Global Community Technology Challenge (GCTC) Workshop Report

Community Strategic Planning Workshop Series 2023

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Smart Cities Infrastructure Program

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Introduction

In 2014, the National Institute of Standards and Technology (NIST) launched an innovative program to help cities improve on successes and build consensus for standards. Known originally as the Global City Teams Challenge and now as the Global Community Technology Challenge (GCTC), this group of community, industry, academic, and government stakeholders serves as a collaborative forum to identify, generate and implement advanced technologies for smart and connected communities.

In 2022, NIST awarded funding to George Mason University (Mason) to conduct a two-part workshop series to develop an integrative and supportive community-centric strategy to inform, strengthen and expand the GCTC program, in an effort to facilitate and enhance advanced technology research, development, and application and develop mission and vision statements to guide the future of the organization.

The GCTC mission is based on the concept that a “Smart City” 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 community, municipality, or region in achieving its vision for public-focused innovation through the application of advanced technologies.

In early August of 2022, the GCTC leadership convened in Arlington, Virginia, at Mason Square on GMU’s Arlington campus as the first workshop meeting in a three-part series. This first workshop, sponsored by the Center for Advancing Human-Machine Partnerships (CAHMP) at GMU, was designed to establish a strategic research vision for the GCTC. The workshop provided the leadership of the SuperClusters (now redesignated as Technology Sectors) 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 mid-September workshop sponsored by the City of Coral Gables, Florida, and held in their Public Safety Headquarters Smart Building. Augmenting the findings of the first workshop, the second workshop held was designed to delineate the specific priorities and activities of the strategic plan. In June of 2023, a third workshop was held in Portland, Oregon to finalize the GCTC community-centric strategic plan and corollary action plan.

Synthesized results from this workshop series are provided below and are intended to: 1) inform and guide the strategic directions 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.

Purpose and Objectives

The goal of the workshop series was to generate a community-focused perspective aligned with and in support of the federally led NIST Smart City Infrastructure program. The specific

objective of the meetings was to solicit GCTC leadership input to articulate vision and mission statements as well as 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 outcome of the workshop series is to assist NIST in developing a plan for the GCTC community developed through a facilitated consensus process involving participant representatives from the leadership of the twelve GCTC technology sectors (i.e., SuperClusters) that comprise the GCTC. The overall purpose of 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; 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.

Background

The leadership of the GCTC SuperClusters (or technology sectors) collectively represent over 220 national and international community-based Action Clusters, organized into the following twelve technology sectors:

- Transportation systems, vehicles, and autonomy
- Data governance and city data platforms and dashboards
- Wireless communications and broadband applications
- Cybersecurity and privacy for public and private sectors
- Public safety and security, and mission critical communications
- Community resilience, adaptability, and sustainability
- Public utilities for energy, water, and waste management
- Agriculture and rural productivity and quality of life
- Smart building technologies and IoT applications
- Education and workforce development
- Community well-being: Trust Integrity Diversity, and Equity (TIDE)
- Smart Regions and collaboration strategies

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The Workshop Series

The workshop series extended the interaction amongst the GCTC leadership participants beyond regular weekly virtual meetings to engage in an intensive and purposeful strategic planning process. The workshops were structured to elicit input into a community-developed strategic plan for the GCTC smart city program as a corollary to the NIST federal program. The first two workshops consisted of two full days and the third one full day of presentations, group discussions, and breakout sessions. The workshop series also included keynote addresses from

federal agency sponsors, research centers, city managers and related professional organizations. This report reflects an analysis and synthesis of this input, vetted by the GCTC leadership.

GMU Workshop – Days 1 and 2

The purpose of the first workshop, held August 25-26, 2022, at the location of the new FUSE at Mason Square economic development center, was to uncover how the GCTC organization currently interacts with internal and external partners to achieve technology deployment and implementation for the purpose of informing the future strategic vision. The leadership group then worked to identify organizational goals, grand challenges, and barriers to inform relevant strategies, research, and development activities for the GCTC.

The workshop began with a welcome from Dr. Liza Wilson Durant, Associate Provost for Strategic Initiatives and Community Engagement and Associate Dean, College of Engineering and Computing, George Mason University. Following the welcome, the context and goals for the workshop were outlined by Dr. Brenda Bannan, Professor, and Dr. David Lattanzi, Associate Professor, both of whom previously served as Co-Directors of the Center for Advancing Human Machine Partnerships at Mason. Dr. Michael Dunaway, NIST Associate Director for Innovation, Smart Connected Systems Division, Communications Technology Laboratory then defined the relationship between the GCTC and the National Institute of Standards and Technology.

The GCTC Technology Sector (or SuperCluster) leads each presented representative projects describing their cities/region involvements, key partners, and technology implementation efforts with an overview of important resources and capabilities that their sector contributes to the GCTC. In addition, the leaders were directed to describe any impact the GCTC, and the SuperCluster activities have had in their communities at the city and state levels. This information was structured to begin to increase the leaders' understanding of the organization's efforts across the different sectors and projects as well as to identify how these initiatives may be related to one another. With this baseline of information, the workshop focus turned toward strategic planning.

The strategic planning process was initiated by generating collective input to begin to articulate a mission statement. This was followed by eliciting and capturing perspectives on the future the GCTC is working to create in the vision statement. The group was then directed to articulate what grand challenges might organize and motivate their efforts as well as what would inspire stakeholders to support the GCTC to inform future activities. Barriers that might prevent the GCTC from successfully addressing these grand challenges or achieving the stated goals and realizing the vision of the organization were also addressed by the group. Finally, input was generated related to the specific research, development, and operational activities that the GCTC should undertake to overcome the barriers and achieve the stated goals. This manifested in generating numerous specific, measurable, achievable, realistic, and timely (or SMART) goals specifying what the group would do, how they would do it, and by when.

GCTC Workshop #1, George Mason University
Left to right: Rendering of FUSE at Mason Square Economic Development Center; Workshop plenary and breakout sessions.

Coral Gables Workshop – Days 1 and 2

The second workshop was held in the City of Coral Gables, Florida on September 12-13, 2022 with the objective to continue to refine the mission and vision statements elicited from the first workshop, as well as further elaborate on goals and targeted activities for the organization. Owing to the continuing obstacles and travel restrictions imposed by the COVID-19 pandemic, the second workshop was conducted in both live and virtual formats, transmitted from the Public Safety and Operations Headquarters in Coral Gables.

The second workshop began with a welcome by Mr. Peter Iglesias, the City Manager of Coral Gables and Mr. Raimundo Rodulfo, Director of Innovation and Chief Innovation Officer for the City of Coral Gables. This was followed by a welcome from Dr. Michael Dunaway and Dr. Brenda Bannan. Mr. Rodulfo then presented details about the smart city initiatives and digital transformation journey of the City of Coral Gables over the last three years. Particularly important for the GCTC leadership's attention were the stated key performance indicators and city-based outcomes for Coral Gables as an example of an innovation and technology strategic plan and smart city process journey. At the end of the first day, the leadership participated in a guided tour of the smart building technology implemented in Coral Gables. This tour included the innovation and technology department, city network hub headquarters data center and distributed cloud, and the smart city hub data control room with digital twin and urban analytics artificial intelligence console. In addition, the GCTC leadership toured the community intelligence center with smart city artificial intelligence and computer vision systems, as well as the police virtual reality training simulator and incident response and de-escalation scenario simulation room. Concluding the day, the leadership group participated in a trolley tour of the City of Coral Gables smart district to see first-hand the related smart city technology implementations.

GCTC Workshop #2, Coral Gables, Florida

Left to right: Mr. Raimundo Rodulfo, Director of Innovation and Chief Innovation Officer for the City of Coral Gables and Mr. Peter Iglesias, the City Manager of Coral Gables; Coral Gables Workshop In-person Attendees

Analyzing Participant Input from GMU and Coral Gables Workshops

Discussion input and participant notes from both workshops were gathered, analyzed, and synthesized to uncover new insights to inform the strategic planning process. The generated information was reviewed by the project investigators in multiple passes through the 57 pages of contributed statements across both workshops. Additionally, the project investigators closely reviewed and cross-referenced the system input with their 37 pages of notes from the first workshop and 30 pages of notes from the second. The goal statements were rephrased where necessary for clarity and the activities were organized by theme or affinity. This information was cross-referenced with the project investigator notes to look for contradictions or gaps in content. The generated insights were synthesized to provide relevant and meaningful conclusions and directions for the GCTC organization. The conclusions of this report were condensed and summarized for review by the leadership group participants to ensure accuracy and completeness.

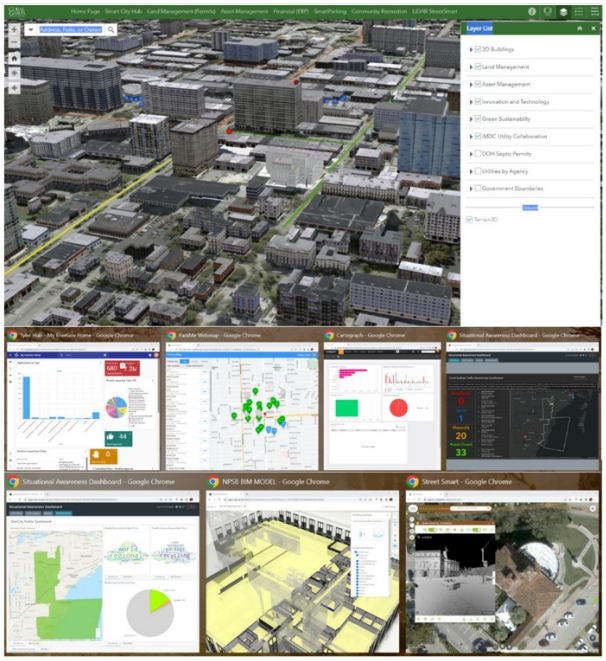
The results of Workshops 1 and 2 were then compiled into two mid-term project progress reports and submitted to NIST in Spring and Summer of 2023.

City of Coral Gables - Innovation & Technology Department
DIGITAL TWIN Smart City Platform
City OS and Horizontal Integration Dashboards

WWW.CORALGABLES.COM/DIGITALTWIN

Benefits:

- This architecture fosters interoperability in real time and connects the dots between all the city's enterprise systems and data domains to improve operational efficiencies and citizen access to digital services.
- Merges the Coral Gables Smart City Hub public platform, the City's Urban Analytics Artificial Intelligence (AI) Internet of Things (IoT) platform, citywide enterprise systems and open data, and a 3D horizontal integration spatial computing platform into one single digital environment.
- It also allows for integration with building information models and immersive virtual reality user experience navigation for operations, inspections, monitoring, and control.
- A smart city open data platform gateway to Web3 and decentralized immersive experience environments.
- Aggregates value and increases visibility and awareness over City operations.
- Provides spatial computing tools that expedite analyses and information sharing between stakeholders



Coral Gables publicly-accessible dashboard of City Digital Twin

Portland Oregon Workshop

The agenda for the concluding session of the workshop series was held in Portland Oregon on June 29, 2023, at the Stoel Rives LLP Meeting Center in downtown Portland. Dr. Wilfred Pinfold of Urban Systems and lead of the GCTC Transportation Technology Sector welcomed the group along with Dr. Michael Dunaway of NIST. The project investigators, Dr. Brenda Bannan and Dr. David Lattanzi then summarized the GCTC strategic planning process to this point providing some direction for the day. Leaders from several smart community related national and regional organizations then introduced themselves including representatives from MetroLab Network, OSPO++, Association of Civic Technologists, Creative and Emergent Technology Institute, City of Portland, State of Oregon, and Digital City Testbed Center. The afternoon sessions consisted of several breakout working groups focused on generating action plans related to the Holistic Key Performance Indicators (H-KPIs), Tools and Software and Communications. A key accomplishment was the confirmation of the Vision and Mission Statements that had been developed in the previous workshops. The afternoon session concluded with the working groups report out with their conclusions, action plans and directions. The principal task of this last workshop in the series was to conduct a review and finalization of the outcomes of the prior two workshops and develop a corollary action plan for the GCTC organization. The team agreed upon targeting several activities over the next two years, which are summarized in the Organizational Goals below.

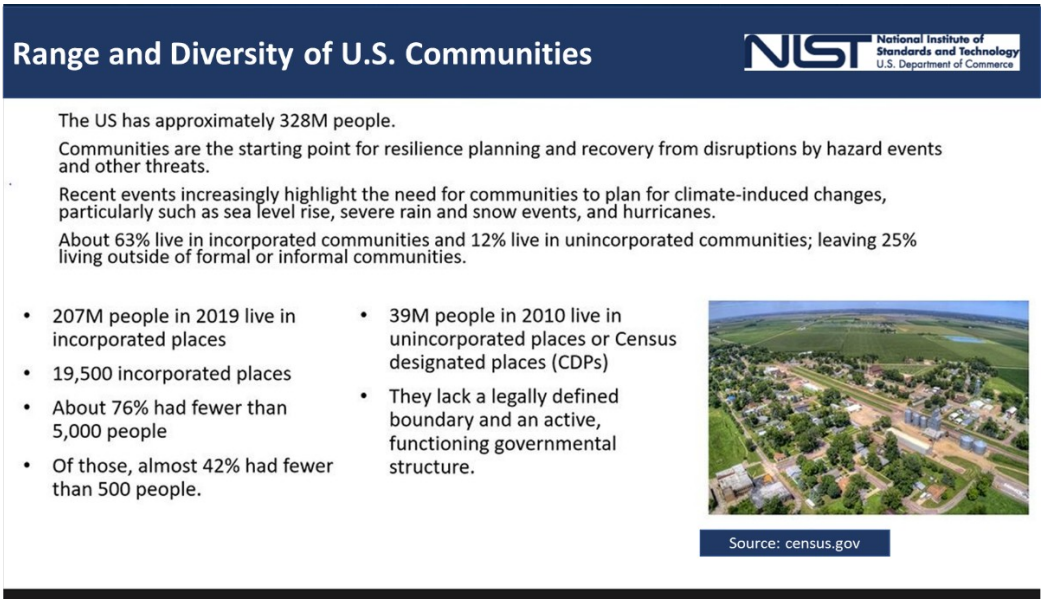
Strategic Planning Vision and Mission

At the conclusion of the workshop series, the GCTC leadership group arrived at a consensus for 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.



Expanding the range and diversity of U.S. communities participating in GCTC

Organizational Goals for the Global Community Technology Consortium

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 two-to-five years. The GCTC goals provide a sense of direction and purpose guiding the organization's strategic decision-making and resource allocation. Broad generated goals for the GCTC organization were synthesized, summarized and categorized under five areas and headings: 1) organizational framework; 2) operational; 3) membership; 4) communication; and 5) scientific approach.

Organizational activities comprise the specific actions, tasks or processes that are undertaken by individuals or teams within the organization to accomplish the organizational goals. These activities are the means through which the organization strives to achieve its desired outcomes. The GCTC strategic planning process included determining activities that align with the organizational framework development, operational, communication and scientific activities that the GCTC should undertake to overcome identified barriers and achieve the articulated goals. Workshop participants generated the following goals to potentially commit to one or more of these action items to progress the organization forward.

1. Organizational Framework Goals

1.1 Identify mechanisms that help translate community needs into actionable items using smart technologies and ultimately engage the community in the improvement of their quality of life. More specifically, develop standardized approaches that help communities know where to start and how to document their progress and successes.

1.2 Determine different community definitions to help drive how GCTC engages different kinds of community types including tribal, rural, large and metros/cities.

1.3 Find effective ways to embrace global trends and developments in the next two years.

1.4 Curate a smart cities community of practice from across government, vendors, and NGOs.

1.5 Create a structure for how different entities involved in GCTC may operate, both together and independently.

Proposed Activities

- Establish a systematic methodology for a Key Performance Indicators (KPIs) Dashboard (Templates, KPIs, Application Programming Interfaces (APIs), Standards) in two years, create a publishable mechanism (knowledge base) incorporating methodologies for three vertical sectors, and in five years encompass all sectors to fully integrate into knowledge base.

- Develop a smart city methodology across KPIs with repeatable smart city pilot solutions that are iteratively fine-tuned by contributing cities who have implemented those solutions previously. Incorporate at least 25 implemented projects in two years across tech sectors, considering the diffusion of low-entry solutions that are sharable across cities, beginning with cities with limited resources. Showcase success stories by 2024 to the United States (U.S.) Congress.

- Generate a minimum viable product (MVP) smart technology system that can be reconfigured for each community sector (e.g., preschool, elderly, BIPOC) and varying scenarios (e.g., fire, flood, heat, healthcare, resilience) for shared distribution and application community by community.

2. Operational Goals

2.1 Catalyze communities around the country to start smart city tech programs, conduct technology pilots and implement solutions that showcase the value of the organization.

2.2 Identify opportunities, purchasing and contractual vehicles related to how to promote and accelerate the deployment of smart community technologies.

2.3 Establish a financially sustainable mechanism(s) to progress toward a self-sustainable organization and expand the influence and best practices from the GCTC community.

Proposed Activities

- Identify and enter into projects that require multiple GCTC technology sectors to work together in ecosystem development. Establish an alignment amongst these sectors to create a live pilot demonstrating implementation and partnerships. For example: implement environmental sensors with publicly available smart city data for sharing with other cities across the nation.

- Identify or develop a single KPI that is easy to implement with an existing community partner to test it. Leverage the results of that testing for building a strategy for incorporating and validating a larger range of KPIs.
- Build, validate, and promote open-source solutions to remove barriers to community access, cost, and technical capabilities.

3. Membership Goals

3.1 Engage existing GCTC cities in activities to renew affiliation with GCTC.

3.2 Engage younger individual participants in GCTC activities considering diversity and inclusion through participation from underrepresented groups and communities.

3.3 Identify and engage with new industry partners.

Proposed Activities

- Build out the community of contributors recognizing past and current contributions for generating relevant shared learnings and insights. Leverage the existing public-private partnership programs related to resilience service offerings generated by an NSF-funded planning grant.

- Strive to include at least 20% of GCTC membership in activities in workshops to comprise persons under age 40 as well as consider diversity and inclusion through participation from underrepresented communities by 2025. Involve young participants and volunteers in GCTC to focus on the future of communities and cities and prepare the workforce of the future to grow industry leaders, government leaders and interest in public service and civic education/design.

- Provide training resources for the GCTC, the community and city staff to increase knowledge and capabilities including social network tools to permit individuals and organizations associated with the GCTC to connect, meet, learn and interact with the broader community.

4. Communication Goals

4.1 Create a GCTC communications plan and strategy.

4.2 Establish a formal engagement mechanism for communities to measure GCTC participation.

Proposed Activities

- Create a GCTC communications plan and strategy by Q4 2024. Create a cohesive outward facing brand with clear naming, structure and business models drawn from the community of practice to clearly articulate affiliation with the GCTC and to align expectations for consistency in messaging when communicating externally.

- Build on the association with NIST and awareness of GCTC and the collective of individual efforts and partnerships. Clarify, document, and publicize the relationship with NIST as a reinforcement of the trust, legitimacy, and longevity of the GCTC brand.

- Draft an "executive summary" version of the strategic plan for city officials and leaders with non-technical, non-scientific language and more oriented to problem-solving, risk, value, growth, and opportunities for city leadership.

- Create promotional activities leveraging associated conferences and certificate courses to create awareness and target decision makers to establish outreach and priorities (e.g., Smart Cities Council, National League of Cities, National Association of Counties, Municipal Information Systems Association of California, and State City Leagues, etc.) by the end of 2024.

5. Scientific Approach Goals

5.1 Create a unified socio-technological framework for the digital transformation of communities.

5.2 Develop several models for deployment across multiple cities with an iterative process working across sectors in collaboration with stakeholders and practitioners including: 1) funding model; 2) stakeholder and community engagement model; 3) operations model; 4) learning and visibility model; 5) replication and scaling model; and 6) training model for other cities.

5.3 Fund and form a university-led smart cities research platform for research and development investment in smart cities within the 2-5 year planning term.

Proposed Activities

- Establish a methodology resulting from existing project implementation (i.e., school resiliency hubs project) that serves as a case example and generates a contribution framework across technology sectors in collaboration with institutional and industry partners, developing a socio-technological infrastructure framework.

- Update the existing knowledge base of action cluster projects to build a semantic structure that frames the applied integrated knowledge for the user. Form a unified blueprint grounded in these projects to extract relevant KPIs and methodologies for cities that promotes the original projects and organizations. Leverage existing blueprints effectively with target audiences in the next six months to begin to uncover these associated methods. Become the trusted advisors of the implementation of this associated methodology.

- Establish a collection of best practices and systemic methods/frameworks from this knowledge base that contribute to a codified framework. This will serve as validation of these integrated, cross-functional methods to assist communities and cities to move toward digital transformation.

- Establish enduring relationships with university research programs related to smart cities or initiate involvement with emergent programs. Involve professors, graduate, and undergraduate students directly in smart city research and development with public private partnerships. Develop a strategy for assisting communities with partnering with research universities to apply for funding for equitable infrastructure projects.

The Global Community Technology Challenge (GCTC) Customer/Client and Value Proposition

One of the issues raised in the workshops was the lack of clarity on the GCTC customer or client and target audience. From the perspective of a collaborative public-private partnership, the clear answer to the question is that cities, communities, and their residents are the primary customary, and the key recipients of the benefits of technology integration. However, from a technological perspective, it was recognized that the GCTC needed a more specific organizational perspective that reflected the challenges cities face in technology development and integration. Thus, a specific target individual or city office rose to the top of the list for defining requirements, approaches, and support that GCTC could offer and provide to cities.

The GCTC Primary Customer

After deliberation, the consensus emerged that the appropriate target office and level for defining smart city requirements is the city manager who is active in the digital transformation of their city. Much of a city manager's work involves gaining consensus, both internal and external, to drive transformation and develop new solutions to address community-driven goals. In many cases, city managers have longer terms than many of their elected counterparts, and this offer longer-term continuity to project development and technology integration. GCTC potential customers in this role need unbiased and reliable information on how to complete a targeted city or community digital transformation involving smart technology systems. These technologies may include but are not limited to Internet of Things (IoT) systems, digital twins, artificial intelligence, machine learning, predictive analytics, or visual machine learning as well as other advanced technologies.

The technology leadership role that represents the GCTC primary customer could also encompass professional titles such as Chief Innovation Officer, Chief Technology Officer, Sustainability Officer, Economic Development Manager and other associated leaders and roles. Other potential professional roles interacting with the GCTC organization may include, but are not limited to Smart City Directors, Directors of Planning and Public Works, or Public Health Officials. These primary customer base could also include city emergency managers and agency leaders aligned with the FEMA National Response Framework and the National Incident Management System in emergency preparedness and response.

The GCTC Secondary Customers

An identified secondary customer base for the GCTC to consider are citizens and residents of communities who are seeking guidance and resources in improving the livability, security, resilience, economic vitality and overall quality of life in their cities, towns and communities. Another customer segment are community developers and those engaged in the public-private partnership efforts that assist communities in enabling smart city services. The membership of the GCTC could also be considered a secondary customer in open source sharing and exchange of best practices, knowledge, and documentation.

Value Proposition for GCTC Customers/Clients

The GCTC's potential customers and clients essentially constitute a community of practice (CoP) with common interests and values. The GCTC serves this community of practice as an association with a common interest in facilitating smart technology services for vibrant, equitable and sustainable communities. Specifically, the GCTC offers these customers and clients a transdisciplinary group of domain experts that can combine different skill sets with deep and wide expertise to assist in creating an implementation framework. This framework may include: 1) assessing existing assets and needs; 2) creating a community engagement/co-creation process; 3) specifying goals and prioritizing projects/investments most likely to help cities achieve their goals; 4) assisting in the identification, application and justification of funding needed to implement those projects; and 5) identify other stakeholders (e.g., private industry, non-profit, community organizations, etc.) needed to achieve their goal and vision. The GCTC also provides access to lessons learned from previous success stories ensuring the translation and contextualization needed for the communities served.

An additional value proposition is that the GCTC serves as an organizational mechanism for federal administrative agencies to interface with local communities that are implementing smart city technologies. This promotes "two-way" communication constituting both a bottom up informing of community needs and experiences as well as top-down through providing a way for federal agencies like NIST to share best practices, broadcast and engage across the local community level.

Action Planning

In conclusion of the workshop series and aligned with the results of the final workshop in Portland, the GCTC leadership identified the following activities to focus on initially:

Create standardized evaluation tools for communities that:

- integrate the NIST H-KPI Framework into city operations;
- ensure compatibility with universal assessment mechanisms;
- demonstrate the tools within established community partnerships

Facilitate the adoption of common and reusable open-source software platform that:

- Are developed through a collaborative process;

- Created within a community of stakeholders that share and improve these tools;
- Employ Open Data Standards (Open Software, Open Application Programming Interfaces, Reference Architectures, Specifications and Data Lakes)
- Consider interoperability as a baseline requirement;
- Identify business cases to that reflect community priorities;
- Draft value propositions to reduce complexity and enhance services;
- Are based on a comparative analysis of previous or current efforts;

Evolve GCTC's communication and outreach strategy:

- Determine a marketing and engagement approach for diverse communities;
- Determine and leverage appropriate social media channels;
- Construct personas and use cases to enhance storytelling;
- Embrace other languages and diverse audiences;
- Focus on economic development outcomes including diversity, equity and inclusion perspectives;

Priorities for GCTC The following guiding principles were considered fundamental to the GCTC program and organization as supporting member to a diverse national-scale public private partnership:

- Providing any city or community the opportunity to join and participate regardless of financial support to create an affiliation and affinity with other smart community programs;

- Encouraging smaller communities who often cannot attract sufficient investment from the private sector to pursue a smart city digital transformation, where the GCTC can play an important role to assist local governments with this challenge;

- Translating global and national priorities, for example, such as the United Nations Sustainability Goals into local community priorities and the donut economy action-lab toolkits as potential guiding frameworks for local and regional transformation; and

- Involving young people and incentivizing students and early career professionals to become experts in this area through gamified approaches, social media, technology demonstrations, city simulations that may hold the keys for attracting youth involvement in the organization.

- Providing a U.S.-oriented approach to open standards development that relies on market actors to build standards in contrast to a consensus or government mandated approach.

City municipal planning, as it exists today, is often siloed into bureaus (e.g., transportation, planning, parks, etc.), therefore, the GCTC has the opportunity to influence this planning at multiple levels including the federal, state and local levels. Specific opportunities such as:

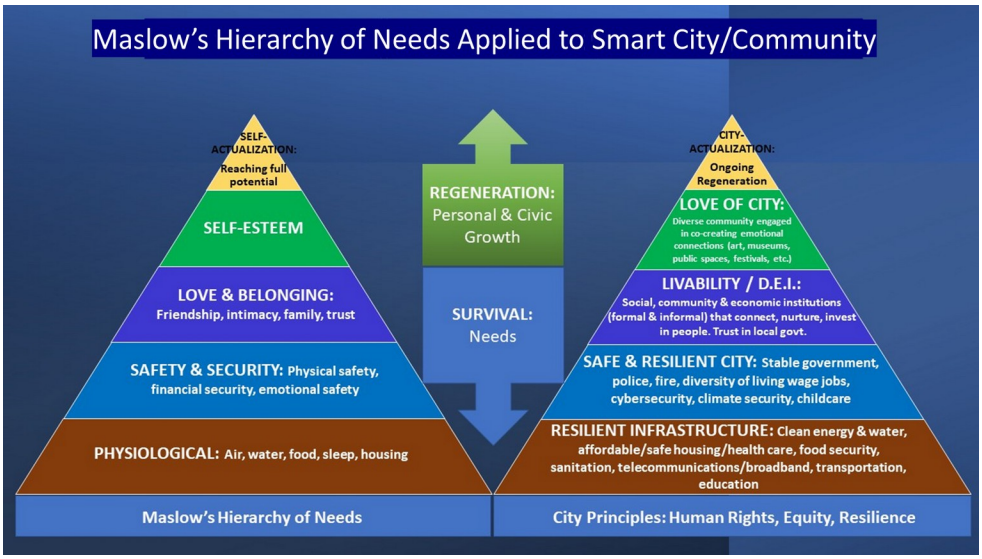
- focusing on neighborhoods where basic day-to-day needs are within walking distance of home;

- targeting the reduction of carbon emissions by decreasing the use of cars and motorized commuting time in a decentralized smart tech urban planning model;

- assisting cities in identifying and building approaches to managing the massive amounts of data and converting it into actionable evidence about what works and what doesn't (e.g., what specific

built environment infrastructure investments are most likely to lead to increases in quality of life outcomes such as reduced floods, diabetes, heat vehicle collisions, pollution, tax revenue, etc.);

Assessing interactions and relationships among factors is fundamental to a holistic understanding of a smart city as of 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 the community's approach to understanding these relationships and priorities, the GCTC has begun developing a model of community requirements based on Abraham Maslow's well-known Hierarchy of Human Needs [8]. Figure 10 offers an early vision of this concept.



Application of Abraham Maslow's Hierarchy of Human Needs to the Smart Community

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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 begins 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, 4, and 7), 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 those 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.

Conclusion

World urbanization is accelerating, representing the biggest challenges of our lifetime for communities of all types. The share of the world's population living in urban centers, which represents just 3% of the world's territory, is expected to rise to 70% by 2050, from 55% now.[1] This highlights a dramatic need to invest in digital solutions capable of cutting overall energy use, reducing dependence on carbon energy sources and material consumption. The United States needs to address the complexity of urban living and the problems of overcrowding, poverty and inequality, digital divide, and unemployment. Our nation must also support rural communities as well as marginalized groups to build resilience and transform physical and digital systems for each and every community to collaboratively design solutions.

The COVID-19 pandemic introduced even greater urgency for local and national governments alike to digitize and modernize public services, including education and health, in order to adapt to the new reality of a worldwide pandemic. It also highlighted the pressing need to bridge the digital divide, especially for marginalized groups and rural communities, and using digital transformation to build sustainable, equitable, resilient, and livable communities.

The GCTC is uniquely positioned to address these urgent and critical needs by providing trusted, unbiased information and best practices and systematic, integrated methodologies that help communities become more sustainable, equitable, resilient, and livable, so no community is left behind. With the association with NIST, supported by the Federal Government, and having a vast network of experts from various disciplines in business, government, and academia, the GCTC has access to the integrative resources, knowledge and expertise to provide thought leadership to address the challenges that lie ahead.

GCTC serves as an organizational mechanism for federal administrative agencies to interface with local communities that are implementing smart city technologies. This promotes "two-way" communication constituting both a bottom up informing of community needs and experiences as well as top-down through providing a way for federal agencies like NIST to share best practices, broadcast and engage across the local community level.

By focusing on best practices, their replication and scaling, ecosystem seeding, and promoting collaboration between communities, the GCTC may become an important catalyst toward the realization of digital transformation, where urban and rural citizens, local governments, communities, and businesses live in and contribute to a digital society that interacts and generates value, benefiting all stakeholders.

By leveraging and adapting lessons from the implementation of smart city and community solutions on a national scale, this digital transformation may provide citizens with better services, resulting in improved quality of life for all. By promoting and nurturing participative and collaboratively designed ecosystems that facilitate and stimulate business, the public sector and citizens may generate, contribute, innovate, and collaborate, to make the country more resilient, competitive, and equitable.

APPENDIX A. Technology Sector Leads and Contributors

The leadership of the GCTC Technology Sectors (formerly, SuperClusters) contributed to the strategic planning process and are listed by each of the twelve Technology Sectors with designated leads:

- **Transportation systems, vehicles, and autonomy**
  Wilf Pinfold, Skip Newberry, Ken Montler and Aaron Deacon
- **Data governance and city data platforms and dashboards**
  Scott Tousley, Jason Whittet, Hugh Harker and Ali Hasan
- **Wireless communications and broadband applications**
  Benny Lee, John Walton, and Bill Pugh
- **Cybersecurity and privacy for public and private sectors**
  Lan Jensen, Pamela Gupta, and Lee McKnight
- **Public safety and security, and mission critical communications**
  Brenda Bannan, Dean Skidmore, and Tonya E. Thornton
- **Community resilience, adaptability, and sustainability**
  Mariela Alfonzo and David Lattanzi
- **Public utilities for energy, water, and waste management**
  Pete Tseronis, John Teeter
- **Agriculture and rural productivity and quality of life**
  Mo Shakouri, Ed Lisle and Josh Seidemann
- **Smart building technologies and IoT applications**
  Jiri Skopek and Raimundo Rodulfo, Barrett Kenney
- **Education and workforce development**
  Deborah Acosta, Ann Marcus, Michael Beck Nandini Ranganathan and Derick Lee
- **Community well-being: Trust Integrity Diversity, and Equity (TIDE)**
  Rebecca Hammons and Stan Curtis
- **Smart Regions and collaboration strategies**
  Jonathan Fink and Eric Rensel

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- **City of Portland**
  Hector Dominguez
- **State of Oregon**
  Erik Brewster
- **Stoel Rives LLP**
  David Durbin, Mars Chou, Mary Hull and Matthew Wilmot