GeoComm

3D and Indoor 9-1-1 Caller Location Mapping White Paper

GeoComm/SCSU Pilot Project

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Preface

"NOVEMBER 14, 2014 - NEWS RELEASE

Wireless Carriers & 9-1-1 Communications Leaders Answer the Call to Improve 9-1-1 Indoor Location Accuracy

Dispatchable location provides address or other critical location information for first responders

WASHINGTON, *November 14, 2014 – AT&T, Sprint, T-Mobile and Verizon Wireless, Association of Public-Safety Communications Officials (APCO) and National Emergency Number Association (NENA) today announced a consensus plan to meet the FCC's challenge to improve 9-1-1 indoor location accuracy."*[1]

3D and indoor location is coming to 9-1-1. While much industry work needs to be done around mobile phone 3D and indoor location acquisition and tracking technologies, considerations and preparations for consumers of this new location data, 9-1-1 PSAPs and emergency response agencies, need to begin now.

This white paper presents a GeoComm pilot project designed to model and test how 3D and indoor 9-1-1 caller location, once available, will impact and benefit 9-1-1 PSAPs and emergency responders. The white paper also examines practical implementation considerations and present day challenges related to end-user 3D and indoor tactical mapping systems as well as indoor and 3D GIS map data development.

Introduction

Next Generation 9-1-1(NG9-1-1) is a modernization of the nation's 9-1-1 system and is being carried out across the country today. While the existing 9-1-1 system has been a success story for more than 30 years, NG9-1-1 provides a more advanced system for accessing emergency response and care. NG9-1-1 leverages and supports new communications tools and technologies which have evolved into common use over the last 15 years, including text messaging, multi-media messaging, and Internet Protocol (IP) changes.

In 2011, the NENA published Version 1.0 of NENA Technical Standard 08-003, Detailed Functional and Interface Standards for the NENA i3 Solution. This standard describes an end-state NG9-1-1 architecture, rather than an immediate "build-to" specification for a complete NG9-1-1 system. The standard anticipates and supports increased precision in geodetic caller location by describing elevation in addition to latitude/longitude coordinates, and directly supports sub-address elements such as building name, floor, suite, unit, room, and seat for indoor locations.

In 2014, the FCC proposed new rules for improving 9-1-1 call location accuracy by including vertical information and indoor sub-address elements. The FCC's actions generated significant industry feedback, discussion, debate, and planning. These rules improve upon existing location accuracy requirements for E9-1-1 today. While much work remains to be accomplished, particularly with respect to device and access network location discovery and tracking, a future state that includes 3D locations for mobile and indoor 9-1-1 callers is now closer than ever before.

As a result, GeoComm has conducted research and development into 3D 9-1-1 call mapping and display systems. GeoComm sought to construct a system capable of identifying and tracking caller location on a 3D tactical map. Once 3D and indoor call locations become available, this system can be used by 9-1-1 call takers, Computer Aided Dispatch (CAD) dispatchers, and emergency responders in the field. GeoComm studied systems and methods for gathering and constructing 3D maps using modern and emerging Geographic Information System (GIS) technology. GeoComm also studied 3D map displays for tracking 9-1-1 caller locations and emergency responder assets on low-cost smartphone and tablet computing devices.

To accomplish the research in a short amount of time, GeoComm assembled a multi-disciplinary team of industry experts to provide inputs into the pilot project. This white paper describes the pilot project, as well as discoveries and issues to be considered as the nation's 9-1-1 system continues to evolve.

NG9-1-1 Support for 3D and Indoor Caller Locations

NG9-1-1 supports both geodetic and civic locations for finding devices calling 9-1-1 based on standards maintained by the Internet Engineering Task Force (IETF). Geodetic locations are coordinate-based geometric shapes, and in NG9-1-1 can include point, polygon, ellipse, circle, or arc-band geometries. Civic locations are city-style addresses that include a house number and street name. NENA 08-003 v.1 describes individual elements of civic addresses, for example, house number, street name, city, and state. Sub address elements are also defined and include, but are not limited to:

- Building name, for example "Town Barber Shop"
- Unit (apartment, suite), for example "Apt 42"
- Floor, for example "4"
- Room, for example "450F"
- Seat (desk, workstation, cubicle), for example "WS 181"[2]

FCC's Proposed Rules

In February 2014, the FCC proposed new rules that would, for the first time, include vertical location information in addition to latitude and longitude for wireless 9-1-1 callers. The proposal requires that after a reasonable implementation period, Commercial Mobile Radio Service (CMRS) providers subject to Section 20.18 of the Commission's rules must:

1. Locate callers within 50 meters for 67 percent and 80 percent of indoor calls within two years and five years of the effective date of adoption of rules, respectively, and;
2. Provide vertical (z-axis) data, within 3 meters accuracy, for 67 percent and 80 percent of indoor calls within three years and five years of the effective date of adoption of rules, respectively.

This additional caller location data would help first responders reduce emergency response times by determining the floor and room in a building from which a 9-1-1 call was placed. The FCC documents suggest the proposed location accuracy improvements could save an estimated 10,120 lives annually. [3]

APCO / NENA / Carrier Consensus Plan

As a result of the FCC's proposed rules, and after eight months of meetings, debate and discussion, the nation's wireless carriers (AT&T, Sprint, T-Mobile, and Verizon) and public safety industry groups (NENA and APCO) have reached a consensus agreement to make improvements in locating cellular 9-1-1 callers that differs from the proposals made by the FCC.[4]

The consensus plan includes a timeline to:

- Verify technologies and vendor performance for indoor and outdoor technologies in a test bed;
- Accelerate the delivery of dispatchable location using indoor technologies with ambitious milestones for demonstration, standards development, and implementation of database and handset capabilities; and

- ☐ Improves existing location technologies for better outdoor and indoor location fixes. [5]

As part of the agreement, the carrier signatories will obtain a location fix using heightened location accuracy technologies for the following percentage of wireless 9-1-1 calls from the date of the agreement based on live call data:

i) 40% of all wireless 9-1-1 calls within two years;
ii) 50% of all wireless 9-1-1 calls within three years;
iii) 75% of all VoLTE wireless 9-1-1 calls within five years; and
iv) 80% of all VoLTE wireless 9-1-1 calls within six years. [6]

This agreement defines dispatchable location as the civic address of the calling party plus additional information such as floor, suite, apartment or similar information that may be needed to adequately identify the location of a calling party.[7]

GeoComm 3D and Indoor Mapping Pilot Project

Clearly, significant work needs to be accomplished around access network location technology and services in order to support 3D geodetic 9-1-1 caller location derivation (latitude/longitude and elevation) as well as civic address location tracking for 9-1-1 callers that includes sub address elements such as building, floor, unit, room, and seat.

However, setting aside the technical challenges around 3D and indoor calling device location acquisition, GeoComm set out to design and implement a pilot system to demonstrate and study practical uses and challenges around the future mapping of NENA and IETF standard indoor 9-1-1 caller locations, and 3D geodetic caller location in advance of national rollouts and implementations.

To complete the pilot project, GeoComm utilized partnerships with the Saint Cloud State University (SCSU) College of Science and Engineering (COSE), as well as GeoComm business partner, Pictometry Inc.

GeoComm provided the overall pilot project scope and design, project coordination, web hosting environment, GIS integration, and mobile messaging framework.

Pictometry Inc. provided highly accurate as-built 3D building models in digital format, created from high resolution multi-pass aerial oblique imagery.

The SCSU COSE developed advanced web based 3D visualization technology, and provided Integrated Science and Engineering Laboratory Facility (ISELF) resources for the project.

Pilot Project Scope

The GeoComm 3D and Indoor 9-1-1 Caller Location Mapping Pilot Project created a mobile smartphone application for simulating 3D and indoor 9-1-1 calls, and a tactical 3D and indoor dispatch mapping application for PSAPs and emergency responders.

Smartphone Application

A smartphone application was created to simulate 9-1-1 calls from 3D geodetic and indoor civic locations. The application supported pre-set geodetic locations, as well as device-derived GPS locations containing latitude, longitude, elevation, and accuracy.

The application also incorporated pre-set civic locations for multiple building locations, including floor and room parameters.

In addition to 9-1-1 call location simulation, the smartphone app was also capable of continuous real-time mobile location broadcasting and mobile messaging, which was used for modeling 3D tracking of emergency responders navigating to incidents.

Dispatch Mapping Application

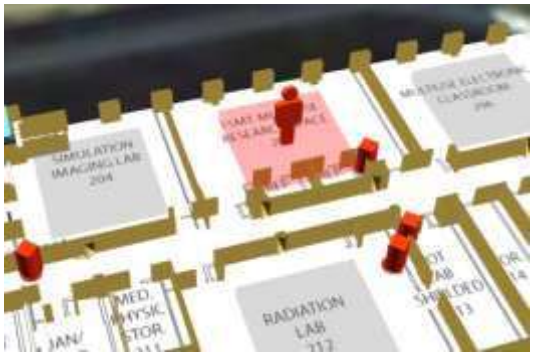
A web based 3D and indoor dispatch mapping application was created for PSAPs and emergency responders. The application displayed a 3D map of the pilot project area. As-built 3D building exterior models were created by Pictometry, using programmatic photogrammetric methods that converted multi-pass aerial oblique imagery into digital 3D building models. Building models were inserted into a 3D web scene that included other GIS data elements such as a 2-dimensional aerial image draped over a digital terrain model. The dispatch application displayed real-time locations transmitted from the smartphone application.

Steven Henningsgard, SCSU student, interacting with the GeoComm 3D and indoor location dispatch mapping system in the ISELF Visualization Lab.

3D and Indoor 9-1-1 Call Mapping and Tactical Visualization

The system created for this pilot project is capable of mapping and tracking the location of a moving smartphone based on the GPS hardware within the phone. In addition to adding a 3D marker into the dispatch map display, the application also displays a confidence sphere around the caller location which is an indication of accuracy and precision calculated by the smartphone's GPS hardware.

The system displays indoor maps in addition to exterior building models. The dispatch mapping application has tools enabling users to turn off exterior walls, and to turn on floor maps of interior spaces. For some buildings, indoor maps were created using Computer Aided Design software. For other buildings, 2-dimensional scanned floor plans were geo-referenced, scaled, and aligned with building floors in the 3D map.



Interior spaces were mapped using NENA 08-003 and IETF civic location sub-address elements that included building name, floor, and room number. In this manner, 9-1-1 calls simulated from rooms in large multi-story buildings could easily be located and displayed on the 3D and indoor dispatch mapping application.

Test Case Scenarios

Hide and seek field exercises were conducted from the SCSU Public Safety Department. Tests calls from indoor and outdoor locations were placed to the SCSU Public Safety dispatch center. SCSU Public Safety Officers then responded to the calls and response times were recorded. Each call scenario was executed twice, first using current technology with no enhancements, and second using the 3D and indoor tactical mapping application in the dispatch center. During the tests, radio traffic was monitored, and after incident interviews with dispatchers and responders were captured.

As anticipated, the scenario testing demonstrated measurable reductions to response times in cases where precise outdoor and indoor location of a caller was unknown.

From left to right, Dr. Adel Ali (Associate Dean and Director of the SCSU School of Computing, Engineering, and the Environment), Mark Gill (SCSU Visualization Engineer), and Guy Konietzko (GeoComm Project Manager) observing field exercises conducted at SCSU

The following example scenario demonstrates tracking a mobile phone indoors (yellow sphere on the left side of the web scene), a fixed telephone extension location (red person icon on the left side of the scene) and an emergency responder navigating to the scene (blue person icon with green confidence sphere on the right side of the scene). The 9-1-1 caller's location is civic with sub address elements indicating an interior space inside a building. The emergency responder's location is a 3D geodetic location calculated by the GPS in the responder's smartphone.

Scenario tracking an emergency responder to an indoor mobile phone location

Findings and Conclusions

GeoComm's test case scenarios, executed with local public safety and emergency response personnel, indicate that the technology can decrease emergency response times in cases where the indoor location of a caller would not otherwise be known, or known only as textual attributes. During "hide and seek" field tests, the system consistently located callers by civic address and sub address elements on the 3D map, including inside specific rooms within buildings, making it easier for emergency responders to find the callers. In addition, emergency response personnel evaluating the application found that floor plans and building models with additional details like equipment locations (fire hydrants, automatic defibrillator locations, etc.), and room names in addition to room numbers (e.g. "Radiation Lab"), were especially useful for creating situational awareness and planning emergency response.

During development of the system, discoveries were made about end-user experience requirements while working in a 3D software visualization environment. 3D environments can be challenging to users unfamiliar with 3D. Users in emergency situations need to be able to quickly and easily get information needed without special training. As a result, the pilot project built "guard rails" enabling users to get to needed information without getting lost in 3D space, such as being tilted at angles, scales, and perspectives that provide little or no value to the user.

The pilot project determined that a number of primary challenges exist for 3D and indoor 9-1-1 call mapping:

- Current outdoor wireless 9-1-1 caller location technology is insufficient for locating callers indoors due to accuracy limitations.
- GPS devices inside mobile phones are unable to reliably calculate latitude / longitude / elevation locations inside buildings.
- Mapping interiors of buildings is challenging; accomplishing this for large scale systems (many buildings) would be time consuming and costly using today's technology.
- Mobile phone location technologies are available today for consumer-facing location-based advertising which exceed location capabilities of the current 9-1-1 system. Industry work needs to be completed to integrate such location technologies into 9-1-1.
- More analysis needs to be performed to determine under what conditions the technology can benefit 9-1-1 call takers and emergency responders. In most but not all cases, the information is more useful to emergency responders than 9-1-1 call takers. Care should be taken to not overload 9-1-1 call takers with extra information that is not needed.
- While viable technology for 3D and indoor call location tracking is undoubtedly emerging in consumer and professional market segments outside of 9-1-1, significant work around technology policy and standards needs to be accomplished in order to properly integrate 3D and indoor caller location into 9-1-1.

The pilot project determined that viable technology exists today for:

- Mass creation of highly accurate 3D exterior building models using automated methods.
- The development of smartphone and tablet 3D web mapping applications that leverage HTML5.
- Location Information Servers (LIS) for storing location of phone endpoints in a multi-line telephone system, including civic sub address elements that can be utilized in existing NG9-1-1 systems.
- Accurate indoor geodetic mobile phone location tracking using specialized WiFi-based location tracking systems and mobility servers available with some enterprise WiFi and unified communication systems.

Trends identified during the pilot project included:

- 3D building mapping and GIS technology is readily available and widely used outside of 9-1-1 today, particularly in facilities and campus environments. Perhaps because of smaller and more self-contained geographies, and innovation and engineering capabilities, 3D maps of university college campuses are emerging faster than for municipalities.
- Availability of consumer grade indoor mapping data products covering areas such as shopping malls, airports, and other indoor public spaces is rapidly increasing.
- Portions of several US cities have already been mapped in 3D - including Boston, Philadelphia, and others from coast to coast - and commercial data products are emerging.
- 3D mapping is becoming prevalent in the consumer world already, with 3D maps available from Google, Esri, and Microsoft.
- Adoption of indoor mobile phone locating technologies, outside of 9-1-1, is rapidly increasing for consumer facing location-based advertising applications.

For more information:

For more information and inquiries regarding GeoComm's 3D and indoor 9-1-1 mapping pilot project, including demonstration requests for your business, jurisdiction, campus, or facility; please contact us at indoor911@geo-comm.com

About Geo-Comm, Inc.

GeoComm (www.geo-comm.com) was founded in 1995 to provide county governments with turnkey emergency 9-1-1 development services. Over the subsequent 19 years, the company has grown to serve more than 12,000 dispatchers in 800 emergency 9-1-1 call centers in the United States, helping to keep more than 84 million people safe. Today, GeoComm has a national reputation as a leading provider of geographic information and communication systems for local, regional, and state government agencies. The company's systems route emergency calls to the appropriate call center, map the caller's location on a dispatchers map, and guide emergency responders to the accident on mobile displays within police, fire, and ambulance vehicles.

GeoComm's mission is: When seconds matter, we help save lives and protect property by providing essential, innovative, location-based solutions to public safety professionals.

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[1] APCO Membership Bulletin – November 14, 2014, Page 3, http://psc.apcointl.org/2014/11/15/apco-and-nena-reach-consensus-plan-with-major-wireless-carriers-on-improvements-to-locating-9-1-1-callers/

[2] Detailed information regarding NG9-1-1 civic address location formats, including sub address elements for indoor mapping, can be found in the following documents:

- NENA, "08-003 v.1 Detailed Functional and Interface Standards for the NENA i3 Solution," June 14, 2011, http://www.nena.org/?page=i3_Stage3
- IETF, "RFC 4119 A Presence-based GEOPRIV Location Object Format," December 2005, http://tools.ietf.org/html/rfc4119
- IETF, "RFC 5139 Revised Civic Location Format for Presence Information Data Format Location Object (PIDF-LO)," February 2008, http://tools.ietf.org/html/rfc5139

[3] Detailed information regarding the FCC's proposed new indoor location requirements and revisions to existing E9-1-1 rules http://www.fcc.gov/document/proposes-new-indoor-requirements-and-revisions-existing-e911-rules

[4] APCO Membership Bulletin – November 14, 2014, Page 3, http://psc.apcointl.org/2014/11/15/apco-and-nena-reach-consensus-plan-with-major-wireless-carriers-on-improvements-to-locating-9-1-1-callers/ 1

[5] APCO Membership Bulletin – November 14, 2014, Page 3, http://psc.apcointl.org/2014/11/15/apco-and-nena-reach-consensus-plan-with-major-wireless-carriers-on-improvements-to-locating-9-1-1-callers/

[6] APCO Membership Bulletin – November 14, 2014, Page 4, http://psc.apcointl.org/2014/11/15/apco-and-nena-reach-consensus-plan-with-major-wireless-carriers-on-improvements-to-locating-9-1-1-callers/

[7] APCO Membership Bulletin – November 14, 2014, Page 4, http://psc.apcointl.org/2014/11/15/apco-and-nena-reach-consensus-plan-with-major-wireless-carriers-on-improvements-to-locating-9-1-1-callers/