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Communications Security, Reliability and Interoperability Council

September 2016 WORKING GROUP 1

Evolving 911 Services

Final Report – Task 2: 911 Location-Based Routing

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# Results in Brief

## Executive Summary

The Communications Security, Reliability and Interoperability Council’s (CSRIC) mission is to provide recommendations to the FCC to ensure, among other things, optimal security and reliability of communications systems, including telecommunications, media, and public safety.

Under current practice, a wireless 9-1-1 call is routed to a Public Safety Answering Point (PSAP) based on the originating cell sector that handles the call. Location technologies for wireless E9-1-1 and commercial location-based services have evolved and may provide a sufficiently accurate quick-fix to use for call routing. Provided location fixes are obtained in 5 seconds or less, location-based routing (LBR) for wireless 9-1-1 calls would allow for delivery of the call to the jurisdictionally appropriate PSAP, thereby reducing call transfers between PSAPs.

Working Group 1 has identified and reviewed several location-based routing methods that could potentially be used for wireless 9-1-1 call routing. Each LBR method has its own characteristics and considerations. In Section 7, each LBR method is reviewed in detail to appraise the impact of its use in routing wireless 9-1-1 calls. Based on this in-depth review, recommendations are made on each method’s use both in the applicable LBR method review and in Section 9 – Recommendations Summary.

# Introduction

This final report documents the efforts undertaken by the CSRIC V Working Group 1 with respect to its Task 2 deliverable on identifying and evaluating location-based routing methods. The characteristics and considerations for each method are outlined, along with any specific architectural, technical, operational and security requirements. In addition, the role and responsibilities of stakeholders of each LBR method is outlined.

## CSRIC Structure

|  |
| --- |
| **Communications Security, Reliability, and Interoperability Council (CSRIC) V** |
| **CSRIC Steering Committee** |
| Chair or Co-Chairs: Working Group 1 | Chair or Co-Chairs: Working Group 2 | Chair or Co-Chairs: Working Group 3 | Chair or Co-Chairs: Working Group 4A | Chair of Co-Chairs: Working Group 4B | Chair or Co-Chairs: Working Group 5 | Chair or Co-Chairs: Working Group 6 | Chair or Co-Chairs: Working Group 7 | Chair or Co-Chairs: Working Group 8 |
| Working Group 1: Evolving 911 Services | Working Group 2: Emergency Alerting Platforms  | Working Group 3: EAS | Working Group 4A: Submarine Cable Resiliency | Working Group 4B: Network Timing Single Source Risk Reduction | Working Group 5: Cybersecurity Information Sharing | Working Group 6: Secure Hardware and Software – Security by Design  | Working Group 7: Cybersecurity Workforce | Working Group 8: Priority Services  |

Table 1 - Working Group Structure

## Working Group 1 Team Members

Working Group 1 consists of the members listed below.

|  |  |
| --- | --- |
| **Name** | **Company** |
| Jeff Cohen – Co-Chair | APCO International |
| Peter Musgrove | ATIS (AT&T)  |
| Elaine Sze | AT&T |
| Jim Thompson | Cal OES, 911 Branch |
| Firdaus Aryana | CenturyLink |
| Melissa Wood | Comcast Cable |
| Roger Marshall | Comtech |
| Brent Bischoff | Cox Communications |
| Andre Savage | Cox Communications |
| Willie King | CSD |
| Brice Hall | DHS |
| Laurie Flaherty | DOT |
| Fred White | Laaser |
| Dorothy Spears Dean | NASNA (VITA)  |
| Steve Mace | NCTA |
| Trey Forgety | NENA |
| Roger Hixson | NENA |
| Kathy Whitbeck | Nsight |
| Jeanna Green | Sprint |
| Greg Schumacher | Sprint |
| Ryan Jensen | T-Mobile |
| Eric Hagerson | T-Mobile |
| Eric Parry | Utah Communications Authority |
| Tony Montani | Verizon |
| Susan Sherwood – Co-Chair | Verizon Wireless |
| Christian Militeau | West |

Table 2 - List of Working Group Members

# Objective

Working Group 1 (WG) of CSRIC V has been charged with completing the following two tasks:

**Task 1: Review Cell-Sector Routing Practices**

This objective is to review public safety and industry Best Practices and Standard Operating Procedures on Legacy, Transitional (IP-based) and Next Generation 9-1-1 (NG9-1-1) systems for rerouting 9-1-1 calls between PSAPs due to the use of cell sectors for routing purposes, and where necessary identify gaps and make recommendations towards optimizing PSAP re-routes. WG previously completed the Task and reported at the March 16, 2016 meeting of CSRIC V.

**Task 2: Make Recommendations for Implementing Location-Based Routing**

* Study and make recommendations on the architectural, technical, operational standards, and security requirements (including cyber) of location based routing that uses longitude and latitude information or other location identification methods (when available) to determine routing to the appropriate PSAP for voice 9-1-1 calls from wireless devices that include Commercial Mobile Radio Service (CMRS), IP-Based (VoLTE, WiFi), and Over-The-Top (OTT) 9-1-1 applications.
* Consider different routing delivery options for LBR methods:
* CMRS delivery option
* VOIP Positioning Center (VPC) delivery option (different routing table)
* External option going direct to PSAP
* Explore and report on the pros and cons of various sources of location information available for location-based routing. This would include the potential reliability and accuracy of the sources, and the transition path to location-based routing of voice 9-1-1 calls from wireless devices from legacy to hybrid and then fully deployed Next Generation 9-1-1 (NG9-1-1) systems. Particular attention needs to be paid to identifying the necessary roles and responsibilities of key stakeholders involved in supporting 9-1-1 calls from wireless devices, and existing and future standards to support the transition.

# Definitions/Acronyms

**A-GPS/A-GNSS** – Assisted Global Positioning System/Assisted Global Navigation Satellite System. System that often significantly improves startup performance—i.e., Time-To-First-Fix (TTFF) of a GPS satellite-based positioning system. A-GPS is extensively used with GPS-capable cellular phones, as its development was accelerated by the U.S. FCC's 9-1-1 requirement to make cell phone location data available to PSAPs.

**ALI** – Automatic Location Identification. Enhanced electronic location system that automatically relays a caller's address or estimated location when he or she calls 9-1-1, whether from a mobile phone or a land line.

**ATIS** – Alliance for Telecommunication Industry Solutions.

**CID** – Cell ID.

**CMRS** – Commercial Mobile Radio Services as defined in Section 20.3 of the FCC’s rules.

**COLD START –** In a cold start,the wireless network or handset shall not make use of any

location assistance information and positioning knowledge retained from a previous attempt,

which would not be available to a person making a 9-1-1 call from a handset that has been turned off for an extended period. ATIS-0500001[Revised in 2011], High Level Requirements for Accuracy Testing Methodologies.

**COS –** Class of Service.A designation of the type of telephone service, e.g. residential, business, Centrex, coin, PBX, wireless.

**CPE** – Customer Premises Equipment.

**CSRIC** – Communications Security, Reliability and Interoperability Council.

**DBH** – Device-based hybrid. An estimation method that typically utilizes either a selection or a combination of location methods available to the handset in a given environment – including crowd-sourced Wi-Fi, A-GNSS, and possibly other handset-based sensors.  It also includes an associated uncertainty estimate reflective of the quality of the returned location.

**ECS** – Emergency Call Server. The functional entity that consists of a Location Retrieval Function (LRF) and either a routing proxy or a redirect server, e.g. an ECS contains a VPC and a Routing Proxy or Redirect Server in NENA I2 architecture.

**ESIF** – Emergency Services Interconnection Forum in ATIS. ESIF develops NG9-1-1 and location accuracy requirements and solutions and is where the industry comes together in a voluntary open forum to identify and resolve technical and operational issues to facilitate interconnection of emergency services networks with other networks (e.g., wireline, cable, satellite, Internet, etc.).

**ESInet** – Emergency Services Internet Protocol Network. An ESInet is a managed IP network that is used for emergency services communications, and which can be shared by all public safety agencies. It provides the IP transport infrastructure upon which independent application platforms and core functional processes can be deployed, including, but not restricted to, those necessary for providing NG9-1-1 services. ESInets may be constructed from a mix of dedicated and shared facilities. ESInets may be interconnected at local, regional, state, federal, national and international levels to form an IP-based inter-network (network of networks).

**ESN** – Emergency Services Number. A 3-5 digit number that represents one or more Emergency Service Zones (ESZs).

**FCC** – Federal Communications Commission.

**FNPRM** – Further Notice of Proposed Rulemaking.

**GIS** – Geographic Information System. Computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface.

**GMLC** – Gateway Mobile Location Center. A computer processing device that can receive and process requests from a location service client (such as a location mapping software application) which are forwarded to the serving mobile location center. The GMLC is used to discover and communicate with a location server that determines the position of the mobile device.

**GPS** – Global Positioning System. Space-based navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.

**HOT START –** In a hot start, all data from a recent position fix is retained from previous attempts and may be utilized in subsequent location fixes. For GPS, this would mean almanac, ephemeris, fine time and accurate position are retained. ATIS-0500001[Revised in 2011], High Level Requirements for Accuracy Testing Methodologies.

**IP-based** – Internet Protocol Based.

**LBR** – Location-Based Routing. A system of rules to varying degrees of complexity dictating to where 9-1-1 calls from various locations are routed.

**LTE** – Long Term Evolution. Commonly marketed as 4G LTE, a standard for wireless communication of high-speed data.

**MMS** – Multimedia Messaging Service. Standard way to send messages that include multimedia content to and from mobile phones over a cellular network.

**MPC** – Mobile Positioning Center. Serves as the point of interface to the wireless network for the 9-1-1 call routing determination and caller location. The entity that retrieves, stores and forwards to public safety the caller location data.

**MSC** – Mobile Switching Center. 2G core network element which controls the network switching subsystem elements. Alternatively or adaptively, MSC can be used in GSM networks as well, if the manufacturer has implemented support for GSM networks in the MSC.

**NEAD** – National Emergency Address Database. A database that utilizes MAC address information to identify a dispatchable location for nearby wireless devices within the CMRS provider’s coverage footprint.

**NG9-1-1** – Next Generation 9-1-1.

**OTT** – Over-The-Top. The delivery of audio, video, and other media over the Internet without the involvement of a multiple-system operator in the control or distribution of the content. The Internet provider may be aware of the contents of the Internet Protocol packets but is not responsible for, nor able to control, the viewing abilities, copyrights, and/or other redistribution of the content.

**PSAP** – Public Safety Answering Point. A point that has been designated to receive 9-1-1 calls and route them to emergency service personnel.

**SMS** – Short Message Service. Text messaging service component of phone, Web, or mobile communication systems. It uses standardized communications protocols to allow fixed line or mobile phone devices to exchange short text messages.

**SOP** – Standard Operating Procedure.

**TDM** – Time-division multiplexing. A method of transmitting and receiving independent signals over a common signal path by means of synchronized switches at each end of the transmission line so that each signal appears on the line only a fraction of time in an alternating pattern. It is used when the data rate of the transmission medium exceeds that of signal to be transmitted. This form of signal multiplexing was developed in telecommunications for telegraphy systems in the late 19th century, but found its most common application in digital telephony in the second half of the 20th century.

**TIA** - Telecommunications Industry Association.

**UE** – User equipment.

**VoLTE** – Voice over LTE.

**VPC** – VoIP Positioning Center. The VPC is a critical element of the i2 Solution defined by the National Emergency Number Association (NENA) for supporting 9-1-1 call originations from VoIP customers. The VPC facilitates the routing of emergency calls and ensures the delivery of location information related to VoIP emergency call originations.

**WARM START –** In a warm start,the wireless network or handset may make use of certain

location information or positioning knowledge retained from a previous attempt, which would

normally be available to a person making a 9-1-1 call from a handset that is maintained on in an

idle mode. ATIS-0500001[Revised in 2011], High Level Requirements for Accuracy Testing Methodologies.

**WEA** – Wireless Emergency Alert. The voluntary emergency alerting system established by Part 10 of the FCC’s rules, whereby Commercial Mobile Service Providers may elect to transmit Alert Messages to the public.

**WG** – Working Group 1.

**Wi-Fi** – Wireless Fidelity.

**WSP** – Wireless Service Providers.

**WTSC** – Wireless Technologies and Systems Committee in ATIS. WTSC develops wireless radio access, system, and network solutions related to wireless and/or mobile services and systems. WTSC develops and continues to enhance solutions necessary to support a U.S. public warning system and wireless emergency alert system.

# Background of Wireless 9-1-1 Call Routing

Timing of every component within the wireless 9-1-1call flow is critical to understanding why the existing call routing and data delivery system is in place and the impacts of potential changes to that system.

The voice portion of the wireless 9-1-1 call is routed by the Mobile Switching Center (MSC) no later than 6 seconds from when the caller presses “send”. Therefore, in order to route on location, that location must be available to the MSC in 5 seconds or less. Most currently deployed wireless 9-1-1 location technologies take an average of 15 to 23 seconds to calculate an E9-1-1 Phase 2[[1]](#footnote-1) fix. FCC rules allow up to 30 seconds for WSPs to generate a Phase 2 fix. Generally, for geodetic location technologies attempting to measure a caller’s location from a “cold start”, the longer the time allowed to determine location, the more accurate the location.[[2]](#footnote-2)

Due to these time constraints, it was agreed in standards documents created with public safety in the early days of E9-1-1 Phase 2, that wireless 9-1-1 calls could be routed using a pre-agreed PSAP to cell sector arrangement. This pre-agreed routing determination allowed a PSAP certainty in call volume and in some cases, funding levels. In addition, troubleshooting call routing questions was easier to resolve due to the pre-determination of the routing location. However, cell sector call routing does present some challenges, including the fact that more than one PSAP can be within the coverage area of a cell sector and RF propagation may result in a 9-1-1 call not originating on the nearest cell sector.

Many PSAPs have existing best practices and standard operating procedures (SOP) in place to transfer calls to another PSAP. This is especially true when it is a common occurrence such as when a cell sector is overlapping a county or state border.

# Key Considerations of Location-Based Routing

Location-based routing of wireless 9-1-1 calls can be accomplished using a number of different methods. Each location-based routing method has its own pros and cons, among other considerations.

In order for location-based routing to be effective in delivering the 9-1-1 call to the jurisdictionally appropriate PSAP, the location needs to be calculated in 5 seconds or less with a fairly high-degree of accuracy. This is more challenging for technologies utilizing location techniques from a “cold start” than those relying on long-term location tracking of callers, also known as “hot start” location methodology.

For example, device-based hybrid (DBH) location solutions rely on callers allowing their devices to continually update their onboard location estimates for commercial location application purposes (e.g. find the closest coffee shop). DBH utilizes either a selection or a combination of location methods available to the handset including crowd-sourced Wi-Fi positioning, A-GNSS (A-GPS and other foreign constellations including GLONASS and Galileo), and possibly other handset-based sensors to continually refine the caller’s location. Should that caller make a 9-1-1 call, their location has already been calculated.

However, many of these DBH and other commercial location solutions are maintained by vendors with proprietary databases and location methodologies, allowing no visibility to WSPs who might want to use these locations for 9-1-1 call routing purposes. If these locations are to be used for location-based routing of 9-1-1 calls, a method for determining the reliability and accuracy of these proprietary databases and resulting locations is needed. Also needed is a method to quickly validate the DBH location (e.g. within cell sector coverage) before its use for 9-1-1 call routing.

# Location-Based Routing Method Review

Working Group 1 used the following format for reviewing each LBR method:

* Pros
* Cons
* Reliability
* Accuracy
* Roles and responsibilities of key stakeholders (technical feasibility)
* Architectural Changes and Technical Standards Impacts
* Operational Standard Operating Procedures (SOP) Impacts
* Security Considerations (including cyber)
* Recommendations

## Hold Call until Phase 2 Available

Option 1: Hold call at Wireless Mobile Switching Center (MSC) or Hold call at the MSC based on delaying routing info from Mobile Positioning Center (MPC)/Emergency Call Server (ECS).

Option 2: Hold call at the PSAP gateway.

Holding the 9-1-1 call at either the MSC or the PSAP gateway until Phase 2 location is available:

* + Pros:
		- PSAP gets Phase 2 location when the call is received at the PSAP Customer Premise Equipment (CPE) or the telecommunicator (TC) position, upon first PSAP query through Automatic Location Identification (ALI) server.
		- Delaying the call until (initial) Phase 2 estimated caller location data is available via the Gateway Mobile Location Center (GMLC) / ALI server query process would resolve the issues with the PSAP often not getting Phase 2 data when the call arrives at the PSAP (due to voice network speed improvements causing initial ALI query before the Phase 2 location is developed and provided to the GMLC).
		- Getting most precise routing decision.
* If Phase 2 estimated caller location data were to be available to support call routing (in lieu of tower and sector pre-defined routing to `most probable’ PSAP), most presumed `mis-routing’ to a pre-defined PSAP would disappear. (Note – this assumes that the relevant databases that control this process are accurate and constantly maintained.)
	+ Cons:
		- Time required to wait – may take up to 30 seconds for a wireless Phase 2 fix. Wait time can be configurable, but lower wait times will lessen the chance of receiving a Phase 2 fix and its potential accuracy. A Phase 2 fix may also not be achievable in certain situations, such as in challenging environments.
		- Caller gets dead air and may hang up. Generally, it is considered undesirable for the caller to receive no response for more than 10 seconds. Any longer time may lead to hang-up and re-dial, or abandoning the attempt.
		- Wireless MSC may time out and default route in 6 to10 seconds, which would defeat the approach.
		- Response to emergency is delayed because delivery of call is delayed.
* Depending on the technique chosen, changes to legacy systems in the WSP and vendor environments would have to be accomplished, likely on the order of a hundred or more network element changes. If legacy E9-1-1 Core and PSAP systems[[3]](#footnote-3) are affected, the quantity would be on the order of 6000-7000 systems.
	+ - Reliability/Accuracy:

No change in reliability, improved accuracy of routing.

* Roles and Responsibilities of Key Stakeholders:

No change.

* ArchitecturalChanges and Technical StandardsImpacts:

For Hold at the MSC or under GMLC control, minor standards changes are likely to define timing changes in processing location data.   For Hold at the PSAP Gateway, software changes and standards changes would be required for E9-1-1 Core system and PSAP CPE to accomplish the hold and release processes that are not involved currently in these systems.

* Operational SOPImpacts:

Delayed call delivery, coping with caller expectations for quicker answer and incident management, but with Phase 2 caller location when the call is received at the PSAP.

* + Security Considerations (including cyber)**:**

No new impacts.

* + Recommendations:
* It is not recommended to delay the call delivery to the 9-1-1 system and associated PSAPs for timeframes related to the current availability of Phase 2 location.

## Interim or Quick Fix

In this LBR method, the 9-1-1 call can be routed using an Interim or Quick Fix that is delivered by the WSP in 5 seconds or less. The X/Y coordinates delivered with the Interim or Quick Fix, are plotted on a geospatial shape file of one or more PSAP jurisdictional boundaries and delivered to the PSAP in which the X/Y coordinates are plotted. Generally, this method necessitates holding the 9-1-1 call at one of the points outlined in Section 7.1, utilizing a timer of up to 6 seconds.

* Pros:
	+ - X/Y routing – Interim or Quick Fix is the only current method to use X/Y for routing an emergency voice call.
		- Some 2G/3G devices can return Assisted Global Positioning System (A-GPS) fix in 5 seconds or less if caller in open sky environment with 4 or more satellites in view.
		- Can be sent to PSAP on first location request.
		- Not spoof-able location because it’s a control plane solution.
	+ Cons:
		- Locations delivered in more than 5 seconds would not be used for routing.
		- Interim or Quick Fixes will likely be less accurate than final fix at 20-30 seconds and may not route to the jurisdictionally appropriate PSAP when the caller is close to a jurisdictional boundary.
	+ Reliability/Accuracy:

In California’s NG9-1-1 Northeast Grant Project using X/Y Location-Based Routing (LBR) (also referred to as Quick Fix Location) in 2014 and 2015, California received 504,884 NG 9-1-1 calls of which 45.47% or 229,558 were subject to LBR. The other 54.53% or 275,326 of NG9-1-1 calls were not evaluated due to deployed technology limitations (at the time of the trial) resulting in excessive X/Y timing delays.

* + - 1. 29.30% or 67,250 of these 229,558 calls using LBR were evaluated and found to use Emergency Service Numbers (ESNs) matching the assigned tower ESN.
			2. 18.52% or 42,509 calls had their ESN changed from the tower assigned ESN to a different ESN based on the X/Y (Quick Fix) Location of the caller.
			3. 43.30% or 99,410 calls timed out past the 6 second LBR Quick Fix acquisition timer setting, and were, as a result, routed to the tower assigned ESN.
			4. 8.88% or 20,389 calls were shown as abandoned for LBR evaluation.
	+ Roles and Responsibilities of Key Stakeholders:

Of the four major WSPs serving California, only one of the four WSPs can provide a Quick Fix within the 6 second timer setting. Most of the carriers need in excess of 20 seconds to provide an X/Y location.

Full participation of WSPs with the capability to hold the call and obtain an Interim or Quick Fix X/Y is not expected to improve in the near future. With the additional requirement to provide X/Y/Z location, the impact on Interim or Quick Fix routing is unknown.

* + - Architectural Changes and Technical Standards Impacts:

No architectural changes at the PSAP if the WSP does the work of generating the Interim or Quick Fix and plotting on PSAP jurisdictional boundaries to determine the PSAP to which to route the call. The PSAP would still receive the expected routing key and perform their ALI queries as usual. If an Interim or Quick fix was obtained and used for routing, the PSAP would receive that fix on their initial ALI query.

The MPCs for 2G/3G networks are currently capable of holding the 9-1-1 call for a configurable length of time and routing on location as opposed to the originating cell sector. However, the ability to utilize an Interim or Quick fix in a 2G/3G network is dependent on the chipset in the device being able to receive and transmit measurements in a few seconds and the location server being able to calculate and deliver to the MPC, a location in 5 seconds or less.

For 4G networks, the 3GPP standard allows for an Interim Fix, but some work is needed in the Location and ECS Servers to process and handle an Interim Fix properly and then, continue to process and handle the final fix as delivered. In addition, the chipset in the device must be able to provide measurements back to the Location Server in a few seconds while continuing to gather measurements for the final fix.

Using a device-provided location for an Interim Fix is possible if provided in the SIP Invite; however, work is needed at the Location and ECS Servers to process and handle properly, including the ability to validate the provided location before using to route a 9-1-1 call.

* Operational SOP Impacts:

Using new location sources to route the 9-1-1 call would not have any negative operational impact to PSAPs, but would lessen the need to transfer calls between PSAPs.

* Security Considerations (including cyber):

For control plane location techniques, used in Interim or Quick Fix, there are no expected security issues over what there is today. User plane location is more susceptible to spoofing; so, a method to validate the location is needed before it is used to route 9-1-1- calls.

* + Recommendations:
* It is recommended that Interim or Quick Fix be used where its implementation is expected to derive sufficient benefit to justify investment. This methodology may have some benefits, but there are some factors that may limit its usefulness and return on investment depending on how implemented.

## Geo-code Registered/Provisioned Civic Address

Registered or provisioned civic address options:

Option 1: Static or nomadic consumer home device that has customer register location of device.

Option 2: Semi-permanent devices or cells installed by carrier or other commercial entity – addresses provisioned by entity.

Option 3: Dynamic geo-code registration – nomadic device that can update its registered civic address in real time through reverse geo-coding.

* + Pros:
		- Options 1 and 2 have a potentially high degree of location accuracy, assuming the device is being used at the address registered.
		- Option 3 can have a high degree of location accuracy so long as the method for determining location prior to civic address registration functions effectively and the base map used for reverse geo-coding is very accurate.
		- All options potentially provide quicker routing and location information delivery to PSAP.
	+ Cons:
		- * Option 1 and 2 are problematic if device is ever used elsewhere either temporarily or if it is moved permanently. Registered civic addresses may not have been updated by consumer or carrier/commercial entity.
			* PSAP that receives call based on registered address may differ from PSAP that receives a wireless call made from the same physical location.
			* When registered addresses are not updated when the device is moved, Options 1 and 2 may result in routing to a PSAP that is nowhere near the 9-1-1 caller, while potentially appearing as accurate to the PSAP that receives the call.
			* Option 3 relies on device-based technology to determine how accurate the address is and may communicate a false depiction of accuracy to PSAP.
			* Option 3 has time considerations regarding how long the device-based technology takes to determine location with suitable accuracy and then, update the registered address before placing or concurrently with placing a call to PSAP.
			* Option 1 and 2 should be done with new devices rather than trying to retrofit devices already in hands of subscribers. For Option 3, it may be possible to push out a software update (e.g. smartphones), but for other devices, it may need to be on a going forward basis.
	+ Reliability/Accuracy:

Potential for landline-like accuracy for both routing and location delivery to the PSAP. This is dependent upon user address updates in Option 1, carrier or commercial entity address updates in Option 2, and device-based information and range of delivery techniques in Option 3.

Reliability varies in Options 1 and 2 and is impacted by movement of the device or use of the device not where expected. Reliability also varies in Option 3 and is impacted by capabilities of the device-based technology and the accuracy of reverse geo-coding base map.

* + Roles and Responsibilities of Key Stakeholders:

Option 1 requires the user to provision and maintain address information. User becomes responsible for the accuracy of the information and for insuring it is kept up-to-date.

Option 2 requires the carrier or commercial entity to provision and maintain address information. Carrier/commercial entity becomes responsible for the accuracy of the information and for insuring it is kept up-to-date.

Option 3 requires that a technology provider accurately determine the location of the device, accurately reverse geo-code that location and update appropriate data repositories in a timely manner. This provider becomes responsible for executing this mechanism every time an emergency call is placed.

* + Architectural Changes and Technical Standards Impacts:

Standards and civic location delivery methods are defined but not universally in place for Options 1 and 2. For Option 3, no impact if done OTT on smartphones and outside of WSP 911 location determination and delivery processes. If delivered into Public Safety network in the same manner as wireless 9-1-1 calls, there would be no impact at PSAP.

* + Operational SOP Impacts:

None if standard wireless 911 call routing and location delivery processes are used.

* + Security Considerations (including cyber)**:**

For all options, storage of registered address should at minimum be subject to appropriate privacy and security protections, and potentially be treated as personally identifiable information (PII) as that term may be defined by the FCC.

* + Recommendations:
* It is recommended that the FCC work with device manufacturers and WSPs to assess the feasibility of enabling all devices used for static and nomadic purposes with the ability to validate if it has been moved and alert the network of its status.

## Device-Based Hybrid Location

Device-based hybrid (“DBH”) location is an estimation method that typically utilizes either a selection or a combination of location methods available to the handset in a given environment, including crowd-sourced Wi-Fi, A-GNSS, and possibly other handset-based sensors.  It also includes an associated uncertainty estimate reflective of the quality of the returned location.

Relying on a handset-based location solution represents, in some ways, a step away from the historical paradigm where the wireless carrier controls the entire E9-1-1 location process from end-to-end.  DBH will likely be one in a series of new/emerging location methods (e.g., NEAD-based dispatchable location positioning) which no longer rely fully on the wireless carrier.

The method is finally becoming available, after years of effort and encouragement by wireless carriers, for use with E9-1-1 location systems – helping to close the performance gap between state-of-the-art commercial systems and E9-1-1 systems.  This development addresses a frequently asked question – “Why can Uber and the Starbucks app find me, but 9-1-1 can’t?” Setting aside the reliability differences and other factors between location services used for commercial purposes, and those used for safety of life, there is merit to exploring how to leverage commercial location technologies for 9-1-1 purposes.

* + Pros:
* The method produces low-latency (typically ~ 5 seconds), high-accuracy location estimates in many environments, including indoors.  Accuracy is in-line with A-GPS, while yield is substantially improved relative to A-GPS (in many cases nearing 100%).  The low latency and high accuracy can both be beneficial to routing 9-1-1 calls.
* DBH is a proven location method for commercial location services. Google maps, Apple maps, Uber and like applications use DBH with very good results, at least in the more ideal outdoor locations.
* The DBH method works well in virtually all environments that have typical to a high density of Wi-Fi access points (essentially dense urban, urban, and some suburban morphologies) – including deep indoor environments where few, if any, other methods provide high-accuracy.
* Recent implementation in Europe (United Kingdom and Estonia) of an Android based solution for emergency services has shown promise for wide spread application of this technology.[[4]](#footnote-4)
* Solutions are available from a wide variety of location providers (Apple, Google, Qualcomm, Skyhook, Nokia/HERE, others).
	+ - * In some instances, these providers offer a network-based equivalent to DBH (UE-Assisted architecture) – where the handset collects the relevant location measurements and provides them to the network, where the position calculation function is completed.
* Cons:
* Generally provided via proprietary, closed database, providing little to no visibility to details of location determination methodology or database maintenance.
* The Wi-Fi component of DBH may not be available in areas with low access point densities, but other methods can typically be effectively utilized in these instances.
* Verification of location against other sources would likely be limited to serving cell location information, if used for call routing.
* Reliability/Accuracy:

There are current examples, like UE-Based A-GNSS location, where the handset is already in control of the entire location solution – including the position calculation function.  Even in these handset-based implementations, consistent, high performance results has been seen across the wide variety of different handset models.

Also, while the functionality of the DBH method does not depend on any user interface settings, the accuracy of the method in response to a 9-1-1 call will likely be enhanced when location tracking is enabled.

While the possibility exists for large location errors on occasion (outliers), this is true for virtually any location method, and validation checks can detect and preclude the vast majority of these cases, even simply using the ultimate arbiter of serving cell location. Furthermore, while the wireless carrier is not in control of the crowd-sourced Wi-Fi database used with DBH, the companies who do control the databases have a long and successful history of compiling, maintaining, and utilizing these databases for reliable positioning – and their ongoing commercial success depends on this pattern continuing.

In fact, Google has recently announced the release of Advanced Mobile Location, an emergency location service that utilizes Wi-Fi crowd-sourced positioning and A-GNSS[[5]](#footnote-5) and is backward compatible for a great majority of Android devices.

* Roles and Responsibilities of Key Stakeholders:

DBH vendors should be responsible for maintaining, operating and verifying accuracy of the Wi-Fi access point location databases they own.

* Architectural Changes and Technical Standards Impacts:

The IMS specifications such as 3GPP TS 23.167, already allow for a usage of device provided location within PIDF-LO in the SIP INVITE at call setup.

Devices may leverage solutions like OMA SUPL or proprietary methods to assist with the location calculation function.

Circuit switched call origination call setup does not have the same ability for a device to provide a location at call setup.

Device provided location could be pulled or pushed (device to location server) by methods other than IMS that are non-standard.

* Operational SOP Impacts:

Device provided location should be validated against alternative location sources such as serving cell location.

Fallback to routing on cell would still be required when device provided location is not available or fails location validation.

* Security Considerations (including cyber):

Data plane path is encrypted end to end.

The serving network routing of E9-1-1 calls might be independent of device provided location calculation function.

Device provided location might be subject to location spoofing.

* Recommendations:
* It is recommended to further study the suitability of device-based hybrid for use in E9-1-1 call routing.  To-date, no location method, other than Cell ID, has proven reliable enough and quick enough to be relied upon for routing 9-1-1 calls to the appropriate PSAP.  While DBH methods are already moving the performance needle to locate wireless callers in challenging indoor environments, it remains to be seen whether this method will prove useful in improving 9-1-1 call routing.
* It is recommended that the FCC reach out to the Smartphone operating system and device providers such as Apple, Google, LG, Nokia, etc. to invite them to participate in 9-1-1 industry forums and standards activities as 9-1-1 location providers and advise on what action(s) by the FCC would be required to provide WSPs with the assurances and protections needed in order for them to implement proprietary 3rd party location solutions.
* It is recommended that WSPs should investigate updating device and location server capabilities to choose for use with 9-1-1 location-based call routing, between obtaining an interim A-GPS location fix or utilizing a current location stored on the device from a commercial location application running on the phone, that has been sanity checked for validity.
* It is recommended that the standard bodies Telecommunications Industry Association (TIA) TR-45.8 and Alliance for Telecommunication Industry Solutions (ATIS) Wireless Technologies and Systems Committee (WTSC) need to review J-STD-036 to determine if any interface, signaling and parameter changes are required in order to support the utilization of a device’s commercial location as an interim location method for delivery and use with wireless 9-1-1 call routing.

## Wireless 9-1-1 Location Accuracy Emerging Technologies

Wireless carriers are in the process of implementing the FCC’s Fourth 4th Report and Order[[6]](#footnote-6) on 9-1-1 location accuracy that includes provisions for an independent Test Bed to assess the indoor location accuracy of carrier-deployed location solutions and new, emerging location technologies, the creation of the NEAD for storing Wi-Fi access points and BlueTooth beacons for determination of dispatchable location, and the establishment of a z-axis metric through the Test Bed process.

The location technologies tested in the Test Bed and currently or subsequently deployed, could potentially be leveraged for location-based routing of wireless 9-1-1 calls if these technologies derive sufficiently accurate location fixes in 5 seconds or less.

* + Pros:
		- As existing location technologies mature, the positioning algorithms will be refined using feedback from live 9-1-1 call data and compliance test data. These refinements may lead to decreases in Time to First Fix (TTFF) and increases in first fix accuracy, allowing for more of these fixes to be generated in 5 seconds or less and therefore, available for location-based routing.
		- New location technologies are likely to be introduced that take advantage of the capabilities of IP-based access networks and inputs from external position sources. Some of these new technologies may allow for quicker fix times with a greater degree of accuracy.
		- Testing has shown that combining additional satellite constellations as support with GPS (referenced as A-GNSS), increases the number of satellites that can be seen by the device, particularly in challenging environments such as indoors, and as a result, increases the number of A-GNSS fixes and the accuracy of those fixes.
			* Hybrid A-GNSS/OTDOA and OTDOA location solutions also show a good deal of promise in improving the accuracy of locations delivered on 9-1-1 calls over other 2G/3G hybrid and network-based location solutions, but it is too early in the deployment cycle of these technologies to see if the TTFF can be improved to the 5 seconds or less required for location-based routing.
	+ Cons:
* For GPS or cell-based locations, the TTFF and the accuracy of a given fix are a function of the environmental conditions in which the 9-1-1 call is made. The more challenging the environment (e.g. deep indoors), the longer it takes to obtain a fix, if position inputs need to be gathered from both GPS and cell-based sources. Dispatchable Locations are not impacted by environment conditions because these addresses are tied to fixed points within a building and not geodetically calculated.

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* + - Until recently, 9-1-1 locations were tested for accuracy compliance using a “cold start” location methodology. This methodology did not allow for the device or the network to utilize previous location knowledge to generate a fix for delivery on a 9-1-1 call. The Emergency Services Interconnection Forum (ESIF) recently changed their testing rules to allow for “warm start” where some device location knowledge can be used in generation of a location fix, but does not allow for device tracking which is considered a “hot start”.
* Reliability/Accuracy:

Radio Access Network technology is dynamic and how a caller connects to the network and the position inputs the device can see will vary across geography, time of day and network availability. Each of these factors has an impact on the fix time and location accuracy.

Position inputs into the calculation of a location fix must be reliable and consistent in order to place any reliance on a given position input.

The data and methodology from which position inputs are derived must be verifiable, and consistently and accurately maintained.

* + Roles and Responsibilities of Key Stakeholders:

The sources of position inputs into a location calculation must be able to assert that their databases and algorithms are maintained in a manner that assures consistent, accurate data and methodology. This includes third party companies or vendors that use proprietary databases and location calculation methodologies to derive caller locations that they purport can be used for 9-1-1 call routing and dispatch.

The users of external position inputs for location calculations (e.g. Wireless Service Providers or WSPs) should be provided with metrics and other performance verification tools to ensure that the position inputs meets quality requirements for emergency services.

The WSP who delivers the 9-1-1 call and is held responsible for the location fixes that are passed to public safety, must have procedures in place to ensure that internal positioning methodologies used are reliable, consistent and performing at expected levels.

* Architectural Changes and Technical Standards Impacts:

There are significant network architectural and device changes for WSPs that move from CDMA-based networks to LTE-based networks. While A-GPS will continue to be supported on LTE networks, new location technologies will also be deployed for LTE wireless 9-1-1 calls. These new technologies, once deployed, will be monitored and enhanced over time.

For WSPs that have UMTS networks in place, network architecture and device changes are not as significant, but new 9-1-1 location technologies, such as A-GLONASS and OTDOA, may be added to the existing mix of location solutions.

Technical standards in standards bodies including 3GPP and ATIS, have already been completed for the base-level 9-1-1 location technologies deployed in LTE networks (e.g. A-GNSS, OTDOA, Hybrid solutions and ECID). Work is in progress for incorporating additional location solutions that include Wi-Fi and beacon positioning, device-based hybrid and Dispatchable Location.

* Operational SOP Impacts:

Operational Standard Operating Procedures will need to be developed by public safety, including additional Class of Service indicators, in order for the dispatcher to best interpret and utilize locations provided on a given 9-1-1 call.

* Security Considerations (including cyber):

The location server, its location inputs, including satellite reference networks, and interfaces with call routing/location delivery servers are already incorporated into WSP network security requirements and monitoring. In addition, the data plane path is encrypted end to end.

New location input sources will need to be subject to the same level of security.

* + Recommendations:
		- It is recommended that the FCC should continue to support the independent testing and analysis of new location technologies that promise significantly increased accuracy and quicker time to first fixes that would allow for their use in routing 9-1-1 calls to the jurisdictionally appropriate PSAP.
		- It is recommended that the FCC should encourage the use of additional A-GPS/A-GNSS satellite constellations by WSPs as one input, among many inputs, into the 9-1-1 location algorithm as it is currently in use for device-based hybrid commercial locations.
		- It is recommended that the FCC should seek assurance from providers of location fixes calculated from proprietary databases sought to be used for routing 9-1-1 calls, that their databases and algorithms are maintained in a manner that assures consistent and accurate locations required for emergency services. Furthermore, the FCC should require these databases to be standards compliant and allow for periodic, standardized accuracy testing conducted by users and recipients of DBH locations, without sending the voice call to PSAP.
		- It is recommended that the FCC should require providers of location fixes calculated from proprietary databases sought to be used for routing 9-1-1 calls, to provide metrics and other performance verification tools to WSPs to ensure that the location fixes meet accuracy and quality requirements.
		- It is recommended that the WSPs who deliver 9-1-1 calls and are held responsible for the calculation of the locations fixes passed to public safety, must have metrics and procedures in place to ensure that internal positioning methodologies used are reliable, consistent and performing at expected accuracy and quality requirements.

# Transition Considerations for PSAP Systems

Transition implies the moving from legacy 9-1-1 to NG9-1-1. The emergency calling architecture has two separate ends or domains, the originating end and the terminating end. Each of these two domains distinguishes themselves from the other based on the functions they employ. An originating domain is responsible for initiating a 9-1-1 call, to do initial call routing, and to acquire location associated with the call. The terminating domain may also perform additional routing, delivers the call, as well as location and call related data.

Each domain can evolve on its own, apart from the other. While the originating domain is inclined to support a variety of media, including voice, text, video, and access technologies such as CDMA, GSM, LTE, Wi-Fi, and performance profiles, 3G, 4G, 5G, etc., the terminating side is the domain that typically uses the terms legacy, transitional, and NG9-1-1[[7]](#footnote-7) to describe how any kind of available data is conveyed to the PSAP.

Despite the clear difference in roles, each end has certain impacts on the other. The following describes impacts to the originating domain, which is often noticed by the terminating end.

## Originating Service Characteristics:

The following scenarios seek to change the TC experience, namely what type of location data they see, and when they see it by changes made to the originating side of the 9-1-1 system, regardless of originating technology.

### Hold Call until Phase 2 Available

Holding the routing of a 9-1-1 call until a Phase 2 fix is available has no technical or service operations impact on either E9-1-1 Core Service systems, or on PSAP centric systems[[8]](#footnote-8). However, there would be a call handling impact because the call would be delayed for the caller and the TC, also delaying response, compared to today’s timing.

### Interim or Quick Fix

No technical or service operations impact on either E9-1-1 Core Service systems, or on PSAP centric systems. Call handling benefits in that more calls would be initially directed to the jurisdictionally appropriate PSAP (rather than a pre-defined `best choice’ PSAP based on cell tower/sector information).

### Geo-code Registered/Provisioned Civic Address

Would require handling of wireless civic address data across the E9-1-1 Core Services systems and the ability to display such address data(and probably including the geodetic (X/Y) data as well) at PSAP centric systems. This is an issue already being developed for National Emergency Address Database (NEAD)-based location service.

For transitional and NG9-1-1 Core Services (NGCS)[[9]](#footnote-9), the ability to receive (by value, literally with the call) or acquire (by reference query) the identified location data in time to process the call for correct routing to the jurisdictionally appropriate PSAP is critical. The design of NG9-1-1 already includes the ability to handle this approach, and the flexibility of PSAP equipment/software is part of NG9-1-1 PSAP requirements. However, these features are dependent on IP-to-IP interconnection between an WSP and NG9-1-1 Core ingress components, a capability proposed but not yet implemented by WSPs.

### Device-Based Hybrid Location

Assuming that all DBH options and combinations involve only geodetic approaches (no civic address component) and current legacy interfaces, the location chosen for delivery to the E9-1-1 Core Services systems and to PSAP centric equipment/software would be handled and appear in the same way as today. For transitional and NG9-1-1 Core Services, options exist to receive (by value, literally with the call) or acquire (by reference) the identified location data in time to process the call for correct routing to the jurisdictionally appropriate PSAP. The design of NG9-1-1 already includes the ability to handle this approach, and the flexibility of PSAP equipment/software is part of NG9-1-1 PSAP requirements. However, these features are dependent of IP-to-IP interconnection between WSP and NG9-1-1 ingress components, a capability proposed but not yet implemented by WSPs.

### Wireless 9-1-1 Location Accuracy Technologies

As a result of changes to be made with the introduction of wireless civic location data in the NEAD context, we believe that any combination of X-Y-Z location and related civic data can be handled in both legacy (E9-1-1 and PSAP) systems, and in transitional and full NG9-1-1 systems and NG9-1-1 PSAP systems design. However, if new considerations arise as new or modified wireless location technologies are tested and deployed, this conclusion could change.

## Terminating Service Characteristics:

### Transition Considerations for Legacy Emergency Services Networks

For legacy emergency service networks that connect to PSAP facilities through a Selective Router using Time Division Multiplexing (TDM) trunks and that rely on an Automatic Location Identification (ALI) database for location information delivery, the impact of location based routing may be significant. For example, any emergency call that is routed based on Phase 2 X/Y (latitude/longitude geodetic) information, may also be presented at the PSAP with the same X/Y information at the time that the call is received, which may have an impact on call handling procedures. Plotting this X/Y fix using mapping tools earlier and sending this data over to PSAPs more quickly than is done currently, may represent optimizations that would otherwise be not available without LBR.

Other impacts to existing PSAP processes may emerge. One challenge is how the location information should be shown along with a description of what is being represented to the call taker. For example, if LBR is utilized, then the information that describes the call as such should be highlighted. Currently, there is no field defined to convey such information. New Class of Service (COS) values could be introduced, but may cause confusion when compared to existing values. Any effort to add new descriptive information should be done using a standards based approach in order to limit variation of implementation.

Delivery of the same X/Y as was used for routing the call should be vetted with respect to the uncertainty and confidence reported that is associated with the coordinates. Telecommunicators must take into consideration the reported uncertainty in order to “trust” the position data. They should also continue to request mid call location updates (e.g. re-bids) to further check the reliability of the initially reported location data, as well as determine if the caller is mobile, regardless of the fact that they may have received a more granular X/Y with the call than the Phase 1 X/Y that would have been originally conveyed to the PSAP.[[10]](#footnote-10)

Inclusion of other types of data:

Legacy ALI systems, including connecting network nodes that deliver data to the PSAP, may require system software changes to be able to deliver an expanded set of location data, including indoor location information, such as building, floor, room, place type, uncompensated barometric pressure, and altitude, etc. Without changing existing systems, some of this new data available to be passed to the PSAP, is largely dependent on the capabilities of the PSAP equipment.

### Transition Considerations for IP-connected Emergency Services Networks

A PSAP that has been upgraded away from TDM trunks in order to utilize IP-based circuits and interfaces, yet that has no ESInet or NGCS, or PSAP related software features to support Core Services functions, falls short of being considered an NG9-1-1 PSAP. In this case, many non-standard solutions either already exist, or could be implemented to deliver a full set of rich data that is available from an MPC/GMLC/LRF without the constraints of the legacy ALI interface. These solutions would be considered proprietary, though they may borrow pieces from an NG9-1-1 architecture, typically using HTTP/HTTPS delivery mechanisms and APIs, including browser based interfaces, but would not necessarily be considered NENA i3 NG9-1-1 standards based.

### Transition Considerations for NG9-1-1 Emergency Services Networks

NG9-1-1 PSAPs would be self-described as being IP-based and connected to and supporting an NG9-1-1 / ESInet interfacing with NGCS elements, and that would be able to present a full set of rich data, including the location by which an emergency call was routed originally, as well as other location data that may have been requested after initial call routing was complete.

# Recommendations - Summary

In Section 7, CSRIC V Working Group 1 has identified and reviewed several location-based routing methods that could potentially be used for wireless 9-1-1 call routing. Within each LBR method, a number of characteristics are evaluated and recommendations to the FCC are identified. These recommendations are summarized below:

* It is not recommended to delay the call delivery to the 9-1-1 system and associated PSAPs for timeframes related to the current availability of Phase 2 location.
* It is recommended that Interim or Quick Fix be used where its implementation is expected to derive sufficient benefit to justify investment. This methodology may have some benefits, but there are some factors that may limit its usefulness and return on investment depending on how implemented.
* It is recommended that the FCC work with device manufacturers and WSPs to assess the feasibility of enabling all devices used for static and nomadic purposes with the ability to validate if it has been moved and alert the network of its status.
* It is recommended to further study the suitability of device-based hybrid for use in E9-1-1 call routing.  To-date, no location method, other than Cell ID, has proven reliable enough and quick enough to be relied upon for routing 9-1-1 calls to the appropriate PSAP.  While DBH methods are already moving the performance needle to locate wireless callers in challenging indoor environments, it remains to be seen whether this method will prove useful in improving 9-1-1 call routing.
* It is recommended that the FCC reach out to the Smartphone operating system and device providers such as Apple, Google, LG, Nokia, etc. to invite them to participate in 9-1-1 industry forums and standards activities as 9-1-1 location providers and advise on what action(s) by the FCC would be required to provide WSPs with the assurances and protections needed in order for them to implement proprietary 3rd party location solutions.
* It is recommended that WSPs should investigate updating device and location server capabilities to choose for use with 9-1-1 location-based call routing, between obtaining an interim A-GPS location fix or utilizing a current location stored on the device from a commercial location application running on the phone, that has been sanity checked for validity.
* It is recommended that the standard bodies Telecommunications Industry Association (TIA) TR-45.8 and Alliance for Telecommunication Industry Solutions (ATIS) Wireless Technologies and Systems Committee (WTSC) need to review J-STD-036 to determine if any interface, signaling and parameter changes are required in order to support the utilization of a device’s commercial location as an interim location method for delivery and use with wireless 9-1-1 call routing.
* It is recommended that the FCC should continue to support the independent testing and analysis of new location technologies that promise significantly increased accuracy and quicker time to first fixes that would allow for their use in routing 9-1-1 calls to the jurisdictionally appropriate PSAP.
* It is recommended that the FCC should encourage the use of additional A-GPS/A-GNSS satellite constellations by WSPs as one input, among many inputs, into the 9-1-1 location algorithm as it is currently in use for device-based hybrid commercial locations.
* It is recommended that the FCC should seek assurance from providers of location fixes calculated from proprietary databases sought to be used for routing 9-1-1 calls, that their databases and algorithms are maintained in a manner that assures consistent and accurate locations required for emergency services. Furthermore, the FCC should require these databases to be standards compliant and allow for periodic, standardized accuracy testing conducted by users and recipients of DBH locations, without sending the voice call to PSAP.
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* It is recommended that the WSPs who deliver 9-1-1 calls and are held responsible for the calculation of the locations fixes passed to public safety, must have metrics and procedures in place to ensure that internal positioning methodologies used are reliable, consistent and performing at expected accuracy and quality requirements.
1. A Phase 2 fix is a location provided to Public Safety with a wireless E911 call that meets accuracy criteria established in FCC rules (47 CFR Part 20). Prior to the Fourth Report & Order, Phase 2 locations for outdoor wireless 9-1-1 calls were required to be within 50 meters for 67% of calls and 150 meters for 90% of calls. The Fourth Report and Order introduced new accuracy rules that apply to both indoor and outdoor 9-1-1 calls to require delivery of a dispatchable location or an X/Y fix within 50 meters for an increasing percentage (over time) of all wireless 911 calls. [↑](#footnote-ref-1)
2. The requirements on WSPs to calculate a location from a “cold start” originated in the early days cell phone usage where phones were powered off to save on battery life and from OET-71 accuracy testing methodology. In addition, subscriber location privacy is preserved under the “cold start” location calculation methodology. [↑](#footnote-ref-2)
3. “Final Report of the Task Force on Optimal Public Safety Answering Point (PSAP) Architecture” <https://www.fcc.gov/document/fcc-releases-tfopa-final-report>. [↑](#footnote-ref-3)
4. Kannan, A., Helping emergency services find you when you need it most, Google Europe Blog, <http://googlepolicyeurope.blogspot.be/2016/07/helping-emergency-services-find-you.html>, last visited July 26, 2016. [↑](#footnote-ref-4)
5. Advanced Mobile Location is now available on all Android phones!, EENA release, <http://us12.campaign-archive2.com/?u=e0c4f1a6abab88a6ea851fe8e&id=cf32c9e8f1&e=d4e67b11d0>, last visited July 26, 2016. [↑](#footnote-ref-5)
6. *Wireless E911 Location Accuracy Requirements*, 30 FCC Rcd 1259 at paras.

121-132 (2015) (“Fourth Report & Order”). [↑](#footnote-ref-6)
7. “Final Report of the Task Force on Optimal Public Safety Answering Point (PSAP) Architecture” <https://www.fcc.gov/document/fcc-releases-tfopa-final-report>. [↑](#footnote-ref-7)
8. “Final Report of the Task Force on Optimal Public Safety Answering Point (PSAP) Architecture” <https://www.fcc.gov/document/fcc-releases-tfopa-final-report>. [↑](#footnote-ref-8)
9. “Final Report of the Task Force on Optimal Public Safety Answering Point (PSAP) Architecture” <https://www.fcc.gov/document/fcc-releases-tfopa-final-report>. [↑](#footnote-ref-9)
10. Some MPC/GMLC systems deliver Phase 1 X/Y along with the cell tower/sector civic address, while others may only deliver the civic address of the cell tower and/or sector. [↑](#footnote-ref-10)