Public Safety Location-Based Services Challenges Report

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Introduction

Since 2019, the National Alliance for Public Safety GIS (NAPSG) Foundation has explored the information axis, or i-Axis, as part of the Public Safety Innovation Accelerator Program (PSIAP) out of the National Institute of Standards and Technology (NIST), Public Safety Communications Research Division. The i-Axis is defined as the abundance of data that could be beneficial for public safety use, such as internet of things data (IoT), the operation of smart homes and cities, and other sensors in use throughout the community.

> The i-Axis project sought to answer the question "how will public safety organizations utilize all of the new indoor technologies (mapping, localization, and navigation) and data sources to effectively improve operations?"

As the team explored best practices, barriers to adoption, and technology advancements over the years, there was an effort to capture ongoing gaps related to indoor mapping, tracking, and navigation.

This report is informed by feedback from the i-Axis community and heavily influenced by the expertise on the Location-Based Services First Responder Working Group. Other input was captured from:

- In-person and virtual events:
  - PSCR Annual Stakeholder Meetings
  - Indoor Wireless Communications Expo speaking opportunities
  - Datamark Orbit speaking opportunities
  - International Society of Fire Service Instructors speaking opportunities
- Innovation Outreach Toolkit – a survey of first responders nationwide on their adoption of LBS technologies
- Gap and priority survey – a survey of first responders nationwide on significant gaps and future priorities of LBS technologies
- Coordination with other NIST PSCR PSIAP awardees
- Best Practices Guide to Indoor Mapping, Tracking, and Navigation public comment period

To accelerate the adoption of emerging technologies related to indoor mapping, tracking, and navigation, this report identifies significant challenges and offers recommendations on future research priorities. More importantly, it draws on the significant feedback from the public safety community and reflects the operational environment today.

> The purpose of this report is to highlight significant mapping, tracking, and navigation challenges, as well as prioritize areas for future research (and funding).

One challenge that is not covered in each section but applies across mapping, tracking, and navigation is the need to identify interoperable data standards when transmitting location-based services information.

Mapping Challenges

Indoor mapping was found to be the most mature field in the i-Axis. Still, significant gaps remain in both the outdoor and indoor space, including:

1. Outdoor and indoor mapping workflows are labor intensive.
2. Standardized symbology across public safety disciplines is not utilized.
3. Mapping data is not dynamic nor tailored to the end user.

Mapping workflows:

Gap:

Most jurisdictions lack a comprehensive dataset of mapping products for existing infrastructure. Detailed floorplans, whether 2D or 3D, are rarely provided to first responders. The inability to create even basic maps, and the lack of easy to use, interoperable, and affordable mapping tools hinders the ability of first responders to integrate geo-located and i-Axis based information.

Recommendation:

A comprehensive mapping workflow for outdoor and indoor products, to include 2D and 3D, should be developed. This solution should leverage emerging technologies such as 3D LiDAR scanning, utilize robots/unmanned aerial systems, and provide a user interface and user experience that is easy to understand by both the first responder community and the public.

Additionally, jurisdictions should create a methodology for identifying infrastructure to be mapped, such as:

- Critical infrastructure and key resources
- Older infrastructure with hand drawn blueprints vs “smart buildings” with comprehensive building information management (BIM) plans

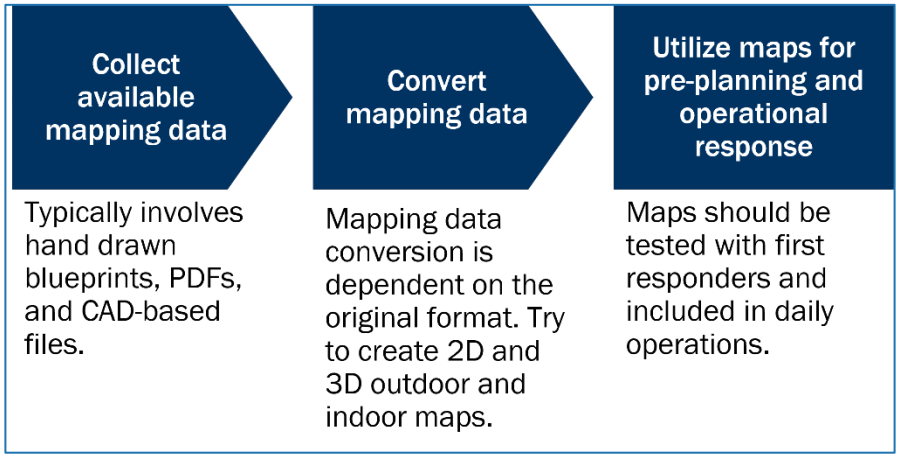

Figure 1 Mapping workflow example

Standardized symbology:

Gap:
Using symbols as a method for communication has been proven to have a more memorable and effective sustained recall compared with text and audio. Unfortunately, standardized symbology, or at least a single standard, is not utilized across disciplines.

Recommendation:
A standardized outdoor and indoor symbol library should be created, and it should include components such as:

- Symbol density and clustering
- Mounted and dismounted symbology
- 2D and 3D symbols
- Standardized color ramps

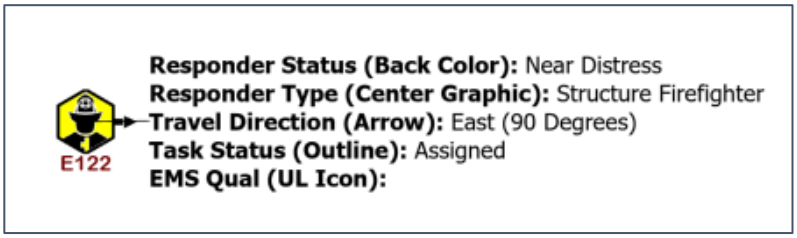

Figure 2 Symbol attributes example

Much like the use of "plain language" when following the National Incident Management System (NIMS), symbols should be interoperable across jurisdictions and disciplines.

Dynamic data:

Gap:
Cognitive overload leads to first responders disregarding, or missing, key pieces of information. As more data is available from the i-Axis, public safety agencies have not prioritized data streams by disciplines, role, or time during an incident.

Recommendation:
Data prioritization by role, position, time of incident, and other factors should be explored. Inundating mapping products with pre-planned data, incident data, and in the future tracking and navigation data will render maps unreadable.

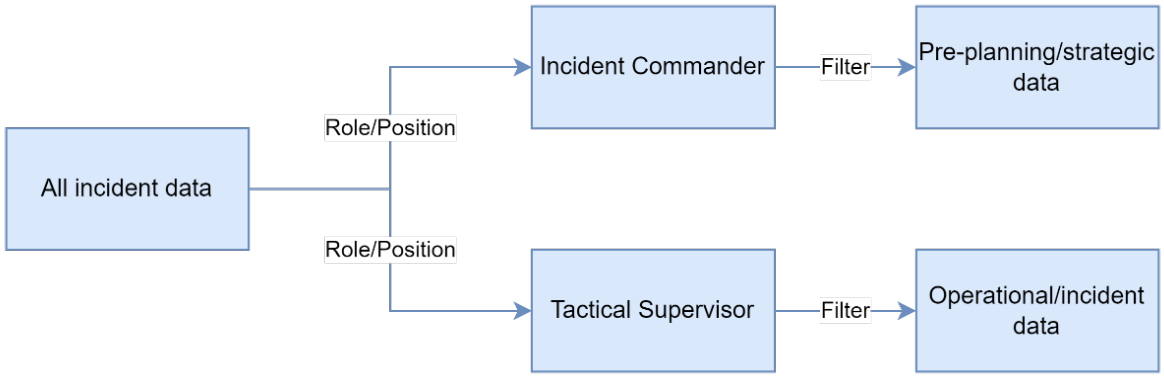

Figure 3 Dynamic data workflow example

Tracking Challenges

Indoor tracking promises to revolutionize public safety response. As of today, tracking technology is not quite ready for public safety use, suffering from challenges including:

1. Tracking technology is not infrastructure-free
2. Tracking policies, procedures, and governance are immature
3. Tracking data (last known point, tracklogs) may clutter the map

In search of infrastructure-free:

Gap:

Widespread adoption of infrastructure-free tracking requires a passive system that is interoperable with existing equipment. Pre-installing indoor positioning systems, requiring unmanned aerial systems or deploying beacons, or requiring responders to calibrate before they enter a building will slow the adoption process. Most existing infrastructure lacks indoor positioning systems, sensors, or other "smart" building features.

Recommendation:

Tracking solutions should be designed, tested, and refined with constant first responder input. Tracking solutions should easily integrate into current equipment such as:

- Fire – SCBAs, turnout gear, fire helmets, etc.
- Law enforcement – duty belt, radio
- EMS – medical kit

Policies, procedures, and governance

Gap:

Agencies are hesitant to adopt tracking technologies before defined policies, procedures, and governance are in place. Concerns around responder safety, data and operational security, and interoperability exist.

Recommendation:

Best practices for tracking technologies should be promulgated, to include:

- Core tracking concepts such as last-known-point and tracklogs
- Refresh intervals
- Information sharing
- Data access, retention, and security

Tracking data

Gap:
Transforming tracking data such as last-known-points and tracklogs into actionable intelligence remains difficult. Form factors, such as smartphones and tablets, limit the available screen space and resolution and are expensive when purchasing "ruggedized" versions to operate in low light, extreme heat, and disconnected environments.

Recommendation:
Research should be conducted into tracking data visualization, to include:

- Tracking at a unit vs individual level
- Dynamic refresh intervals to reflect maydays/officer down scenarios
- Battery life expectancy
- Data retention, access, and security best practices

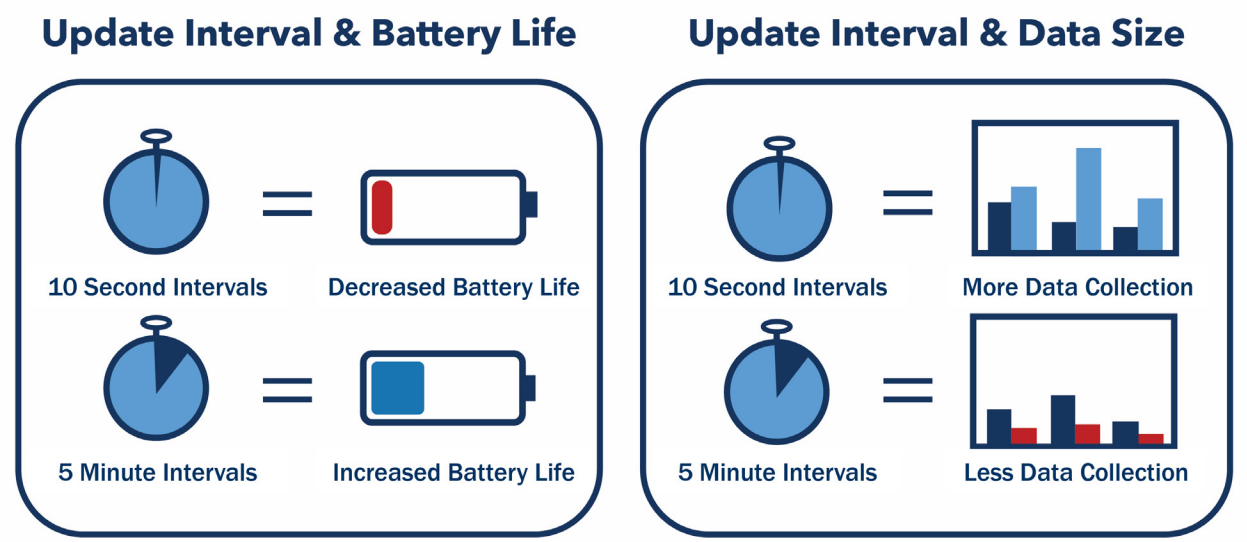

Figure 4 Tradeoff examples

Navigation Challenges

Indoor navigation is dependent on indoor mapping and tracking. Indoor navigation challenges are more complex because of the dynamic operational environment, mutual aid concerns, and unique discipline characteristics.

1. Routing roles and responsibilities are not clearly defined
2. Navigation technology and directions do not easily transfer to the operational environment
3. Internal networks do not exist, and the workflows are complex

Roles and Responsibilities

Gap:

As the response environment has become more complex, it is no longer feasible for a single person to ingest and act on the navigational data available. There are no best practices for how routing may work in the indoor environment.

Recommendation:

Research and development into ideal roles and responsibilities for indoor navigation using scenario-based exercises should be explored. As emerging technology is adopted, options for routing may include:

- Responder-centric routes: This would entail a responder navigating themselves with a smartphone, heads-up display, or another device without any interaction from outside personnel.
- Incident command routing: This would entail a position within incident command giving verbal routes and/or drawing routes on the navigational interface.
- Emergency communications routing: This would be a progression over typical outdoor/vehicle routing. Dispatchers may be able to provide limited indoor routing instructions but will quickly be overwhelmed when multiple resources are on scene.

Standardized navigation terminology for the indoor space that is simple and easy to understand in stressful situations should also be developed. This is critical when creating interoperable systems with multiple response organizations.

Operational Nuances

Gap:

Fast-paced incident response does not lend itself to dynamic routing, immediate field-data collection for observation conveyance, or seamlessly integrate with how responders navigate

day-to-day. Mutual aid partners may not have access to the same technology and internal networks.

Recommendation:

Research and development into true operational requirements such as dynamic routing, differentiation between barriers and impedances, and navigation visualization should be conducted. This research should consider how people typically navigate (e.g., Google Maps, looking directly at a device) vs the need to interact directly with the specific hazard (e.g., fire, flood, casualties).

Internal Networks

Gap:

In general, internal routing networks do not exist, and the workflows for creating them are labor intensive.

Recommendation:

Like the scalability and workflow concerns with indoor mapping, creating indoor routing networks before an incident is critical. Although tools exist, they require technical experience and are very labor intensive.

A comprehensive network design and workflow system should be created that enables first responders to create indoor maps as they walk through buildings and create pre-plans.

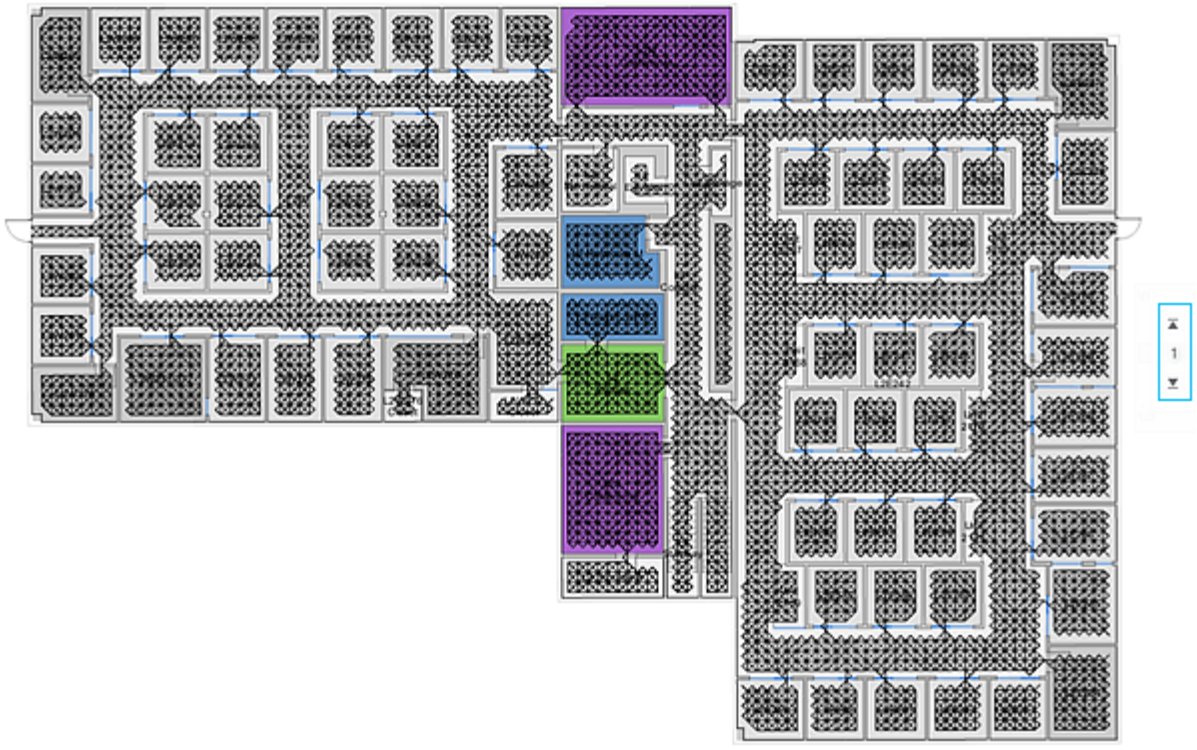

Figure 5 Indoor network example

Next Steps

Gap	Solution	Responsible Party
Difficult mapping workflows	Roadmap and/or tool development for first responders to easily create maps.	• Private sector mapping providers • Public safety research organizations
Lack of standardized symbology	Standardized public safety symbol library for dismounted/mounted resources, in 2D and 3D, with functionality such as symbol clustering and color ramps.	• Symbol library owners (e.g., NWCG, Esri, NAPSG Foundation, NFPA)
Lack of dynamic data/rules-based data	Research report and prototype to deliver data based on role, position, time of incident, and other factors.	• Public safety organizations • Vendors
Lack of infrastructure free tracking	Research and development into infrastructure free tracking for all public safety disciplines.	• Existing tracking solution manufacturers • NIST
No defined tracking policies and procedures	Creation of rules-based tracking policies, procedures, and governance based on case studies and/or simulations.	• Public safety professional organizations
Tracking data is too complex	Research into tracking data consumption such as tracking at a unit vs individual level, refresh intervals, battery life expectancy, etc. Additional research into visualizing tracking data on a map.	• Existing tracking solution manufacturers • Public safety organizations
No defined indoor navigation roles and responsibilities	Research and development into ideal roles and responsibilities for indoor navigation using scenario-based exercises.	• Public safety organizations
Need to define operational navigation	Research and development into true operational requirements such as dynamic routing, differentiation between barriers and impedances, etc.	• Public safety research organizations
Need to create internal networks	Roadmap and/or tool development for first responders to easily create indoor networks.	• Private sector mapping/navigation providers • Public safety research organizations