GLOBAL CITY TEAMS CHALLENGE

Blueprint for Smart Public Safety in Connected Communities

An Initiative of the Global City Teams Challenge

August 28, 2017

Principal Authors

Brenda Bannan, PhD
Jack Burbridge
Michael Dunaway, PhD
Dean Skidmore

Key Contributors

Alison Brooks, PhD
Thomas Crane
Ron DiBiase
Samantha Dubrow
Paul Hopingardner
Troy Icenhour
Kamesh Namuduri, PhD
Clint Osborn
Tejbir Singh Phool
Hemant Purohit, PhD
George Thomas

Points of Contact:

Michael Dunaway, PhD
Co-Chair, Public Safety SuperCluster
Informatics Research Institute (IRI)
University of Louisiana at Lafayette
Lafayette, LA 70506
337.482.0615 (office)
mdunaway@louisiana.edu

Dean Skidmore
Co-Chair, Public Safety SuperCluster
IoT+LTE Consulting Group
10528 New Arden Way
Raleigh, NC 27613
919.345.3367 (mobiile)
deanskidmore55@gmail.com

Jack Burbridge
Office of the Chief Technology Officer
200 I Street SE
Washington, D.C. 20003
202-715-7536 (office)
jack.burbridge@dc.gov

Brenda Bannan PhD
Division of Learning Technologies
College of Education and Human Development
George Mason University
Fairfax, VA 22030
703.993.2067 (office)
bbannan@gmu.edu

Sokwoo Rhee, PhD
Associate Director
Cyber-Physical Systems Program
National Institute of Standards and Technology
Sokwoo.rhee@nist.gov
301.975.6325 (office)

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Introduction

This Blueprint for Smart Public Safety in Connected Communities originated from the Global City Teams Challenge (GCTC) sponsored by the National Institute of Standards and Technology (NIST). GCTC focuses on spurring the community adoption of smart city technologies to solve the complex challenges faced by modern, connected communities. The Public Safety SuperCluster is one of six initial SuperClusters of city technology teams, and seeks to address this fundamental question: From a whole-of-community perspective, what is the contribution of technology developers, researchers, and communities to ensuring the safety and security of modern societies, and how is it to be pursued now and into the future? The primary audiences for this *Blueprint* are community leaders, emergency planners, and technology decision-makers in the broad area of public safety. It is also aimed at technologists and researchers seeking to develop effective solutions that meet stakeholder needs.

Blueprint Purpose and Organization

This *Blueprint for Smart Public Safety for Connected Communities* is a guide for cities to identify, assess, develop, and apply cutting edge technologies to the challenges of public safety in advanced, complex, and technologically integrated communities, or "Smart & Connected Communities" (S&CC).

This *Blueprint* is organized around the following four Focus Areas[1] under the scope of public safety:

- **Public Safety & Response** – Coordination of emergency operations among responder agencies (e.g., firefighting, emergency medical services, emergency management, search and rescue, and law enforcement);
- **Emergency Management and Preparedness** – Coordination of local, regional, and federal agencies and resources across the traditional emergency management cycle (Prevention, Protection, Mitigation, Response, Recovery);
- **Disaster Recovery** – Integration of policy and social, economic, and behavioral dimensions, including continuity of governance, risk communications, disaster planning, preparedness, and recovery services to the challenge of post-disaster community recovery; and
- **City Resilience** – Application of advanced and emerging technologies to the broader challenges of community resilience, environmental monitoring, public health, and general sustainment of quality of life and social cohesiveness and identity.

Each section addresses specific requirements that determine the approach for technology research, development, testing, and evaluation (RDT&E), as well as technology applications and systems relevant to the individual Focus Areas. These contribute to the goal of smart public safety implementation addressed in Section V. Finally, the last section addresses next steps for communities and for the Public Safety SuperCluster, itself. The *Blueprint* is therefore intended to also serve as the charter for an ongoing public-private partnership (PPP) to bring together member communities, technology developers, research

[1] Focus Areas were identified during the initial Public Safety SuperCluster Working Group meeting in October 2016 and defined through Working Group sessions in early 2017.

laboratories, and end-users to identify challenges and define requirements for public safety in S&CC and share best practices, concepts of operations, and form pilot studies for technology test and evaluation.

Background and History of the Public Safety Initiative

The initiative for Smart Public Safety in Connected Communities is a collaboration among city-based technology development teams dedicated to addressing current and future challenges in public safety within S&CC. This initiative originated from the NIST-sponsored Global City Teams Challenge. Established in 2014, GCTC serves as a platform for local government agencies and technology providers to identify solutions to vexing municipal problems through the deployment of smart city technology applications. The GCTC is comprised of geographically focused "Action Clusters" from cities across the U.S. and the world. Its goal is to spur collaboration among innovative local governments and agencies, nonprofits, and private companies to overcome challenges and develop solutions with leaders in the Smart City and Internet of Things (IoT) fields. Through participation in the GCTC, companies, universities, and nonprofits showcase their technologies to potential customers or partners and collaborate with local government leaders and technology developers to deploy interconnected solutions, thus contributing to NIST's effort to develop technical standards for IoT and S&CC.

In October 2016, the GCTC organized Action Clusters into a set of "SuperClusters" based on specific community services and mission areas. The Public Safety SuperCluster (PSSC) was formed with the goal of identifying technologies, processes, and strategies from among GCTC members to enhance public safety, emergency preparedness and management, disaster recovery, and community resilience. The PSSC's initial goals were to:

1. Develop, integrate, and pilot technology applications, and test new operational concepts and employment methods in collaboration with first responders, public safety officials and government agencies; and
2. Improve disaster preparedness, response and recovery and improve overall community resilience against the hazards and risks that threaten modern societies.

In addition, the PSSC aimed to improve policies and procedures for integrating advanced communications methods and decision systems to enhance interagency planning, situational awareness, and coordination of resources within S&CC. The PSSC focused specific attention on the integration of current and future technologies (cloud computing, big data analytics, mobile connectivity and social networking), as well as innovation accelerators required to deliver outcomes (e.g., Internet of Things (IoT) and cognitive technologies) required to digitally transform public safety, and to build resilience and sustainability into the technology ecosystem that comprises S&CC.

Currently, few formal venues or opportunities exist for collaboration between technology researchers and developers, public safety agencies and professionals, and local government officials and community leaders where capability gaps and priorities for public safety, resilience, and sustainability can be discussed and potential technology solutions identified. Moreover, the trend toward S&CC—coupled with dramatic change in hazards and threats to complex, urban societies—argues for a standing organization

and framework for identifying innovative public safety technologies, strategies, and capabilities within a fully collaborative, multi-disciplinary environment. To that end, this initiative aims to form an enduring PPP to build capacity in interdisciplinary, integrative research in public safety technologies across a coalition of public safety officials, private sector developers, university researchers, community stakeholders, and government agencies to examine innovative concepts that enhance public safety, community resilience, and urban sustainability. The initiative has four objectives:

1. Identify capability gaps and national challenges in public safety that existing and maturing research projects among GCTC member communities and technology firms can address;
2. Establish a forum for nurturing integrated, multi-disciplinary research in public safety strategies and technologies with input from first responders, emergency planners, and community leaders;
3. Identify opportunities to collaborate with state, county, and municipal partners to define requirements and validate approaches for enhancing community resilience and responding to and recovering from disasters and civil emergencies; and
4. Identify opportunities for supporting programs in Science, Technology, Engineering and Math (STEM) education—engaging students and emerging scientists and professionals to nurture the next generation of researchers, technologists, and practitioners dedicated to research and technology development in the interest of public safety.

The immediate goal is to increase awareness of emerging technology applications and enhance opportunities for collaboration among GCTC member communities and S&CC partners in the areas of public safety, security, and resilience. More broadly, this initiative serves as a dedicated forum for information sharing to advance state-of-the-art, public safety-related technologies and concepts. The initiative will encompass technological, social, and security dimensions of public safety enhancements and determine requirements for both cognitive and collaborative infrastructures, broaden awareness and expand knowledge of technology developments, and disseminate outcomes through GCTC, S&CC, and the public safety community. It will serve as a repository of current best practices in Smart Public Safety, and support the expansion of this concept to other communities in the U.S. and internationally.

Adopting a "Whole Community" Approach to Public Safety

The starting point for Smart Public Safety in S&CC is recognition that emergency preparedness, response, and recovery is a "whole-of-community" responsibility that integrates resources, capabilities, technologies, talent and leadership from across government and public sector agencies, first responders and emergency management, privately held utilities and services, commercial entities, local leadership, and residents. Traditionally, public safety has been the domain of trained professionals—including law enforcement and other first responders, emergency management agencies, and critical infrastructure providers and operators, such as electrical power companies and public works and transportation agencies. Planning, training, exercising, and preparedness has fallen on those agencies as part of their professional preparation for incident response. In the U.S., in the wake of the 9/11 terrorist attacks and

Hurricane Katrina, the Federal Emergency Management Agency (FEMA) developed formal doctrine for emergency and disaster response under an Incident Command System (ICS) and then incorporated this into the National Incident Management System (NIMS) to standardize emergency operations and establish a framework for coordination among responders, units, and jurisdictions and support mutual assistance.

Coordination with the civil population, however, had been largely confined to exercises involving segments of local government agencies and leadership, and the occasional table-top or scenario-based exercise involving support from local community groups—usually in the role of victims or casualties for the benefit of training professional first responders, emergency managers and elected officials.

More recently, it has been widely acknowledged that disaster response, as well as preparedness and recovery, involves the entire civil population of a community. This has led to the emergence of the whole-of-community strategy for disaster and emergency management[2] and publication by FEMA and U.S. Department of Homeland Security (DHS) of the National Preparedness Goal (2015), the National Mitigation Framework (2016), and the National Disaster Recovery Framework (2016) that emphasize whole community responsibility for disaster planning, preparedness, and response. This perspective of the collective responsibility is not limited to disaster and emergency management agencies, but is also seen in the U.S. Department of Justice Community Oriented Policing Services (COPS) program, which engages the public through community outreach, engagement, and education to improve community security and safety and to improve police-community relations.[3] Figure 1 shows a federal view of the roles and resources that the whole of community approach to public safety can engage.

Figure 1: Composition of the Whole Community (DHS National Mitigation Framework, 2016)

[2]FEMA FDOC-104-008-1, 2011. A Whole Community Approach to Emergency Management. 2016. Also, Graham, D. "We are All First Responders," Interview with FEMA Administrator, Craig Fugate. *Atlantic Magazine. 3 Sep 2015.* https://www.theatlantic.com/national/archive/2015/09/we-are-all-first-responders/402146/

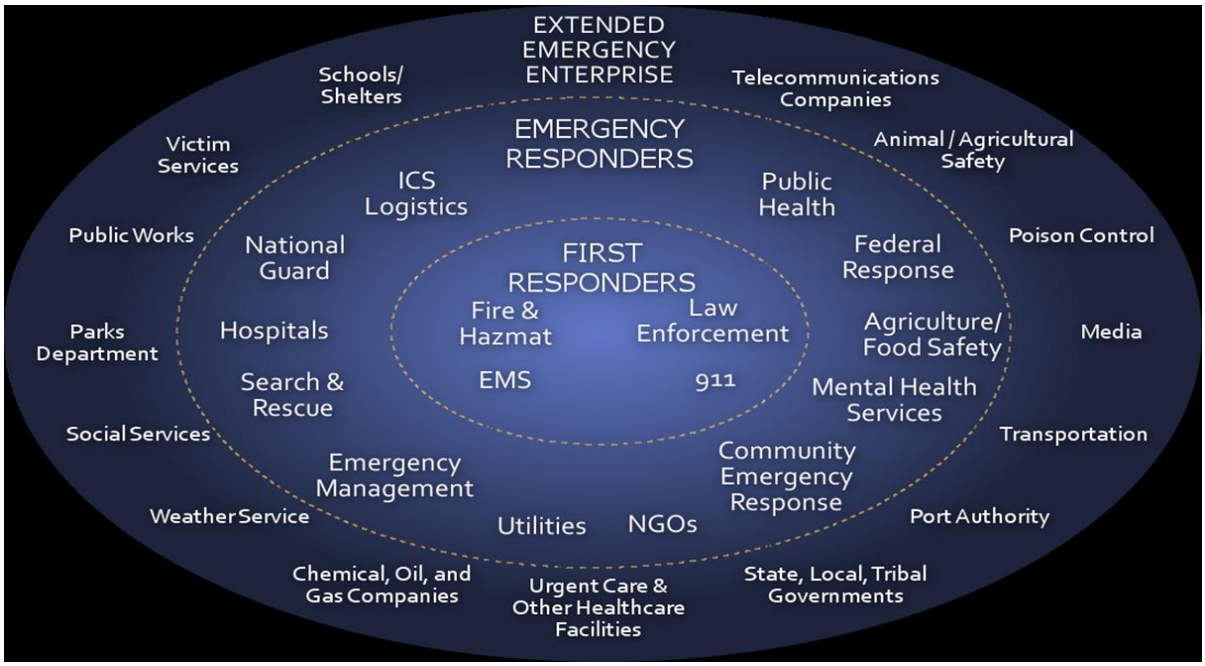
[3] U.S. Department of Justice. Community Oriented Policing Services. https://cops.usdoj.gov/Default.asp?Item=34.

Envisioning a Smart Public Safety Ecosystem

A significant aspect of the Smart Public Safety Initiative is its charter and composition as a PPP dedicated to requirements definition and technology development across the entire public safety sector—not simply for coordinating disaster response and recovery operations. In relation to the whole-of-community approach to disaster management, the concept of the PPP has come to mean the formalization of the need to share information and resources between public sector agencies and private sector businesses and non-profits as a "force multiplier" for local or regional disaster preparedness, prevention, response and recovery. In the context of Smart Public Safety, however, the PPP's role also includes identifying challenges and requirements and applying new technologies that are jointly designed, developed, prototyped, and fielded by a partnership of technology firms, research centers (including university, commercial, and government affiliated centers), government agencies, first responder groups, and public service end-users.

In the daily management of Public Safety Incidents, a wide range of personnel, agencies, and resources is often involved in the response to a critical incident. Figure 2 shows the numerous resources, agencies, and participants responsible for implementing community-wide Smart Public Safety. The center represents the primary First Responder community (law enforcement, fire/search & rescue/hazmat and EMS) and 9-1-1 call-taker/dispatch centers. Surrounding these first responder agencies, lead and supporting agencies provide specific technical capabilities and services during an incident. At the outer-most ring, extended emergency enterprise organizations may have supporting roles and responsibilities at times during incident management.

Figure 2: Entities and organizations with responsibility for Public Safety



A fundamental principle for technology development in the public safety arena is the value of dual-use or multi-purpose technology applications that public safety can leverage both during normal operations ("Blue-Sky Days") and emergency or disaster situations ("Dark-Sky Days"). This approach to smart public safety is cost-effective and facilitates efficient operations because users are already familiar with systems from daily use that they will apply during a crisis.

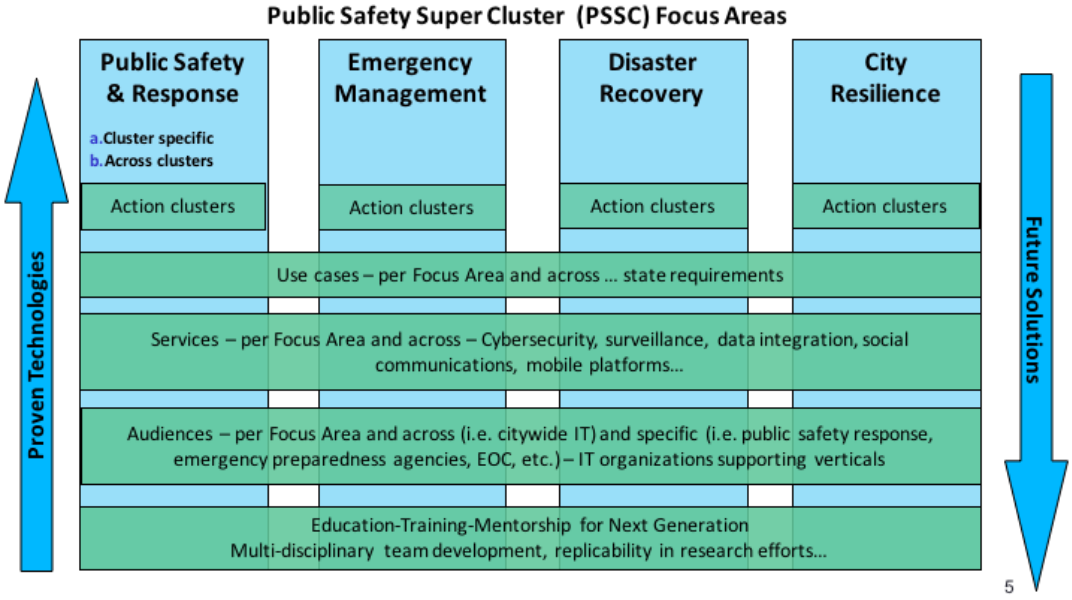
The capabilities expected of the Smart Public Safety solution touch upon three key areas:

- Improved safety and situational awareness for first responders, incident command, local authorities, and governance (to include community leadership);
- Enhanced collaboration between agencies to enable the whole-of-community approach to planning, preparedness, response, and recovery; and
- Mission-effectiveness, defined as the efficient employment of resources involving all responsible agencies or organizations across the full spectrum of emergency or disaster management.

Defining PSSC Focus Areas and Scope

In March 2017, the PSSC conducted a series of online surveys and held a two-day workshop among its member communities to determine the PSSC scope and focus. Participants identified four Focus Areas (Public Safety & Response, Emergency Management, Disaster Recovery, and City Resilience), each with distinct characteristics and specific technology requirements, yet also sharing elements such as use cases, services, users, and education and training opportunities (Figure 3). The exercise enabled PSSC Action Clusters to identify an "entry point" for individual technology applications either developed or in development to solve specific local problems in public safety. Collaboration among PSSC member communities also helped identify opportunities to apply individual technologies across focus areas.

Figure 3: PSSC Organizational Structure for Smart Public Safety



The diagram's structure served as the process guide for PSSC Action Clusters to design and organize an approach to Smart Public Safety that evolved into this *Blueprint*. Elements of the process included:

- Participation of GCTC Actions Clusters that formed the original membership of the PSSC, along with their individual, city-based technology solutions;
- Development of a series of use cases, incident scenarios, and technology requirements that served as frames of reference or context for the PSSC Action Clusters (see Appendix C);
- Identification of the emergency and community services that apply across each Focus Area;
- Stakeholder input from audiences, agencies, and participating actors involved in community Public Safety;
- Recognition of the need for education, training, and mentoring initiatives that are directed toward Smart Public Safety.

The two arrows on either side of the diagram indicate that the PSSC Blueprint is based on existing proven technologies for public safety, as well as those that define or will address future needs, requirements, or solutions.

In the March 2017 PSSC workshop, each Focus Area team was given a 2-part task:

- Define the Focus Area Scope Statement, Mission Statement, and Focus Area goals; and
- Identify departments within public safety agencies, components of those departments, significant city requirements, and existing resources to meet those goals.

Teams then described best practices and guidelines that city agencies can use to plan for and implement a "Smart Public Safety" initiative within a specific region, community or jurisdiction.

As an example, some capability gaps described in this blueprint are associated with the inability of agencies or organizations to access broadband services and gain critical situational awareness during emergencies. Lack of interoperability between first responders is a fundamental capability gap, and is often a consequence of inadequate access to the technology that enables mission critical interoperable broadband communications, in-field sensor-based data capture, real-time data analytics to analyze said data, and visualization solutions that most expeditiously provide that information back out to incident command and affected stakeholder groups. The lack of timely and sufficient incident data—or the ability to transmit and receive that data—is a capability gap that contributes to suboptimal situational awareness at the Incident Command Post or Emergency Operations Center (EOC). Major capability gaps during emergencies can often be traced to a common issue: inadequate access to applications, shareable information, and timely actionable intelligence due to the lack of a dedicated high-speed data network to make the information accessible. Smart Public Safety solutions that address the needs for new or advanced technologies, agency policies or enhanced Standard Operating Procedures, and integrated training between personnel involved in the activities of the four Focus Areas identified by the PSSC can play a key role in resolving these gaps.

I. Public Safety & Response

This section addresses technology requirements definition, development, and deployment among traditional public safety and first responder agencies—police and fire, EMS, search and rescue, and emergency management, particularly as employed in EOCs. These agencies and services constitute the inner ring of Figure 1 on page 8.

After identifying organizations involved in daily public safety incident management, this section provides an overview of U.S. models for best practices. To strengthen consistency at the local, city, state, and national levels, operating best practices must be implemented consistently at each level to assist incident command centers, incident commanders and first responders from law enforcement, fire, EMS, and 9-1-1 Public Safety Answering Point (PSAP) centers responsible for successful incident response.

This section also provides input from the March 2017 PSSC Workshop, in which participants identified key requirements, resources, and guidelines for cities to effectively adopt smart technology in public safety and response.

Key Characteristics

Public safety and response agencies have specific advantages and limitations for adopting new and particularly cutting-edge technologies Factors influencing decisions to adopt new technologies include:

- Long-standing organizational histories, culture, and ethos, and a formalized operational doctrine within individual agencies and collectively through the NIMS/ICS structure;
- Specific technical and professional skills and a facility with integrating and deploying tested technologies and systems that add value to mission accomplishment;
- Demands and requirements for 24x7 readiness for emergency response that limit the ability to conduct operational test and evaluation, and customarily remove operating teams and management from direct involvement in research and development of new systems; and
- An institutional bias toward incremental improvements in tested and deployed systems, rather than adoption of cutting edge technologies that could require technical and doctrinal change. This is an understandable result of these agencies' 24x7 readiness posture, and to typically limited budgets that are directed to covering operational and contingency costs.

Priorities for technology solutions are focused on safety of individual responders and protection of mission effectiveness, communications interoperability between responder agencies, enhancing situational awareness between field units, incident command and EOCs, and improving decision-making based on real-time access and processing of data and situational reporting.

U.S. Models for Public Safety Response

Public safety officials and first responders—such as EMS, fire-rescue personnel, and law enforcement officers—need to share vital data or voice information across disciplines and jurisdictions to successfully respond to day-to-day incidents and large-scale emergencies. Many people assume that emergency response agencies across the nation are already technologically interoperable. However, first responders often cannot talk to some parts of their own agencies—let alone communicate with agencies in neighboring cities, counties, or states.

To help address issues in interoperability and incident management, the U.S. Department of Homeland Security (DHS) has developed tools such as the Interoperability Continuum, National Incident Management System (NIMS), and Incident Command System (ICS), which support the foundation for a "Smart Public Safety" implementation. FEMA has defined NIMS[4] and the supporting training for the ICS[5] as a proposed national guideline for consistent operational implementation for public safety incident management.

Interoperability Continuum

Developed with practitioner input by DHS's SAFECOM program, the Interoperability Continuum tool[6] is designed to assist emergency response agencies and policy makers to identify five critical success streams that must be matured to achieve a sophisticated interoperability solution: governance, SOPs, technology (both voice and data), training and exercises, and usage of interoperable communications. Jurisdictions across the nation can use the tool to track progress in strengthening interoperable communications. Figure 4 provides a depiction of the Interoperability Continuum.

To drive progress along the five streams of the Interoperability Continuum, emergency responders should observe the following principles:

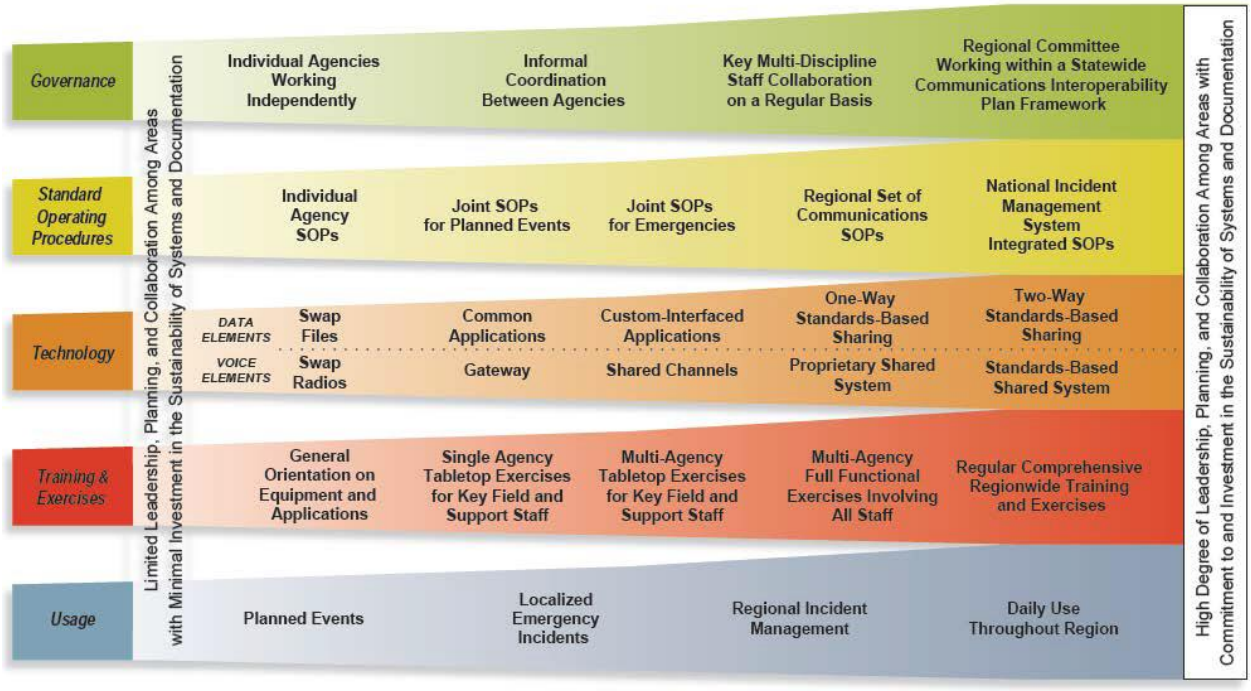
- Gain leadership commitment from all disciplines (e.g., EMS, fire-rescue response, and law enforcement;
- Devise the appropriate governance arrangements;
- Foster collaboration across disciplines through leadership support;
- Interface with policy makers to gain leadership commitment and resource support;
- Use interoperability solutions regularly;
- Plan and budget for ongoing updates to systems, procedures, and documentation; and,
- Ensure collaboration and coordination across the continuum.

Interoperability is a multi-dimensional challenge. To gain a true picture of a region's interoperability, progress in each of the five inter-dependent elements must be considered. For example, when a region

[4] https://www.fema.gov/national-incident-management-system
[5] https://training.fema.gov/emiweb/is/icsresource/trainingmaterials.htm
[6] https://www.dhs.gov/publication/interoperability

procures new equipment, that region should plan and conduct training and exercises to make the best use of that equipment.

Figure 4: Public Safety Interoperability Continuum – Maturity Levels



Optimal interoperability is contingent on an agency's and jurisdiction's needs. The Interoperability Continuum is designed as a guide for jurisdictions pursuing a new interoperability solution based on changing needs or additional resources. One important factor to note about the continuum is that while organizations mature accordingly from left to right in each stream, for many agencies the third level in any given stream could be its desired end-state. More in-depth information on the Interoperability Continuum Elements is located at: https://www.dhs.gov/publication/interoperability/.

Incident Management

While the Interoperability Continuum assists agencies in assessing their respective maturity in establishing communications and collaboration among multi-disciplinary teams, NIMS provides a flexible but standardized set of practices to manage incidents—with emphasis on common principles, a consistent approach to operational structures and supporting mechanisms, and an integrated approach to resource management.

NIMS is a systematic, proactive approach to guide departments and agencies at all levels of government, nongovernmental organizations, and the private sector to work together seamlessly and manage incidents involving all threats and hazards—regardless of cause, size, location, or complexity—to reduce loss of life, property and harm to the environment. NIMS is the essential foundation to the National

Preparedness System (NPS) and provides the template for the management of incidents and operations in support of all five National Planning Frameworks.

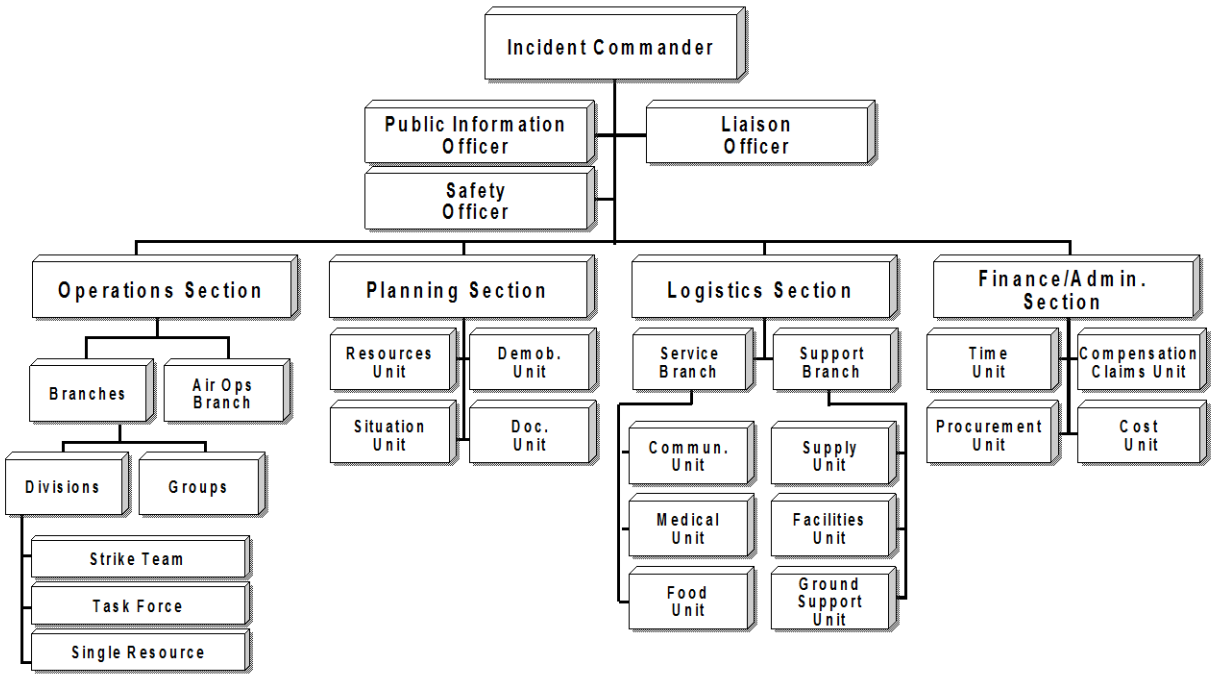
Incident Command and Operations

Within NIMS, ICS[7] is a management system that enables effective and efficient domestic incident management by integrating a combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure (see

Figure 5). ICS is normally structured to facilitate activities in five major functional areas: command, operations, planning, logistics, intelligence and investigations, and finance and administration. This fundamental form of management enables incident managers to identify the key concerns associated with the incident—often under urgent conditions—without sacrificing attention to any component of the command system.

Figure 5 offers a suggested guideline for an organizational structure that each public safety agency involved in mission critical incident management should implement. There is not necessarily one department for each of the blocks below, but in most implementations, several organizational functions may be performed by one department or even one individual.

Figure 5: FEMA Common Incident Command Organizational Structure



[7] https://www.fema.gov/incident-command-system-resources

Smart Public Safety and Response Implementation: PSSC Workshop Outputs

Participants in the March 2017 PSSC Workshop explored how the Public Safety Interoperability Continuum, NIMS, and ICS needed to evolve to a "Smart Public Safety" system to more fully support S&CC. Participants first defined the focus area scope, mission statement, and goals. They then identified requirements, existing resources, and technology solutions to be adopted, and action areas for cities.

Scope and Mission

The Public Safety & Response Focus Area team defined its scope as: *to identify the problem statements, challenges, and solutions to existing governance, procurement rules, operating procedures, and technology integration to provide fire, law enforcement, EMS, 9-1-1 PSAPs, government officials, and other decision-makers with better situational awareness tools and information before, during, and after daily public safety incidents to maintain community functions, ensure the public safety of city residents, and ensure the safety of first responders.*

Its mission was: *Help first responders and smart city managers use technology, processes, and collaborative data sharing and training to get the right information to the right people at the right time, in the most actionable format.*

Goals

Goals for the Focus Area:

- Draft the blueprint/playbook of guidance for cities to support improvements to situational awareness to ensure a common operating picture.
- Select a lead city to review and provide feedback on changes to the draft blueprint/playbook.
- Review the full listing of Action Clusters related to public safety and identify how Action Cluster initiatives/projects can be replicable.

Goals for the Public Safety Blueprint

- Develop an inventory of assets (what does the community have and need).
- Ensure the quality, integrity, and harmonization of data between agencies and first responders.
- Support data analytics, utilization, visualization, and mobility to get the right information to the right people.
- Improve interoperable communications between agencies (including data, voice, and video capabilities).
- Support collaboration and coordination systems operating throughout the public safety incident cycle.

- Assist public safety agencies and community leaders in designing and distributing effective public messages, public service announcements (PSAs), and best practices to ensure an informed public.

City Requirements

PSSC participants identified the following key requirements from communities for smart city for public safety incident management:

- **Technology:** Identify ecosystem requirements to support IoT, analytics, visualization, mobilization of data, including devices, software, and applications.
- **Cybersecurity:** Develop principles for protecting IoT data and devices.
- **Communications and Data:** Support the interoperability of communications and data streams between agencies.
    - Join standards that are currently uncoordinated.
    - Normalize data (e.g., CAD system).
    - Ensure the system is consistent and readable.
- **Communications for Responders:** Support mission critical voice, including moving from old to new technology.
- **Communications for Dispatch:** Support an effective and enhanced dispatch system (Next Gen 9-1-1).
    - Include texting capabilities.
    - Enable management of the many types of data coming into dispatch centers.
    - Support a feedback loop to help citizens act.
    - Incorporate needs of the end users.
- **Communications for the Public:** Support public alerting systems (e.g., AMBER Alerts, geo-fencing).
- **Include citizen-facing platforms** to enable public alerting to disseminate critical information.

Existing Resources to Meet Requirements

- **Policy and Procedures**
    - Governance guidelines
    - Operating procedures for incident operations and management (e.g., NIMS)
- **GCTC Action Clusters and Community Groups**
    - Projects for the public safety sector (e.g., for NG 9-1-1, active shooter, unmanned aircraft systems)
    - Use cases (e.g., for cybersecurity)
- **Financial Models**
    - Grants.gov portal for federal grant announcements
    - NIST Public Safety Communications Research Grants (including the Prize Challenge)

- **Partnership Models**
    - PPPs focused on interoperable communications

Technologies, Systems, Services and Solutions to be Adopted

- **Information Technologies**
    - IoT solution components
    - Mobile solutions
    - Cognitive solutions
    - Cloud technologies
    - Social Media data
    - Video analytics solutions
- **Communications**
    - Land mobile radio (LMR) systems and upgrades
    - Satellite radios
    - Fiber networks
    - Deployable system communications
    - Broadband and wireless
- **Mapping and Location**
    - Geospatial information systems (GIS)
    - Automatic vehicle location (AVL)
    - Location-based service (LBS) tracking for phones
- **Analysis**
    - Visualization (e.g., user interface, user experience [UI/UX])
    - Data analytics (e.g., multi-modal biometrics)
- **Information Sharing**
    - Computer-aided dispatch (CAD)
    - Fusion centers
    - Real-time intelligence centers (RTCCs, RTOCs, virtualized intelligence centers)
- **Documentation**
    - Records management systems (RMS)
    - Digital evidence management
    - Shared portals
    - Microsoft Office360
    - Active Directory
    - Federated Directory
    - Master Name Indices

City Needs to Implement Smart Public Safety

Today, public safety agencies have many needs to implement a "Smart Public Safety" initiative. Workshop participants identified the following key action areas for cities:

- **Reform procurement rules and funding mechanisms** to support public safety technology investment.
- **Encourage culture change** to increase leadership and vision to implement technologies (a global issue).
    - Funding is needed for training on technology.
- **Leverage lessons learned** from major events to drive change (e.g., equipment modifications, governance and operating procedures, and collaboration).
- **Focus on cross-agency planning and collaboration** (e.g., establish working groups).
- **Identify the return on investment** (ROI) for executing use cases and case studies.
    - ROI analysis
    - Business plan
    - Statement of benefit to the citizen
    - Return on citizen investment
    - Economic development
- **Define the business case** for investing in technologies.
    - Encourage dual/multiple uses of technologies (emergency/non-emergency, safety/non-safety).
    - Define the safety case – will the technology help or hinder?
    - Leverage test cases to prove the technology and reduce risk of implementation.
- **Develop public-private partnerships**.
    - Focus on cross-agency collaboration and planning.
    - Leverage the collaborative nature of jurisdictions.
    - Include elected officials, including the mayor, city/county commissions, and boards.
    - **Define the value proposition** of the technology investment and potential outcomes that positively impact the jurisdiction and/or elected officials' platforms or priorities.

II. Emergency Preparedness

This section addresses the integration of traditional public safety and response into the broader scope of overall community preparedness, planning, and response. It deals with the development and coordination of multi-team systems of emergency response agencies with supporting and secondary organizations that interface directly with front-line responders during a disaster or civil emergency. Collectively, these organizations occupy the inner and second circles of Figure 1 on page 8, and constitute the combined response capability of a community, jurisdiction, or region and may be augmented by additional resources deployed through Emergency Management Assistance Compacts (EMAC) with adjacent states or jurisdictions or from federal sources, such as FEMA and other agencies.

For technology solution providers, this section provides insight into EM workflows and decision-making priorities. Industry may better address EM needs by understanding the concepts, frameworks, and language EMs use. Technology solutions should address identified gaps in a way EMs understand within the context of the critical operations they manage. Therefore, this section begins with an overview of emergency management models and best practices that will inform development of a shared language for identifying and articulating fundamental EM requirements.

For EMs, this section provides insight into the relevant data, tools, and technology solutions available to meet their needs and ways to effectively evaluate and integrate technologies and associated protocols. Goals include:

- Improve EMs' ability to evaluate and integrate S&CC/IoT technology into their emergency preparedness, management, and response processes—both for day-to-day operations (Blue-Sky days) and large-scale, unusual emergencies impacting multiple systems (Gray-Sky days).
- Enable technology solution providers to better understand and address EM needs through meaningful use cases by presenting EM frameworks and language.
- Suggest a collaborative, participatory process for design and integration of IoT solutions involving emergency management professionals, IT solution providers, and the community.
- Provide examples of how existing IoT technologies can help provide solutions to city challenges.
- New vulnerabilities created by the connectedness of the previously unconnected.

Key Characteristics

In general, the whole-of-community approach begins to have impact with emergency preparedness and management, where benefit from new technologies and their integration via advanced wireless networks supporting deployed sensors and IoT is most easily achieved. For preparedness, dual-use or multi-purpose technologies with utility in both Blue-Sky and Dark-Sky scenarios can achieve the greatest cost-effectiveness and potential for rapid adoption.

Key characteristics of the emergency preparedness and management approach to smart technology solutions include:

- More diverse opportunities for identifying and defining requirements to improve public safety (i.e., a bigger market-place) and higher likelihood that technologies can be adopted without disrupting operational readiness of critical agencies and community functions;
- Connection with critical infrastructure systems already undergoing fundamental technology upgrades and transitions, including the adoption of high-speed wireless networks, embedded IoT sensors, data-mining and social networking platforms, resilient electrical grids, and general access to commercial enterprises that support these systems;
- Close relationship with both commercial and public research and development institutes, and a willingness to accept a certain amount of risk in technology investment; and,
- Risk of developing or adopting systems incompatible with current systems used by first responders and agencies or that require fundamental changes in operating doctrine or procedures among those agencies.

Integrating S&CC and IoT technologies into the emergency preparedness process brings opportunities (such as better situational awareness) and complexities (such as increased volume and variety of data) for emergency managers. As communities adopt smart technologies, they must rethink policies, operating procedures, and interagency planning and communications for all phases of emergency management to fully leverage new opportunities. Similarly, while the S&CC/IoT technical community has made significant advances in developing technology solutions, they must incorporate input and context-specific validation from emergency managers (EMs) and related personnel to fully meet user needs.

Emergency Preparedness Models and Best Practices

Two current models serve as sound examples of operational systems for organizing emergency management and response structures: the U.S. National Response Framework and National Preparedness System, and the international *Cluster System* adopted by the United Nations. Both represent best practice foundations and a shared language for identifying and assessing emergency management needs, and may be adapted for use in S&CC for potential IoT integration and innovation. Successful smart technology solutions will address specific needs jurisdictions may have within these frameworks. In either case, similarity with existing operationally tested frameworks is a virtue and should be pursued in U.S. and international applications within S&CC to the extent feasible.

U.S. Model

The U.S. National Response Framework/National Preparedness System (NRF/NPS) model establishes a single, comprehensive approach to incident management within the U.S. The NRF is used to achieve the National Preparedness Goal of a secure and resilient nation with the capabilities required across the whole community to prevent, prepare for, respond to, and recover from terrorist attacks, major disasters, and other emergencies.[8]

[8] https://www.fema.gov/pdf/emergency/nrf/nrf-core.pdf

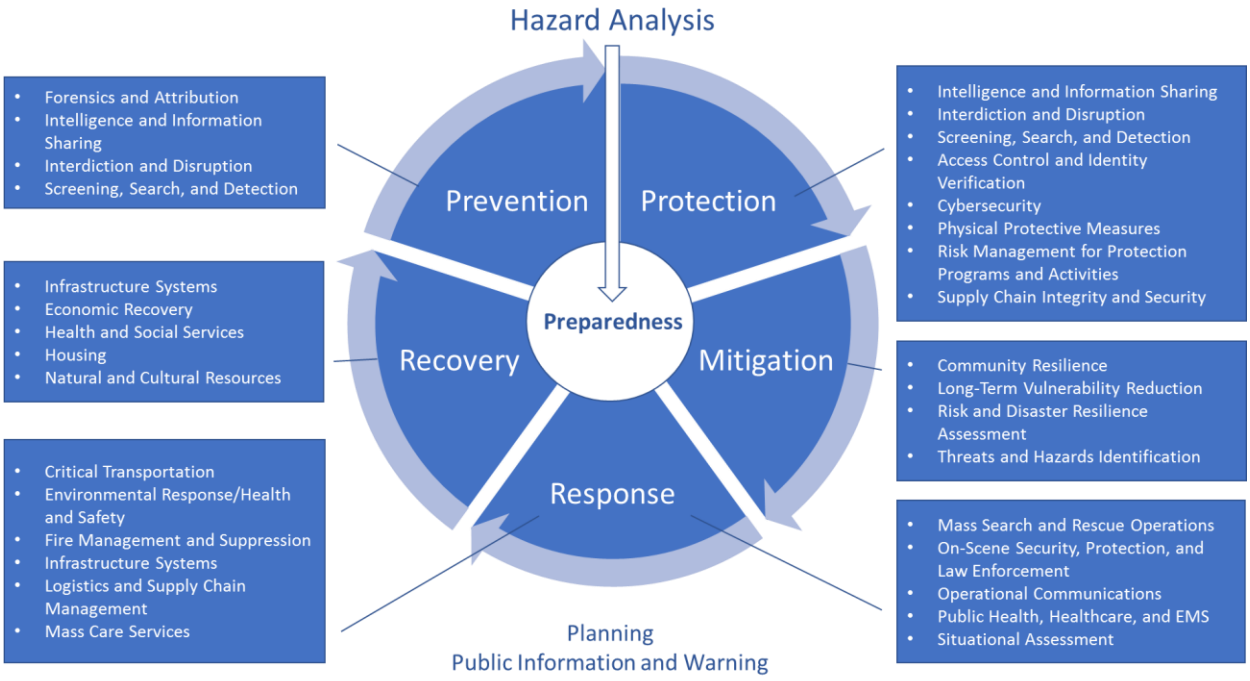
The NPS preparedness cycle comprises the five key phases or mission areas of emergency preparedness and response: prevention, mitigation, response, recovery and protection. Within these phases are identified analysis and assessment actions include:

- **Threat and Hazard Identification and Risk Assessment (THIRA)** – A four step common risk assessment process that helps a community develop a comprehensive hazard catalogue for threats and hazards of greatest concern, community defined desired outcomes, risk overview with hazard profiles and estimated impacts, and capability targets. There are 24 risk categories.[9]
- **Core Capabilities Analysis** – Communities engage in gap analysis planning efforts with capabilities falling into mission areas.[10] As gaps are identified, specific needs emerge. Technology plays a role in helping EMs address these gaps within a core capability and across capabilities and in performing consequence analysis.

Technology solutions and innovations may enhance risk assessment through data collection and aggregation, modeling, predictive analysis, and dashboard views.

Figure 6 shows the 32 core capabilities as they relate to the five mission areas of the NRF cycle. Hazard analysis is key to overall preparedness goals; planning and public information and warning are associated with all phases.

Figure 6: National Preparedness Cycle Mission Areas and Core Capabilities



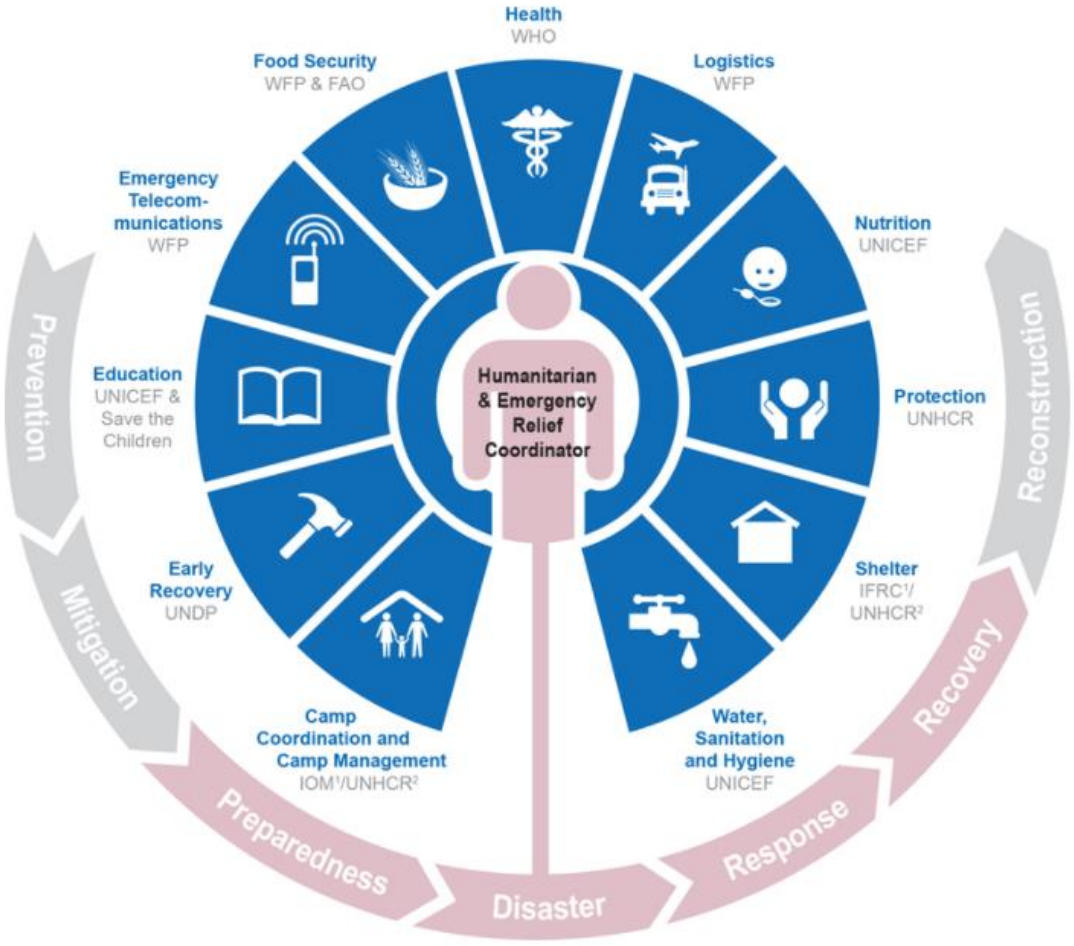
[9] https://www.fema.gov/media-library-data/8ca0a9e54dc8b037a55b402b2a269e94/CPG201_htirag_2nd_edition.pdf
[10] https://www.fema.gov/core-capabilities

International Models

When a large-scale emergency occurs, the capacity of a city, state or national emergency management infrastructure may be insufficient to handle the response alone. Therefore, in the international space, when multiple organizations respond, effective coordination among response stakeholders is essential for meaningful emergency management. Good coordination stems from effectively involving multiple teams and stakeholders and minimizing gaps and duplications in the response work across organizations. However, the need of inter-agency coordination expands to all phases of the crisis management from prevention to reconstruction and it is the core of large-scale emergency preparedness.

To address this complexity of coordination across the diversity of organizations involved (e.g., governmental vs. non-governmental vs. voluntary), the domain expertise and skills required, and the varied tasks, United Nations has proposed a Cluster System[11] as shown in Figure 7.

Figure 7: UN Cluster System



[11] https://www.humanitarianresponse.info/en/about-clusters/what-is-the-cluster-approach

According to the United Nations Inter-Agency Standing Committee (IASC), the primary goal of this Cluster Approach is to strengthen system-wide preparedness and technical capacity to respond to large events or emergencies and to provide clear leadership and accountability in the main areas of emergency and humanitarian crisis response. At the nation level, it helps strengthen partnerships such as with the NRF in the U.S; and the predictability and accountability of international humanitarian action can be better understood with its help. By improving prioritization and clearly defining the roles and responsibilities of humanitarian organizations, the Cluster Approach has common features and synergies to NRF and NPS. The IASC guidelines and the UN Office of Coordination for Humanitarian Affairs[12] emphasize:

- Supporting service delivery by providing a platform for agreement on approaches and elimination of duplication;
- Informing strategic decision-making for the humanitarian response through coordination of needs assessment, gap analysis and prioritization;
- Planning and strategy development including sectoral plans, adherence to standards and funding needs;
- Advocacy to address identified concerns on behalf of cluster participants and the affected population;
- Monitoring and reporting on the cluster strategy and results; recommending corrective action where necessary; and,
- Contingency planning/preparedness/national capacity building where needed and where capacity exists within the cluster.

The Cluster Approach objectives are like those of the NRF. In addition, in the international disaster response practice, the International Federation of Red Cross and Red Crescent (IFRC) Societies identifies the following elements in its comprehensive disaster preparedness strategic practices[13] which can be adopted in a proposed model for defining preparedness requirements in a smart city context (Figure 8).

Figure 8: IFRC Elements for Comprehensive Disaster Preparedness Strategic Practices

1. Hazard, risk and vulnerability assessments	2. Response mechanisms and strategies	3. Preparedness plans
4. Coordination	5. Information management	6. Early warning systems
7. Resource mobilisation	8. Public education, training, & rehearsals	9. Community-Based disaster preparedness

[12] IASC Guidance Note on Using the Cluster Approach to Strengthen Humanitarian Response: https://www.humanitarianresponse.info/system/files/documents/files/IASC%20Guidance%20Note%20on%20using%20the%20Cluster%20Approach%20to%20Strengthen%20Humanitarian%20Response%20(November%202006).pdf

[13] IFRC Disaster Preparedness guide: http://www.ifrc.org/Global/Publications/disasters/all.pdf

City Emergency Management Needs and Resources

As emergency managers plan for and respond to emergencies, they see the need for smart technology solutions to support all phases of the NPS preparedness cycle or international preparedness models.

To provide effective smart solutions for emergency management, technologists must understand EMs' values, priorities, processes, goals, and specific requirements that support them, as well as the broader ecosystem of resources available. EM goals may include: reducing overall risk, knowing hazard asset impacts, automating awareness, and so on.

For example, emergency preparedness and management involves coordinating information and professionals in a multi-team response with complex interdependencies of communication. resource sharing, and allocations to address any significant emergency such as an active shooter, terrorist attack, high-rise fire, and so on. The required multi-agency response demands enhanced situation awareness, judgment, and decision-making—providing an opportunity for IoT technologies to inform emergency managers through real-time data collection and visualization as well as other potential capabilities.

While all jurisdictions prepare for emergencies, the level of smart technology integration in this process depends on available resources, funding, experience, threats confronted, and other factors unique to each community.

Requirements

Participants in the March 2017 PSSC Workshop identified the following key requirements for technology solutions for emergency management and preparedness:

- **Shared Situational Awareness:** The need for common platforms and operating procedures for all entities that share information and participate in emergency decision-making.
- **Governance:** The need for a governance structure that defines smart city/IoT processes from procurement through implementation and ensures accountable oversight.
- **Collaboration:** The need to bridge the gap between technologists and public safety personnel—finding a shared language based on a clear understanding of requirements and priorities.
- **Data:** The need for planners to access the right data and make it actionable for emergency management and response.
- **Adaptation:** The need to map solutions to existing emergency management frameworks and systems, rather than use "one-off" solutions, and to adapt to change.
- **Planning:** The need to scale response capabilities to meet emergencies—technology can enable broader adoption. Scalability for scope and price in smaller jurisdictions is critical for broader adoption and longer-term commercialization of technologies.

Participants also identified technology design, development, and integration processes to address emergency management needs for:

- **Modeling and simulation**:
    - Models for standardizing risk assessments and planning to:

        - Understand gaps in capabilities and resources against potential threats
        - Identify and prioritize threats and assess risk
        - Identify and link pre-assessment interdependencies
    - Resilience mapping, gross modeling, and simulation tools
- **Communications**: Robust and interoperable systems and data that can lead to informed action, along with more human expertise across systems.
- **Information sharing**: Full-scale situational awareness capable of integrating data from a broad range of systems, including open data, city-owned IoT, smart buildings, environmental sensors, and other sources.
- **Participatory, collaborative design, and innovation**: involving all stakeholders and community members in design, development and integration of IoT technologies for emergency management.

Resources

PSSC Workshop participants identified the following resources that EMs utilize for preparedness. Technology solutions can also strengthen the management and integration of these resources and their accessibility to emergency managers.

- **Planning Models and Capabilities**
    - Interoperable models and decision tools to enable:
        - Regional, national and international planning and risk assessment
        - Supply chain and logistics management
        - Management of communications resources
        - Post-disaster community recovery
- **Partnership Models**
    - Mutual aid relationships
    - Integration of citizen resources, such as Citizen Corps Councils, Community Emergency Response Teams, Medical Reserve Corps, Fire Corps, and Neighborhood Watch
- **Personnel and Facilities**
    - Local and regional government-owned infrastructure
    - Privately owned infrastructure (telecommunications; transportation, etc.)
    - Business, financial and economic resources
    - Governance, community anchors, social services, and leadership

Adopting Technology Solutions to Address Emergency Management Needs

Priorities for technology solutions are focused on improving coordination among multi-team systems of responders; the integration of both public and private data and information into emergency preparedness

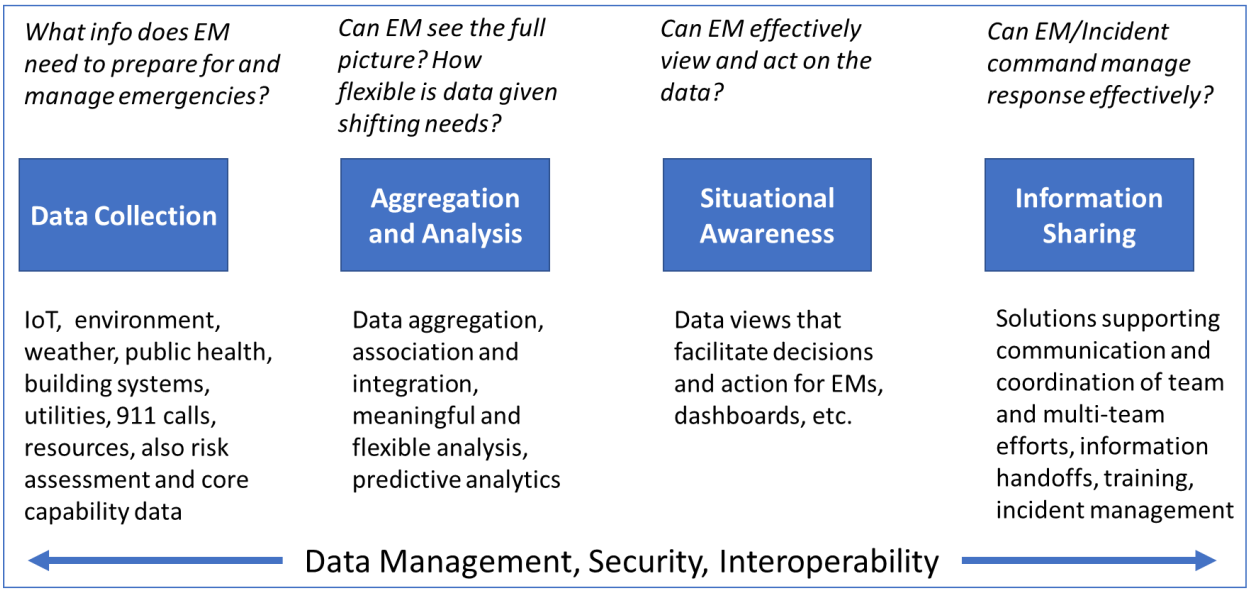
practices (such as access and portability of critical medical data among patient populations), and similar challenges that have legal, proprietary, and security barriers, as well as policy implications.

Technology Requirements Development Process

As smart technologies expand the range of available data for EMs to make better planning and response decisions, solutions must meet EM requirements for how that data will be synthesized and used. Can EMs apply data within various forecasting models based on specific situations? Can they integrate different elements and run predictive analysis? Is the data presented in a way that EMs and incident command can effectively use? Do solutions enhance the effectiveness of intra- and inter-team communications and response?

An important objective is helping technology providers fully understand the complexity of emergency response and the ecosystem of people, organizations, and resources involved so they can effectively address these demanding situations with technology applications and IoT innovations. Involving stakeholders in identifying problems and generating ideas, and enabling technology developers to immerse themselves in EM roles, context, and workflow is critical to meeting EM needs with targeted solutions. To articulate a broad process model that may consider local needs for emergency management, we must first consider the EM's role and actions in identifying specific information needs and data management for effective visualization and response (see Figure 9).

Figure 9: Emergency Management Smart Technology Solution Evaluation



In this model, data management, security, interoperability, and other requirements such as reliability, scalability, and availability are required throughout the ecosystem. Solution features such as plug and play, multiple use, and ease of use are critical to acceptance.

Technologies should:

- Draw upon data that can be acted on for emergency planning and response.

- Improve the handoff of information across systems – including addressing handoff issues through simulation, training, and modeling.
- Be based on open standards that enable interoperability for device interchangeability and data sharing.
- Leverage non-government resources (e.g., business/community/region) and mutual aid (e.g., human and material resources).
- Leverage dual or multi-use technologies where possible for improving ROI (for more information, see the later section on "Seeking Co-Benefits with Dual-Use Technologies."
- Provide user experience that meets specific public safety requirements in a range of environments and use scenarios.
- Provide adequate training to optimize use and applicability in a wide range of scenarios.

Aligning Technology Efforts with City Needs

To ensure technology efforts align with city needs, technology solution providers should work with stakeholders to:

1. Identify the problem to be solved within a recognized emergency management model, such as NRF, considering direct and secondary consequences of an emergency (for example, a water system failure impacts ability to fight fires) and the scope across phases from planning through recovery.
2. Analyze available data and identify gaps in understanding or response. This may include an assessment of hazards, consequence, cross agency needs/assets analysis, impact analysis, GIS/mapping, and other existing data modeling/analysis.
3. Identify specific requirements within core capabilities and gaps across the response spectrum that IoT/smart technology may address. This includes planning and response goals and technology needs analysis.
4. Address the problem by repositioning, improving, or integrating existing technologies where feasible or innovating new solutions where necessary.
5. Explore multi-use cases for solutions, addressing one or more core capabilities and primary and secondary benefits.
6. Identify funding opportunities that can support initial implementation and sustaining operations.
7. Build standards-based solutions so that data is interoperable by default.

Applied Research and Development Process

One model technology providers may consider is the applied research and development process for engineering smart city solutions, which incorporates a user-centered or user experience (UX) design and research approach. This is an iterative, progressive, and agile four-phase design process applicable for generating, refining, and scaling emergency management IoT solutions (see Table 1 on page 33).

- **Research and Analysis** – Elicits collaborative analysis and city assessment with citizens and stakeholders to establish a common vision for smart city innovation. This UX design process also permits emergency managers to work from established processes and frameworks familiar to them so that technology developers can intersect in this process to target their needs for UX smart city systems.
- **Ideation** – Establishes a collaborative design process with citizens and stakeholders to elicit multiple perspectives on the problem, generate multiple design ideas, and prioritize and clarify the behavioral or performance targets aligned with meaningful data streams for smart city IoT innovations.
- **Refinement** – Advances the generated prototype through establishing contextual relevance and usability via lab and field testing of the prototype, progressively refining and evolving the innovation, and establishing and expanding targeted metrics and measures to better determine return on investment or impact.
- **Solution** – Incorporates methods to monitor and report out the initial design strategy as well as impact for learning about how the smart city solution was adopted, adapted, and integrated throughout the system. This phase can define incentives for use and impact on citizen's lives as well as provide impetus for empirical investigation of the use, impact, and scaling of the innovation.

Case Study: Multiteam Interaction and Training of City-Wide Emergency Management

***Identified Gap and Solution**: In a city-based emergency or disaster, multiple teams—including emergency operations, FEMA, Department of Homeland Security, law enforcement, EMS, fire and rescue, and hospital trauma teams—must work together in a coordinated response. However, these teams rarely train together. Key to designing an effective multiteam smart IoT solution is understanding the impact of cross-team interaction and learning from team members' real-world interactions as part of a larger city-wide system.*

To address this gap, Smart Emergency Medical Team Training developed an IoT system to improve the capture, analysis, and visualization of mobile behavioral data from proximity sensors worn by individual team members engaged in a multi-team, live simulation context. The objective was to identify and uncover important individual, team, and cross-team behavioral data and patterns (e.g. response time, proximity to the patient and, activity of individuals, teams, and representative of the overall multiteam system, etc.) to improve experiential learning during the debrief from cross-team interaction in high fidelity simulation training. The goal is to improve patient care, cross-team coordination and city services teams' response time.

The Iterative user experience (UX) design and research process included:

- ***Research.** Through a multiteam training effort focused on extracting, treating and transporting a patient quickly to the hospital emergency room, the research team closely examined, generated, and evaluated best practices in emergency management, response, and healthcare disciplines to understand the context and problems through the users' experience. From this analysis, prototyped IoT solutions were developed. An agile, flexible UX design process was leveraged aligning with the city's core capabilities and risk assessments.*
- ***Analysis.** Researchers conducted multiple, detailed investigations and observations of relevant user work processes in live simulations within and across teams to determine target audience(s), system requirements and to model usage, tasks and information flow. These provided the basis for user requirements for the system.*
- ***Ideation.** The refined design goal, drawn from data analysis and generated design models, was directed at improving coordination, situational awareness, learning and performance of the multiteam system. The process strives to uncover the system requirements to iteratively design a system to meet team members' work goals. In the use case, iterative design cycles continued in the development and integration of existing sensors and custom information systems toward the goal of visualized heterogeneous data sources (e.g. biometric body worn sensors, proximity beacons, 911 dispatch, GPS, GIS, and social media digital data) to provide information on inflection points between the teams—for example, when the patient is handed off from the EMS to the hospital trauma bay team.*
- ***Refinement.** Refining the prototype represents the hard work of bringing an idea to life, progressively testing it through solicitation of targeted feedback and continually improving it through 1) progressive prototyping, 2) deploying, testing and evaluating the system and 3) adopting participatory design.*
- ***Solutions.** The solution generated through a UX design and research process joins end user experience and knowledge with a design and prototype based on rich data from the context of use. The solution has improved ecological validity and is tested in context, thus demonstrating improved opportunities to transition and scale into other environments. While still in development, the project's iterative prototyping with a participatory design process has garnered interest from other cities and expanded in scope. Deploying an early IoT solution prototype with iterative cycles of improvement permits other cities to consider the adoption, adaptation and diffusion of similar systems in their local contexts as well as provided additional input on the design and use.*

Seeking Co-Benefits with Dual-Use Technologies

During an emergency, time matters. Smart systems/IoT solutions can bring information to decision-makers faster and with more fidelity than ever before, even when those systems are not purposefully designed for emergency management. Cities and technology developers can tap into this potential by considering the co-benefits to emergency management within their existing portfolio of systems and products. Systems designed for building security, energy management, and water/wastewater surveillance all have the potential to guide better decision-making during an emergency with limited additional costs.

As an example, many local jurisdictions use city buildings as sites for providing emergency shelter for displaced residents when their homes are not habitable following an emergency. During a large emergency that includes power outages, road closures, and other impacts, local jurisdictions must send out a representative to each potential shelter site to confirm that the facility is running, on primary or generator power, and the IT connectivity necessary to support operations. This information gathering requires time and slows the response.

At the same time, many jurisdictions are automating their building systems through sensors and other smart technology. The primary benefit of the system is to save operating costs, extend the life of those building systems, and reduce energy consumption. If these smart systems are already linked back to a central system for daily operations and management then that information can also lead to faster decision-making during emergencies. In our example, if the building sensors show that the building is on primary power with adequate IT connectivity, it allows decision-makers to select sites for emergency sheltering without sending a staff member to the site to evaluate it. This saves staff time and allows the shelter to open more quickly.

Guiding Questions

For Cities

1. Has the city identified and prioritized key threats/hazards?
2. Has the city identified key capability gaps and requirements?
3. What are the city's top emergency management needs and at what point(s) in the National Preparedness cycle do these occur? Where, when, and how does the city most need help?
4. What information do city emergency managers need for preparedness? How should data be organized and analyzed to support emergency management and response? How should data be accessed for effective emergency management decision-making and coordination?
5. After initial emergency response, what are secondary or other related needs of the city?
6. Who are the different users of data from IoT solutions and what systems/platforms can be leveraged? Do we need to innovate (new technology), integrate (existing technologies), repurpose (leverage deployed technologies to meet new requirements)?

7. What current or future IoT/smart solutions can support city emergency management and secondary needs, when in the cycle, how, and to what degree?
8. What are the best current options for my city given available resources?
9. What resources are available to obtain and use the solution? (capital and operational funding, personnel, training, etc.) What additional resources are needed now and in the future?
10. What is the plan to sustain technology development and use into the future?

For First Responders and Response Agencies

1. Based on the THIRA, what are the region's/community's key threats/hazards?
2. Have responder agencies identified key capability gaps and technology requirements?
3. What information do First Responders and Emergency Managers need require, and when do they need it? How should data be organized and analyzed to support emergency management and First Responders? How should data be accessed for effective emergency management decision-making and coordination?
4. After initial emergency response, what are secondary or other related needs of Emergency Management and response agencies?
5. What data from IoT systems/platforms can be leveraged to improve situational awareness and decision-making? Must new technologies or applications be developed, or can existing technology systems be more usefully integrated to meet new requirements)?

For Technology Solution Providers

1. Does the technology solution adequately reflect an understanding of what city EMs need at a situation-problem level?
2. What specific threats and core capabilities does my solution address?
3. How and at what point in an emergency does my solution help? (In preparation, protection, mitigation, response, recovery phases?)
4. Does my system design meet industry standards, best practices and public safety end-user and responder requirements?
5. Is the solution closed or open–how adaptable, scalable, replicable, cost-effective, easy-to-use is it?
6. What additional/secondary benefits will the solution provide to city? How can the solution be applied to address broader city needs? (such as resilience, economic development, public health, community engagement, etc.)

Table 1: Applied Research and Development Process – Questions and Methods

Research and Analysis	Ideation	Refinement	Solution
Questions • What threats and hazards (from THIRA process) are of greatest concern for our community? • What are the relevant gaps and problems in our city and specific needs aligned with mission areas (e.g. prevention, protection, mitigation, response and recovery)? • How do we characterize or frame the problem with EM stakeholders and community members? • What are city-based networks, systemic, cultural, and social influences on problem? • What is the ecosystem of organizations, people, activities and places relevant to the identified problem? • Who is the targeted audience(s) for the smart city system? • How to build alliances/working/design groups, advocacy and trust for new ideas in this city? • What information can be gleaned or adapted from research, applications, in other cities? • How to connect gaps in capabilities and resources to potential threats for our city?	**Questions** • How to include community members in a collaborative smart city design process? • What functional requirements fall from the integration of information from research and analysis? • How can we generate multiple ideas based on targeted needs and requirements? • What relevant behaviors, workflow, learning or performance targets are actionable for the targeted system innovation? • What are the relevant physical, contextual or ambient interactions among people, devices, and tasks given the targeted communication, data, and/or information sharing in this context? • What are functional segments of the design for relevant user tasks and how can these be integrated into a holistic system design? • What types of interactions are relevant (e.g. physical, movement, gesture, biometric, sound, etc.)? • How are specific requirements integrated into a holistic system to address the identified need?	**Questions** • Is the enacted system usable and relevant to users, stakeholders? • How can we evaluate the prototype? • How can we progressively iterate from proof-of-concept to iteratively build and refine the system? • What elements of the system should be refined, eliminated, or revised? • What city-level ROI, measures, or metrics are applicable? • What are the system levers, drivers, or outcomes that can demonstrate impact on the city problem? • What city impact or system effectiveness can be determined? • How to grow and scale the system?	**Questions** • How to monitor and report on strategy and results of EM IoT solution? • What factors may influence the adoption, adaptation, and diffusion of this system? • How does the system mutate and evolve based on targeted use? • What are incentives for sharing ideas and reuse? • How does the new system influence the quality of life of citizens? • What new problems or issues emerge? • What policies and cultures shape citizen use or non-use of the system? • What are mechanisms for sharing data, models, software, hardware, etc.? • What is the business value of the system? • How can we empirically investigate the impact of the system? • How does social network activity change before and after the system implementation?

• How to identify and link pre-assessment interdependencies? • What is the associated UX Smart City design goal, associated users and metrics that can define success for the system? • What data streams are actionable (and in what ways) for the identified city need? • Can we meaningfully integrate multiple data streams to inform the problem? • What are current communication, data, and information sharing systems? • What are possible future systems based on identified needs, applicable/potential data streams and available IoT/smart technologies? • What use cases or user story-maps may be conceptualized that demonstrate value of this system for our city?	• What analytics or data streams can align with performance, behavior, or learning to measure improvement? • What is the connected device infrastructure –input and output of information flow? • How can we physically model and test parts of this system and iteratively evolve the conceptual design? • How do we narrow focus to generate ideas for a system proof-of-concept? • What are the usability and aesthetic design considerations of the system? • How can we create a coherent design across devices or contexts? • What are considerations for interface and visualization of actionable data (input, screens, displays, etc.)? • How is the system especially applicable for this city? • How can data streams be integrated and interoperable?		• How to scale innovation in the system?
Methods • THIRA assessment • Core capabilities analysis • Analysis of smart city readiness • Service ecology or ecosystem mapping • Planning and strategy development • Identify stakeholders and networks • Needs assessment/gap analysis • Problem definition	**Methods** • Participatory Design • Requirements analysis • Cognitive task analysis • Identify workflow, learning and/or performance targets and outcomes • Network, system flows and feedback loops • Framing and reframing problem • Idea generation	**Methods** • Iterative feedback on conceptual design • Citizen critique • Cognitive walkthroughs • Iterative field testing of prototype • Hardware engineering and testing • In-situ product testing	**Methods** • City-level reporting of impact • Perceived value of system • Performance analysis • Qualitative Research • Quantitative Research • Social Network analysis

• Define smart city design goals, metrics and targets • Personas • Prioritization of needs • User Experience (UX) Design Inquiry • Contextual inquiry and analysis • Comparative analysis • Bottom up/top down work flow analysis • Surveys • Observation/Focus groups • Interviews • Benchmarking • User Journeys or story-mapping • Use cases • Case studies	• Modeling workflow, interactions, communications, data flow, etc. • Design informing models – environment, social and process flow models • Generative design methods – sketching, storyboarding, user journey mapping, etc. • User walk-throughs • Heuristic evaluations • Expert Panels • City visits • Modeling • Simulation • Best Practices generation • Technical workshops • Iterative design • Engineering infrastructure diagrams with available internet-enabled devices and data streams • Prototyping • Alignment of behaviors and performance outcomes with data streams • Design reviews with citizens, stakeholders	• Evaluation methods such as: feasibility testing, pilot testing, usability testing, expert review, formative evaluation • Determine relevant applied and empirical research methods such as: observation, video analysis • Identify metrics and outcomes at various levels of city system • Document design reviews • Iterative and agile revision	

Adapted from:

Ratti, C. & Claudel, M. (2017) The city of tomorrow: Sensors, networks, hackers, and the future of urban life. New Haven, CT: Yale University Press.

Townsend, A. (2013). Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia. W.W. Norton & Company.

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III. Disaster Recovery

This Focus Area of the Smart Public Safety initiative describes planning considerations for research and development (R&D) to enhance the ability of Smart & Connected Communities to efficiently manage the recovery of community functions and restoration of economic and social stability following regional or large-scale disasters and civil emergencies. What distinguishes disaster recovery from response described in previous sections is that recovery is principally concerned with the identification, mobilization, and employment of community and private sector resources, rather than those of the professional responder agencies. In post-disaster recovery, the responsibility for restoration of critical infrastructure systems, continuity of governance and community services, and the recovery of economic stability and commercial activity rests largely on local government agencies and the civil population, itself. And unlike professional emergency response agencies, local government, the private sector, and civic leaders have limited opportunity to conduct training or coordinated exercises on community recovery, outside of continuity of operations planning within their own organizations.

Key Characteristics

The recent publication of the National Disaster Recovery Framework (FEMA 2014) has begun a process of "operationalizing" the whole of community approach that is fundamental to the recovery of a community after a disaster. However, the NDRF is a strategic document and provides little by way of actual guidance for community organization or planning. Specific characteristics of this area that relate to technology development and the application of smart city applications:

- Disaster Recovery is a new opportunity (i.e., a market) for technology development and integration. Public officials and private sector decision-makers currently lack the decision-making aids, data sharing networks, and operational protocols already in use by first responders.
- The Disaster Recovery area is amenable to research, technology development, and pilot testing unencumbered by the requirement for 24x7 readiness that response agencies must maintain.
- However, there is little opportunity to conduct operational testing or piloting of recovery technologies or methods, since any operational employment will likely be under the most strenuous and critical of circumstances. Likewise, there is little documented experience to draw on for guidance or comparison.
- The development and integration of technology systems or applications relating to disaster recovery will necessarily require compatibility with legacy systems of emergency management and first responder agencies, which play an active role in coordinating the transition from disaster response to recovery, and continue to public safety functions alongside agencies involved in the recovery of community services and public safety infrastructure.

Approach for Disaster Recovery in Smart and Connected Communities

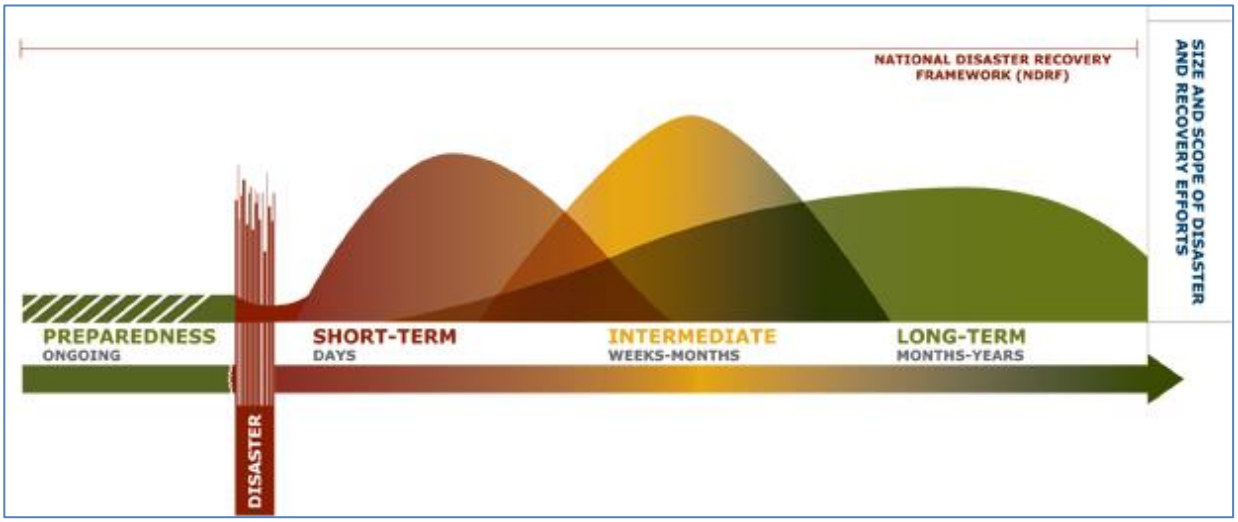
As described in the two previous sections, the areas of Public Safety and Emergency Preparedness principally involve professional disciplines of law enforcement, fire-fighting, EMS, and search and rescue that have specialized equipment, communications devices, vehicles and transport, and personnel protection equipment (PPE). These professions are supported by dedicated industry and commercial partners, and guided by professional, fraternal, and trade associations that define requirements, establish professional standards, and provide oversight in R&D and test and evaluation (T&E) of technologies and equipment. Within the last two decades, there has been a similar evolution in professionalization and the application of specialized technologies for Emergency Management and EOCs, particularly in the areas of information display and decision-support, geographic information systems and computer-based mapping, and improvements in connectivity and data sharing between operations centers and units in the field.

In contrast to the other sectors covered in this *Blueprint*, Disaster Recovery is largely the domain of authorities not specially trained in emergency procedures or disaster management, such as local and regional governmental authorities, the commercial sector, and the civil population itself. Unlike preparedness and response that are covered by NIMS/ICS, disaster recovery is guided only by the National Disaster Recovery Framework (NDRF) published by FEMA in 2014, ten years after NIMS/ICS was adopted by the first responder community. While the NDRF provides a conceptual framework and planning factors relevant to community recovery efforts, the document does not provide a doctrine or methodology for community recovery efforts in the same way that NIMS standardizes disaster response and coordination. Disaster recovery is the responsibility of the community at large, for whom there is no current process grounded in decades of professional experience, documentation, and lessons learned.

Disaster recovery is an emerging discipline in the field of emergency management, and at this point is the least mature of the five functions of the incident management cycle (prevention, protection, response, recovery, and mitigation). As will be described in the next section on City Resilience, capabilities for effectively managing disaster recovery would contribute significantly to the overall resilience of a city or region. An effective, proven strategy for disaster recovery is thus one of the unmet needs in community resilience implementation.

Figure 10 illustrates the timeline for disaster recovery, which can stretch from weeks into years, and remains the purview of the community, local government agencies, the private sector, and the affected population. Dedicated resources to restore normal community functions like school systems, the medical and public health infrastructure, the commercial sector and employment and tax bases are lacking.

Figure 10: National Disaster Recovery Framework timeline for disaster recovery



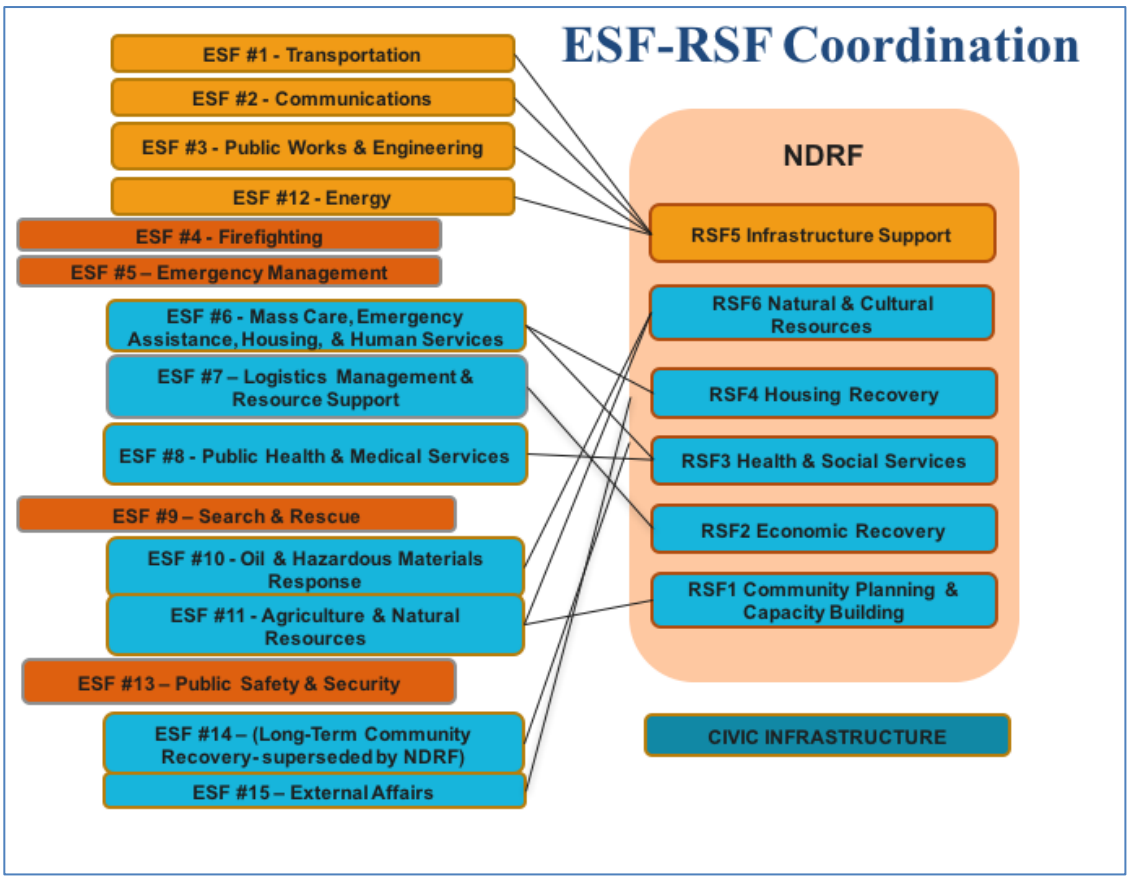
Of greater significance than the lack of formal doctrine, is that no training program or certification process exists for the local government officials, community leaders, business owners, or citizens who suddenly find themselves in the role of disaster managers during the recovery phase. Unlike professional agencies such as fire-fighting, law enforcement, or emergency medical services, there is no ongoing training program to hone planning skills or "certify" a community and its leadership in disaster recovery. In reality, the process and skills are acquired through "on the job training" among community leaders under the most stressful possible conditions. Traditionally, every disaster recovery executed by a local community has been a one-off design developed by the community itself. An additional challenge lies in establishing usable measures of effectiveness and metrics for determining which recovery approaches or strategies deliver the most benefit at the least cost, in both monetary and social terms.

A second challenge in the disaster recovery field is that public officials and community leaders who must recover a disaster-impacted community are rarely exposed to the challenges they will face in a disaster, except when it is suddenly thrust upon them. The challenge is not simply in designing and testing disaster recovery protocols and strategies, but in making them amenable to "just in time delivery" in the immediate aftermath of a crisis, when city officials, department heads, economic development organizations, non-profits and volunteers, and community leaders must all determine the path forward for restoring their damaged community, based on little or no prior experience in the task.

A useful approach for distinguishing the scope of emergency response from that of recovery is provided by the Emergency Support Functions (ESFs) and Recovery Support Functions (RSFs) established by DHS and FEMA and articulated in the National Preparedness Goal and National Disaster Recovery Framework. The ESF and RSF models describe a set of core capabilities and competencies in emergency response and disaster recovery (15 ESFs and 6 RSFs). While these provide a notably federal perspective on the scope of public safety, the ESF/RSF framework offers a useful structure for identifying areas of public safety where research and development of technology applications may achieve significant benefits for public safety

and overall community resilience. Appendix A lists ESFs and RSFs and citations for the FEMA websites where the documents may be accessed.

Figure 11: Relationships between Emergency Support Functions (Preparedness and Response) and Recovery Support Functions (Recovery).



The key challenge for ensuring capabilities for effective disaster recovery in S&CC is to provide technologies that can support multi-agency, community level decision-making and collaboration under conditions when infrastructure systems are damaged or of limited availability, and numerous priorities compete for immediate attention. A planning assumption is that the NDRF/RSF approach should form the basis for future disaster recovery protocols and technology development efforts.

The following section addresses considerations for technology strategies to enhance overall City and Community Resilience, which in turn, also serve to build capacities for disaster response and recovery and overall public safety.

IV. City Resilience

The previous section focused on technology development to support whole community planning for disaster recovery, with emphasis on the requirements for multi-agency planning and decision-making involving an entire community and its physical, economic, and social resources.

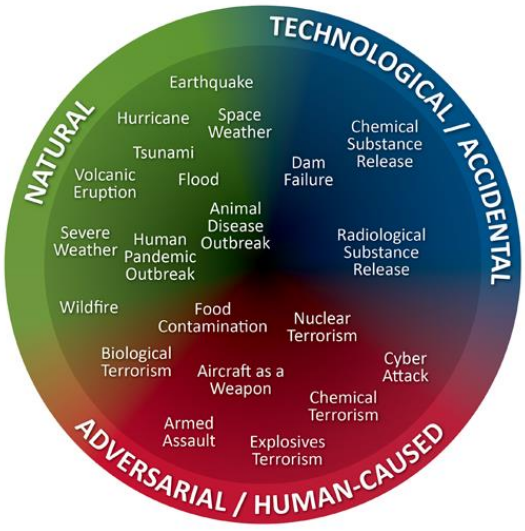
Technology development strategies to enhance City (or Community) Resilience are closely aligned with capabilities for disaster recovery, insofar as they involve the entire scope of community functions. However, developing a technology strategy for enhancing the resilience of a community or region involves more than focusing on disaster response or recovery (or disaster resistance, as it is sometimes called), or even on the single issue of public safety as traditionally defined. A holistic approach to resilience and community sustainability involves the broad spectrum of human activities and interactions within the community as the sum of relationships between four interconnected systems:

1. The natural environment of geography, climate and weather;
2. The built environment of the city habitat, its engineered systems, and physical infrastructure;
3. The social environment of human population, communities and socio-economic activities; and
4. An information ecosystem that provides the means for understanding, interacting with, and managing the relationships between the natural, built, and human environments.

As the nation and its communities become more connected, networked, and technologically sophisticated, new challenges and opportunities arise that demand a rethinking of current approaches to public safety and emergency management. An integrated approach to city and community resilience holds the potential to greatly enhance overall public safety, emergency response, and disaster recovery, while addressing new and emerging threats to public safety and security.

Community resilience-building is effectively an aspect of mitigation planning. Figure 12 illustrates the range and relationships among the hazards that community resilience programs in the public safety arena may need to address.

Figure 12. Examples of Threats and Hazards Facing Communities (DHS National Mitigation Framework)

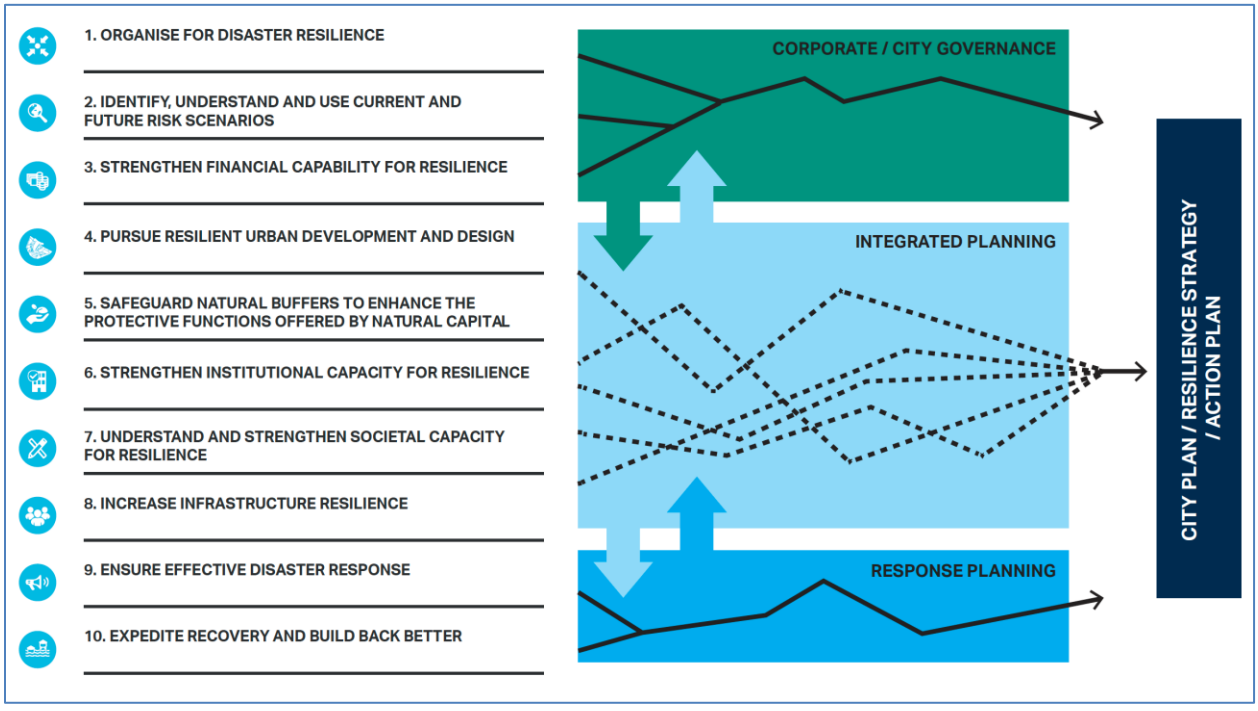


After nearly a decade of research, planning, policy development, and implementation, there is no shortage of models, frameworks, and guidance documents for developing and establishing a community resilience program. (By way of example, simply conduct an online search for "community resilience frameworks," or "smart city.")[14] One widely accepted strategy is the "Sendai Framework" of the United Nations Office for Disaster Risk Reduction.

Resilience as defined by the Sendai Framework is the ability of a system, community, or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its Essential basic structures and functions through risk management. Increasingly, in the context of cities resilience is framed around the ability to withstand and bounce back from both acute shocks (natural and manmade) such as floods, earthquakes, hurricanes, wild-fires, chemical spills, power outages, as well as chronic stresses occurring over longer time scales, such as groundwater depletion or deforestation, or socio-economic issues such as homelessness and unemployment.

The United Nations Disaster Resilience Scorecard for Cities is a recommended starting point for cities to self-assess their preparedness. This Scorecard is structured around the "Ten Essentials for Making Cities Resilient", first developed as part of the Hyogo Framework for Action in 2005, and then updated to support implementation of the Sendai Framework for Disaster Risk Reduction: 2015-2030.

Figure 13: The Ten Essentials of Making Cities Resilient from the Sendai Framework



[14] The Sendai Framework of the United Nations Office for Disaster Risk Reduction us one notable example. A second is the Rockefeller 100 Resilient Cities program. Both are cited in the References and Resources section.

As shown in Figure 13, the Ten Essentials for Making Cities Resilient offer a broad coverage of the many issues cities need to address to become more disaster resilient:

- Essentials 1-3 cover governance and financial capacity;
- Essentials 4-8 cover the many dimensions of planning and disaster preparation;
- Essentials 9-10 cover the disaster response itself and post-event recovery.

Planning Strategies

A city is a system of systems, with each of those systems (e.g. communications, water, sanitation, energy, healthcare, welfare, law and order, education, businesses, social and neighborhood systems) potentially having separate owners and stakeholders. Resilience needs consideration within and across each of these systems and therefore can only be achieved through effective collaboration.

A range of actors—whether government, private business, community groups, academic institutions, other organizations or individuals—have roles to play in maintaining and improving city resilience. Ideally, local government authorities (which often have the best convening power) should take the lead in conducting the assessments of the Scorecard. A multi-stakeholder dialogue and approach between key city stakeholders will be necessary to complete the Scorecard, and is essential in the push towards more resilient cities.

Local governments that have used the Scorecard have found it useful at a range of levels:

- As a high-level survey, often via a 1 or 2-day workshop – this can be supported by questionnaires that participants fill out in advance. Sometimes an average or consensus score is applied at the level of each of the "Ten Essentials," rather than for each individual criteria / assessment;
- As a limited exercise focusing on some individual Essentials, to create an in-depth review of some specific aspects of resilience, e.g. community-level preparedness;
- As a detailed review of the city's entire resilience position, likely to take one to several months to complete.
- In light of user feedback, the Scorecard now offers the potential for scoring at two levels:
  - Level 1: Preliminary level, responding to key Sendai Framework targets and indicators, and with some critical sub-questions. This approach is suggested for use in a 1 to 2-day city multi-stakeholder workshop. In total, there are 47 questions / indicators, each with a 0 – 3 score;
  - Level 2: Detailed assessment. This approach is a multi-stakeholder exercise that may take 1 – 4 months and can be a basis for a detailed city resilience action plan. The detailed assessment includes 117 indicator criteria, each with a score of 0 – 5. Note that the criterion in the detailed assessment may serve as helpful discussion prompts for a preliminary level workshop.

Some intentional overlap exists between the preliminary and detailed assessments. Cities completing the detailed assessment should find it easier if they have already completed the preliminary. The detailed assessment is designed to build on the preliminary, but prompts deeper thought, review and consultation. Download a detailed assessment from: http://www.unisdr.org/campaign/resilientcities/home/toolkit.

- While the Scorecard aims to be systematic, individual scores may unavoidably be subjective – use judgment to decide which scores apply most closely to your level of disaster resilience. Recording your justification for each evaluation score will enable validation, as well as future revisions and tracking of progress;
- Disaster risk reduction and building resilience needs to be a collaborative effort. Some aspects of disaster resilience may not be under the control of local governments (for example, the city's electricity supply or phone system may be operated by a separate agency or private utility, or there may be a provincial or neighboring government that also needs to be involved). The Scorecard should be completed in consultation with these other organizations. The consultation process will also help to engage and build understanding, ownership and alignment with these other organizations;
- Consulting citizen groups as you complete the Scorecard will improve the validity of your results;
- Being as accurate and realistic as possible will help identify areas of vulnerability, enabling their prioritization for attention and funding;
- The Scorecard may not address all the disaster resilience issues facing your city. If in doubt, take advice from an expert in risk management or another relevant discipline.
- The Scorecard provides an aspirational definition of disaster resilience – it is unlikely that any city will score maximum points, and most will not score more than 50%. The intention of the Scorecard is to guide cities towards improved disaster risk reduction, and to challenge complacency.
- The scores are not normative and therefore not comparable across different cities. The Scorecard was not designed to facilitate competition between cities, but to identify and promote sharing of knowledge.

Considerations for Technology Development and Insertion

The challenges or threats to public safety and security depicted in Figure 12 offer opportunities for introducing technology advancements to improve the resilience and sustainability of the overall community ecosystem. RDT&E of advanced technologies would, for example, include such priorities as:

- Design and integration of intelligent infrastructure—including embedded sensors, IoT, wireless information technologies, and real-time data capture and analysis;
- Improvements in environmental monitoring and predictive analytics that could contribute to public health monitoring, as well as the monitoring of geological and environmental conditions;
- Resilient infrastructure design with emphasis on electrical grid and telecommunications systems that can sustain public communications and connectivity during emergencies and disasters;
- Enhanced data analytics leading to better modeling and display of decision-making within multi-agency and multi-disciplinary team systems, that are appropriate to Blue-Sky city management

and daily operations, but which can transition seamlessly to high-criticality decision-making under the stress of Dark-Sky disasters and civil emergencies.

In this regard, the technology development projects within GCTC member communities exemplify the range of technologies and concepts with potential for improving the overall community resilience. Currently, the SuperClusters are organized into five areas of research and development for technology insertion:

- Transportation
- Energy, Water, and Environment
- City Data Platform / Dashboard
- Public WiFi / Broadband
- Public Safety

Collectively, these SuperClusters represented 92 participating city and technology developer teams, and a portfolio of over 100 Smart City Applications, each of which contributes to some aspect of improving the resilience, health, safety, or quality of life within a connected community.

The next section offers a general approach for designing and implementing a Smart Public Safety Program within a Smart and Connected Community. Like this *Blueprint*, itself, the approach is based on the initial work of the PSSC during its first year, and will be expanded with input from PSSC member communities and Action Clusters, based on the real-world experience of developing, piloting, and implementing smart technology applications for public safety, disaster response and recovery, and community resilience.

V. Designing and Implementing a Resilient, Smart Public Safety Program

From Stand-Alone Pilots to Responsive Ecosystem

To be successful, a smart city technology solution must mature from a pilot that meets research and development goals, to a sustainable system that can be replicated or scaled to provide key capabilities that respond to operational requirements, while driving further innovation in a broader, more responsive ecosystem. The ability for projects to provide expanding impact into multiple areas (with primary and secondary benefits) is a key consideration for technology applications to support S&CC.

A brief survey in Spring 2017 of active GCTC action clusters revealed the following initiatives focused on emergency preparedness and response, along with action clusters that leverage open data, overall city resilience, transportation, citizen engagement, utilities, public health, and other sectors. This list is not exhaustive, as new action clusters are forming and developing technology solutions on an ongoing basis.

Flood and severe weather warning sensor systems – Emergency Preparedness (Prevention, Protection, and Mitigation)

- Advanced Flood Warning and Environmental Awareness System
- Next Generation Resilient Warning Systems for Tornados and Flash Floods
- Real-Time Threat Monitoring and Management for City Underground Infrastructure
- Safe Town Resilient Communication Platform “NerveNet” for Earthquakes and Tsunamis
- Water Level Management for Flood Prevention
- Seismic and Infrastructure Monitoring
- Atmospheric Sensing for Severe Weather Threats
- Air Quality Sensing Supporting Public Health
- StormSense Flood Forecasting

Emergency Response (Mitigation, Response, and Recovery)

- Drone-based smart emergency response for surveillance and data collection
- Deployable communications and decision support for Incident Command Systems
- Artificial Intelligence and predictive analytics for emergency responders
- Geo-fenced alerting solutions to reduce response times for responders
- Intelligent mobile battery storage systems to support city resilience and emergency response
- Multi-time scale logistical scheduling, maintenance and dispatch for emergency services
- SMART multi-team response training for emergency medical teams
- Business EOCs (staffed and/or virtual)

Other

- Open data platforms for scalable and multi-domain IoT applications for environmental and infrastructure monitoring to support predictive analytics
- Real Time Resilience – Data treatment tools supporting real-time decision-making
- Community traffic guidance and control system supporting disaster response and evacuation
- Safe community awareness and alerting network

Priorities for Technology Development and Implementation to Enhance Public Safety

A key challenge facing communities in addressing the potential hazards and vulnerabilities that must be addressed in a Smart Public Safety program resides in simply finding a methodology for dividing the challenge into manageable phases or steps. During deliberations among members of the PSSC Working Group, we discovered the need to develop a process like the community problem-solving approach provided in the Comprehensive Preparedness Guide for Pre-Disaster Recovery Planning developed by FEMA (Figure 14). While this approach is directed at planning for disaster recovery, it offers a useful approach for determining technology development opportunities or insertion points that might improve overall City Resilience or the capability for a community to effectively plan for, and recover from a disaster or civil emergency. As a guideline for identifying technology requirements and priorities, this process may prove useful.

Figure 14. Comprehensive Preparedness Guide Planning Steps (FEMA Pre-Disaster Recovery Planning Guide for State Governments, 2016)

1. Overall Planning Considerations

The following are the high priority challenges and opportunities identified by the PSSC for technology applications that would enhance public safety and community, city, or regional resilience.

Goal: Enable effective decision-making and coordination of resources, talent and community energy to effectively maintain and restore community functions, and recover community vitality whenever impacted by localized civil emergencies, or large-scale, regional disasters.

Objective 1: Identify opportunities for technology applications to provide just-in-time access to relevant information and decision support aids to improve collaborative planning, and to mobilize resources to speed restoration of community functions.

Objective 2: Ensure that technology development and insertion within S&CC supports current and future needs for both organization and system compatibility (i.e., enhances an open community, as well as an open technology standard).

Objective 3: Provide relevant information to all citizens to ensure the preservation of community cohesion, social structures, and motivation, to engage the talent and energy of the entire community.

Objective 4: Ensure the ability within all technology applications and systems for data capture, transfer, and analysis to improve future disaster recovery methodologies and develop a "learning organization" approach to community resilience.

Objective 5: Build a culture of resilience across community functions, focused on disaster recovery as a critical community capability (i.e., plan for Recovery, rather than simply for Response).

2. End-Users and Audiences for Public Safety Technologies

- Smart cities (i.e., networked and technologically sophisticated)
- Non-Smart cities (i.e., traditional cities with legacy IT infrastructures)
- Communities of any size and geography (scalability)
- First Responders and response agencies
- City agencies, services, departments (critical infrastructure systems and public works)
- Medical services (hospitals; pharmacies; clinics; veterinary)
- City / Community services
    - Non-profits; private voluntary organizations; Faith-based organizations
    - Volunteer Organizations Active in Disasters (VOADs)
    - Philanthropic organizations
- Business / Retail Big-Box (National chains) + Small Business (Local/community)
- Schools and childcare services
- Individual citizens and households
- English Proficient / Non-native English speaking communities

3. Priorities for Cities to Build Resilient Systems and Enhance Public Safety and the Ability for Efficient Recovery

- Communications (internal and external) with priority on public Wi-Fi and mobile devices communications for dispersed and fluid population
- Collaboration capabilities for decision-makers at all levels
- Dedicated communications for Governance / Leadership
- Infrastructure situational awareness among agencies responsible for critical systems
- Data capture, storage, processing, retrieval, and
    - Actionable and secure
    - Dynamic and evolving
    - Accessible and available
- Education / training for community preparedness and recovery using a model of Plan/Organize/Equip/Train/Exercise/Improve
- Social Science research and analytics in such fields as
    - Behavioral economics / organizational behavior / risk/disaster behavior
    - Goal: Change human behavior at the individual and community level and improve individual and community resilience against future events.

4. Current and Future Resources and Technology Investments for Public Safety

- Resilient, pervasive internet (near-universal access to information / knowledge)
    - Ubiquitous, uninterruptible power and communications network
    - Dedicated communications channels for civil officials and responders (i.e., FirstNet)
    - Similar dedicated communications channels for civil population for disaster recovery management (i.e., a FirstNet for the civil population)
    - Graceful degradation and restoration of capability based on priority of need
- Research into leadership methods for ensuring credibility and openness during crises
- Community Centers (i.e. rallying points for community coordination - both real and virtual)
- Community planning system and decision support tools
- AI + Machine Learning (i.e., disaster communications that learn the community)
- Modeling and Simulation for training and Course of Action/Alternatives analysis

5. Strategies for Ensuring Adoption of Smart Public Safety Goals

- Develop a strong Business Case for technology investment and adoption (e.g., technologies with utility during both “Blue Sky” and “Dark Sky” conditions)
- Develop a "Safety Case" that addresses opportunity costs and potential losses from a failure to invest in public safety technologies (essential to assure city government/leadership of the value,

reliability, and applicability, and to serve as shield against liability) to ensure political and financial investments in recovery and resilience strategies are accepted

- Business community and private sector involvement and support
    - Strategies to share / defray liability
    - Surmount information management challenges, particularly under degraded conditions
- Higher fidelity Geo-fencing of hazard/warning alerts and localization and discrimination to avoid "crying wolf" syndrome and population overload from frequent alerts
- Engage the expertise and involvement of legal profession in city recovery and resilience efforts.
- Investments in public safety technologies should be backed by research and Pilot Tests as a community risk-reduction strategy

Next Steps for the Public Safety SuperCluster

In addition to developing this *Blueprint for Smart Public Safety*, the members of the GCTC Public Safety SuperCluster intend to continue engagement with Action Clusters of the GCTC that have projects of benefit to public safety, disaster response and recovery, and community preparedness. The goal for the PSSC is to continue to refine the *Blueprint* with input from PSSC Action Clusters, and engage new member cities and technology developers. Future initiatives include:

1. Participating via Action Clusters to address technology shortfalls in public safety. This involves expanding existing action clusters and starting new action clusters by developing new GCTC and PSSC member cities, assist in identifying funding sources, and building a multi-disciplinary team.
2. Adapting the Smart Public Safety solution guidance documentation to assist cities in planning and implementing a program within their respective cities.
3. Contingent upon the availability of resources, holding multi-regional table top exercises for specific public safety scenarios that demonstrate action cluster capabilities and program guidance.

The initiative has four objectives and four next steps:

1. Identify capability gaps and national challenges in public safety that existing and maturing research projects among GCTC member communities and technology firms can address; ***NEXT STEP #1 - Finalize and Publish the Blueprint for Smart Public Safety for Connected Communities and begin work with Action Clusters on a detailed Playbook for implementing in pilot communities.***

2. Establish a forum for nurturing integrated, multi-disciplinary research in public safety strategies and technologies with input from first responders, emergency planners, and community leaders; ***NEXT STEP #2 - Work with the PSSC Membership and associated Action Clusters to establish regular meetings for bringing representatives across whole Communities together to share improvements to the Blueprint and Playbook.***

3. Identify opportunities to collaborate with state, county, and municipal partners to define requirements and validate approaches for enhancing community resilience and responding to and recovering from disasters and civil emergencies.
   NEXT STEP #3 - Begin a Public-Private-Partnership consultative process to assist municipalities with planning, funding and implementing the "Smart Public Safety" Program.

4. Identify opportunities for supporting programs in Science, Technology, Engineering and Math (STEM) education—engaging students and emerging scientists and professionals to nurture the next generation of researchers, technologists, and practitioners dedicated to research and technology development in the interest of public safety.
NEXT STEP #4 - Working through our Academia & research partners, build a STEM education plan for "Smart Public Safety" for the "Whole Community" initiative.

Appendix A: Emergency Support Functions

FEMA Emergency Support Functions (ESFs) may be selectively activated for both Stafford Act and non-Stafford Act incidents. Not all incidents requiring Federal support result in the activation of ESFs. For Stafford Act incidents, the National Response Coordination Center (NRCC) or Regional Response Coordination Center (RRCC) may activate specific ESFs or other Federal agencies (OFAs) by directing appropriate departments and agencies to initiate the actions delineated in the ESF Annexes. Resources coordinated though ESFs are assigned where needed within the response structure. For example, if a state requests assistance with a mass evacuation, resources from several different ESFs may be integrated into a single Branch or Group within the Operations Section. During the response, these resources would report to a supervisor within the assigned Branch or Group.

Recovery Support Functions (RSFs) are established as annexes to the National Disaster Recovery Framework (NDRF) and support the community, lead agencies, and private sector enterprises in planning and coordinating the recovery of a community from the effects of a catastrophic disaster or emergency.

The following table illustrates the rough correspondence between ESF/RSF structures.

ESF	Coordinator	Roles
ESF #1 – Transportation	**US Department of Transportation**	Aviation/airspace management and control Transportation safety Restoration and recovery of transportation infrastructure Movement restrictions Damage and impact assessment
ESF #2 – Communications	**US Department of Homeland Security (DHS)**	Coordination with telecommunications and information technology industries Restoration and repair of telecommunications infrastructure Protection, restoration, and sustainment of national cyber and information technology resources Oversight of communications within the Federal incident management and response structures
ESF #3 – Public Works and Engineering	**US Department of Defense (U.S. Army Corps of Engineers)**	Infrastructure protection and emergency repair Infrastructure restoration Engineering services and construction management Emergency contracting support for lifesaving and life-sustaining services
ESF #4 – Firefighting	**US Department of Agriculture (US Forest Service)**	Coordination of Federal firefighting activities Support to wildland, rural, and urban firefighting operations
ESF #5: Information and Planning	**DHS (FEMA)**	Collects, analyzes, processes, and disseminates information about a potential or actual incident Conducts planning activities
ESF #6: Mass Care, Emergency Assistance, Temporary Housing and Human Services	**DHS (FEMA)**	Mass care Emergency assistance Disaster housing Human services

ESF #7 – Logistics Management and Resource Support	**General Services Administration and FEMA**	Comprehensive, national incident logistics planning, management, and sustainment capability Resource support (facility space, office equipment and supplies, contracting services, etc.)
ESF #8 – Public Health and Medical Services	**US Department of Health and Human Services (HHS)**	Public health Medical Mental health services Mass fatality management
ESF #9 – Search and Rescue	**DHS (FEMA)**	Lifesaving assistance Search and rescue operations
ESF #10 – Oil and Hazardous Materials Response	**US Environmental Protection Agency**	Oil and hazardous materials (chemical, biological, radiological, etc.) response Environmental short- and long-term cleanup
ESF #11 – Agriculture and Natural Resources	**US Department of Agriculture**	Nutrition assistance Animal and plant disease and pest response Food safety and security Natural and cultural resources and historic properties protection Safety and wellbeing of household pets
ESF #13 – Public Safety and Security	**US Department of Justice**	Facility and resource security Security planning and technical resource assistance Public safety and security support Support to access, traffic, and crowd control
ESF #14: Long Term Community Recovery		Long Term Community Recovery is superseded by the National Disaster Recovery Framework (NDRF): http://www.fema.gov/nationaldisasterrecoveryframework
ESF #15 – External Affairs	**DHS**	Emergency public information and protective action guidance Media and community relations Congressional and international affairs Tribal and insular affairs

Sources: https://emilms.fema.gov/IS230c/FEM0104160text.htm and https://www.fema.gov/recovery-support-functions

Appendix B: Recovery Support Functions National Disaster Recovery Framework

RSF	Title	Function
1	Community Planning and Capacity Building	Coordinates support (technical, financial, capacity) and helps build the recovery capacities and community planning resources of state, tribal, territorial, and local governments before and after disaster events. Focuses on enhancing governmental capacities to effectively plan for, manage, and implement disaster recovery activities in large, unique or catastrophic disasters.
2	Economic Sector and Commerce	Integrates the expertise of the Federal government to help local, state, and tribal governments and the private sector sustain and/or rebuild businesses and employment, and develop economic opportunities that result in sustainable and economically resilient communities, after significant natural and man-made disasters. Core Capabilities include: • Communication and information sharing • Communication and information sharing • Economic recovery impact assessment/analysis • Development of an Economic Recovery Action Plan • Implementation support and progress monitoring
3	Health and Social Services	Assists locally-led recovery efforts in the restoration of the public health, health care, and social services networks to promote the resilience, health and well-being of affected individuals and communities. Emphasizes the ability to restore and improve health and social services networks and promotes the resilience, health (including public health, behavioral health, and medical services), independence, and well-being of the whole community
4	Housing	Addresses pre- and post-disaster housing issues and coordinates and facilitates the delivery of Federal resources and activities to assist local, State and Tribal governments in the rehabilitation and reconstruction of destroyed and damaged housing, whenever feasible, and development of other new accessible, permanent housing options.
5	Infrastructure Systems	Integrates the capabilities of the federal government to support Tribal, State, and Local governments and other public and private infrastructure owners and operators to expedite long–term infrastructure recovery.
6	Natural and Cultural Resources	Integrates Federal assets and capabilities to help State and Tribal governments and communities to address long-term environmental and cultural resource recovery needs after large-scale and catastrophic incidents. Emphasizes the ability to protect natural and cultural resources and historic properties through appropriate actions to preserve, conserve, rehabilitate, and restore them consistent with post-disaster community priorities and in compliance with appropriate laws.

Source: https://www.fema.gov/recovery-support-functions

Appendix C: PSSC Action Cluster Technology Applications

This section will be completed with the addition of projects and technology demonstrations that were displayed at the August 2017 Global City Teams Challenge Exposition in Washington, D.C.

This section provides descriptions of the research projects, technology applications, and concept demonstrations of PSSC Action Clusters and member cities and technology developers. Updates to this section will be made and new projects added as the PSSC Action Cluster team grows and technology applications are added.

The Public Safety SuperCluster encourages all members of the GCTC Action Clusters to provide copies of other projects that have relevance to Public Safety, or that improve the overall resilience of communities, cities or regions. As appropriate, we

1. A 1- to 2-page (front/back) Overview / Concept of Operations / Abstract of your project along with your city affiliation and a lead Point of Contact; and
2. A 1-page graphic that illustrates your technology application or concept.

The PSSC is open to membership by all communities, private sector enterprises, non-governmental organizations, and government agencies (at all levels), who share an interest in addressing current and future challenges in public safety, disaster preparedness, and community resilience through the development and integration of advanced technologies

Glossary

DHS	Department of Homeland Security
EMAC	Emergency Management Assistance Compacts
EOC	Emergency Operations Center
ESF	Emergency Support Functions
FEMA	Federal Emergency Management Agency
GCTC	Global City Teams Challenge
ICS	Incident Command System
IoT	Internet of Things
NDRF	National Disaster Recovery Framework
NIMS	National Incident Management System
NIST	National Institute for Standards and Technology
PPP	Public Private Partnerships
PSAP	Public Safety Answering Point
PSSC	Public Safety Super Cluster
RSF	Recovery Support Functions
S&CC	Smart & Connected Community

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