NIST Technical Note 1914

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2015 Location-Based Services R&D Summit

EXECUTIVE SUMMARY

PURPOSE

The Public Safety Communications Research Program (PSCR) convened over 80 stakeholders at the Department of Commerce Labs, Boulder, CO campus to build on the findings presented in the 2015 Location-Based Services R&D Roadmap Report. The Location-Based Services (LBS) Summit – held October 21-22, 2015 – intended to socialize the roadmap with a broader stakeholder base and determine the core technology challenges inhibiting public safety's effective and expanded use of LBS in daily operations.

The Summit identified clearly defined LBS technology gaps, prioritized capabilities, and specific problem statements that could be addressed using NIST R&D funds.

Workshop Results

Attendees were instructed to identify and prioritize the most pressing technology gaps limiting the use of LBS in public safety today. Gaps were prioritized based on PSCR's investment criteria developed in close collaboration with FirstNet and the PSAC.



Using the investment criteria above, Summit attendees identified the following six gaps as the highest priority LBS R&D investment areas for PSCR to consider as it transitions into LBS Program planning and execution:

Priority R&D Topic Areas



- ✓ 3D Geolocation
- ✓ Mapping
- ✓ LBS Interoperability
- ✓ LBS Power Consumption
- ✓ Standardization of LBS Capabilities
- ✓ Location-Enabled Wearable Devices

Attendees developed problem statements for each LBS R&D topic area

Attendee Developed Problem Statements

3D Geolocation

Inability to precisely and persistently locate public safety persons and assets in order to locate responders in trouble and manage public safety personnel & assets in real-time.

First responders need to obtain the civic address/coordinates of the public safety personnel and asset location, plus additional information such as floor, suite, apartment, or other information needed to adequately identify the location of the first responder and/or assets.

Information includes: Indoor, outdoor, 3D location, latitude, longitude, altitude, and other pertinent geo-location data.

Solutions need to account for public safety reliability and resiliency requirements.

Mapping

Lack of a nationwide interoperable 'base map' providing for collaboration that includes: Uniform, interoperable base layer; Survey level accuracy; Multi-organization collaboration; Interoperable access; Credentialing/User-profile; 2D & 3D; Indoor and outdoor locations.

Lack of capability to capture and integrate data into 'base map'.

LBS Interoperability

Lack of interface interoperability between applications, devices, positioning, mapping, and location information sharing. There needs to be a uniform way to read in and display maps.

Need for interoperable wearables and sensors.

Need a framework for testing and certification (software development kit/location toolkit).

LBS Power Consumption

Intelligent LBS chip and application management is not driven by use case, role, situational awareness, status, etc.

LBS today are too reliant on GPS which has a variety of cons (including significant power consumption) and needs to be augmented by other LBS technologies.

No clear understanding of the power consumption of various LBS technologies.

Maps are not cached on public safety devices, which increases power consumption.

Persistent reliance on visual LBS user interfaces drains power.

Standardization of LBS Capabilities

As location based services evolve and are used by public safety, a uniform, interoperable, and secure framework needs to exist to ensure that the location information available is accessible and consumable by public safety (or shared with others as appropriate).

Location-Enabled Wearable Devices

Location-enabled wearable devices or sensors are not currently designed to operate in all environmental conditions and are not designed to meet a tiered set of public safety specific requirements which address ruggedization, usability, operability, redundancy, mapping data, on/off network, user/command interfaces, and positional capabilities.

GAP: 3D Geolocation

PSCR

Inability to precisely and persistently locate public safety persons and assets in order to locate responders in trouble and manage public safety personnel and assets in real-time.

Summary: First responders need to obtain the civic address/coordinates of the public safety personnel and asset location, plus additional information such as floor, suite, apartment, or other information needed to adequately identify the location of the first responder and/or assets. Information includes: indoor, outdoor, 3D location, latitude, longitude, altitude, and other pertinent geo-location data. Solutions need to account for public safety reliability and resiliency requirements.

Current State Impacts

Who?

Public safety entities and first responder functions: law enforcement/Fire/EMS, search & rescue, emergency management, and command & control

What?

Public safety activities requiring rapid response and/or detailed planning: incident management, disaster planning, rapid response

How?

Current gap prevents deployment of LBS apps...restricting location to general proximity, preventing public safety officials from locating assets by z-axis

Current Initiatives?

Operational need and Federal guidance (FCC 4th Report & Order) have spawned Industry activity in the space: barometric-based z-axis capability, sensor data for indoor location

Development Enablers

Requirements to collect:

Location Accuracy:
Allowable levels of location uncertainty across X, Y, Z axis & associated required confidence levels

Signal Specs:
Baseline performance levels for LBS signals including bandwidth, data rate, and immunity to noise

Data Refresh Rate:
Operational requirement for LBS data refresh time intervals, referred to as 'Delta t'

Standards to develop:

Signal Structure:
WiFi/BT/UWB signal designed for positioning use (in addition to coverage & speed)

Location Data Format:
Data format standard for interoperability between units or devices

X, Y, Z Axis Minimum Operating Standards:
Define guidelines for public safety geolocation accuracy, update rate, and latency

Technological capabilities to build:

Composite Geolocation:
Decipher location from multi-sourced data including, GPS, OTDOA, WiFi, LTE-U, Bluetooth, etc.

Pressure Sensor Compensation:
Incorporate real-time barometric pressure variation to support z-axis accuracy

Capability Enhancement:
Further develop existing capabilities: GPS/GNSS, TOA, OTDOA, AoA, RSS & models

Measurement capabilities to deploy:

X,Y,Z Precision Metrics:
Measure key geolocation metrics: DOP, time-to-fix, delta t: refresh

3D Geolocation Test Bed:
Environment to test measurement methods simulating: indoor, outdoor, impairments, geometric dilution of precision conditions

3D System Calibration:
Precision reference measurement system for 3D LBS & assess accuracy across devices/systems

Future State

Gap Stakeholders:

Public safety units responsible for tactical coordination and/or logistics and event planning will benefit greatly from 3D geolocation capability development. Anticipate primarily servicing elements with a first response element

Public Safety Operations:

First responders arrive on scene equipped with real-time environmental & contextual site intelligence (building, floor, room & method of approach data) based on X,Y & Z location-based services data broadcast from critical assets. Data enables complete situational awareness, coordinated search & rescue, and avoidance of dangerous environments including fire flow & friendly fire

Technical Barriers

(1) Hardware (battery life, ruggedization, local processing power)
(2) Network (coverage, spectrum availability)
(3) Sensor performance

Potential Disruptors

(1) Internet of Things (commercial users saturate spectrum)
(2) Increased device loading due to advanced technologies may outpace development of devices

GAP: Mapping

PSCR

Public Safety lacks a nationwide interoperable 'base map' to provide cross-agency collaboration and data input

Summary: Interoperable 'base map' needs to include: Uniform, interoperable base layer; Survey level accuracy; Multi-organization collaboration; Interoperable access; Credentialing/User-profile; 2D & 3D; Indoor and outdoor locations. Lack of capability to capture and integrate data into base map.

Current State Impacts

Who?

Public safety first responders and dispatch as private sector, utilities, and infrastructure developers

What?

Public safety operations requiring fire/medical/law enforcement and special ops

How?

Inability to utilize and share a common base map hampers public safety's capability for efficient response across municipalities, jeopardizes first responder safety, and hampers the adoption of emerging GPS & 3D geolocation (z-axis) technologies

Current Initiatives?

DHS is developing the NICS platform, an open source collaborative architecture that integrates LBS and other sensors. DOT is developing the E911 dispatchable location database and mapping technology

Development Enablers

Requirements to collect:

Map Visuals:
Appearance of visual details, visual quality, and organization of layered data sets needed for the operating environment

Map Attributes:
Data elements rendered on Public safety map for operational use, may include: building properties, motion, weather

Data Governance:
Data input, transfer, credentialing and federated nodes of control for adoption of mapping into chain-of-command

Standards to develop:

Base Map:
Common base layer map, symbols, and cartography for uniform adoption

Data Format:
Consistent mapping data format for interoperability and synchronization between entities

Composite Mapping Technique:
Used to deconflict disparate input map types and collate data

Technological Capabilities to build:

'In-Building' Maps:
Data rich building maps for critical buildings in US (malls, airports, stadiums, commercial skyscrapers, gov facilities, etc.)

Real-time Mapping Tool:
Capability to sense, ingest, and populate indoor/outdoor map data in real time to central database

Federated Data System:
Aim to deploy a local control LBS system that 'syncs' with master LBS data in the cloud

Measurement Capabilities to deploy:

Progress Milestones:
Roadmap for mapping capability progress (requirements, standards, testing) against promulgated timeline

Data update rate:
Test time frame between map input/update and receipt by Public safety user

Future State

Gap Stakeholders:

Public safety units responsible for tactical coordination and first response operations will benefit greatly from mapping capability development. Mapping will create opportunities for industry and entrepreneurs to develop applications and tools to leverage mapping data

Public Safety Operations:

First responders arrive on scene equipped with coordinated plan of engagement for emergency environment based on mapping data. Planning will include advanced strategy & tactical planning, environmentally informed equipment decisions, and real-time data sharing across public safety entities. These capabilities are supported by the free exchange of location information between app developers and CAD vendors

Technical Barriers

(1) Base map standardization: Jurisdictional specific data may be in disparate formats and/or not have sharing capability
(2) Scope of mapping: Compilation of raw data, map images, continuous update will be immensely time intensive
(3) Indoor mapping tool: Low-cost solution needed to 'map' indoors

Potential Disruptors

(1) Virtual reality
(2) Smaller, smarter hardware, cameras and sensors

GAP: LBS Interoperability

There exists a lack of interoperability between LBS applications, devices, positioning, mapping, and information sharing.

Summary: First responders require a common, interoperable LBS framework moving from data collection (wearables & sensors) to display devices to mapping and logistical planning. Public safety requires a framework for testing and certification (software development kit/location toolkit) to enable development.

Current State Impacts

Who?

Public safety personnel responsible for coordinating communications and incident response, including incident commanders and dispatchers

What?

All coordination and communication activities conducted with multiple agencies at a given scene

How?

Inability to ingest and respond to standardized and shared LBS intelligence creates overlapping and inefficient use of critical resources in incident response, fracturing inter-agency coordination. Inefficiencies slow adoption of LBS by reducing the potential value-add of LBS capabilities

Current Initiatives?

Current work in the space includes proposed standards to the FCC E911 indoor location requirements and efforts by TCS, Intrado, and other industry developers

Development Enablers

Requirements to collect:

Data Storage Requirements:
Capacity and capabilities needed to store common set of LBS data, i.e. cloud, servers, etc.

Current State Capability:
Specific interoperability problems experienced currently to baseline against future state.

'Public Safety' Specifications:
Gather public safety specific operating requirements to distinguish from existing promulgated private sector reqs

Standards to develop:

Data Protocols:
Consistent processes and governance for raw information handling (x,y,z, motion, environment, wind, etc.)

Location Data Format:
Consistent format for location data for interoperability between units and devices

X, Y, Z Minimum Operating Standards:
Defined guidelines for public safety geolocation including update rate, accuracy, & latency

Technological Capabilities to build:

Common Cloud Platform:
Central and secure hub for data storage, processing, and retrieval on a national scale

Map Composite Engine:
Data integration tool utilized to standardize co-located mapping data from disparate sources

Federated Data System:
Aim to deploy a local control LBS system that 'syncs' with master LBS data in the cloud

Measurement Capabilities to deploy:

Progress Milestones:
Roadmap for mapping capability progress (requirements, standards, testing) against promulgated timeline

Future State

Gap Stakeholders:

Tactical public safety units responsible for coordinating across agencies and disciplines as well as technology hardware and application providers across the public safety domain

Public Safety Operations:

Public Safety functions and responds to incidents in a seamless and coordinated manner with situational awareness up, down, and across the chain-of-command. Agencies arrive on scene with pre-planned operational capabilities and update coordination plans in real time. The public safety domain is supported by widespread access to innovative, cost-efficient technology enabled by state of the art products and applications

Technical Barriers

(1) Proprietary solutions; sophisticated but lack incentives to share information
(2) Computational complexity; disparate data forms and chart data
(3) Lack of interoperability between networks; inability for wifi, Bluetooth, LTE to handoff communications in-buildings

Potential Disruptors

(1) Closed or proprietary solution fails to evolve: public safety becomes 'locked in' to solution that is surpassed by emerging technologies
(2) Proliferation of technology: development of incompatible solutions

GAP: LBS Power Consumption

Current technologies delivering relevant positioning data and location based services to mobile users drain battery at an unsustainable rate, impeding adoption of LBS for public safety

Summary: Intelligent LBS chip and application management is not driven by use case, role, situational awareness, status. etc. LBS today are too reliant on GPS which has a variety of cons (including significant power consumption) and needs to be augmented by other LBS technologies. Maps today are not cached on public safety devices, which forces reliance on the network, increasing power consumption. Persistent reliance on visual LBS user interfaces drains power. There is a lack of practical alternatives to power intensive visual LBS user interfaces.

Current State Impacts

Who?

Public safety personnel that currently use or would benefit from LBS data on a mobile device include law enforcement/Fire/EMS, and secondary responders

What?

Public safety operations impacted by this gap include search, rescue and recover, incident command, command & control functions

How?

High power consumption levels result in shortened battery life on devices utilizing LBS and contribute to limited adoption of LBS capabilities

Current Initiatives?

Industry is leading battery life innovation including developing apps to reduce power consumption. Apple is working on doubling battery life in its next generation of handsets

Development Enablers

Requirements to collect:

Power/charge Metrics:
Identify number of battery life hours per charge, time required to recharge full battery

Operating Conditions:
Environment in which battery is operable, i.e. temperature, pressure, humidity, water resistance, etc.

Hardware Properties:
Dimensions and weight required for operating in the field environment.

Standards to develop:

Power Consumption:
Develop a 'rate of use' protocol to serve as a benchmark for Public Safety market devices

Localization Systems:
Standard for indoor localization systems installed in buildings that do not require public safety infrastructure and equipment

Cloud/Local Handoff:
Protocol for handoff between cloud based maps and core memory stored maps

Technological Capabilities to build:

Power Management Application:
LBS app for public safety smart phones that manages and optimizes battery life across device

Wireless Charging:
Over the air power sharing and charging for public safety smart phones and LBS devices

Dynamic Prioritization:
Ability to detect mission critical environment and prioritize communications and LBS applications in real time

Measurement Capabilities to deploy:

Power Consumption:
Uniform system to measure power consumption by function and by application

Usage Testing:
Measure delta between power model simulations and actual operational environment testing

Indoor Localization Testing:
Localization systems tested in large buildings using different construction materials, various modes of mobility, etc.

Future State

Gap Stakeholders:

Public safety officers who rely on wireless technology to perform duty functions. Vendor and application development community will benefit from increased demand for high-performing technology and applications

Public Safety Operations:

Public safety is able to move from mission to mission seamlessly with a single device leveraging all value-add data and functions from the device simultaneously. Officers suffer from no gaps in performance or accuracy due to battery and/or power. Officers may rely on apps and devices in more situations due to improved device stamina

Technical Barriers

(1) Form factor limitations
(2) Battery technology (does not follow Moore's Law)

Potential Disruptors

(1) Emerging LBS technologies consumption may outpace rate of battery performance improvement

GAP: Standardization of LBS Capabilities

PSCR

Location information is not available, accessible, consumable, or sharable within and across public safety agencies due to a lack of a uniform, interoperable, and secure framework for LBS

Current State Impacts → Development Enablers → Future State

Who?

Public safety entities and the industry that builds tools to support public safety operations are effected, including: app developers, hardware manufacturers, product engineers, etc.

What?

In addition to public safety activities, public safety administrative activities are uniquely affected by this gap, including finance, IT, and communications

How?

Applications and devices that will increase efficiency and cohesion within and between agencies are not able to be developed on a large scale, creating communication gaps in incident response and additional and potentially duplicative administrative tasks

Current Initiatives?

Efforts include the FCC 4th Report and Order, ATIS standards for indoor location accuracy, DHS NICS system, and 3GPP LBS Standard Releases 12 & 13

Requirements to collect:

Collaborative Tools:
Identify tools utilized in operating environment to share information (map mark-up, chat across agencies, etc.)

'Public Safety' Specifications:
Gather public safety specific operating requirements to distinguish from existing promulgated private sector reqs

Baseline Capability:
Snapshot of interfaces and technologies used currently to generate and display location info and existing protocols for interoperability

Standards to develop:

Data Protocols:
Consistent process and governance for raw information handling (x,y,z, motion, environment, wind, etc.)

Location Data Format:
Consistent format for Location data for interoperability between units and devices

Emergency Management API:
Facilitate common LBS public safety data and tasks

Technological Capabilities to build:

Cloud Synchronization:
Ability to synch data, end-user sessions, etc. between local LBS and cloud-based LBS systems

LBS-LTE Integration:
LBS systems integrated with communications systems (i.e. application layer receives data from LTE network, attached UEs location of towers)

Open Source Protocols:
Open source transport layer protocols (i.e. expansion of WebRTC)

Measurement Capabilities to deploy:

Confidentiality:
Verify that data is shared only among authorities (persons or organizations) with access credentials

Recency
Measure that up-to-date data is accessible as needed and as authorized

Integrity:
Test authenticity, reliability, and accuracy of incoming LBS data

Gap Stakeholders:

Public safety units responsible for tactical coordination and/or logistics and event planning will benefit greatly from standardization, including administrators who purchase and communicate across agencies

Public Safety Operations:

Public Safety is able to source interoperable technologies from a variety of vendors so that all available data will be input into an engine that can modify the contextual environment in real-time and provide reliable information to users of the information. Public safety agencies across the nation improve decision making, training, efficiency, coordination, resulting in saved lives and property

Technical Barriers

(1) Proprietary technology: currently built by vendors, may be difficult to migrate to standard
(2) Diverse system types: complicates standardization effort

Potential Disruptors

(1) Internet of Things (commercial users saturate spectrum)
(2) Advanced mapping capability

GAP: Location-Enabled Wearable Devices

PSCR

Location-enabled wearable devices and/or sensors are not currently designed to or capable of operating in all environmental conditions

Summary: Devices and/or sensors are not designed to meet a tiered set of public safety specific requirements which address ruggedization, usability, operability, redundancy, mapping data, on/off network, user/command interfaces, and positional capabilities.

Current State Impacts

Who?

Public safety officers in the operational environment and their associated command and control elements

What?

Public safety operational activities are affected as well as entities who require live data and intelligence to effectively execute the mission. Also affected are administrative/logistic planning elements who rely on a common and total picture of the operating environment.

How?

The lack of LBS wearable devices limits LBS from acting as a functional resource in the field. Operational officers lack live data and intelligence and command and control elements lack the intelligence to best deploy and protect public safety resources.

Current Initiatives?

DHS is currently conducting a 'First Responder Wearables' research project

Development Enablers

Requirements to collect:

Mission Critical Data:
Group of data sets that will be required for live feedback to the user in the field: location data, biometrics, video, etc.

Operating Conditions:
Environment in which device is operable, i.e. temperature, pressure, humidity, water resistance, etc.

Physical Properties:
Dimensions, ruggedness, and weight required for operating in the field environment.

Standards to develop:

Measurement Units:
Consistent terminology for describing impact, smoke/particle resistance, etc.

Internet of Things Protocol:
Protocols and data formats for Internet of Things specific to public safety wearable devices.

Standards Integration:
Need to blend/incorporate existing standards sets for IoT/M2M (OneM2M and public safety communications standards)

Technological Capabilities to build:

Beacon System:
Use of range/azimuth as tool to find users in areas that have no network access/coverage

Relative Positioning:
Positioning calculations using public safety vehicles

IoT Sensors:
Physical sensors that can operate in public safety environment, sense and categorize data, and transmit data to networks

Measurement Capabilities to deploy:

Mobility:
Mobility of deployed devices needs to be measured for uncertainty

Future State

Gap Stakeholders:

Public safety officers in ther operational environment as well as private users, DoD, and workers in the chemical, utility, and manufacturing industries' plant workers.

Public Safety Operations:

On-body sensors gather critical data points from the person and/or robot and the environment. This keeps the user safe through live alerts & 3D situational awareness and provides better tactical coordination through a total view of the operating environment at mission command and control.

Technical Barriers

(1) Radio interference between devices
(2) Thermal and high temperature effects on electronics
(3) Size of devices and wearables
(4) Battery life for wearables

Potential Disruptors

(1) Wireless technology that allows non-rugged devices to sit in safe places (inside gear, inside vehicle)

Acronyms Used

3GPP	Third Generation Partnership Project
AoA	Angle of Arrival
ATIS	Alliance for Telecommunications Industry Solutions
BT	Bluetooth
CAD	Computer Aided Design
DHS	Department of Homeland Security
DOP	Dilution of Precision
DOT	Department of Transportation
EMS	Emergency Medical Services
FCC	Federal Communications Commission
EMS	Emergency Medical Services
IoT	Internet of Things
LTE	Long Term Evolution
LTE-U	Long Term Evolution in Unlicensed spectrum
M2M	Machine to Machine
NICS	Next Generation Incident Command System
OTDOA	Observed Time Difference of Arrival
RSS	Rich Site Summary
TCS	Comtech TeleCommunication Systems, Inc.
TOA	Time of Arrival
UE	User Equipment
UWB	Ultra-wideband