah [22], licensed Google imagery is only accessible to licensees, with the potential for similar changes [23] at the Federal level.

I. Authority, Governance, and Management of the Theme

Since the last 2015 COGO Report Card for Imagery, lead agencies (FSA and USGS) have created a Strategic Plan and implemented reporting practices to provide information to populate the GeoPlatform. In several respects efforts to improve identification of, access to, and delivery of the varied data sets show appreciable improvements.

A significant amount of orthoimagery is collected at the local, regional, and State levels throughout the United States. An analysis of NSGIC’s 2015 Geospatial Maturity Assessment (GMA) shows that 28 states had achieved a “level of completion,” from 96% to 100%. Five states had between 26% and 74% coverage. **Figure 3**

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shows that four states were “planning to implement a program to acquire statewide orthoimagery within the next 24 months”.

Twenty-one States indicate that they had “a systematic program [25] in place to collect this data with local government” [26]. Twelve States indicated that they lacked a systematic program. The 2015 GMA results also show that 30 States have a “designated steward [27] for this data layer.” [28]

Approximately half of the States and the District of Columbia have nearly 100% orthoimagery coverage, and that number may have increased since 2015. These have been supported by designated “stewards” and/or “programs” (both undefined terms in the 2015 GMA) through a wide range of financing mechanisms. There seems to be a higher prevalence of orthoimagery programs east of the Mississippi (see Figure 4), which may be a result of several factors including 1) smaller states, 2) leaf-off imagery requirements not addressed by some Federal imagery programs, and 3) higher population densities demanding finer resolution imagery that are not currently the focus of Federal imagery collection programs.

J. Acquisition Platforms

A wide range of platforms and sensors are used to acquire imagery including, but not limited to, satellites, planes, helicopters, and UAS. Advanced UAS technology and the emergence of small satellites [30] (micro, nano, pico) present tremendous opportunities to the imagery operations industries and their consumers. These new platforms are beginning to add to the nation’s inventory of imagery. Because many imagery collections have been acquired by commercial entities or ad hoc by a disparate set of public entities, access to these assets may be limited.

The lack of a management strategy during the rapid proliferation of sensors on UAS platforms often facilitates interoperability with other satellite or airborne platforms (<http://www.sat-drones.com>). Subsequently this interferes with use of integrated technical and statistical data. The use of standards and best practices for these geospatial data must be incorporated into the handling practices of a big volume of data, their metadata, and their accuracy. Federal agencies

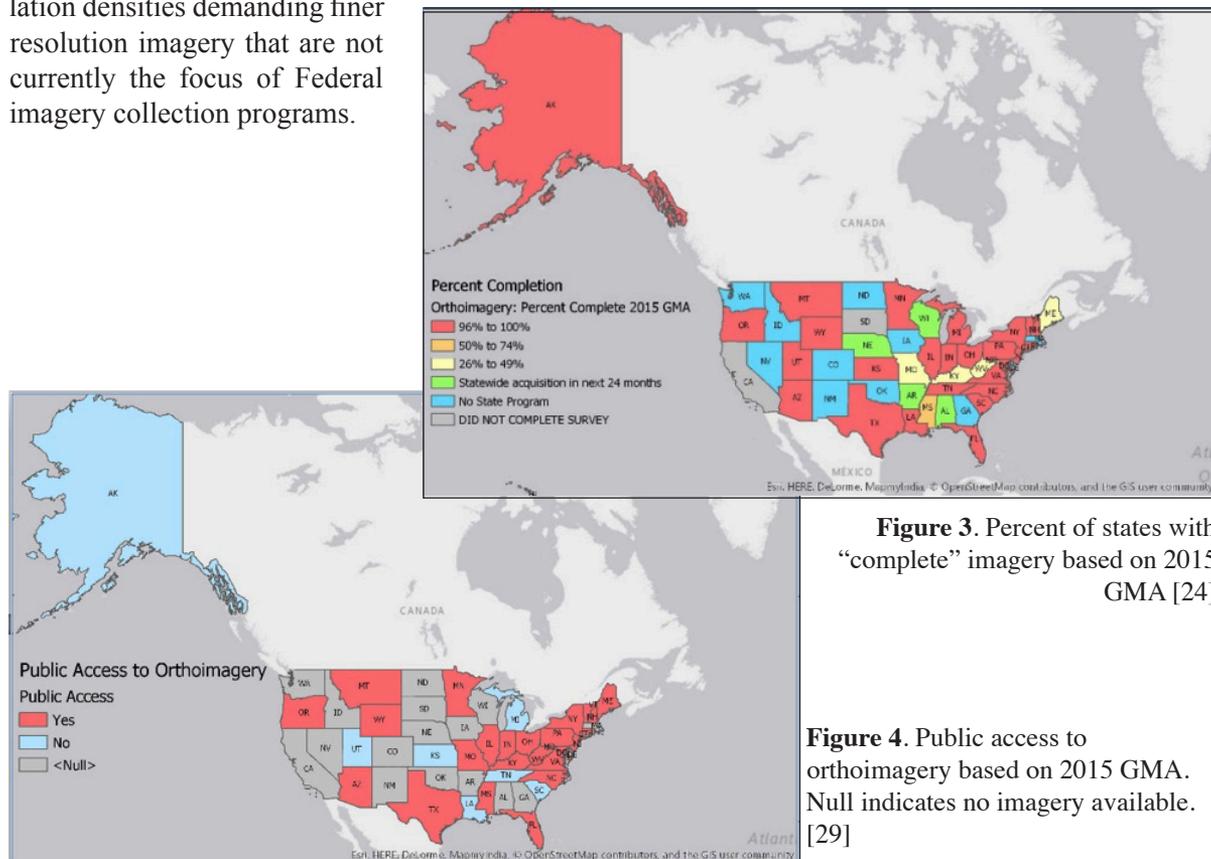


Figure 3. Percent of states with “complete” imagery based on 2015 GMA [24]

Figure 4. Public access to orthoimagery based on 2015 GMA. Null indicates no imagery available. [29]

like the USGS and NOAA have begun to develop data management strategies and approaches to address these challenges [31].

II. ORTHOIMAGERY THEME ASSESSMENT

CAPACITY

The Framework's capacity to meet current and future demands:

The FGDC's "Theme Implementation Plan for Imagery Theme" [32] reflects a continuing commitment to numerous Imagery Theme NGDA data sets and programs to address requirements of Federal, State, local and tribal government users. However, these assume ongoing administrative and budgetary support, a significant assumption in an era of government cost cutting.

As an example, regarding one of the key satellite imagery programs, a recent analysis of emerging requirements for Landsat, identified by non-Federal customers, [33] indicates needs for enhanced revisit and improved spatial resolution. In addition, in June 2017, the USGS National Land Imaging program office — then Land Remote Sensing program office — issued a request for information from the land imaging community for user requirements for future Landsat systems. [34] These and others inputs, such as the Landsat Science Team, Landsat Advisory Group of the National Geospatial Advisory Committee, AmericaView, the Decadal Survey, and international cooperators are providing community input to augment Federal civil requirements collection efforts, providing a diversity of input to inform the SLI Landsat 9 follow-on mission formulation as part of the NASA / USGS Sustainable Land Imaging Program.

Despite good news for Landsat users, concern should be expressed regarding the future of the NAIP program. Threats to funding may affect the capacity of the program and thereby jeopardize future acquisition efforts. NAIP will continue as a public domain data set for the Fy2019 acquisition period. However, the Farm Service Agency (FSA) is confronting the need to con-

sider alternate funding solutions and is working with the Office of Management and Budget. The FSA has been reviewing a commercial-off-the-shelf licensed dataset which would remove future NAIP collections from the public domain. An alternative would be to revert to collecting agriculture-only data [35]. This could severely undermine the NGDA Imagery Theme's program portfolio and jeopardize the health and effectiveness of this Framework theme.

Despite uncertainty surrounding the resolution of this funding issue, FSA and OMB are to be commended for heeding the concerns of the user community and sustaining the current approach through FY19, while the study is completed.

State-level orthoimagery programs continue to thrive in some States and struggle in others. As with some federal programs, some states have begun to move to a licensed imagery model given the opportunity to reduce costs.

The ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) is a set of Japanese imaging sensors flying on Terra, a satellite launched in December 1999, acquiring data from February 2000, as part of NASA's Earth Observing System (EOS). All ASTER data is freely available [36].

MODIS (MODerate-resolution Imaging Spectroradiometer) is a sensor launched into Earth orbit by NASA in 1999 on board the Terra Satellite, according to a descending orbit (north to south in the morning), and in 2002 on board the Aqua satellite, according to an ascending orbit (south to north in the afternoon). The data are openly available [37], but in three areas the MODIS products can be improved; by making most products available at 250-meter spatial resolution; by doing a daily repeat; and by developing a standardized protocol for the metadata regarding every MODIS product.

NOAA's Coastal Mapping Program acquires aerial imagery along 95,000 miles of U.S. coastline to support NOAA's Coastal Mapping Program and NOAA's Emergency Response Imagery requirements. Imagery is collected

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using medium format digital cameras installed on airborne platforms. Since 2009, orthorectified digital imagery has been made available through NOAA’s Digital Coast in order to increase support for multiple uses of the data as outlined in NOAA’s Integrated Ocean and Coastal Mapping Initiative. Georeferenced and orthorectified digital imagery data sets collected after natural disasters are made available on the NOAA Emergency Response Imagery Website [38] and in the USGS Hazards Data Distribution System [39]. This is an event-based interface that provides a single point-of-entry for access to remotely sensed imagery as it becomes available during a disaster response.

CONDITION

The existing or near-term condition of the Framework themes as an integrated whole:

The NGDA data sets within the imagery theme have varying parameters supporting a robust set of user requirements. The 2017 NGDA Lifecycle Maturity Assessment [40] provides some insights, based on user input, comparing the feedback of the assessed maturation to the optimized standard relative to specific lifecycle stages of the data set. The Imagery Theme matrix illustrated in **Figure 5** shows that most data sets have a ranking greater than or equal to

3 (“managed: Predictable Level=3”), with most data sets categorized as “Optimized; Established Level = 5.” [41]

What is also significant is the attention NDOP has given to its annual reporting. The NDOP Subcommittee noted numerous accomplishments in its FY 2016 report [43] (October 1, 2015 – September 30, 2016) including:

- Nearly 1.7 million square miles were acquired by FSA, including 14 states at .6m resolution through partnership “buy-up” option and 8 states at 1 m resolution.
- NAIP implemented an Early Access Web Service to expedite use of pre-processed collections for rapid response within 2 to 7 days.
- Evaluation continued for the new High Resolution Hexagon Image Program licensed data set, with 1-foot resolution, that is typically acquired concurrently with NAIP collection.
- High-resolution scanning of the National High-Altitude Program (NHAP) historic photography continued such that nearly 70% of that source was available at the close of FY 2016.
- The USGS High-resolution Orthoimagery Program’s distribution portal was retired at

NGDA Dataset LMA Summary Table											
Dataset	Submission Status	Overall	General	Inventory				Use			Agency Abbreviation
				Define	Evaluate	Obtain	Access	Maintain	Evaluate	Archive	
Landsat 4-5 Thematic Mapper (1982 - present)	Complete	5/5	5/5	4/5	5/5	5/5	5/5	5/5	5/5	5/5	DOI-USGS
Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)	Complete	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	3/5	NASA
Moderate Resolution Imaging Spectroradiometer (MODIS) - Aqua	Complete	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	3/5	NASA
Moderate Resolution Imaging Spectroradiometer (MODIS) - Terra	Complete	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	3/5	NASA
NOAA Coastal Mapping Remote Sensing Data	Complete	5/5	5/5	5/5	5/5	4/5	5/5	4/5	5/5	5/5	DOC-NOAA
High Resolution Orthoimagery	Complete	5/5	5/5	5/5	5/5	4/5	5/5	5/5	5/5	5/5	DOI-USGS
Landsat 7 Enhanced Thematic Mapper Scan Line Corrector Off (ETM SLC-off) (2003-present)	Complete	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	DOI-USGS
Landsat 1-5 Multispectral Scanner (1972-1992)	Complete	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	DOI-USGS
The National Agriculture Imagery Program (NAIP) Imagery	Complete	5/5	5/5	5/5	5/5	4/5	5/5	5/5	5/5	5/5	USDA-FSA

Figure 5. Lifecycle Maturity Assessment Table for Imagery Data Sets [42]

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the end of FY2017 but all imagery was integrated into the USGS archives and the catalogue of that collection has been published.

- 95 tide controlled coastal imagery data sets to support shoreline mapping were collected.
- Oblique imagery along the West and Mid-Atlantic coasts for coastal zone management was added.
- NDOP members collaborated to secure orthoimagery for areas in Hawaii and the US Pacific Basin

It is encouraging to see the public reporting of NDOP accomplishments as well as the subcommittee's assessment of the Imagery Theme via the GeoPlatform Performance Dashboard. That, however, does not imply that all users are completely satisfied or not interested in improvements to the state and condition of NDOP data sets. A university from the AmericaView consortium conducted a study with the US Forest Service, Geospatial Technology and Applications Center, searching current literature and found no research that specifically investigated or quantified the georeferencing error of NAIP. That report [44] also noted NAIP metadata provided with imagery should be expanded to routinely include attributes such as spectral sensitivity curves of the sensors used, as well as information regarding the vendor's estimate of spatial accuracy. The FSA does conduct internal quality assurance assessment to assure that all vendors' collection meets product accuracy specifications. Although not automatically provided with the requested imagery data, that spatial accuracy metadata is available upon request for any user performing external analysis. In addition, as the use of NAIP collection expands, some users are attempting to do more than the original data set requirements had specified, including spectral analysis and research. As the NAIP data sets attract new customers, those customers seek more spatial, spectral, and temporal improvements, which simply cannot be met without improved funding and revised business models. As noted by NDOP leadership, "to manage cost, NAIP imagery is collected using different airborne sensors from multiple manufactures and they are not radiometrically calibrated to a standard specification

which prevents consistent radiometry."

Another area of concern to many is the retirement of the USGS High-resolution Orthoimagery portal and the loss of public domain access to current commercial imagery over key areas of the US. The EnhancedView contract of the National Geospatial-Intelligence Agency (NGA) includes a licensing agreement for high resolution commercial imagery, which has been frequently exercised by the federal civil community. During summer of 2018, NGA and the National Reconnaissance Office (NRO) determined that NRO would assume responsibility for the EnhancedView contract. That decision raised concern that the federal civil community would no longer be serviced by the contract. NGA has reassured the community that licence interpretation and enforcement remain with them and that federal civil agencies will continue to submit imagery needs through NGA.

In addition, it is not clear how orthoimagery collected for precision agriculture, energy, environment, disasters and other societal areas will be integrated. Metadata and orthoimagery integration from sensors in several airborne platforms need to be included and harmonized with U.S. data.

FUNDING

The funding capability of the Framework:

Specifically, for NAIP, consistent funding sufficient to fully realize program goals (yearly CONUS coverage at one-meter resolution or better) has been an issue since the program's inception. Federal Government budget reductions are projected in FY18 and beyond, and as noted earlier, FSA is investigating cost-saving changes and/or alternate approaches to NAIP following 2019.

The Landsat program has been funded for Landsat 9, which is a functional equivalent of the Landsat-8 spacecraft launched in February 2013. In October 2016, that satellite and its sensors were officially allowed to enter the production phase for launch in 2020 to avoid any gap in Landsat data. That imagery remains high priority

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under the U.S. Sustainable Land Imaging Program, discussed below.

The ASTER sensor will be operational on the Terra platform until at least 2022. As a result, the geospatial community in the United States can count on imagery from ASTER and MODIS over the next few years.

Although between 2012-2015, the funding in the space sector, from both public and private sources, rose 400 percent globally, funding within the US has been declining. Over \$ 4 billion in 2014-2015, became \$2.3 billion in 2015 and fell to \$1.5 billion in 2016 [45]. The capital remains available, but its dissemination is more conservative. On October 26, 2017, according to the Euroconsult report “Satellite-Based Earth Observations: Market Prospects to 2026,” earth observations imagery can reach 8.5 Billion USD by 2026 based on present-day growth trends, but in another model, can reach 15 billion USD. [46]

FUTURE NEED

Whether future-funding prospects will be able to meet the need:

In the previous description of the “Condition of the Theme,” this evaluation noted that users of orthoimagery are frequently identifying expanded uses of the various data sets and articulating both the benefits and the shortfalls that must be considered as future strategic objectives and implementation plans are prepared for NGDA imagery programs.

Users consider NAIP to be particularly useful but worry about future accessibility. Their ongoing experience shows that NAIP outperforms its cloud coverage specification, enabling some low-cost change detection and feature extraction tasks for an end user needing relatively high-resolution images. Continuation of the NAIP program, with reliable accessibility is most desirable. Higher resolution and improved temporal collections for the phenology throughout the growing season are seen as future needs.

An Earth Observation Assessment was conducted in 2012 [47] with 300 federal experts

documenting the societal benefits of hundreds of Earth observing systems. Findings revealed the notable impact of the Landsat satellites and led the Administration to commit to a long term Sustainable Land Imaging (SLI) program. [48] SLI is a NASA-USGS partnership to develop, launch, and operate a spaceborne system that will provide researchers and other users with high-quality, global, continuous land-imaging measurements. The SLI program includes the launch of the Landsat 9 mission in 2020 and a sustained multi-year technology development and system innovation effort in order to evaluate new measurement technologies for a follow-on mission to Landsat 9. Under the SLI program, the USGS and NASA are planning to work together to ensure sustained access for another 20 years.

Further, the USGS EROS Center’s release in October 2017 of the “Analysis Ready Data (ARD)” for Landsat holdings will enhance use by providing geographically tiled and reflectance-consistent data sets that will support time analysis for change detection.

PUBLIC USE

The Framework’s ability to provide data resources that meet the everyday needs of organizations and the general public, and to provide data resources that meet the need to respond to public safety incidents, natural disasters, and other emergencies:

USDA/FSA believes that NAIP’s widespread use can also be considered an indicator of product quality and user approval. For example, ESRI provides a NAIP imagery layer, mass market mapping services such as Google and Bing Maps use NAIP as a background layer, and many - if not most - US Government agencies, as well as academia use NAIP in some fashion. This broad spectrum of users suggests that the program is meeting the needs of many Federal, State and local users.

Orthoimagery access, discovery and sharing for rapid mapping is critical to the management of data at the federal level in any disasters. More-

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over, IowaView, a member of the remote sensing consortium AmericaView, commented: “Access to older and planning for new imagery in future years is very important to Iowa in the effort to control nutrient runoff into our waterways. We need to monitor progress and having current/new imagery is crucial. Whenever our Orthoserver goes down we get many calls and e-mails right away. The Orthoserver has imagery services for every year of NAIP for Iowa, served and managed by the ISU GIS Facility. We’d love to have resolution below 1m but keeping the 4 band (RGB plus IR) data is the most important. It’s helpful in the summer photos but would be even more useful if the NAIP program expanded to include a spring flight. There is growing interest in detecting cover crops and a spring and summer 4 band data set to compare would be wonderful.”[49]

There is growing pressure on orthoimagery program managers to justify the costs of public domain imagery programs. This has already led to the elimination of public domain imagery programs in some states (e.g. Massachusetts [50] and Utah [51]), with the potential for similar changes at the federal level [52].

III. GRADE OF ORTHOIMAGERY THEME

This committee assigned a grade of B- (Requires Attention) for the orthoimagery theme. The Imagery Theme is in fair to good condition but requires attention. The NDOP Subcommittee and lead agencies (USGS and USDA/FSA) should be commended for their efforts since the last COGO report card, including GeoPlatform evaluations and reporting as well as ongoing NGDA program support for NAIP, Landsat, ASTER and MODIS. Their efforts have not gone unnoticed. However, concern is growing that limited Federal funding for imagery programs, such as NAIP, may result in more restrictive data access models as Federal and State agencies consider a move toward licensed imagery products. The near elimination of the High Resolution Imagery program [53], and its removal from

the GeoPlatform, represents a clear threat to the future availability of public-domain high-resolution orthoimagery. In some cases, incomplete metadata has hampered the discovery, integration, and use of imagery. Assigning a grade of B (Adequate for Now) would fail to capture the underlying pressures and limitations of some NGDA programs and data sets. As a result, the COGO review committee believes a grade of B- is warranted for the Imagery Theme.

IV. SUMMARY AND RECOMMENDATIONS

The COGO Evaluation Team for the NSDI Imagery theme has determined that an overall grade of “B-” is warranted for this theme. Programs such as Landsat, ASTER and MODIS would be in the A- range for their current and near-term future stability, meeting user specified requirements and assessing future requirements. NAIP, although prized by its contributors and users, is confronted by the uncertainty of funding and demands for more phenology opportunities (e.g. leaf-on vs. leaf-off, consistent radiometry, etc.).

Although the NSDI, FGDC, GeoPlatform, and the NDOP are focused on acquisition and management of data sets, either primarily or predominantly funded by the Federal government, an assessment of the national condition of an Imagery Theme cannot ignore the vast amount of orthoimagery collected by States. Much of that data is freely accessible, is high resolution, and follows the accepted data standards. Whether included within the NDOP, the State collections are invaluable to the NSDI performance.

This Report Card subsection did not evaluate the status of lidar images derived from the intensity values. The process of creating images from vector intensity data requires the exercise of judgment so this collection is left to the Elevation Theme of the COGO Report Card.

Although some initiatives may have already been underway when the 2015 COGO NSDI Report Card was issued, the energized focus of

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the FGDC and the GeoPlatform efforts is clearly pronounced. Preparing strategic and implementation plans for each theme and identifying criteria to measure progress is appreciably more mature than three years ago. Attention to the needs of customers, as evidenced by the RCA-EO and NAIP Team commitments, demonstrates a willingness to design systems, sensors, data sets, and services that reflect those needs. However, NDOP agencies should look beyond the needs of Federal users and consider the requirements of other important constituencies.

The most obvious risk to all geospatial data and services, including orthoimagery, remains sufficient funding at all levels. This has led to a push toward licensed imagery products at the Federal and State level. The risk is that imagery becomes less “free and open”, creating “walled gardens” that are reflective of a trend toward greater market segmentation within the imagery industry.

The geospatial community should pay close attention to the growth of both cloud-based storage and cloud-based services and processing. The community should stay active in the groups developing the data architectures to facilitate the standards-based integration of the cloud-based datastores and services, continue to demand good metadata, and strongly promote the sharing of non-proprietary and non-licensed imagery with the public.

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VIII. TRANSPORTATION DATA THEME

EXECUTIVE SUMMARY

The Transportation Data theme was one of original themes, and it is critical to the Nation's geospatial practitioners and decision makers. Even though some of the deficiencies from the first assessment are not solved, good progress has been made. Improvements with coordination between DOT and NSDA owners through the Transportation Subcommittee Coordination Group, with programs such as MAP 21 and ARNOLD, and access to new technologies by partnered private agencies has increased the development and utilization of these data sets tremendously. As this theme matures, the community of data provider and uses has to discuss and act proactively towards disruptive technologies such as the Internet of Things and autonomous vehicles so that these advancements can be taken advantage of effectively and efficiently by federal, state, and local agencies

THEME GRADE: C
REQUIRES ATTENTION

I. DESCRIPTION OF THE FRAMEWORK

A. An Introduction to the Theme

The Transportation Data theme was one of original themes established in 2002 and is critical to the Nation's geospatial practitioners and decision makers.

Since the beginning, the Department of Transportation (DOT) has been tasked with the development and maintenance of the spatial representation of the networks that includes roads, railroads, air, transit, and inland waterways. Because the DOT does not own these data, the coordination between these federal agencies can be daunting. In addition, the Census Bureau developed and maintained a separate data set containing street centerlines and railroads as key components of the TIGER system. Furthermore, local jurisdictions including Native American entities are responsible for digitalization of this data for local utilization which has added to this complexity along with national transportation data sets developed by

private agencies such as Google, HERE WeGo, Garmin, and Apple to name a few.

Because of this, the transportation theme has some of the same issues as the Address Theme in that there is variation in the quality, completeness, and accuracy between local agencies, states, federal, and private business datasets. In addition, there are variations in data schemas, field naming conventions, and levels of normalization that lead to difficulties in sharing and aggregating data from multiple jurisdictions.

This evaluation reviews the efforts completed since the 2015 Report Card, at which time the Transportation Data Theme was graded at the D level. According to the 2015 report card, this grade reflected the poor stewardship prior to 2015 of the multiple sources of road centerline data (e.g. TIGER, ARNOLD, and privately produced) in use by federal agencies, and the lack of collaborative goals within the various modes of transportation including rail and water ways.

B. The Theme Definition

Transportation data are used to model the geo-

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graphic locations, interconnectedness, and characteristics of the transportation system within the United States. The transportation system includes both physical and non-physical components representing all modes of travel that allow the movement of goods and people between locations. Sub-themes representing the physical components of the transportation infrastructure include the road, railroad, transit, and waterway networks, plus airport facilities.

C. Lead Agency and Current Activities

The NSDI has had the responsibility for a national spatial database since 1992, with that responsibility reiterated in 1994 by EO 12906 to incorporate commercial data. The FGDC can be applauded for its collaboration with Esri (a commercial partner), OpenStreetMap (a British non-profit), the TIGER program (Census Bureau program),

MAP 21 (a funding and authorization bill), and the NationalMap (USGS program). [References respectively are: www.esri.com; www.openstreetmap.org; www.census.gov/geo/maps-data/data/tiger.html; www.fhwa.dot.gov/map21/; and www.usgs.gov/core-science-systems/national-geospatial-program/national-map]. Each effort contributes to the transportation theme, but all efforts should be coordinated, integrated, and shared as a holistic effort rather than continue as separate endeavors. **Table 1** from the [Transportation Theme FY17 Implementation Plan Report](#) shows current progress status on the Theme's Strategic Plan goals and objectives by the DOT and the National Geospatial Data Asset (NGDA) data sets owners.

The [Transportation Subcommittee Coordination Group](#) through the FGDC provides yearly activity reports on the collaboration between the state,

Table 1. Current progress status on the transportation theme's strategic plan goals and objectives for 2017.

Summary of Goals and Objectives Undertaken During 2017	Status
Goal 1: Facilitate the Sharing of Transportation Geospatial Data	
Objective 1.1: Provide Web Feature Services for the National Geospatial Data Asset (NGDA) datasets for the Transportation Theme	In Progress
Objective 1.2: Leverage the Geospatial Platform	In Progress
Goal 2: Ensure the Effective Development of the Transportation NGDA Datasets	
Objective 2.1: Continued development and support of the All Roads Datasets and its related Address Range-Feature Name Relationship	In Progress
Objective 2.2: Continued development and support of the Rail	In Progress
Objective 2.3: Continued development and support of the Airports and Runways	Recurring (completed for 2017)
Objective 2.4: Continued development and support of the Transit	Recurring (completed for 2017)
Objective 2.5: Continued development and support of the Bridge	In Progress
Objective 2.6: Continued development and support of the Intermodal Facilities	In Progress
Objective 2.7: Continued development and support of the Navigable Waterway, Ports, Locks and inland Electronic Navigation Charts	Recurring (completed for 2017)
Objective 2.8: Continued development and support of the Traffic Analysis Zones NGDA	Recurring (completed for 2017)
Goal 3: Convene Leadership of the Transportation Geospatial Community	
Objective 3.1: Lead and participate in the development and coordination of national and international standards applicable to the transportation geospatial community	In Progress
Objective 3.2: Lead the transportation geospatial community and advocate shared resources	Recurring (completed for 2017)

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federal, and private sector agencies concerning transportation data-related activities. This subcommittee supports the efforts of the DOT and this theme.

Improvements are needed with the workflow coordination between federal, state, and local transportation related agencies as well as potential commercial partners. Concern remains that workflows are underfunded and understaffed. That jeopardizes keeping multi-modal transportation data current with continuous maintenance or sufficiently accurate across multiple jurisdictions, which often rely upon gasoline/fuel taxes for funding work.

D. Collaboration and Partnerships

Currently, there has been great progress on the concerns identified in the last report. Within the *Transportation Theme Strategic Plan* of 2016 – 2019, goals and objectives were defined for all 16 NGDA data sets for continuous development and to provide a roadmap for the DOT and NGDA data set owners.

To help with these issues, the All Roads Network

of Linear-Referenced Data (ARNOLD) and the MAP 21 programs have provided guidelines on the data governance and funding avenues to federal and state agencies. This has helped with the coordination and development of data sets pertaining to the road network.

Table 2 lists all the federal agencies that are coordinated by the DOT and the data sets each agency maintains and supports. As the partners move forward, the strategic plan for this theme and the coordinated efforts of the DOT will need to address the current technology shift to the Internet of Things and autonomous vehicles, and its effect on transportation.

E. Standards

The original standards development consisted of the 2008 Framework data standards for the transportation base, rail, road, transit, and inland waterways. Since the endorsement and adoption of the 2011 United States Thoroughfare, Landmark, and Postal Address Data Standard by state, federal, and some local agencies, addresses are commonly included as road feature attributes.

Table 2. Federal agencies coordinated by DOT and the datasets each agency maintains and supports.

Transportation Theme NGDA Datasets	NGDA Agency
Airports	USDOT FAA
Runways	USDOT FAA
Intermodal (Freight)	USDOT BTS
Roads	DOC - Census
2010 Census Traffic Analysis Zone (TAZ)	DOC - Census
Rail Lines	USDOT FRA
Rail Nodes	USDOT FRA
Inland Electronic Navigational Charts (IENC)	DOD - USACE
Locks	DOD - USACE
Ports	DOD - USACE
Waterway Lines	DOD - USACE
Waterway Nodes	DOD - USACE
Intermodal (Passenger)	USDOT BTS
Bridges	USDOT FHWA
Transit (Lines)	USDOT BTS
Transit (Stations)	USDOT BTS

In addition, the DOT is following the guiding principles from the strategic plan for the continuous development and enhancement of this theme.

Federal agencies that produce, collect, maintain, or use transportation spatial data either directly or indirectly will (1) recognize and manage their transportation spatial data as capital assets, (2) facilitate non-Federal participation in the development of the NSDI, and (3) work together through the FGDC to provide effective and efficient use and management of geospatial data in the digital environ-

ment for the benefit of the Nation.

The guiding principles for the federal geospatial community include the following:

- Ensure that spatial data from multiple sources (Federal, State, Tribal, regional, and local governments; academia; and the private sector) are available and easily integrated to enhance understanding of our physical, natural, and cultural world.
- Facilitate the development of authoritative National Geospatial Data Assets that are complete, accurate, current, standards-compliant, and at the scale needed for shared uses by Federal, State, Tribal, regional, and local governments, academia, the private sector, and the public.
- Protect the privacy and security of citizens' personal data and ensure the accuracy of statistical information about people, both in raw form and in derived information products.
- Enable access for all citizens to spatial data, information, and derivative and interpretive products, in accordance with Office of Management and Budget Circulars A-130 and A-16 and the Open Data Policy (OMB Memorandum M-13-13).
- Protect proprietary interests related to licensed information and data.
- Enable interoperability of information systems through the use of open and machine-readable formats to enable access to resources from multiple agencies and partners. Ensure that investment and policy decisions consider the expected return on investment and effective use of resources.

G. Estimate of Theme Completeness

- *Definition:* Complete
- *Strategic Plan:* Complete
- *Implementation Plan:* This has been developed from 2016 – 2019 with defined goals and objectives with yearly progress reports.
- *Data sets:* Data are still being continuously developed at all government levels. There has been a large push with MAP 21 and ARNOLD

for the local agencies to provide this data to the state and federal agencies. In addition, these programs have provided funding and guidelines for federal agencies to create and manage specific data sets. There is work to be done maintaining the data sets, facilitating the usage at the local level, and planning for disruptive technologies but the theme is moving in the right direction.

G. Accessibility of Data

The number one goal from the Theme's goals and objectives is to "Facilitate the Sharing of Transportation Geospatial Data". The success of this goal is being measured through providing web services to the NGDA data sets and leveraging the Geospatial Platform. In addition, the Geospatial Platform and Data.gov are integrated, which has improved the availability and accessibility of the data to the public.

H. Authority, Governance, and Management of the Theme

Under OMB Circular A-16, DOT has always been the steward for Framework data relating to transportation. It chairs the Transportation Subcommittee, which is responsible for the coordination of transportation data-related activities among agencies and establishes a mechanism for the coordinated development, use, sharing, and dissemination of best practices, standards, and data for transportation.

II. TRANSPORTATION DATA THEME ASSESSMENT

The following are metrics that can be discussed by the DOT with NGDA owners that could have a positive impact on the development and utilization of the theme's data sets in the future.

- Consider addressing funding as a separate metric on its own, such as "Future Need." While funding sources, whether originating from the federal government as grants or matching funds through IGAs or public/private partnerships are one thing that is needed

in the future, it is not the only thing.

- Because different federal road centerline databases have been developed by different units with poor integration, they can be inconsistent or incompatible. Furthermore, the specific purpose of these data sets has contributed to this concern even more. These data sets fall into three specific categories.

- Spatial and attribute accuracy for routing purposes
- Relative location of addresses for emergency response
- Accurate assessment of assets related to the centerline

Metrics to assess the similarity of these differing centerlines should be considered such as the “percent of matching nodes”, “percent of matching links between the different data sets”, or “percent of matching addresses”.

- “Data Governance” as it pertains to established policies, procedures and standards to ensure data integrity should be considered and assessed periodically.
- Number of multimodal transportation themes that can be seamlessly included in a centralized department.
- Percent of arcs, nodes, and addresses that coincide with the centralized street network.
- Percent decrease in funding of spatial transportation efforts which divert from centralization.
- Percent of roads represented and percent with the GIS line work within the bounds of the actual road.
- Percent ability to locate events within a threshold, say 50 feet.
- Basic shortest route analysis (911) and performance of a test set of origins and destinations.

III. GRADE OF TRANSPORTATION THEME

Even though some of the deficiencies from the first assessment are not solved, good progress has been made. Improvements with coordination between DOT and NSDA owners through the Transportation Subcommittee Coordination Group, with programs such as MAP 21 and ARNOLD, and access to new technologies by partnered private agencies has increased the development and utilization of these data sets tremendously. As this theme matures, the transportation spatial data community has to discuss and act proactively towards disruptive technologies such as the Internet of Things and autonomous vehicles so that these advancements can be taken advantage of effectively and efficiently by federal, state, and local agencies.

Grade for this theme is a C = Requires Attention

Framework Evaluators

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Reviewer of Transportation Data Framework Assessment

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Federal Liaison

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APPENDIX A

The Twelve Member Organizations of the Coalition of Geospatial Organizations (COGO)

American Society of Civil Engineers (ASCE) - Geomatics Division

The American Society of Civil Engineers (ASCE) represents more than 145,000 members of the civil engineering profession worldwide and is America's oldest national engineering society. ASCE's mission is to provide essential value to our members and partners, advance civil engineering, and serve the public good. ASCE advances technology, encourages lifelong learning, promotes professionalism and the profession, develops civil engineer leaders, and advocates infrastructure and environmental stewardship.

The purpose of the Geomatics Division is to provide leadership, within the engineering profession, for the acquisition and management of spatial data required as part of scientific, administrative, legal, and technical operations for surveying, cartography, photogrammetry, multi-purpose cadastre, remote sensing, and geographic information systems; to foster the development of policy, guidelines, and specifications; to encourage the advancement of geomatics education; and to foster the dissemination of information.

American Society for Photogrammetry and Remote Sensing (ASPRS)

Founded in 1934, the American Society for Photogrammetry and Remote Sensing (ASPRS) is a scientific association serving thousands of professional members around the world. Our mission is to promote the ethical application of active and passive sensors, the disciplines of photogrammetry, remote sensing, geographic information systems, and other supporting geospatial technologies; to advance the understanding of the geospatial and related sciences; to expand public awareness of the profession; and to promote a balanced representation of the interests of government, academia, and private enterprise.

The American Association of Geographers (AAG)

The Association of American Geographers (AAG) is a nonprofit scientific and educational society founded in 1904. For more than 100 years the AAG has contributed to the advancement of geography. Its members from more than 60 countries share interests in the theory, methods, and practice of geography, which they cultivate through the AAG's Annual Meeting, scholarly journals, and the online AAG Newsletter.

The AAG promotes discussion among its members and with scholars in related fields, in part through the activities of its affinity groups and more than 60 specialty groups. The meetings and activities of our regional divisions provide the opportunity to network with colleagues.

The Cartography and Geographic Information Society (CAGIS)

The mission of the Cartography and Geographic Information Society is to support research, education, and practice to improve the understanding, creation, analysis, and use of maps and geographic information to support effective decision-making and improve the quality of life. The society serves as a forum for the exchange of original concepts, techniques, approaches, and experiences by those who design, implement, and use cartography, geographical information systems, and related geospatial technologies.

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The GIS Certification Institute (GISCI)

The GIS Certification Institute (GISCI) is a tax-exempt, not-for-profit organization that provides the geographic information systems (GIS) community with a complete certification program, leading to GISP recognition. GISCI offers participants around the world, from the first early years on the job, until retirement, a positive method of developing value for professionals and employers in the GIS profession. We offer the only industry-wide, internationally-recognized, software-agnostic Certification available to geospatial professional around the world.

International Association of Assessing Officers (IAAO)

IAAO is a nonprofit, educational, and research association. It is a professional membership organization of government assessment officials and others interested in the administration of the property tax. IAAO has a membership of more than 7,400 members worldwide from governmental, business, and academic communities. The mission of IAAO is to promote innovation and excellence in property appraisal, assessment administration, and property tax policy through professional development, education, research, and technical assistance.

The Management Association for Private Photogrammetric Surveyors (MAPPS)

The Management Association for Private Photogrammetric Surveyors (MAPPS) is the only national association of firms in the surveying, spatial data, and geographic information systems field in the United States. MAPPS member firms are engaged in surveying, photogrammetry, satellite and airborne remote sensing, aerial photography, hydrography, aerial and satellite image processing, GPS and GIS data collection, and conversion services. Our associate members include firms that provide products and services to our member firms, as well as other firms world-wide. MAPPS' primary objective is to develop strength and unity on matters affecting the interests of its member firms. It is intended to promote a quality, profitable profession, interaction among firms, and advance education, both professional and public. The organization monitors and works to affect legislation that impacts the profession. It is the purpose of MAPPS to promote the business interests of the profession.

National Society of Professional Surveyors (NSPS)

NSPS strives to establish and further common interests, objectives, and political effort that would help bind the surveying profession into a unified body in the United States. NSPS aims to advance the sciences and disciplines within the profession; enhance the image of the surveying profession in the eyes of the public; build self-esteem and professionalism; encourage cooperation between the public and private practices; establish channels of communication with other societies and assist in the exchange of information on laws, education, professional practice, and other concerns; promote the profession through an active public relations program; advance the protection of public welfare relative to surveying and mapping issues; encourage high standards of ethical and professional behavior; promote public faith and confidence in the profession; support new practical methods of surveying; promote good business practice; monitor national and state laws and regulations; encourage improved higher education curricula for surveyors; and honor persons for service to the public, the surveying profession, and the NSPS Foundation Inc.

National States Geographic Information Council (NSGIC)

NSGIC's mission is to promote statewide geospatial coordination activities in all states and to be an effective advocate for states in national geospatial policy and initiatives, thereby enabling the National Spatial Data Infrastructure (NSDI). The National States Geographic Information Council (NSGIC) is an organization committed to efficient and effective government through the prudent adoption of geospatial information technologies (GIT). Members of NSGIC include senior state geographic information system (GIS) managers and coordinators. Other members include representatives from federal agencies, local government, the private sector, academia, and other professional organizations. A rich

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and diverse group, the NSGIC membership includes nationally and internationally recognized experts in geospatial information technologies, data creation, and management as well as information technology policy.

The University Consortium for Geographic Information Science (UCGIS)

The University Consortium for Geographic Information Science (UCGIS) is a non-profit organization that creates and supports communities of practice for GIScience research, education, and policy endeavors in higher education and with allied institutions. We aim to be the professional hub for the academic GIS community. The UCGIS mission is to advance research in the field of geographic information science; expand and strengthen geographic information science education; advocate policies for the promotion of the ethical use of and access to geographic information and technologies; and build scholarly communities and networks to foster multi-disciplinary GIS research and education.

United States Geospatial Intelligence Foundation (USGIF)

USGIF's purpose is to promote the geospatial intelligence tradecraft and to develop a stronger community of interest between government, industry, academia, professional organizations, and individuals who share a mission focused around the development and application of geospatial intelligence to address national security objectives.

Toward this end, the Foundation shall seek to accomplish the following broad objectives: sponsor, conduct, and support public discussion groups, panels, lectures and forum, for an interchange of views and the instruction of the public on the topics under review; publish and distribute educational publications relevant to civic associations, governmental bodies, libraries, schools, universities, and other interested groups; conduct sponsor or promote educational programs including, but not limited to, programs for teachers, administrators, and students; and award scholarships to students at accredited institutions of higher education to pursue geospatial intelligence disciplines.

Urban and Regional Information Systems Association (URISA)

The Urban and Regional Information Systems Association (URISA) is an independent, not-for-profit 501c (3) organization established in 1966. From webinars and workshops to multi-day conferences, URISA presents an abundance of educational programs, offers volunteer GIS expertise through its GIS Corps program, and assists government agencies with benchmarking GIS maturity through its GIS Management Institute.

URISA fosters excellence in GIS through its programs, guiding and supporting GIS professionals throughout their careers. URISA is considered to be the premier organization for the use and integration of spatial information technology to improve the quality of life in urban and regional environments. URISA promotes the effective

APPENDIX B

Framework Theme Evaluators and FGDC Resource Experts

	Framework Evaluators	FGDC Resource Experts
Address	Martha Wells, Theme Lead, URISA Katherine Cargo, URISA Tony Simental, GISCI Dan Goldberg, UCGIS	Lynda Liptrap, Census Steve Lewis, DOT
Cadastral	Shelby Johnson, Theme Lead, NSGIC Dan Fastene, IAAO Ed Crane, URISA Doug Vandegraft, CaGIS	Don Buhler, BLM Bob Ader, BLM
Elevation	Doug Schneider, Theme Lead, NSPS Evon Silvia, ASPRS & NSPS	Diane Eldridge, USGS Dan Roman, NOAA Ashley Chappell, NOAA Lorna Schmid, USGS Juliana Blackwell, NOAA
Geodetic Control	Glen Thurow, Theme Lead, NSPS Jon Gustafson, NSPS	Diane Eldridge, USGS Dan Roman, NOAA Ashley Chappell, NOAA Lorna Schmid, USGS Juliana Blackwell, NOAA
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Orthoimagery	Steve Sharp, Theme Lead, GISCI Lucia Lovison-Golob, CaGIS Roberta Lenczowski, ASPRS	John Cullen, USGS Shirley Hall, USDA-FSA
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