NIST Special Publication 1900
NIST SP 1900-207

Global Community Technology Challenge (GCTC)

Strategic Plan 2024-2026

Smart Connected Systems Division

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Edward Griffor
David Wollman

This publication is available free of charge from:
https://doi.org/10.6028/NIST.SP.1900-207

C Y B E R - P H Y S I C A L S Y S T E M S

NIST NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

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June 2024

U.S. Department of Commerce
Gina M. Raimondo, Secretary

National Institute of Standards and Technology
Laurie E. Locascio, NIST Director and Under Secretary of Commerce for Standards and Technology

NIST SP 1900-207
June 2024

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Publication History
Approved by the NIST Editorial Review Board on 2023-12-06

How to Cite this NIST Technical Series Publication
Dunaway M, Roth T, Griffor E, Wollman D (2024) Global Community Technology Challenge (GCTC) Strategic Plan 2024-2026. (National Institute of Standards and Technology, Gaithersburg, MD), NIST Special Publication (SP) NIST SP 1900-207. https://doi.org/10.6028/NIST.SP.1900-207

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Public Comment
NIST expresses gratitude for the constructive comments submitted on the Initial Public Document (ipd), many of which have been incorporated into this version. Further comments on this document may be submitted at any time to: GCTCinfo@nist.gov.

All comments are subject to release under the Freedom of Information Act (FOIA).

Abstract

This publication provides a Strategic Plan for the Smart City Infrastructure (SCI) program of the National Institute for Standards and Technology (NIST), the research laboratory of the U.S. Department of Commerce. The SCI program manages the Global Community Technology Challenge (GCTC), a nationwide public-private partnership of cities and communities; local and state government agencies; and private-sector for-profit and non-profit entities. The GCTC is dedicated to improving the urban, suburban, and rural ecosystems and residents' overall quality of life through the integration of advanced cyber-physical systems and Internet of Things (IoT)-based technologies. NIST serves as coordinator for this partnership in collaboration with other federal agencies and offices that sponsor smart city-related projects and research activities. The convention "smart city," is used generically throughout this document to represent any city, township, or community that develops, invests in, and integrates digital technologies to improve city services for the benefit of the community and its residents.

This strategy is based on a consensus planning process chartered by the NIST SCI program in collaboration with the leadership of twelve GCTC technology sectors (i.e., working groups), who collectively represent over 220 regions, cities and communities that have initiated smart city programs or projects as GCTC member communities. This document aligns with the current Administration, Department of Commerce, and NIST strategic documents, and covers a planning period of three years, from 2024-2026.

Keywords

Smart cities and communities; Cyber-physical systems; Internet of Things (IoT); Key Performance Indicators (KPIs); Critical infrastructure; Smart city standards; Community resilience; Urban and city planning; Mission critical communications.

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Acknowledgements

This page acknowledges the members of the GCTC leadership team who participated in the 2022-2023 strategic planning workshops and contributed to the development of this document.

Their participation in this effort was indispensable and is greatly appreciated.

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Executive Summary

This publication provides a Strategic Plan for the Smart City Infrastructure (SCI) program of the National Institute for Standards and Technology (NIST). The SCI program coordinates research in smart city technologies and manages the Global Community Technology Challenge (GCTC—formerly the Global City Teams Challenge) a public-private partnership established by NIST comprised of smart cities and communities in the U.S. and among international partners. This plan covers a 3-year period of research, development, testing, and evaluation from 2024 to 2026 and has three principal objectives:

1) Establish a research-based, scientific foundation for the Smart City Infrastructure program and the GCTC—in collaboration with NIST research programs and operating units—with emphasis on the measurement of outcomes of technology integration within smart cities.

2) Broaden the definition of "smart cities" to include rural areas and smaller municipalities and address current challenges of smart connected systems in order to enhance access and transparency, build community integrity, and ensure equitable distribution of benefits to all community residents.

3) Continue advancing the GCTC as a national and international public-private partnership with federal government sponsorship dedicated to the development, testing, and integration of advanced technologies for the benefit of cities and communities.

Appendix A to this document summarizes a corresponding 3-year plan for the Global Community Technology Challenge developed through a consensus planning process involving a team of community and technology leaders of the GCTC program. The Appendix consolidates successes and lessons learned by GCTC member communities, and experiences gained from analysis of the broader smart city landscape and offers a community-focused perspective on this national public-private partnership of smart cities and supports the federal (NIST) program described in Sections 1-4. The consensus strategy was developed through a series of Strategic Planning Workshops held from 2022-2023 with the leadership of the GCTC Technology Sectors, which collectively represent over 220 U.S. and international community-based Action Clusters, organized into the following twelve technology sectors:

- Transportation infrastructure, autonomous systems, and vehicles
- Wireless communications and broadband applications and access
- Cybersecurity and privacy for both public and private sectors
- Data governance and city data platforms and dashboards
- Public utilities for energy, water, and waste management
- Public safety, health, and security; mission-critical communications
- Community well-being; trust, integrity, diversity, and equity
- Community resilience, adaptability, and sustainability
- Agriculture and rural productivity and quality of life
- Smart building technologies and IoT applications
- Smart Regions and collaboration strategies
- Education and workforce development

The GCTC Strategic Plan is based on the concept that a "smart city"[1] is a community ecosystem in which advanced technologies are adopted in order to increase the efficiency, availability, and accessibility of city services with the goals of improving city operations, enhancing public safety and community resilience, equitably distributing economic and social benefits, and improving overall quality of life for residents. The principal goal of this program is to support the ability of any region, municipality, community, or neighborhood in achieving its vision for public-focused innovation through the application of advanced technologies.

This document and the strategy that it describes should be considered a "living document" and will be updated as the plan, the IoT and CPS[2] technologies, and the smart cities movement evolve.

[1] The term "smart city" as used throughout this document is a widely accepted term to represent any city, community, town, or region that develops, invests in, and integrates digital technologies with the goal of improving services and operations, enhancing cost-effectiveness, and improving resident's quality of life (See Section 1.3). Where the term Smart City is capitalized in this document, it references the NIST Smart City Infrastructure program or other NIST initiatives or documentation. Where the term appears in lower case, it refers to smart cities, generically (e.g., the "broader smart city community").

[2] Internet of Things (IoT) and Cyber-Physical Systems (CPS) are foundational technologies in smart cities and are described in this document.

1. Introduction and Origin of the GCTC

This publication provides a Strategic Plan for the Smart City Infrastructure program (SCI) of the National Institute for Standards and Technology (NIST). The SCI program conducts research in smart cities and IoT-based technologies and coordinates the Global Community Technology Challenge (GCTC—formerly the Global City Teams Challenge) a smart cities program established and maintained by NIST.

The GCTC is an international public-private partnership of cities and communities, local and state government agencies, private-sector for-profit and non-profit entities, universities, and research institutes dedicated to improving urban, suburban, and rural environments and residents' quality of life through the integration of advanced cyber-physical systems and Internet of Things (IoT)-based technologies. NIST serves as the federal coordinator for both the national and international dimensions of the partnership, in collaboration with other federal agencies and offices that sponsor smart city-related projects and research.

The National Institute of Standards and Technology (NIST) is the research laboratory of the Department of Commerce with the mission to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life. Through the creation and sponsorship of the GCTC, NIST plays a significant role in catalyzing the transition of advanced technologies and standards to states and local communities in order for them to improve options for technology integration. The resulting integrations can allow communities to improve city services, build resilient infrastructure, advance economic equity and sustainability, and improve residents' overall quality of life. NIST's focus on creating critical measurement solutions and promoting the development and adoption of consensus-based standards provides a unique contribution as a federal agency partner to the global smart cities movement. Likewise, NIST's development of frameworks, measures of effectiveness, and analytic tools offers city officials, community leaders, and citizens the ability to more effectively assess investment options and to make informed decisions about benefits, costs, and achievements in advancing city goals and objectives through the integration of advanced technologies. As explained in the NIST Strategic Plan 2020-2025,

> NIST engages in technology transfer working directly with companies and organizations locally and nationally to transfer technology developed in the NIST labs. For NIST to accomplish its mission, our research results must reach the private sector for implementation." [1].[3]

The GCTC originated from a 2013 initiative of NIST and its Presidential Innovation Fellows, working in partnership with the White House Office of Science and Technology Policy (OSTP) and other federal agencies, called the "SmartAmerica Challenge," which had the goal of accelerating the development and integration of advanced technologies to address a wide array of challenges facing cities, both in the U.S. and globally. The GCTC was formally established by NIST in 2013 as the Global City Teams Challenge and held its inaugural workshop at NIST's Gaithersburg campus in September 2014, with a call to city teams, technologists, and researchers with experience in developing and integrating Cyber-Physical Systems and Internet of Things (IoT) technologies at the municipal and regional levels. The principal

[3] Appendix C contains citations and references from current federal agency strategy documents relevant to smart systems, cities, and communities, which serve as many of the source documents for this strategic plan.

challenge that the GCTC was established to address was articulated in a NIST Special Publication (1900-01), issued in 2016:

> "Hundreds of cities and dozens of technology providers are working to realize civic benefits and potential profits across a broad range of services and markets. However, the critical goal of interoperability is in danger of being overwhelmed by the large wave of isolated and customized solutions, along with the accompanying proliferation of proposed standards and protocols" [2].

Furthermore,

> "… many current smart city ICT[4] deployments are based on custom systems that are not interoperable, portable across cities, extensible, or cost-effective." However, "if too many details are standardized, innovation is overly constrained; if nothing is standardized, the result is non-interoperable clusters of function that are not easily integrated." [2].[5]

In response to these challenges, the GCTC adopted the following four goals for the program:

1) Stimulate the growth and assembly of a large and diverse set of smart city projects, and build a broad community of organizations and individuals working in the smart city space.
2) Using this GCTC community of projects as an "at-scale testbed environment," apply a variety of analytical approaches to distill significant commonalities and identify quantifiable measures of effectiveness and metrics for success.
3) Through an iterative process of conferences, expos, and networking, work with the GCTC community to encourage the entire smart city community toward greater interoperability, scalability, measurability, and replicability, define best practices, and encourage coherence.
4) Use insights from the GCTC ecosystem, with its expanding and diverse application space to inform development of the NIST Cyber-Physical System testbed and research program.

The GCTC was built on a structure of community-focused "Action Clusters" from cities across the U.S. and the globe. Action Clusters represented city teams, organizations, industries, and agencies "taking action" on specific city challenges. The goal of the GCTC was to spur collaboration among innovative local governments and agencies, nonprofits, private companies, and university research centers to overcome challenges and develop solutions with leaders in the smart city and IoT fields. Through participation in the GCTC, companies, universities, and nonprofits showcased their technologies to potential customers and partners and collaborated with local government leaders and technology developers to deploy interconnected solutions. The program goals identified in the original NIST 2016 report had by 2019 achieved a significant benefit for the GCTC member communities, as well as for the larger national and international smart city and stakeholder communities. Figure 1 provides the 2022 depiction of the extent of GCTC member communities.

[4] Information and Communication Technologies

[5] A history of the GCTC is outlined in two NIST Special Publications, 1900-01 (2016) cited above, and NIST Special Publication 1900-204 published in 2019. Citations and links are in the Reference section of this document.

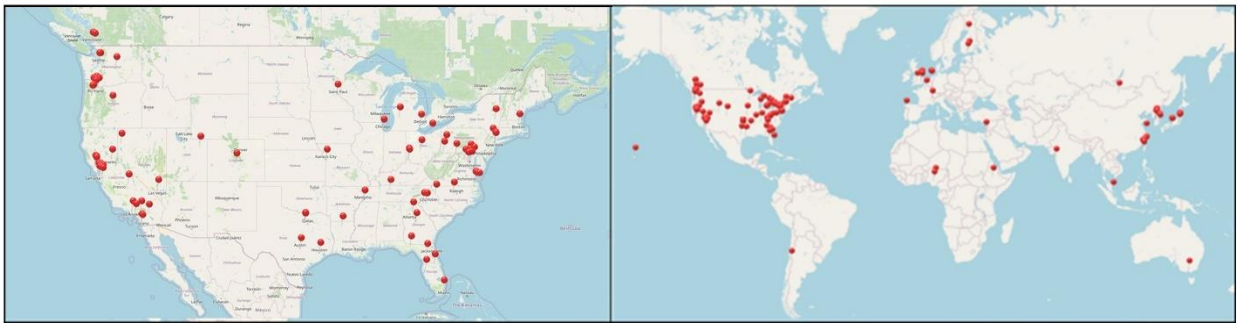

Figure 1. GCTC U.S. membership and global partners 2016-2022.

Since its launch at the 2014 NIST workshop, the GCTC program had by 2022 evolved into a network of over 220 U.S. and international cities and communities, involving over 500 industry, academic, and government stakeholders who jointly develop and deploy advanced technologies for smart cities and communities. The program has created an ecosystem for information sharing in which communities can gain tangible benefits from collaboration and exchange of best practices to improve efficiency, lower costs through economies of scale, and improve the lives and economic benefits to their populations.

In October 2016, the GCTC organized its 160 existing Action Clusters into a set of "SuperClusters" based on specific community services, infrastructure sectors, and mission areas. The SuperClusters have since evolved as the organizing structure for the GCTC, representing specific technology sectors or focus areas, while also coordinating the activities of a diverse set of community Action Clusters from cities and regions across the nation and among international partners. By 2019, the initial seven SuperClusters had expanded to nine, and in 2020 two more were added to comprise eleven technology sectors and working groups. In early 2022 a twelfth Supercluster was initiated, with a focus on trust, integrity, diversity, and equity. The current organizational structure for the GCTC includes the 12 Technology Sectors illustrated in Figure 2.

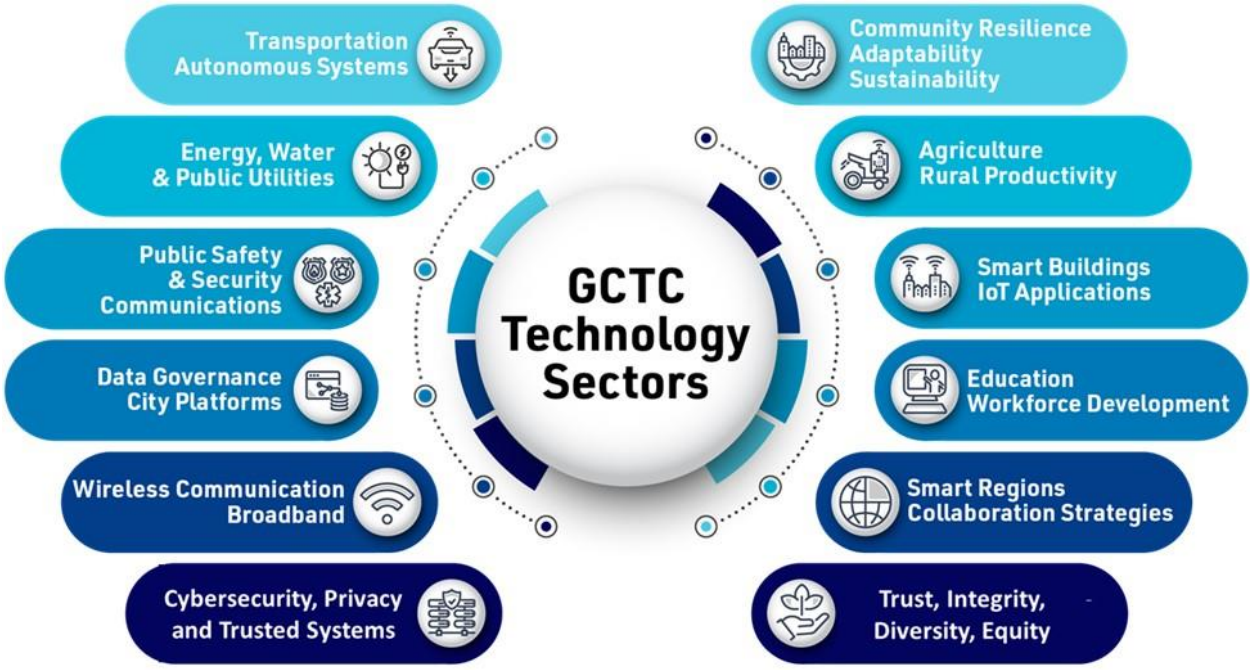

Figure 2. GCTC Technology Sectors

Many of the SuperClusters have since published a blueprint or guidebook for communities to use in establishing a smart city project or program in a specific technology or service sector. All blueprints are accessible from the main GCTC website [2]. Figure 2 depicts the organizational structure, now designated simply as GCTC Technology Sectors.

1.1. Purpose of a Strategic Plan for GCTC

With the successful establishment of the GCTC community in 2014 and implementation since 2016 of the organizing structure provided by the Technology Sectors, there is now a need for a common, integrated strategy to guide the GCTC program, and to provide a unified approach to smart city research, development, test, and evaluation (RDT&E) within the GCTC and the NIST Smart City Infrastructure program. There are also significant benefits to be gained for the larger smart city community—within the U.S. and among international partners—by the establishment of an integrated strategy for enabling cities to measure and assess smart city investments through a sponsoring agency at NIST under the Department of Commerce.

The development of an integrated approach to smart city initiatives will likewise support the NIST mission to initiate standards development, enhance measurement science, and assist in developing common architectures and key performance indicators (KPIs) for the integration of IoT-based sensors, cyber-physical systems, and communications technologies in smart cities and communities. The active leadership and engagement of NIST in support of local officials, agencies, industries, and citizens through the GCTC program represents a significant step toward ensuring that federal research investment and outcomes have an impact in local communities, and tangible benefits for their residents.

Of equal importance is the growth and transformation of the GCTC program in light of the continuing maturity and more widespread acceptance of smart city technologies and initiatives. The adoption of such technologies as broadband communications, artificial intelligence, autonomous vehicles, data mining, and networked sensors has transcended both the state of the art and the extent of dispersion of advanced technologies that existed at the time the GCTC program was launched. Likewise, there now exist a number of non-profit and research institute-based smart city programs, which contribute to the broader smart cities community through their own unique identities, regional perspectives, partner bases, and sponsorship of national and international conferences. Based on its relationship to the NIST Smart Connected Systems Division, the GCTC can support the common interests of those organizations through outreach and collaboration, participation in public workshops and conferences, and sharing of best practices to the mutual benefit of cities, communities, regions, and organizations.

Finally, the significant changes in the natural, social, and virtual environments within the last several years—to include significant threats to the urban environment such as climate change, extreme weather and natural disasters; threats to cybersecurity, trust, and privacy for organizations and individuals; and the most recent threat posed by a global pandemic and its widespread social, political and economic impacts—argue for a reassessment of current and future priorities for the GCTC and the larger smart city community.

In recognition of the foregoing successes and challenges, this Strategic Plan initiates a redesignation and rebranding of the GCTC as the **Global Community Technology Challenge.** This change in program name recognizes the global nature of current challenges to the urban environment and the range of the adoption of smart technologies among cities and communities, both in the U.S. and internationally. This Strategic Plan for the GCTC is intended to address these and other considerations and initiates a 3-year program of research and development, evaluation, and implementation of smart city concepts, technologies, and standards in collaboration with GCTC member communities, private sector organizations, government agencies at the federal, state, and local levels, and international partners with similar smart city and community initiatives and goals. The key objective of this strategy is to establish extensible, standardized technologies and processes for measuring effects and outcomes as the foundation for the continued advancement of the GCTC and the expanding smart cities community in support of the NIST and Department of Commerce missions, as described in a recent White House Budget Memorandum:

> "Agencies should collaborate to promote world-leading research and innovation boosting American industries and quality American jobs in emerging technologies … and actively pursue public-private partnerships that will expedite American leadership in technologies to grow our inclusive 21st Century digital economy." (EOP FY 2023 Budget Memorandum M021-32, p. 3). [3].

1.2. Audience for the GCTC Strategic Plan

This document is intended to serve three primary audiences:

1) First and foremost, it provides background and future direction of the NIST GCTC and Smart City Infrastructure (SCI) program to inform NIST leadership and research staff and NIST Operating Units and assist in identifying opportunities where NIST research efforts can contribute to the development of smart city technologies.

2) Secondly, this document provides guidance to the GCTC leadership in defining programmatic priorities and direction from the perspective of the federal sponsoring agency (i.e., NIST) while serving as a guide for development of the community-focused strategy provided in Appendix A.

3) Finally, the Strategic Plan will provide guidance in defining priorities for GCTC communities and regional programs and assist in building a common approach to smart city initiatives, while establishing a reference point for future planning within the GCTC. The document will also inform GCTC member communities of opportunities for collaboration with NIST research staff in evaluating advanced smart city technologies for their communities.

1.3. Concept and Definition of a Smart City

This GCTC Strategic Plan is based on the concept that a "smart city" is a community ecosystem in which advanced digital technologies are adopted in order to increase the efficiency, availability, and accessibility of city services with the goals of improving efficiency in city operations, enhancing public safety and community resilience, equitably distributing economic and social benefits, and improving overall quality of life for residents. In this document, where phrases such as "smart city," "urban ecosystem," "urban environment," and "smart systems" are used there is no inherent criteria of size, population, geography, or typology that constrains or limits considerations as a "smart city." A principal goal of this program is to support the ability of any community, municipality, or region to achieve its vision for public-focused innovation through the application of advanced technologies. This definition is equally applicable to rural towns, communities and agricultural regions having more dispersed populations that would benefit from digital communications and connectedness. For purposes of this strategy, a smart city (community, town, region, etc.), will be considered one that puts priority on, and engages in activities (including research and development) that enable the:

> **"Efficient use of digital technologies to provide prioritized services and benefits to their community."** [4]

Ultimately, these technologies and the outcomes of their adoption can be analyzed and potentially quantified along a number of vectors to include:

1) Number of digital services and benefits
2) Efficiency in implementation, and reuse or dual-use
3) Quality of services and benefits delivered
4) Alignment with community priorities

A principal goal of this strategy and the GCTC program will be to consider the smart city in a holistic and comprehensive manner, aligning projects at the community, municipal and regional levels to consider the inter-relationships among the social, built, and natural environments, as well as between critical infrastructure sectors, cyber-physical systems, and IoT-based technology applications. In 2022, NIST issued Special Publication 1900-206, "Smart Cities and Communities: A Key Performance Indicators Framework," that provides a depiction of the relationships between technologies and data systems, service platforms, and community outcomes within a representative smart city [4]. Figures 3 below is excerpted from that publication and illustrates the network of relationships between technologies, platforms, and outcomes as an approach to understanding the smart city holistically as a networked system of systems.

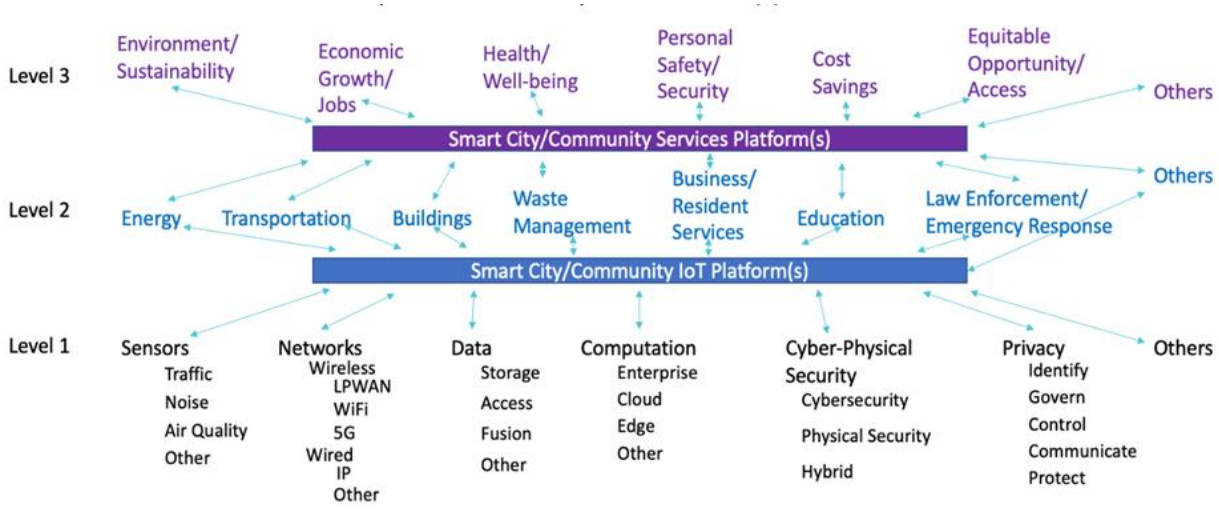

Figure 3. System levels and relationships of smart city platforms, services, and outcomes [4]

As explained in the NIST Key Performance Indicators Framework, the ***holistic relationships*** among elements of a smart city or community may be represented as a series of discrete steps in a data or information flow or pathway. Each step consists of a source, path, and destination, representing sensors, platforms, data stores, applications, etc. that are the origin for the data or information transmitted along a specified path. The path represents the means for transmission and may include wired or wireless networks or other transmission methods. The destination is the application, platform, data store, etc. receiving the transmitted data or information. Figure 3 depicts the smart city structure at three interacting levels of analysis–technologies, infrastructure services, and community benefits—based on the community network of sensors, data, platforms, and systems.

In Figure 3, Level 1 focuses on enabling technologies and their core capabilities. Examples of technologies include sensors and actuators, networks and connectivity, data systems, and computational hardware and software systems. Examples of core characteristics are the elements of trustworthiness – security, privacy, resilience, reliability, and safety. Data analytics at this level focus on non-biased data, technology, and service metrics such as network capacity, sensor accuracy and coverage, system downtime and recovery, conformance with security and privacy guidance, etc.

Level 2 describes the infrastructure services and operations that enable a city or community to function. Infrastructures include those in the communications, transportation, energy, water, and buildings sectors, which range from roads and bridges to networks, pipelines, electric grids, and commercial and residential structures. Key services include emergency response and law enforcement, waste management, education, and city/community services. Data analytics at this level are centered on measures of infrastructure functions, such as broadband access and public transit use, and on service effectiveness, such as emergency response time and access to education.

Level 3 illustrates the benefits that community residents, businesses, and organizations can attain through the equitable access to technology adoption as determined through the analysis of Key Performance Indicators to achieve a holistic integration of the city's infrastructure. Examples include personal safety and security, business and job growth, health care, environmental quality, and other quality of life factors including culture, arts, and entertainment. Data and analytics at this level focus on the experiences of residents, visitors, and businesses throughout the city or community.

A key consideration for any smart city development or deployment is the role of **interoperability** in ensuring that technologies integrated into city infrastructure and operations are fully compatible with existing or legacy systems and will accommodate future improvements and new applications to be incorporated. For this reason, interoperability may be considered a fundamental requirement for any smart city project or program. As a foundation of both the SCI and GCTC programs, this strategic document adopts the definition and concept of interoperability provided in NIST Special Publication (1108r4), NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 4, described in Figure 4 [5].

"Interoperability" as defined in the NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 4.0

Interoperability [i]s the capability of two or more networks, systems, devices, applications, or components to work together, and to exchange and readily use information — securely, effectively, and with little or no inconvenience to the user.

The benefits of interoperability are broad and reach all stakeholders at all scales. Interoperability is a hedge against technology obsolescence, maximizes the value of equipment investments by increasing usage for secondary purposes, and facilitates combinatorial innovation by allowing coordinated small actions across diverse stakeholders and devices to have grand impacts. The interoperability value proposition can be realized in any system domain, from the utility to the customer and beyond.

Interoperability is therefore key to maximizing the benefits of technology investments. Yet because it is not easy to directly quantify the value of seamlessly exchanging a single bit of information in a complex system … the value of interoperability is most often thought of in the context of what is avoided: the expensive and time-consuming set of activities necessary for one-off integrations of incompatible systems.

NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 4, 2021 pp. 1 – 3.

Figure 4. NIST definition of "Interoperability" as a foundation of smart city development [5]

With these definitions and the representations of community platforms, infrastructure, and levels of analysis in mind, this strategy will endeavor to enable development of both conceptual and technical foundations for analyzing smart cities and communities as networks of systems within a geographic region that are purposefully designed to enhance the security, economic vitality, and quality of life among the residents.

2. Strategy for the Next Phase of the NIST GCTC

The smart city may be considered as an evolution of advanced digital technologies employed to provide services for the benefit of society, standing at the intersection (in both time and geography) of complex challenges that arise from current local, regional, national, and global trends. In such an environment, the transformation of a city or community will be dependent on the community's investment in digital technologies and the alignment of those technologies with the economic, social, cultural, and environmental goals that the community has established for itself.

In the initial years of the GCTC (and the broader smart cities movement, as well) the principal focus was on developing and integrating technology applications that would address the urgent challenges cities faced in developing, managing, and improving critical infrastructures, solving seemingly intractable challenges such as vehicle traffic management, the resilience and operation of public utilities during disasters, and improving communications with residents via information technologies and city dashboards. Later, the key challenges and many of the technology applications were directed at understanding the city's or community's built environment and its relationship to the natural environment. Much of the energy and

resources invested was in developing methods and technologies to enhance understanding—that is, situational awareness—of the relationships occurring across critical information sectors, and between the built infrastructure and the natural environment, particularly those dedicated to enhancing decision-making through the integration of data systems. Over the past several years, however, there has been an evolution of thinking across the smart cities community toward a more holistic understanding of what actually constitutes "smartness" in a city or community. This trend has, in effect, redirected the focus of digital transformation away from technology development and integration, per se, and towards the objectives or goals that the community has established for itself, with technology adoption and digital transformation as a means to those ends. Figure 5 is a simplified depiction of the evolution of the GCTC (and the broader smart city community) areas of focus over the last decade.

Figure 5. Evolution of the smart city concept and dimensions

More recently, as cities and communities have become more connected, networked and technologically sophisticated, new challenges and opportunities have arisen that demand a rethinking of traditional approaches to sustainability, resilience, public safety and social services, information and communications, and the human relationship to technology. The design and integration of intelligent infrastructure—including embedded sensors, the Internet of Things (IoT), advanced wireless information technologies, real-time data capture and analysis, and AI-based decision support—hold the potential to greatly enhance economies, social interaction, public safety and security, and overall community resilience, while addressing new and emerging challenges in urban society. At the same time, however, the trajectory toward universal connectedness, pervasive computing, and technological integration at all levels of society has challenged many of our traditional notions of what it means to live in an open society with high quality of life. This highlights the tensions between a number of social and technological priorities:

- Safety and Security vs. Openness and Convenience
- System Complexity vs. System Reliability
- Community Security vs. Individual Privacy
- Artificial Intelligence vs. Human Autonomy
- Universal Accessibility vs. Transparency and Trustworthiness

As a consideration of these and other challenges, the smart city is now widely understood to include the need to address challenges in the social, economic, and cultural dimensions of the urban environment, as well as the integration of technology into human society and individual lives. The objective is to employ advanced technologies to mitigate the inherent tensions that exist in seemingly competing community priorities exemplified by those listed above. The ultimate goal is to approach smart city design from a more

holistic perspective and achieve an integration of systems and relationships between the human population and the built and natural environments.

This strategic plan and the next phase of the GCTC will therefore include considerations of the broad spectrum of technological, environmental, social, and human dimensions of the urban and rural ecosystem and will put emphasis on how those factors—including intangible factors such as community well-being, social connectedness, diversity and cohesion, and community resilience and integrity—should be understood, measured, and prioritized as both characteristics and determinants of the smart community.

2.1. GCTC Vision and Mission

To date, there are few formal organizations or opportunities that exist for collaboration between technology researchers and developers, public agencies and professionals, and local government officials and community leaders where capability gaps and priorities for community development can be discussed and potential technology solutions identified and tested. Moreover, the trend toward IoT sensors and cyber-physical systems—coupled with dramatic changes in hazards and threats to complex, urban societies—argues for an organization and framework for identifying innovative technologies, strategies, and capabilities within a fully collaborative, multi-disciplinary environment.

To that end, the goal of the GCTC is to establish an enduring, international public-private partnership to build capacity in research and development in technologies for public benefit through engagement with a coalition of community officials and leaders, private sector developers, university researchers, community stakeholders, and government agencies at all levels. This partnership will examine and facilitate the adoption of innovative concepts that enhance the delivery of public services in such areas as public safety, health, and security; economic vitality and equity; community resilience and sustainability; and challenges at the interface between urban and rural ecosystems. The initiative has five principal objectives:

1) Support the smart city movement by nurturing integrated, multi-disciplinary research in strategies and technologies across technical, jurisdictional, and geographic boundaries;
2) Identify and address capability gaps and challenges and assist in developing frameworks, analytic methods, and resources to build a scientific foundation for smart cities and communities;
3) Facilitate collaboration with federal, state, county, and municipal partners to define and validate technology requirements, metrics, and standards for enhancing community services and operations;
4) Engage with international partners and allies to enhance cross-border interoperability, international standards development, and mutual objectives for environmental sustainability and resilience, economic growth, and common values for sharing the benefits of advanced technology integration.
5) Sponsor opportunities for enhancing programs in Science, Technology, Engineering, Art, and Math (STEAM) and other interdisciplinary educational programs to engage the next generation of scientists, engineers, technologists, community leaders, and citizens while contributing to local and regional workforce development goals.

As in the previous years, the immediate goal of the GCTC is to provide a forum for increasing awareness of emerging technology applications and enhancing collaboration among GCTC member communities and smart city partners. Future efforts will be dedicated to enhancing research and information sharing and to advance state-of-the-art, technologies and concepts. The Vision and Mission Statements to guide the GCTC are as follows:

> **VISION:** Sustain a federally sponsored collaboration among communities dedicated to improving city services and enhancing quality of life through the integration of advanced technologies.
>
> **MISSION:** GCTC will coordinate a public-private partnership of communities dedicated to accelerating the integration of advanced technologies to achieve digital transformation and enable communities to become more sustainable, equitable, resilient, and livable.

As the GCTC sponsoring organization, the NIST Smart Cities Infrastructure program will identify research opportunities and develop methods for assessing options, measuring outcomes, and developing standards and key performance indicators to assist city officials, community leaders, and citizens in assessing benefits, defining costs, and achieving community goals from the adoption of advanced digital technologies.

3. Principal Goals of the GCTC 2024-2026

A principal objective of the NIST Smart City Infrastructure (SCI) effort is to build collaborative research partnerships between NIST laboratories and Operating Units with the advanced technology initiatives of U.S. cities, industry partners, and university research laboratories. Through the Global Community Technology Challenge, the SCI research program leverages smart cities and communities in partnership with NIST expertise in measurement science and standards development to build a network of community-focused "living laboratories" to define a science-based understanding of how cities function as complex adaptive systems having technological, environmental, economic, and social dimensions. Research into current and future challenges in smart cities and communities will necessarily involve multi-dimensional problems in IoT modeling and simulation, interoperability, automation and autonomy, and data analytics that will bridge diverse domains and stakeholders.

This section highlights three defining goals under the GCTC Strategic Plan and orients the GCTC toward specific accomplishments at the program level with community and city partners. In several cases, achieving these goals will be contingent on dedicated funding, either through NIST program funds, or though partnership with other funding agencies or community and corporate partners.

3.1. Goal 1: Establish a research-based, scientific foundation for the NIST Smart Cities Infrastructure program, the GCTC, and the broader smart cities community.

This goal will focus on aligning the Smart City Infrastructure program and GCTC public-private partnership with the work of the NIST laboratories and Operating Units with the goal of leveraging NIST research that would advance smart technologies to benefit communities. GCTC will target both internal (NIST) and external (other federal agency) outreach to expand the research base and empirical foundations of the Smart City Infrastructure program. A related goal is to develop a catalog of research projects and organization contacts engaged in projects that are directly or indirectly related to GCTC and smart cities initiatives. This effort will include the following:

- Develop a repository and library of GCTC and smart city sources, resources, apps, courses, etc. and make it available to GCTC, the smart city community, and the general public.
- Define a program of research on standards and key performance indicators for smart cities, in collaboration with GCTC communities and Standards Development Organizations (SDOs).

- Initiate Pilot Tests of H-KPI implementation in select GCTC smart cities with a focus on public safety, mission-critical communications, community resilience, and sustainability.

3.2. Goal 2: Broaden the scope and agenda for smart cities to address current challenges and achieve the equitable distribution of outcomes for community residents, businesses, and organizations.

A priority research area within the GCTC is directed at understanding the nexus between the adoption of digital technologies and the enhancement of social and economic benefits accruing from the community's investment in those technologies. The term adopted in the GCTC for the ultimate goal of the smart city is "Integrity" (depicted in Figure 5) as both an engineering concept (i.e., systems or design integrity) and as an ethical or moral construct reflecting the public's trust in technologies, data, and decision systems, as well as in the community's decision-makers, leadership, and relationships. The "smart city" is now widely understood as a balance among technical, environmental, socio-economic, and cultural dimensions of the urban environment, and not simply the adoption of advanced technologies to increase efficiencies and cost-effectiveness. To that end, the GCTC program is initiating a focused research effort on defining the characteristics of trust, integrity, diversity, and equity as a foundation of the smart city that yields measurable outcomes in quality of life and overall community well-being.

The GCTC Trust, Integrity, Diversity, and Equity (TIDE) project focuses on identifying KPIs to assess the intersections of smart city technologies and applications with the outcomes sought to build community integrity at both the system and societal levels. The TIDE concept as applied within the GCTC program is not directed solely at measuring social and economic outcomes, but rather at defining a broad metric for understanding the holistic relationship between the integration of advanced technologies with the goals of the community. In this regard, "diversity" is more aligned with the broad definition established by the International Telecommunications Union (ITU) Study Group (SG 20) on Internet of Things (IoT) and Smart Cities and Communities (SC&C) [6], which characterizes diversity from five perspectives:

- Diversity of services and applications.
- Diversity of data and data sources.
- Diversity of devices, networks, and transmission methods.
- Diversity of sensing modes and sensor systems.
- Diversity of management and governance modes.

This effort will focus on the identification of key performance indicators and factors contributing to the enhancement of Trust, Integrity, Diversity, and Equity (TIDE), and will initiate several multi-disciplinary research focus areas across GCTC member communities to include:

- Incorporation of "Trust, Integrity, Diversity, and Equity (TIDE) as a cross-cutting foundation of the GCTC and smart cities in a manner similar to the cross-cutting priority given to cybersecurity and privacy considerations across all sectors and infrastructures of smart cities.

- Expand GCTC partnerships to include smaller cities, underserved communities, urban "technology deserts," and constituencies who have not been engaged in GCTC and smart city efforts. A specific focal point of this effort is to include Native American and Tribal regions and communities.
- In consideration of current hazards and risks to communities, development of a risk management framework for public safety, health, and resilience in smart cities to enhance public safety planning and communications to achieve "whole community" disaster preparedness, response, and recovery.

The long-range goal of this effort is to develop a methodology for measuring (directly or indirectly) the impact of technology programs within a city or community toward improving community integrity, economic vitality, and overall quality of life and societal well-being and ensure the equitable distribution of benefits across the diverse communities that typify a complex, modern city.

3.3. Goal 3: Enhance the national public-private partnership of smart city programs, research institutions, private sector enterprises, and the Next Generation of community leaders, scientists, and researchers.

This is the principal public-facing goal of the GCTC and continues the collaboration strategy and community outreach that has been the core and hallmark of the program since its launch in 2014. A major change in direction is the intention to pursue more targeted themes in GCTC conferences and workshops and expand the type, size, and description of communities engaged in GCTC, both domestically and internationally. Priority program initiatives for this area include:

- Increase GCTC outreach and engagement with private sector business and industry and assist in building collaborations with smart cities and communities. To this end, GCTC will collaborate with the Baldrige Excellence Program [7] to develop a framework for smart cities to guide communities in the design, integration, and evolution of smart systems in urban and rural environments.
- In partnership with the Department of Commerce's International Trade Administration (ITA), the Department of State (DOS), and other federal agencies, support collaborations with allied smart city programs and increase U.S. representation at international smart cities conferences and events. Coordinate with ITA and DOS to support the global network of U.S. field offices and overseas missions on matters related to smart cities and technologies, and enhance U.S. participation in international standards development organization (SDO) working groups on smart cities.
- Engage students and support outreach programs and technology demonstrations and competitions at high schools, community colleges, and universities, in order to nurture the next generation of researchers, technology developers, and entrepreneurs and build long-term continuity in the national smart cities movement.

4. Project Priorities for Smart City Infrastructure and GCTC Programs

A key objective of the SCI program is to build partnerships between GCTC member communities, research centers, and researchers of the Operating Units and research laboratories of NIST, particularly in the fields of data analytics, autonomous systems, public safety communications, resilient infrastructure, energy systems, and other multi-disciplinary research areas relevant to smart cities. In support of NIST research priorities, GCTC member cities are positioned to serve as "living laboratories" and testbeds to assess the

impact of research into the integration of IoT systems and communication technologies in real-world applications. Participation of NIST researchers with projects relevant to smart cities will advance development and adoption of IoT applications and smart city standards and provide NIST with direct access to end-user communities for fielding advanced technologies within complex, multi-dimensional environments. For the 2024-2026 period, the following research efforts are of priority interest.

4.1. Research and identify Holistic Key Performance Indicators (H-KPIs) for smart cities

In February 2022, NIST published a document in the CPS Framework Series that introduced the concept of Holistic Key Performance Indicators (H-KPIs). The document, "Smart Cities and Communities: A Key Performance Indicators Framework" (NIST SP 1900-206, described in section 1.3 above), has received significant attention from smart cities stakeholders. This effort will develop a new area of measurement science based on implementation of H-KPIs to analyze smart city technology networks and quantify efficiencies in the delivery of city services, improvements in infrastructure resilience, and enhancement to residents' overall quality of life. The H-KPI implementation will enable quantitative measurement and assessment of smart city systems, infrastructure, and communications networks, and add an empirical foundation to smart city technology adoption that is scalable to any size city or community.

As a priority endeavor, the project will conduct an initial workshop in 2024 in collaboration with the Communications Technology Laboratory's Public Safety Communications Research (PSCR) program and the Engineering Laboratory's Community Resilience program to identify KPIs and develop a conceptual framework for community coordination of preparedness, response and recovery and engage the civil population in a "whole community approach" to public safety and disaster response in smart cities.

Subsequent efforts in 2025-2026 will develop a preliminary model of KPIs in critical infrastructure systems that share common characteristics and are thus applicable and scalable to all communities. The goal is to define the factors that would enable development of a holistic model of city or community digital infrastructure (i.e., H-KPIs) and expand the knowledge of city systems and intersections that either present vulnerabilities to be protected, or opportunities to enhance public safety, community resilience, and environmental sustainability. Finally, the project will identify potential pilot cities/communities for H-KPI demonstration based on data availability and shared stakeholder interest across a spectrum of city sizes and demographic, geophysical, social, and economic dimensions.

4.2. Build a GCTC Open Knowledge Network and Best Practices Repository (GCTC-OKN)

The Global Community Technology Challenge (GCTC) is a NIST-led public-private partnership representing over 220 U.S. and international cities that have collaborated since 2014 on developing an information sharing network as the foundation of the smart city research and development activities. GCTC member cities constitute a de facto Open Knowledge Network of smart cities and communities with the common goal of information sharing of data, technology solutions, best practices, and experience in the development and integration of IoT technologies. However, to date, there is no consolidated repository on smart city topics or research efforts that are available to the public. The lack of a central repository or library of smart cities resources is a significant deficit for smart cities and sponsoring agencies and organizations.

As a priority, this effort will catalog current NIST documents, frameworks, and publications that can inform GCTC and smart cities projects and begin building a library of documentation, best practices, lessons

learned, and resources from any smart cities program or sponsoring organization. This research activity will lay the foundation for an open knowledge network (OKN) via a Wiki-based information sharing platform to catalog and archive relevant smart city documents, NIST publications, lessons learned, and activities between the GCTC communities and technology developers, industry partners, university research centers and national laboratories engaged in smart city initiatives. The GCTC OKN is in prototype form on a publicly accessible site (https://OpenCommons.org) and contains links to smart cities activities, GCTC newsletters, the NIST GCTC pages, and other resources. In succeeding years, the GCTC OKN Wiki will be enhanced to support collaboration opportunities among member communities on research gaps and needs, smart city data, information, frameworks, and standards. The long-term goal is to serve as a repository for smart city knowledge and best practices from GCTC communities, partnering organizations, and the broader smart city ecosystem that are available through a wiki-based site that can be accessed and edited by registered GCTC members.

4.3. Collaborate with Baldrige Excellence Framework for Smart Cities and Communities

In collaboration with the NIST Baldrige Excellence Program [7], the SCI and GCTC programs will begin development of a Framework for Smart City Excellence based on a Capability Maturity Model to guide communities in the design, integration, and evolution of smart systems in urban—and rural—environments. This effort will build on the previous years' efforts to develop and publish blueprints or frameworks for individual GCTC Technology Sectors, and aims to develop a standard, integrated methodology or strategy that communities can adopt for establishing goals and priorities, identifying opportunities, and planning smart city enhancements, regardless of community size, description, geography, demography, or economy. The effort will adopt the key focus areas from the current Baldrige Excellence Framework, with modifications to target application to smart cities and communities:

- Digital transformation and economic sustainability
- Organizational and infrastructure resilience
- Innovation and workforce development
- Trust, Integrity, Diversity, and Equity.

In addition, given the centrality of cyber-physical systems and IoT-based infrastructure to smart cities, this effort will adopt the principles of the Baldrige Cybersecurity Excellence Builder and the NIST Cybersecurity Framework 2.0 [8] to further assist communities in enhancing the security of their critical infrastructure systems, data, and communications, while protecting the privacy and welfare of their citizens. Modeled on the approach implicit in the NIST Cybersecurity Framework, this initiative will adopt the methodology of a Capability Maturity Model to enable communities to define and achieve progressive levels of success and security in the digital transformation of their communities. This project will engage a partnership of GCTC member communities, private sector and industry experts, and citizens' groups in developing the Framework for Smart City Excellence over the next three years.

4.4. Develop a Framework for Standards for Smart Cities and Communities and participate in international Standards Development Organizations (SDOs)

In 2023, the White House issued the United States Government National Standards Strategy for Critical and Emerging Technology (NSSCET) with the objective of increasing private and public sector engagement with Standards Development Organizations (SDOs) to "foster U.S. and likeminded nations' competitiveness in emerging markets and work to vigorously promote our shared values and market economies based on impartial and effective standards" [9]. The NIST NSSCET Working Group and Standards Coordination Office lead development of an implementation strategy for the NSSCET and will be conducting outreach to the business sector, industry, technology developers and U.S. SDOs to define appropriate standards for critical and emerging technologies.

Smart cities are cited in the NSSCET as among the specific applications of critical and emerging technologies that "impact our global economy and national security." The Smart Cities Infrastructure program will be supporting NIST and the SCO in defining the approach to standards development and implementation that is appropriate to the smart cities movement, which—like the U.S. standards process itself—is based on voluntary, collaborative and open development that respects individual community priorities, resources, and jurisdictions. As a function of the NSSCET discovery process, the Smart City Infrastructure program will host a workshop of GCTC member communities to define an approach to smart city standards and develop a Framework for Standards for Smart Cities and Communities that reflects U.S. principles and goals.

In addition to facilitating opportunities for collaborations with U.S. smart cities, industry partners, and other stakeholders, the NIST SCI and GCTC programs engage with selected international Standards Development Organizations involved in smart city research and development efforts. Experience gained through GCTC activities and interactions with U.S. communities informs NIST participation in standards development efforts for U.S. smart cities and systems, while engagement with international SDOs provides context for U.S. smart cities participation in international SDOs. Collaborating SDOs include the U.S. Technical Advisory Group (TAG) of the IEC Systems Committee for Smart Cities [10], ISO/IEC Joint Working Group 14 on Smart Cities Reference Architecture, and Study Group 20 on Smart Sustainable Cities of the International Telecommunications Union (ITU) [11], as well as the UN Sustainability Goals and U.S. collaboration through the United Nations Foundation [12]. Collaboration includes interaction with other U.S. federal agencies with membership on the US TAG that engage with international partners and SDOs in international collaborations and cooperative agreements related to smart cities and technologies.

4.5. Provide Technical Guidance to GCTC Member Communities and Smart City and Community Partners

Citizen expectations, sustainability needs, and maturing IoT technologies are fueling interest in smart city systems. Developments related to AI and IoT data in the wider digital economy are shifting policy ideas. Single-technology initiatives, such as ubiquitous municipal Wi-Fi and smart streetlights, are now viewed as components—and often a starting point—for development of a larger, smart city program. There is also a shift from short-term demonstrators and pilot projects to sustainable infrastructure technologies that can operate for decades rather than periods of a few months or years. While technology innovation matters, the new era focuses on delivering citizen outcomes. This envisions smart city technologies as enabling tools, affordability being the result of standardization for economies of scale, and interoperability being the foundation for cross-silo innovation and collaboration between cities and across regions. [13].

The NIST Smart City Infrastructure program provides technical support and guidance to activities of the Global Community Technology Challenge and the national and international public-private partnership committed to smart city and community development. A priority of the GCTC effort is to build partnerships between the GCTC member communities and research centers, researchers, and operating units of NIST, particularly in the fields of data analytics, autonomous systems, public safety communications, resilient infrastructure, energy sustainability, IoT interoperability, and other areas that require multi-disciplinary approaches to solving challenges of complex smart city systems.

The NIST Smart City effort anticipates supporting at least one NIST-sponsored workshop or conference annually and maintaining GCTC participation in other national and international smart city events. The program sponsors quarterly workshops scheduled and conducted by GCTC Technology Sectors to maintain regional and community outreach between NIST and member communities, cities, and regions. Workshops on technical aspects of smart cities and IoT/CPS integration serve to build the smart cities research network and strengthens the relationship between the NIST GCTC program and participating “living laboratory” communities. These workshops will serve to identify opportunities for collaboration between research universities and technology developers, federal laboratories, and research facilities, including NIST.

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List of Symbols, Abbreviations, and Acronyms

AI	Artificial Intelligence
AR/VR	Augmented Reality / Virtual Reality
CISA	Cybersecurity and Information Security Agency
CPS	Cyber-Physical System
CTL	Communications Technology Laboratory
DHS	Department of Homeland Security
DOS	Department of State
EOP	Executive Office of the President
GCTC	Global Community Technology Challenge
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
ISAC	Information Sharing and Analysis Center
ISO	International Organization for Standardization
ITA	International Trade Administration
H-KPI	Holistic Key Performance Indicators
KPI	Key Performance Indicator
NIST	National Institute of Standards and Technology
NITRD	Networking and Information Technology Research and Development
NSF	National Science Foundation
NTIA	National Telecommunications and Information Agency
OKN	Open Knowledge Network
OSTP	Office of Science and Technology Policy
PSCR	Public Safety Communications Research (NIST program)
R&D	Research and Development
RDT&E	Research, Development, Test and Evaluation
S&CC	Smart and Connected Community (NSF program)
SCSD	Smart Connected Systems Division
SCI	Smart City Infrastructure (NIST program)
SDO	Standards Development Organization
SMART	Specific, Measurable, Achievable, Realistic, Timely
STEAM	Science, Technology, Engineering, Art, and Mathematics
TAG	Technical Advisory Group
TIDE	Trust, Integrity, Diversity, and Equity

Appendix A. Integrating a Community Perspective into the GCTC Strategic Plan

This Appendix is intended to capture community perspectives related to the NIST GCTC and smart cities, generally. These perspectives were generated during the course of three workshops involving GCTC leadership, and incorporate ideas and concepts from industry, academia, government, and other organizations. This report was prepared as an account of a workshop. It is intended to document external perspectives and does not necessarily represent official NIST positions.

5.1. Background on the GCTC Strategic Planning Process

In 2022, NIST initiated a cooperative agreement with George Mason University (GMU) to coordinate the development of an integrative and supportive community-centric strategy to complement the NIST SCI program and inform and strengthen the GCTC in its role as a nation-wide public private partnership. This activity included a workshop series with the intention to define guiding principles, identify opportunities for advanced technology research, development, and application of smart city concepts and technologies, and develop mission and vision statements to guide the future of the organization.

In August 2022, the GCTC leadership convened at the George Mason University campus in Arlington, Virginia in the first workshop in a three-part series. The workshop was attended by the co-chairs of the twelve GCTC Technology Sectors (Figure 2), each of whom had long-standing participation and leadership in the GCTC, as well as experience in designing and guiding smart city endeavors within their own communities. In all, 28 members participated in one or more of the three workshops, and are listed in the Acknowledgements page on page V of this document. (Owing to the COVID-19 pandemic and impact on travel, two of the sessions accommodated virtual participation by some members). The first workshop, sponsored by the Center for Advancing Human-Machine Partnerships (CAHMP) at GMU, was intended to establish a strategic research vision for the GCTC. The workshop provided the leadership of the GCTC Technology Sectors and other attendees an opportunity to better understand how the GCTC interacts with internal and external partners to achieve technology deployment and implementation for the purpose of informing the strategic vision. This workshop was followed by a September 2022 workshop sponsored by the City of Coral Gables, Florida, and was held in the Public Safety Headquarters Smart Building. Augmenting the findings of the first workshop, the second workshop was designed to identify the specific priorities and activities of the strategic plan. In June 2023, a third workshop was held at Portland State University in Portland, Oregon to finalize the GCTC community-centric strategic plan and goals.

Synthesized results from the workshop series were intended to: 1) inform and guide the strategic direction of the GCTC organization to benefit communities and the public; and 2) yield insights into the complex and interdependent challenges of disseminating and implementing advanced technology systems in the smart and connected communities vision. The results of the discussions and planning process provided a

real-world, community-level perspective for the GCTC Strategic Plan, and outcomes of the workshop series were incorporated into the GCTC Strategic Plan 2024-2026. A Workshop Report is issued separately and posted on the GCTC OpenCommons web portal. (Establishment of the GCTC resource and OpenCommons portal was one of the major outcomes of the GCTC community planning process and is described briefly in section 4.2 above). Other key outcomes from the strategic planning process are highlighted below.

5.2. Purpose and Objectives

The goal of the workshop series was to generate a community-focused perspective on the agenda and priorities to be pursued by GCTC communities and partners. The specific objective of the meetings was to solicit GCTC leadership input to articulate vision and mission statements and to identify forward looking goals and activities for the volunteer organization to inform a community-based strategy for the GCTC, as well as smart and connected communities across the nation. The workshop series served to define a plan for the GCTC community through a facilitated consensus process involving participant representatives from the leadership of the twelve GCTC technology sectors that comprise the GCTC. The overall objectives for identifying new strategic plans for the GCTC in these workshops was: 1) to nurture integrated, multidisciplinary research and development in smart city strategies and technologies; 2) to address capability gaps and national challenges in smart city technologies; and 3) to identify new opportunities to collaborate with federal, state, county, and municipal partners to define requirements and validate approaches for enhancing community services and efficiencies.

5.3. GCTC Community Vision and Mission

At the conclusion of the workshop series, the GCTC leadership group arrived at consensus on the vision and mission statements for the organization. This vision and mission will begin to provide broad guidance and define priorities for the GCTC local and regional communities to assist in building a common approach to GCTC smart city initiatives, creating a common reference point for future planning of the GCTC program and organization. The vision and mission statements generated by the group during the workshop series are:

> **Vision:** GCTC communities that have achieved a digital transformation enabling them to become more vibrant, resilient, equitable, sustainable, agile, and connected.
>
> **Mission:** To support the digital transformation of communities by providing trusted, unbiased information, best practices, and systematic, integrated methodologies that help communities become more sustainable, equitable, resilient, and livable.

The key outcome of the workshop series was a consensus-based structure and set of objectives for the GCTC defining the future functions and relationships for the community and regional public private partnerships that characterize the GCTC. Organizational goals refer to the overarching objectives or outcomes that the GCTC aims to achieve in the next 2-5 years. The GCTC goals provide a sense of direction and purpose guiding the organization's strategic decision-making and resource allocation.

5.4 Community-Level Principles for Guiding the GCTC Program

Through the Strategic Planning Workshop series, the GCTC leadership identified five principles that will guide public outreach, civic engagement, and project adoption into the future. While specific GCTC community projects, agendas, and priorities will continue to evolve (just as smart city technologies will), these principles will form the core of the program and its relationship to communities, for-profit and non-profit organizations, and research institutes.

1) Provide any city or community with the opportunity to participate in GCTC activities and create an affiliation with other smart city and community programs, and encourage the free and open access to knowledge, resources, and experience.
2) Encourage and support smaller communities who often cannot attract sufficient investment from the private sector to pursue smart city digital transformation, and assist in identifying available federal, state, local, and philanthropic funding sources.
3) Assist in providing access and interpreting national and global guidelines (e.g., the NIST Cybersecurity Framework 2.0; U.N. Sustainable Development Goals) as potential foundational documents for pursuing digital transformation of cities and communities.
4) Provide a U.S.-oriented approach to open standards development of smart city-related technologies and applications that relies on consensus and market actors to design and develop standards that are voluntary, consensus-based, and private sector led.
5) Encourage students, early career professionals, and young people to become engaged in smart city technologies, concepts, and projects through such approaches as digital games, hackathons, social media and tech demonstrations and simulations in smart cities and communities.

5.5. GCTC Research and Development priorities for 2024-2026

During the three workshops, broad goals for the GCTC organization were distilled into a number of specific project goals and undertakings based on a consensus of the leadership. Some of these projects will be adopted within specific GCTC communities as prototypes or directed to potential research and development efforts by collaborative teams, local communities, or partner organizations. Timelines for development of these efforts will evolve as this strategy is further refined and implemented. The following efforts were identified as the top areas of smart city technology and concept development and will be pursued as GCTC priorities.

1) Define mechanisms that can help translate community needs into actionable goals using smart technologies that ultimately engage the community in improving quality of life for residents. More specifically, develop standardized approaches that help communities know where to start and how to document their progress and successes.
2) Create an organizational structure to enable different entities involved in GCTC to operate together and independently (i.e., separately within a community, or collaboratively across a region). Define community strategies that can help GCTC engage different kinds of communities in pursuing smart city goals and initiatives (e.g., tribal, rural, small towns, and metropolitan cities).
3) Establish a systematic structure and methodology for design of a Key Performance Indicators (KPIs) Dashboard (Templates, KPIs, Application Programming Interfaces (APIs), Standards) and

create a publishable mechanism (knowledge base) incorporating methodologies for differing city infrastructure sectors.

4) Catalyze communities around the country to start smart city programs, conduct technology pilots and implement solutions that showcase the value of integrating smart digital technologies in city operations and services. Identify opportunities and purchasing and contractual vehicles to promote and accelerate the deployment of smart community technologies.
5) Initiate projects that require multiple GCTC technology sectors to work together in ecosystem development. Establish an alignment across sectors and sponsor live pilots to demonstrate collaborative planning and implementation.
6) Establish enduring relationships with university research programs related to smart cities and assist with emergent programs, and engage professors, graduate, and undergraduate students in smart city research and development. Develop a strategy for assisting communities in partnering with research universities and applying for funding for equitable infrastructure projects.
7) Update the existing knowledge base of Action Cluster projects and build a semantic structure that frames the applied integrated knowledge. Build a catalog of these projects to extract relevant KPIs and promote successful projects and organizations.
8) Build, validate, and promote open-source solutions to remove barriers to community access, cost, and technical capabilities, and create a unified, socio-technological framework for the digital transformation of communities.
9) Develop training resources for GCTC member communities to increase knowledge and capabilities including social network tools to permit individuals and organizations within the GCTC to connect, meet, learn, and interact with the broader community. Create an "Executive Summary" version of the GCTC strategic plan for city officials and community leaders with non-technical, non-scientific language oriented to problem-solving, risk assessment, value generation, and growth opportunities.
10) Involve high school and university students, city officials, and community volunteers in GCTC to focus on the future of communities and cities and prepare the workforce of the future to grow industry and government leaders and generate interest in public service and civic education/design among the next generation of U.S. citizens and community residents.

5.6. Summary and Path Forward for the GCTC

As a trusted organization with national and international experience in smart cities, the GCTC and its member cities comprise a team with depth and breadth of knowledge to assist new communities in achieving their specific goals toward digital transformation. By leveraging the institutional knowledge and scientific credibility of NIST, the GCTC has the potential to generate urban and rural living laboratories and assist communities in conducting pilots of smart city technologies.

As in many technical fields, city municipal planning is often siloed into bureaus (e.g., planning, transportation, parks and recreation, public works, etc.). The GCTC can assist communities in developing a holistic approach to community planning at multiple levels and perspectives. Smart technology design paired with human-centered urban design opens the opportunity to leverage generated data incorporating an evidence-based model to inform decision making at the city or community level, and more broadly disseminate outcomes and lessons learned across the research and academic communities.

Most cities have generated massive amounts of data but may not understand—or have the technical capabilities—to translate that data into evidence about what works and what does not. Starting with a baseline assessment of the built environment, available data and existing services can provide a foundation to work toward progressive improvement to ensure that cities and communities use limited resources in the most efficient and cost-effective way. Therefore, a core program goal for the GCTC is to assist cities and communities to understand "what to measure, and how to measure it" in order to achieve the community's smart city program goals.

Understanding interactions and relationships among diverse factors is fundamental to a holistic understanding of a smart city as an ever-growing network of sensors, data streams, and service platforms, accessed via digital information technologies, in alignment with community objectives, priorities, and measured outcomes. As a way of depicting the relationships and defining a structure for community relationships, the GCTC has begun developing a model of community functions based on Abraham Maslow's well-known Hierarchy of Human Needs [13]. Figure 6 offers an initial vision of this concept.

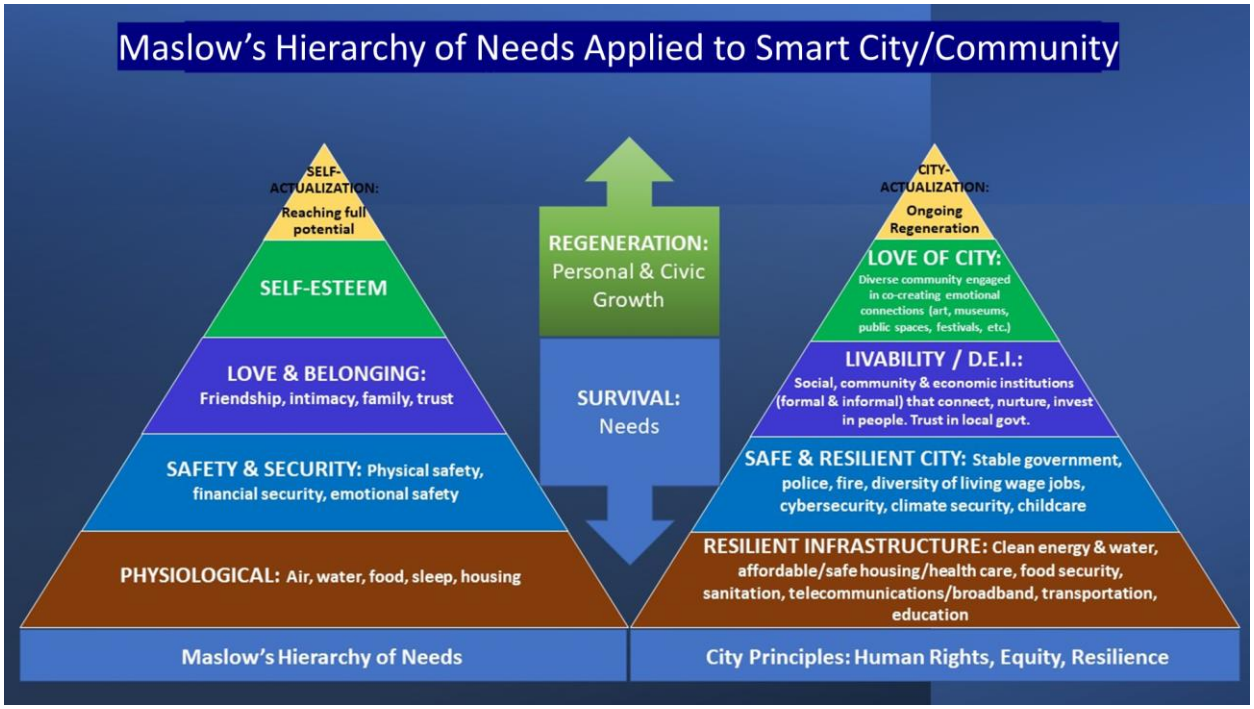

Figure 6. Application of Abraham Maslow's Hierarchy of Human Needs to the Smart City [13]

As depicted in Figure 6, city needs and aspirations are built on a foundation that provides for the most basic services: security and safety; public health; access to water and food; reliable electrical power and accessible communications. Higher up in the development of a smart city, however, fundamental priorities for efficiency in delivery of basic city services begin to reflect aspirations for community integrity and livability, economic stability and equity, and quality of life across all of the communities and neighborhoods within a city or region. As noted above (and depicted in Figures 3 and 4) the current goal for the GCTC—and for smart city planning in general—is no longer to focus on the integration of new technologies, or

even the collection and management of big data, but rather the use of digital resources, information, and capabilities to achieve measurable improvements in security, livability, and quality of life for all residents, and to aid in establishing trusted relationships between government, private sector enterprise, organizations and citizen groups, and the communities that define a smart city.

The GCTC program can assist communities in articulating a clear rationale for pursuing smart city initiatives and infrastructure through its network of educational institutions, experienced local governments, industry partners and federal, state, and local agencies. Any city or community has the opportunity to join and participate in the GCTC and create affiliations with other smart cities and programs and to design a program for digital transformation, whether it is a large metropolitan city, an underserved inner-city neighborhood, or a rural community in an agricultural region.

By working with the GCTC, cities can establish an objective, quantitative and qualitative baseline of the built environment, community assets and resources, and identify opportunities for improving efficiencies and effectiveness in delivery of city services. The GCTC program can help cities understand where to begin to improve their infrastructure and technology assessment processes and to measure progress by identifying holistic KPIs, eliciting citizen priorities, addressing community needs, and establishing methods for measuring and understanding relationships between city infrastructure, platforms, and services.

The GCTC leadership believes that a co-designed and agile orientation drawing from the collective experiences of GCTC communities and the relationship with NIST offers a clear path forward for positive transformation of cities. Through the adoption of digital technologies based on common standards and frameworks and a collaborative and co-designed approach involving the broad constituencies and stakeholders, each city and community is capable of achieving its goals for digital transformation. The GCTC leadership is committed to sharing knowledge of smart cities deployments with other cities and assisting in developing an integrative framework grounded in real-world experience and applications to guide communities in digital transformation and achievement of their smart city vision.

Appendix B. Citations from current U.S. Federal Agency Strategies relevant to the NIST GCTC Program and Smart Cities

This appendix contains selected quotations and sections from current federal strategy documents that are relevant to U.S. research and development, transition, and adoption of technologies for smart and connected communities. While there is no designated federal coordinating office for smart technologies, systems, or communities, these citations point to a set of common characteristics and requirements that are identified at the federal level and directly engage or involve collaboration and coordination with state, local, tribal, and territorial (SLTT) authorities and with cities and communities across the nation.

EXECUTIVE OFFICE OF THE PRESIDENT

United States Government National Standards Strategy for Critical and Emerging Technology (May 2023). The White House. Washington, D.C. https://www.nist.gov/standardsgov/usg-nss.

> "The United States will prioritize efforts for standards development for a subset of CET that are essential for U.S. competitiveness and national security …
>
> "There are also specific applications of CET that departments and agencies have determined will impact our global economy and national security. The United States will focus standards development activities and outreach on these applications, which include:
>
> • Automated and Connected Infrastructure, such as smart communities, Internet of Things, and other novel applications.
>
> • Automated, Connected, and Electrified Transportation, including automated and connected surface vehicles of many types and unmanned aircraft systems, many of which may be electric vehicles (EVs), along with the safe and efficient integration into smart communities and the transportation system as a whole, including standards to integrate EVs with the electrical grid and charging infrastructure;
>
> • Cybersecurity and Privacy, which are cross-cutting issues critical to enabling the development and deployment of emerging technologies and promote the free flow of data and ideas with trust.

EXECUTIVE OFFICE OF THE PRESIDENT MEMORANDUM M021-32 (27 Aug 2021)

Multi-Agency Research and Development Priorities for FY 2023 Budget

MEMORANDUM FOR THE HEADS OF EXECUTIVE DEPARTMENTS AND AGENCIES (whitehouse.gov)

https://www.whitehouse.gov/wp-content/uploads/2021/07/M-21-32-Multi-Agency-Research-and-Development-Prioirties-for-FY-2023-Budget-.pdf

1. **Catalyze research and innovation in critical and emerging technologies.** Agencies should collaborate to promote world-leading research and innovation boosting American industries and quality American jobs in critical and emerging technologies, including artificial intelligence (AI), quantum information science (QIS), advanced communications technologies, microelectronics,

high-performance computing, biotechnology, robotics, and space technologies … "[and] should actively pursue public-private partnerships, as allowable, that will expedite American leadership in these technologies to grow our inclusive 21st-century digital economy. (p. 3)

2. **Innovation for equity**. The President has implemented a whole-of-Government equity agenda. Federal agencies should prioritize R&D investments in programs with strong potential to advance equity for all, including people of color and others who have been historically disadvantaged, marginalized, and adversely affected by persistent poverty and inequality. As part of this focus, agencies should consider programs and initiatives, including community-level capacity building and training that expand equitable inclusion in Federal science and technology programs and the use of scientific and technological innovation to advance equitable outcomes. For example, open science and other participatory modes of research, such as community-based datahubs that give citizens access to information and data, as well as community-engaged research that respectfully provides opportunities for the participation in science and technology of those historically excluded from the scientific enterprise. (p.3)
3. **National security and economic resilience.** Agencies' plans and budgets should support the research, development, and application of technologies that protect American security and strengthen our economic resilience. … and new capabilities for defending critical infrastructure and sensitive networks against cyberattacks and supply chain attacks, including improved authentication mechanisms, zero-trust architectures, and better intrusion detection capabilities. Investments in economic resilience should emphasize technologies that ensure safe, clean, and reliable access to critical products, materials and minerals, including new manufacturing and biomanufacturing processes that can cost-effectively produce key goods on demand. (p. 4)
4. **Other R&D Program Guidance.** To build a trustworthy and engaged U.S. science and technology (S&T) enterprise, agencies should prioritize making Federally funded R&D: open to the public in a findable, accessible, interoperable, and reusable way; more rigorous, reproducible, and transparent; safe and secure; grounded in assessment of ethical, legal, and societal implications … "including community-level capacity building and training … and the use of scientific and technological innovation to advance equitable outcomes. (p. 4).

U.S. CONGRESS. Public Law 117-58 Infrastructure Investment and Jobs Act, Nov 15 2021
U.S. Congress. Infrastructure Investment and Jobs Act [H.R. 3684]. Public Law 117-58. 15 Nov 2021. https://www.congress.gov/bill/117th-congress/house-bill/3684/text

SEC. 25002. SMART COMMUNITY RESOURCE CENTER.

(1) RESOURCE CENTER.—The term ''resource center'' means the Smart Community Resource Center established under sub-section (b).

(2) SMART COMMUNITY.—The term ''smart community'' means a community that uses innovative technologies, data, analytics, and other means to improve the community and address local challenges.

(b) ESTABLISHMENT.—The Secretary shall work with the modal administrations of the Department and with such other Federal agencies and departments as the Secretary determines to be appropriate to make available to the public on an Internet website a resource center, to be known as the ''Smart Community Resource Center'', that includes a compilation of resources or links to resources for States and local communities to use in developing and implementing—

SEC. 25003. FEDERAL SUPPORT FOR LOCAL DECISIONMAKING.

(a) LOCAL OUTREACH.—To determine the data analysis tools needed to assist local communities in making infrastructure decisions, the Director of the Bureau of Transportation Statistics shall perform outreach to planning and infrastructure decision-making officials in units of local government and other units of government, including a geographically diverse group of individuals from—

(1) States;
(2) political subdivisions of States;
(3) cities;
(4) metropolitan planning organizations;
(5) regional transportation planning organizations; and
(6) federally recognized Indian Tribes.

U.S. DEPARTMENT OF COMMERCE Strategic Plan 2022-2026. Innovation, Equity, and Resilience. Strategic Plan | U.S. Department of Commerce

1. **Strategic Objective 1.2. Accelerate the development, commercialization, and deployment of critical and emerging technologies.** Strategy 2. Strengthen U.S. participation in technical standards development. NIST will work to increase diverse participation and leadership in standards development committees, invest in relevant research activities, and support efforts to improve the overall stakeholder experience in standards development. Strategy 3. The Department will improve the transfer and commercialization of technology from Federal Government labs through efforts like NIST's lab-to-market program and by helping entrepreneurs access new technology and patent innovations. The Department will also invest in innovation ecosystems incentivizing partnerships between industry; institutions of higher education; nonprofits; and Federal, state, and local governments to promote a seamless innovation pipeline. (p. 13)
2. **Strategic Objective 2.1. Drive equitable, resilient, place-based economic development and job growth.** Strategy 3. To scale the next generation of technological innovation, maintain global competitiveness, and ensure everyone benefits from the innovation economy, the Nation must harness the potential of all regions, workers, and businesses. This means expanding support for innovation ecosystems all across America, beyond a handful of urban centers. … The National Institute of Standards and Technology (NIST) will strengthen efforts to leverage its nationwide expertise, facilities, and partnerships, as well as provide funding and technical assistance to enhance information sharing among researchers and entrepreneurs. This expanded integrated network will help ensure more efficient and equitable diffusion of the technology and knowhow needed to innovate. (p. 31).

3. **Strategic Objective 3.3 Accelerate development and deployment of clean technologies.** Strategy 3 NIST and NOAA will partner to support the development of climate-ready infrastructure. NIST Laboratories will provide access to unique facilities and testbeds to accelerate the development of climate mitigation technologies … and improve the performance and accuracy of climate observing systems. These programs allow communities to prepare for, respond to, and mitigate the impacts of climate change and enable industry to advance vital technologies that will reduce the Nation's carbon footprint. (p.48).

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY 2021-2025 Strategic Plan

https://www.nist.gov/system/files/documents/2021/06/04/11.%20Sberegaeva%20NSP%20VCAT%20update%20%281%29.pdf

1. **Vision**: NIST will be the world's leader in creating critical measurement solutions and promoting equitable standards. Our efforts stimulate innovation, foster industrial competitiveness, and improve the quality of life. (p. 3)

   NIST is the sole government laboratory with a mission to enhance industrial competitiveness, and it does that through its unique role in measurement science, standards, and technology. In fulfilling this mission, NIST has an outsized impact on the U.S. economy, quality of life, and national security. (p.4)

2. **Action 7.** The impact of NIST's work is directly correlated to our ability to ensure our stakeholders and customers' expectations are met for high quality products and services, knowledge of best business practices, and objectivity in all technical and business decisions. Increase the successful transfer of NIST-developed technologies by applying Baldrige best practices to streamline and enhance customer and stakeholder engagements. (p. 10)

3. **Action 8.** Improve stakeholder awareness of NIST by clarifying and sharpening NIST's strategic communications and initiating an effort to rebrand NIST.

   Improve consistency of messaging in communications to stakeholders will help them identify and share NIST's priorities, capabilities, and value. NIST must ensure its priorities are clear and all communications to broad audiences in industry, academia, government, media, the broader public, and within NIST are aligned with its core messages. (p. 10)

4. **Strategic Goal 1: Position NIST to Advance U.S. Measurement Science and Innovation** Many of the emergent national priority issues that NIST is asked to address are cross-disciplinary and draw upon expertise available across NIST. NIST must remove barriers between organizational units to best leverage the world-class expertise contained across the institute. NIST should explore the range of partnership approaches and external engagement models to continue to effectively fulfill its mission. (p. 13)

5. **Strategic Objective 1.1**: Increase agility, promote collaboration, and maintain technical excellence to strategically advance emerging technologies and address national needs. (p. 13).

   - Foster a culture that promotes cross-OU collaboration, both socially and technically, including in areas of national need. (p. 13)

6. **Strategic Objective 1.3**: Develop creative models that strategically expand our external engagement and impact, aligned with our mission to maximize value of technical programs. (p. 13)
    - Take a more purposeful approach to identifying and nurturing external partnerships.
    - Establish and implement rigorous, fair, and transparent mechanisms to assess the effectiveness and impact of existing partnerships.
7. **Strategic Goal 2: Maximize NIST Stakeholder Impact through High-Value Service Delivery.**

    NIST engages in technology transfer working directly with companies and organizations locally and nationally to transfer technology developed in the NIST labs. For NIST to accomplish its mission, our research results must reach the private sector for implementation. While NIST has a strong reputation for technical excellence, it does not have a strong "brand" for which it is readily identified. (p. 15)
8. **Strategic Objective 2.1**: Facilitate the transfer of NIST knowledge, inventions, and technologies from the laboratory to the marketplace. (p. 15)
    - Improve communications about NIST tech transfer processes and policies.
    - Ensure businesses are aware of opportunities to transfer NIST knowledge and technologies.
    - Pilot new efforts and policies for NIST to catalyze technology transfer improvements.
9. **Strategic Objective 2.2**: Provide high quality products and services that NIST's customers and other key stakeholders value. The lack of a unifying brand and clearly articulated priorities supporting that brand are major issues that limit NIST's effectiveness in reaching stakeholders.
    - Adopt organizational branding best practices to enhance NIST's reputation with key stakeholders as a leader in advancing innovation and economic impact.
    - Enhance internal and external communications management and policies in ways that encourage a "One NIST" culture and support organizational branding efforts.
    - Implement strategic communications planning led by Public Affairs, with participation by all NIST operating units, focused on priority messages, tactics, and metrics of success. (p. 15)
10. **Strategic Goal 3: Create the Infrastructure for a 21st Century Research Institution.** Emerging scientific, engineering, and cyber research are relying more critically on computation, data, and informatics to fulfill the NIST mission of enhancing U.S. industry and innovation. (p. 17)
11. **Strategic Objective 3.1**: Facilitating a next-generation research and data infrastructure.

    Public-private partnerships in science and technology using next-generation instrumentation that deliver research results to our community will extend our metrology expertise into the data sciences, computational frameworks, and networked architectures. Adapting our mode of operation for this research-driven infrastructure serving cross-organizational goals is essential for our mission to be successful into the future.
    - Provide a sustainable open access research framework. (p. 17)

12. **Strategic Objective 3.4. Adopt and transition to modern business systems and operational practices to improve transparency and agility.**

    To improve business systems and services, NIST needs to implement a business system evaluation tool or practice, a discretionary funded program, a business system review, and standard business workflows. (p. 18)

    - Streamline business system workflows (via adoption Salesforce for GCTC CRM).

13. **Strategic Goal 4: Build a One NIST Culture.** Our workforce is the most critical asset of the institution, and future success or failure will hinge on the steps we take now to ensure its health and effectiveness for years and decades to come. People want to work in an environment that is accepting of all backgrounds and promotes equality and fairness … in an environment where everyone feels engaged, appreciated, and empowered. (p. 19)

14. **Strategic Objective 4.2**: Create an engaged, empowered, and agile NIST workforce aligned with the One NIST vision and NIST core values.

    - Incentivize cross-collaboration between different OUs and improve the engagement and empowerment of the NIST workforce. (p. 19)

NETWORKING AND INFORMATION TECHNOLOGY RESEARCH AND DEVELOPMENT
Smart Cities & Communities Task Force October 2018

Connecting and Securing Communities. A Guide for Federal Agencies Supporting Research, Development, Demonstration, and Deployment of Technology for Smart Cities and Communities

https://www.nitrd.gov/pubs/NITRD-Connecting-Securing-Communities-Federal-Guide-2018.pdf

1. Smart city/community projects are inherently state and local efforts, but there are many ways for the Federal government to support these efforts, including R&D leading to new innovations, advising on security and resilience, sharing data, and helping to track progress. To be an effective partner, Federal agencies must align their efforts with state, regional, and local needs while incorporating appropriate public-private and public-academic partnerships. (p. 2)

2. Federal smart city/community activities need to be iteratively informed by cities and communities and should reflect the diverse challenges faced by cities/communities of all types (e.g., rural, suburban, urban, peri-urban, tribal, small, and large). (p. 3)

   Considerations should include privacy and security, social, behavioral, and economic factors (e.g., health, education, and socioeconomic status), effective Internet access, and outreach and educational resources. Finally, Federal support for technologies and programs intended to advance smart city efforts must be designed to work within a wide variety of resource environments, policy settings, and legal and regulatory frameworks. (p.3)

3. The challenge for cities and communities lies in spanning traditional boundaries. Interagency coordination and the convening power of Federal agencies can catalyze enhanced cooperation and new partnerships across agencies, sectors, and stakeholders. (p. 4)
4. The Federal Government can foster industry-driven standards; sharing of successful practices domestically and internationally; interoperable and replicable solutions to increase global trade, investments, and export opportunities; and provide global leadership for smart cities/communities. (p. 4)
5. "The transition of research innovations to practice is critical to ensure that smart city/community innovations benefit cities and communities, and their residents, and that they yield the greatest return on investment for the Federal Government. This requires an approach that bridges the chasm between fundamental science and engineering research and full production. Federal agencies must work synergistically with industry, nongovernmental organizations, and other stakeholders to shepherd innovations using transition-to-practice programs to efficiently move research findings to translation and adoption, and fully realize their value." (p. 8.)

DEPARTMENT OF HOMELAND SECURITY Strategic Plan Fiscal Years 2020-2024

The DHS Strategic Plan Fiscal Years 2020-2024

https://www.dhs.gov/sites/default/files/publications/19_0702_plcy_dhs-strategic-plan-fy20-24.pdf

1. **Goal 5: Strengthen Preparedness and Resilience**

   Objective 5.1: Build a National Culture of Preparedness

   The United States must strive for a future where disasters cause fewer disruptions and less destruction throughout our communities. The prevalence of disaster declarations and recovery costs over the last decade demonstrate the need for local communities to improve their preparedness for predictable natural events. Building more resilient communities and investing in mitigation measures are the best ways to reduce risks to local communities arising from the loss of life, economic disruption, and infrastructure restoration. (p. 44)

FEDEERAL EMERGENCY MANAGEMENT AGENCY FEMA Strategic Plan 2022-2026

2022–2026 FEMA Strategic Plan | FEMA.gov https://www.fema.gov/about/strategic-plan

1. **Objective 2.2 Build a Climate Resilient Nation**

   Many communities are faced with aging infrastructure, which can increase risk from major disasters. As the frequency of these disasters accelerates, the agency must increase climate adaptation investments across the nation. … To have the greatest impact, FEMA encourages smart investments in system-based, community -wide projects to protect those at the most severe and persistent risk. For example, helping a community adopt and enforce disaster resistant building codes improves the resilience of the whole community. Research has shown that every dollar invested in building to the latest codes and standards results in $11 of future avoided losses. (p. 17)

Objective 2.3 Empower Risk-Informed Decision-Making.

The future disaster environment will not resemble that of the past, or even what is experienced today. To build long-term resilience, communities must understand their future risk — and have the resources and capacity to reduce that risk. … Collaboration across all parts of communities, at all levels, will be necessary to develop comprehensive information about local infrastructure, land use, building code standards, and factors to enable better risk-informed decision making. (p. 18).

Department of HEALTH AND HUMAN SERVICES (HHS)

Strategic Plan FY 2022 – 2026 | HHS.gov

https://www.hhs.gov/bout/strategic-plan/2022-2026/index.html

1. **Objective 1.2 Reduce costs, improve quality of healthcare services, and ensure access to safe medical devices and drugs**

   Implement and assess approaches to improve healthcare quality, and address disparities in healthcare quality, treatment, services, and outcomes**.** Support research and evaluation of expanded use and availability of telehealth and telemedicine, including effects on quality, access, costs, reimbursement, and care outcomes and harms, to inform the long-term approach to using telehealth and to improve access to care for underserved populations

2. **Objective 2.1: Improve capabilities to predict, prevent, prepare for, respond to, and recover from disasters, public health and medical emergencies, and threats across the nation and globe**

   Apply lessons learned from the use and application of technology, data, and research to improve preparedness and health and human services outcomes during emergencies and disasters.

   Enhance research, analytic, and learning capabilities through more efficient, accurate, and trusted collection, application, and integration of data from new and existing data streams across a series of disciplines, including demographic, environmental, genetic or genomic, biomedical, economic, geospatial, and ecological data, to better understand health impacts of emergencies and disasters.

   Improve coordination and collaboration efforts with federal, state, tribal, local, territorial, and international partners to enhance integrated surveillance and monitoring capacity to ensure equity in emergency response planning, coordination, and delivery and sustaining global health security.

   Invest in modernizing information technology infrastructure to foster data sharing and inter-operability across systems in coordination with partners to ensure data insights are representative, actionable, and readily available to decisionmakers and researchers before, during, and after an emergency or disaster to inform preparedness, response, and forecasting

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U.S. DEPARTMENT OF TRANSPORTATION Strategic Plan for FY 2018-2022

U.S. Department of Transportation - Strategic Plan for FY 2018 - 2022

https://www.transportation.gov/sites/dot.gov/files/docs/mission/administrations/office-policy/304866/dot-strategic-planfy2018-2022508.pdf

1. **Strategic Objective 1: Development of Innovation**

   Encourage, coordinate, facilitate, and foster world-class research and development to enhance the safety, security, and performance of the Nation's transportation system.

   Innovation development requires research and active transfer of relevant technologies and practices to and from private and public sectors, academia, and State, local, and Tribal agencies. Accordingly, DOT funds and facilitates research that supports the development and deployment of innovative practices and technologies in the transportation system. Moving forward, DOT will work with other Federal agencies, research institutions, and the private sector to develop and enhance new technological tools capable of improving safety, security, and performance of the transportation system in both urban and rural areas. Priority areas include: improving cybersecurity; improving transportation infrastructure durability, resilience, and cost effectiveness; and, improving the movement of goods and people of all abilities. (p. 30)

U.S. DEPARTMENT OF ENERGY Office of Energy Efficiency and Renewable Energy (EERE)

2016-2020 Strategic Plan EERE_Strategic_Plan_12.16.15.pdf (energy.gov)

https://www.energy.gov/sites/prod/files/2015/12/f27/EERE_Strategic_Plan_12.16.15.pdf

1. **Goal 3: Improve the energy efficiency of our homes, buildings, and industries (p. 15)**

   Demonstrate that Next-Generation Efficient Homes and Buildings are Affordable, Healthy, and Durable. The 1 million homes and 1.5 billion square feet of commercial buildings typically built each year, along with significant renovations in existing buildings, provide a unique opportunity to build in energy waste-cutting measures. EERE's activities in this area, such as the Building America program and Challenge Home partnership, will engage designers, home builders, and building scientists to demonstrate that high performance buildings incorporating new design options can be built and commercially sold. EERE will develop and leverage energy modeling and integrated design techniques and whole building verification to address the significant number of small and medium-sized buildings across the country.

2. **Goal 5: Enable the integration of clean electricity into a reliable, resilient, and efficient grid**

   … new platforms such as smart buildings with advanced sensors and controls have the potential to reward building owners and users for investing in assets with the ability to help integrate clean energy and improve the reliability of the system. To fully capture this potential, EERE will investigate new market and business models—integrating energy supply, demand, and related building services—that provide new avenues and incentives for consumer participation in clean energy. One potential model is that of transaction-based energy services, which make use of grid-

responsive building assets to improve system reliability, while ensuring optimal outcomes for all parties based on pre-defined boundaries. (p. 23)

3. **Goal 6: Lead efforts to Improve Federal Sustainability and Implementation of Clean Energy Solutions**

   Collaborate with multiple partners across sectors to develop, test, and implement effective energy management practices and systematic energy technology deployment. … EERE will work with states, municipal governments, universities, hospitals, schools, and the private sector to share federal advances and learn from them as they utilize technologies, practices, and tools. (p. 29)

US DEPARTMENT OF AGRICULTURE Strategic Plan FY 2018-2022

USDA Strategic Plan FY 2018 - 2022

https://www.usda.gov/sites/default/files/documents/usda-strategic-plan-2018-2022.pdf

1. **Strategic Goal 4: Facilitate Rural Prosperity and Economic Development**

   When rural Americans share the same level of infrastructure services as the country's urban areas, rural communities can make even greater economic contributions with healthy businesses and families. Just as economic and social science research informs decision-makers regarding current trends in rural America and gaps in existing markets, USDA may then provide benefits to rural American businesses and citizens. USDA will leverage funds, stimulate private-public partnerships, and engage in collaboration to build rural infrastructure including broadband, community facilities, safe and affordable housing, health services and facilities, and provide capacity building to help underserved communities become thriving communities." … A connected rural America enables global commerce for small businesses, precision agriculture, just-intime manufacturing, efficient transportation, and multiple other productivity benefits. A connected rural America also ensures modern education, remote training for workforce development, and cost-efficient and effective healthcare. (p. 33).

2. **Community Infrastructure**: Facilitate and leverage direct investment in community and commercial infrastructure that supports rural economies. Investment in rural human-services transportation, utilities, and commercial infrastructure addresses primary business needs, fosters entrepreneurship, attracts corporate investment, and reduces unemployment. Much-needed investments in broadband high-speed internet connectivity for schools and libraries, healthcare and wellness facilities, as well as power, telecommunications, water, and waste management systems will be prioritized and measured for outcomes. (p. 34)

3. **Strategic Partnerships**: Leverage strategic partnerships with other Federal agencies, State and local governments, non-profits, and the private sector to increase USDA efficiency and effective-ness at facilitating rural prosperity and promoting economic development and growth. (p. 35)