May 12, 2014

**VIA ELECTRONIC FILING**

Rx Networks Inc.
Suite 800, 1201 W. Pender Street
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Federal Communications Commission
445 – 12th Street SW
Washington, DC, 20554
Attn: Ms. Dana Zelman

**RE: Notice of Proposed Rulemaking "Wireless E911 Location Accuracy Requirements" Federal Register Vol. 79, No. 60. dated March 28, 2014 ("Notice")**

Dear Ms. Zelman:

Rx Networks respectfully submits comments to the Federal Communication Commission (FCC) regarding the above referenced Notice. Please note that we are only providing comments to topics for which we have domain knowledge, specifically the area of location technology.

Rx Networks is a provider of Assisted-GNSS (A-GNSS) data to nearly all mobile operators in North America for use as part of their E911 Phase II infrastructure. In addition, Rx Networks offers and continues to evolve technologies that address indoor location, complementing A-GNSS through techniques such as Cell-ID and Wi-Fi positioning, sensor technologies, and enabling network and indoor infrastructure to be self-locating. More information on the company is available at www.rxnetworks.com.

Should you have any questions or require further clarification regarding our submission, please contact the undersigned by electronic mail (astimpson@rxnetworks.com) or by written correspondence to the above address.

Sincerely,

**Rx Networks Inc.**

Adrian Stimpson
Senior Vice-President

**RX NETWORKS' SUBMISSION TO REQUESTS FOR COMMENT IN**

**NOTICE OF PROPOSED RULEMAKING Vol. 79, No. 60**

**General comments:**

Based on our industry experience as a developer and provider of location software and services, it is our opinion that the following are essential considerations for developing an effective E911 indoor location capability:

1. Maximize use of existing technology, specifically: cellular ID (Cell-ID) and Wi-Fi Access Point (AP) location databases, A-GNSS services, and smartphones with their multi-radio/multi-sensor capabilities and their ability to crowd source information such as barometric pressure and report changes in Cell-ID and Wi-Fi AP locations.
2. Require device OEMs to make their radio and sensor interface layers available so that additional signals of opportunity (e.g. Wi-Fi) and outputs such as barometric pressure can be used to help locate a wireless 911 caller. For the developer community this will also enable further development of location capabilities, something notably restricted on platforms such as Apple's iOS and Microsoft's Windows Phone operating systems.
3. Use multiple technologies concurrently during a wireless 911 call in order to ensure the best possible time to first fix, regardless of the use case. The recommended technologies are available today and include: A-GNSS (using both real-time and predicted forms of assistance), Wi-Fi & Cell-ID positioning, and sensors (primarily for barometric pressure sensing to determine floor level).
4. Enable self-location of assets such as small cells, DAS arrays, Wi-Fi Access Points, and LTE-based wireless home phone systems so they become reliable location reference points. Self-location eliminates the potentially life-threatening risk of human error in recording and managing the location of assets used to position emergency calls.
5. Only use high availability providers to process location requests such as the CMRS provider, or a third party provider of location services who can provide a 99.999% SLA. By contrast, we would not recommend relying on non-SLA'd location services from device OEMs and consumer location providers.
6. Ideally, contract a centralized organization to cost-effectively and consistently perform location related services for CMRS providers. This organization would maintain and protect a superset of mobile operator base station almanacs for Cell-IDs and provide a national Wi-Fi AP database. The organization could also support CMRS providers with A-GNSS software and data, provide cloud based GNSS processing for self-locating small cells, DAS arrays, and Wi-Fi APs, and provide other location determination and assistance services.

As a provider of location and assistance services to over 1 billion phones worldwide, plus as the leading supplier of A-GNSS data for E911 in North America, Rx Networks has the expertise to assist in implementing the above.

Specific comments in response to the Notice are provided below. All figures in square brackets refer to the paragraph number of the Notice.

*[4] "We also seek comment on whether we should revisit the timeframe established by the Commission in 2010 for replacing the current handset- and network-based accuracy requirements with a unitary requirement, in light of the rapid proliferation of Assisted Global Navigation Satellite Systems (A-GNSS) technology in wireless networks and the prospect of improved location technologies that will soon support 911 communication over LTE networks.*"

The originally network- and handset-based capabilities have been superseded or augmented through the availability of technologies involving signals of opportunity (including Wi-Fi, Cell-ID, Bluetooth and other signals), multi-constellation A-GNSS, and sensor based location determination. Accordingly, we feel a unitary requirement would be appropriate.

*[5] "Specifically, we seek comment on whether to implement the following measures:*

- *Adopt a 30-second requirement for the maximum time period allowed for a CMRS provider to generate a location fix ('time to first fix') in order for the 911 call to be counted towards compliance with location accuracy requirements.*
- *When measuring compliance with location accuracy requirements, allow CMRS providers to exclude short 911 calls (e.g., calls lasting 10 seconds or less) that may not provide sufficient time to generate a location fix.*
- *Standardize the content and the process for delivery of confidence and uncertainty data that is generated by CMRS providers for each wireless 911 call and delivered to PSAPs on request.*
- *Require CMRS providers to inform PSAPs of the specific location technology or technologies used to generate location information for each 911 call*
- *…. "*

Rx Networks would like it to be noted that current technology will provide indoor and outdoor location fixes in the range of 2 to 3 seconds. In some cases the initial fix will be less accurate than subsequent fixes (a design trade-off for time to first fix vs. accuracy) but may be still be sufficiently accurate. The fix can be subsequently refined with a rebid within the contemplated 30 second window. However, we defer to the CMRS providers with regard to the contemplated 10 and 30 second requirements as the provider manages the call setup. With today's technology, determining location is not expected to be the limiting factor in meeting these objectives.

The establishment of a standard for reporting confidence and uncertainty would eliminate the need to report the type of location technology used for the fix. The latter would be useful for analyzing the performance of, and level of reliance on, each technology but likely provides unnecessary information to the PSAP and risks assumptions being made about the performance of each technology, something that will change over time as the technologies evolve.

*[32] "We seek comment on what universal costs would be necessary across all indoor location technologies, as well as on any specific costs that are unique to different technologies…. Additionally, we seek comment on whether additional costs would be passed on to consumers, resulting in higher rates…."*

For E911 Phase II compliance, there was a substantial cost burden on the mobile operator. Now that the majority of wireless phones are smartphones (i.e. with A-GNSS, Cell-ID, and Wi-Fi positioning) and 80 percent of smartphone usage occurs inside buildings[1], the cost is being partially shared with the public through their purchase of the enabling devices and associated data plans. This is not to suggest that the operator's role is insignificant, but the operator benefits from the presence of these on-board capabilities and can further influence the configuration of them to help meet the indoor location requirements set by the Commission. Such configuration options might include the mandating of extended ephemeris technologies for A-GNSS, pressure sensors for z-axis resolution, opening up the APIs to the radio interface and sensor layers, and the use of reliable and consistent location services for Cell-ID and Wi-Fi location lookups.

Rx Networks feels there is a case, in terms of both cost and performance, for the establishment of a central and standardized service to process location requests, particularly for smaller CMRS providers. A federated but clearly demarked (for proprietary reasons) base station almanac of Cell-IDs and reliable North American database of Wi-Fi access point locations, in addition to cost effective provision of A-GNSS and barometric pressure data, could be part of such a standardized and cost-effective service.

This type of centralized, clearinghouse approach has been successfully used to enable SMS interoperability between operators and differing mobile technologies.  It is also being used today to support global mobile voice and data roaming services. It also bridges the technical gaps, simplifies business-partner relationships while minimizing capital outlays.

Rx Networks believes that while beacon based solutions can provide relatively high accuracy, when deployed nation-wide they may not provide the most cost-effective solution for the mobile operator and, by extension, the public.

Rx Networks submits that a more cost-efficient yet highly effective solution can be realized by making better use of existing smartphone technologies that can be used for positioning, by CMRS providers requiring their suppliers of small cells, Wi-Fi APs, and wireless home phone systems to include self-locating technology (see comments to paragraph 36 below), and by providing a standardized central service for processing location requests.

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[1] Per Notice, paragraph 25.

*[36] "Some industry representatives note the possibility for improved indoor accuracy with the implementation of small cell networks…."*

Rx Networks agrees that, by definition, small cells create the potential for improved indoor accuracy, provided the small cell is properly geotagged in the CMRS provider's base station almanac. Human error (incorrectly recording location or not recording it after the move of a small cell) is a concern already voiced by some CMRS providers to Rx Networks, particularly when subcontractors are used to deploy the cells. While it is a relatively small number of cases where the small cell is incorrectly tagged, the error, particularly in the case of an unrecorded move, could render the 911 call unserviceable.

Rx Networks proposes that operators should mandate the implementation of self-location technology in small cells to eliminate this risk. Specifically, the small cells should include a hybrid suite of cloud based GNSS processing (for latent GNSS fixes deep indoors), and Wi-Fi & Cell-ID positioning. This would not only facilitate improved wireless 911 indoor location, but would also be of benefit to the operator for asset management and detecting unapproved moves, adds, or changes.

While the majority of mobile phones are smartphones, enabling small cells with self-locating technology will provide a powerful indoor location capability for locating legacy phones (including non-GNSS equipped phones) due to knowing the true location of the cell which, by definition, has a small radius service area and therefore small search ring.

It should be noted that the same technology for geotagging small cells could be applied to Wi-Fi access points (APs). Most Wi-Fi positioning systems use crowd-sourcing techniques to identify the location of the APs. Due to the small coverage area of APs and the use of multilateration, this works quite well. However, some enterprise class routers, deployed deep indoors, are excluded from the location databases or suffer from inaccurate location estimates. If the APs under the control of a mobile operator are required to use self-locating technology this would further improve indoor performance. Similarly, wireless home phone services that provide home phone service over the CMRS provider's network could also benefit from self-locating technology.

*[39] We seek comment on the extent to which mandating a 50-meter accuracy requirement to indoor calls – after a reasonable period of time – would encourage CMRS providers to work with location and device vendors to implement the advances being made in indoor location technology.*

The CMRS providers will have to work with location and device vendors in order to meet any effective (in terms of accuracy) mandate. As mentioned in earlier comments by Rx Networks, the technology to achieve the goals of the FCC (and therefore the CMRS providers) exists today, but it will require specific technical requirements (e.g. mandated extended ephemeris, exposing of Wi-Fi radio and sensor outputs) to be set out in the CMRS providers' marketing requirement documents (MRDs) issued to their device suppliers.

There is also considerable benefit in having a two-way exchange of information between location enablers such as Rx Networks and the CMRS providers given each party's complementary expertise.

*[43] "We also seek comment on whether the proposed two-stage reliability requirements are feasible in light of the types of specific challenges that CMRS providers may confront in indoor environments, such as the proliferation of signal boosters within buildings. We seek comment on the extent to which these types of indoor-specific challenges may affect a providers' (sic) ability to deliver location information in compliance with our proposed reliability thresholds for indoor calls."*

The use of signal boosters or DAS (note – we assume these are not small cells, but active or passive repeaters of a macro cell) in indoor locations can create a material error in determining location if Cell-ID is the only location input available. However, if our recommended multi-technology approach is used it is likely that a higher confidence fix will be realized through Wi-Fi and/or A-GNSS based location fixes, or in the case of DAS, by adding a Wi-Fi beacon and self-location capabilities to discrete DAS elements.

*[44] "At the same time, we recognize that certain in-building systems and access devices – such as a Distributed Antenna System (DAS) network – could be programmed to provide specific location information, including building address and floor level information, for the origination of the indoor call. In addition to our proposed 50-meter accuracy requirement, should we consider adopting an alternative indoor location requirement that CMRS providers can satisfy by delivering a caller's building address and floor information?"*

Because signals can traverse floors and a DAS system may not be differentiated by floor level, such an approach may be unadvisable. As with small cells, there is also significant risk of human error in hard coding address/floor information and managing moves and changes of the RF systems.

*[45] "Further, we propose that the combined 50-meter accuracy and 67- and 80-percent reliability requirements comprise the sole ring for testing indoor location accuracy. We seek comment on this proposal. We note that, in the context of E911 location accuracy based on outdoor measurements our rules include a 'dual search ring' system, with different reliability thresholds for 50-meter and 150-meter accuracy. While a dual search ring requirement was a reasonable approach based on outdoor measurements, a search ring larger than 50 meters is unlikely to yield sufficiently granular information to prove useful to public safety in the context of locating a caller indoors. "*

We agree with this observation and feel that, given the state of the available technology, a single search ring with the proposed confidence and accuracy requirements is both desirable and achievable without incremental cost [per request for comment in paragraph 46] over a dual-ring system.

*[49-58] Comments on Proposed Timelines*

Rx Networks is not in a position to comment on the suitability of the proposed timelines for the CMRS providers to provide end-to-end service, but we can comment on the typical timelines required to implement the location technology.

The technology required to meet the Commission's targets is available today, although it has been used primarily for LBS services and without an SLA. To bring these capabilities together in an integrated fashion, suitable for E911 and provided with an SLA, the following approximate timelines would apply for integrating the technology:

1. Up to 24 months for mandating and realizing the necessary features and APIs on smartphones. These may include A-GNSS (real-time and predicted), Cell-ID and Wi-Fi positioning technologies, and barometric pressure sensors.
2. Up to 24 months for enabling and deploying self-location for small cells, wireless home phone devices, and Wi-Fi access points. This will require specification to the manufacturers by the CMRS providers but also collaborative work between the device suppliers, the CMRS providers, and the provider of the location service such as Rx Networks. It is envisioned that this could be accomplished within 12 months but there is considerable room for delays associated with contract discussions and acceptable test periods prior to deployment. Note that Rx Networks has presented a plan to some CMRS providers and their suppliers for providing an after-market dongle to self-locate legacy equipment.
3. 12-18 months to establish a centralized facility that manages the proposed superset of CMRS provider base station almanacs, a national Wi-Fi AP database, and provides the corresponding location lookups, as well as A-GNSS and other location services. This is already being provided to some CMRS providers today by Rx Networks. This task would also require establishing a consistent set of practices across carriers, commissioning and testing.

The above items could be pursued concurrently. Even allowing for significant delays from the above timelines, the proposed five-year time frame proposed by the Commission would seem achievable from a technology perspective.

There is a concern that legacy phones (with limited radio and sensor capabilities) can negatively affect compliance statistics, but during the five year period these phones will have mostly reached end of life, being replaced by more capable phones, even at the lower price ranges.

To ensure the context of our comments are clear, we wish to restate that our comments with regard to timelines are presented from a technology and external logistics (OEM devices, APs, small cells) perspective and we defer to CMRS providers opinion with regard to the complementary CMRS provider infrastructure and PSAP integration components of the Notice.

*[61] "Specifically, we propose to require CMRS providers to deliver z-axis location information within 3 meters of the caller's location, for 67 percent and 80 percent of indoor wireless 911 calls within three years and five years of the effective date of adoption of rules, respectively." [69 – related]*

While no specific comment was requested in paragraph 61, Rx Networks wishes to comment that we feel the goal should be +/-1.5 meters (67%) not +/-3 meters in order to ensure correct floor level. Uncertainty spanning 6 meters will cross floor boundaries and lead to inaccurate floor determination. 1.5 meter uncertainty is achievable using Rx Network's Zed™ service so the proposed three- and five-year timeframes are more than reasonable. Zed uses a combination of the input from a barometric pressure sensor in a smartphone with an offset pressure reference provided by Rx Networks, combined with sophisticated algorithms to determine the approximate location (+/- 1.5 meters) of the phone.

With regard to paragraph 69, specifically whether test bed performance should establish criteria for adoption of z-axis requirements, we caution that while this is an excellent start, testing in specific and known environments can show results that may not be cost effectively reproduced nation-wide. We therefore support the "adoption of rules" approach.

*[64] "…we seek comment on whether an initial deployment requirement of three years from the effective date of our new rules would be achievable, including whether such a timeframe ensures that CMRS providers have sufficient competitive choices of vendors and time to incorporate, test, and deploy their technology of choice, and whether setting such a timetable would spur the advancement of vertical location solutions already in development."*

Notwithstanding our comment to paragraph 61 with regard to accuracy, we believe a timeframe of two to three years will be required to allow for sufficient testing and implementation by the CMRS providers and deployment of a sufficient number of sensor-equipped phones to provide a high enough compliant yield in the z-axis. Setting the target and timeline will likely stimulate the advancement of solutions currently available or under development.

*[65] "We also seek comment on the potential costs associated with a vertical location requirement. If a provider were to modify handsets to incorporate barometers in handsets, for example, what would be the cost per handset?"*

Multi-function sensors are increasingly incorporating a barometric pressure sensor as part of the suite of sensor inputs, meaning that there is no discrete incremental cost for incorporating it. Notwithstanding this, it may be necessary for CMRS providers to mandate the inclusion of barometric sensors (with exposed APIs) in their MRDs to ensure compliance with z-axis requirements. An exemption would be appropriate for legacy smartphones and non-smartphone originated calls in the first 5 years due to the relatively small number of phones equipped with barometric sensors at the time of this submission.

*[66] "To the extent that PSAPs must take additional measures to be capable of receiving z-axis information, we seek comment on what steps must be taken and any corresponding costs…."*

Rx Networks acknowledges that there is a considerable downstream effort required to process the z-axis information so that it is actionable by PSAPs. Our comments are limited to our ability to provide an elevation figure. The ability of the PSAP to determine the correct floor number as presented to the first responder upon arrival will depend on statistically reliable assumptions or custom information regarding particular buildings. In particular, having access to a database of buildings' height above mean sea level would be most useful.

Having said this, even knowing an elevation figure has some utility which would appear to be valuable as stated in paragraph 28 of the Notice, *"A number of public safety commenters state that virtually any improvements in indoor location capabilities would be desirable, even if relatively modest or incremental."*

*[76] "First, we propose that the test bed should reflect, to the extent possible, a representative sampling of the different real world environments in which CMRS providers will be required to deliver indoor location information. We seek comment on whether, by doing so, the test bed could provide reliable information about how location technologies perform in different circumstances, without necessitating ubiquitous testing in real-world environments"; and [81] "Are there factors such as beacon or cell tower density and topology that may cause the test bed results to differ materially from performance for actual 911 calls outside the test bed? Should the test bed be constrained to a small geographic area, similar to the CSRIC IV example, or should the selection of test points change periodically or cover a larger geographic area?"*

The nature of indoor location testing is such that there will be a wide variance in performance. Even A-GNSS fixes will vary based on the constellations being used, their geometry at the time of the test, and the age of the assistance data. Rx Networks recently conducted indoor location tests on one, two, and three constellation combinations of GPS, GLONASS and Galileo which confirmed this. For technologies such as Wi-Fi and Cell-ID positioning, the density, geometry, and quality of the transmitter geotags will all significantly affect the location accuracy.

In a known test environment, much of this can be controlled or pre-surveyed by the vendor wishing to demonstrate their technology - beacons can be installed, Wi-Fi APs and Cell-IDs can be meticulously measured in or around the test site, etc. This is not to say that such grooming of test sites is not useful for proving the efficacy of a particular technology, but the extensibility of such systems to a nation-wide system needs to consider time, cost, and logistics of ensuring a similar experience.

As previously mentioned, Rx Networks recommends the use of existing technology to help create the indoor location infrastructure. Specifically, the power of smartphones to crowd source otherwise unknown information regarding the location of Cell-IDs, Wi-Fi APs, and barometric pressure will help rapidly expand the capability of certain technologies from the test bed to the real world.

At that point, which should fall within the deadlines set by the Commission, compliance testing using random, real-world locations would be advisable, although we acknowledge that the cost might be prohibitive as it must be done over large number of test sites to ensure a representative result.

*[77] "More specifically, we propose to measure latency from the time the user presses SEND after dialing 9-1-1, to the time the location fix appears at the location information center."*

We wish to point out that measuring latency in this manner should identify the critical path dependency. That is, in poor signal conditions, it is likely that location will be determined by the device well in advance of successful call setup.

It should also be noted that the trend towards persistent location, where the device is continually establishing its location, typically for LBS applications and social networking purposes, would make it possible to transmit the user location immediately upon call setup.

*[82] "…we propose allowing the indoor test bed administrator sufficient discretion to determine the actual test approaches to be used, e.g., the number of test points, number of test calls, and best combination of devices to test simultaneously per technology."*

We agree with this and further recommend that a consultative discussion take place between the vendor and the test bed administrator to understand the nature of the technology being tested. For example, if the solution uses crowd sourcing to maintain system health and address new and changing environments, it may be appropriate to do "before and after" tests to show the potential for the technology to quickly adapt and demonstrate the desired results.

It may also be the case that, through multi-party consultation with the test bed administrator, a combination of vendor technologies could be applied for best results.

[*93] "Given the ability of A-GPS to perform well across a large number of indoor environments, together with the fact that the majority of CMRS providers are already using handset-based, A-GPS solutions, we believe that only a limited number of environments would require additional infrastructure in order for CMRS providers to comply with our proposed indoor accuracy requirements. We therefore believe that indoor location across all areas is technologically feasible, as well as economically reasonable."*

The statements in paragraph 93 relates to the statement in paragraph 92 that says, in part, *"…CMRS providers also confirm that A-GPS technology works well in most indoor locations, and U.S. Census data suggests that the majority of indoor environments are likely to be the types of structures that are suitable for A-GPS location-based solutions…"* with subsequent reference to, *"…an indoor, two-story structure…."*

While Rx Networks is the dominant provider of A-GNSS services used for E911, and we can attest to the benefits of A-GNSS in this regard, we wish to comment that those same residents require wireless E911 to serve them when not at home, particularly on the z-axis when working in locations where A-GNSS is challenged such as multi-story office blocks, educational institutions, and the like. By definition, z-axis location is also essential for multi-story complexes and therefore should include a multi-technology approach. Per comments requested in paragraph 94, it would seem most appropriate to target accuracy requirements based on call volumes and residential density rather than the number of indoor structures.

*[96] "…we anticipate that the z-axis requirement should be applied co-extensively, in the same geographic areas, with any x- and y-axis indoor requirements. In the alternative, we seek comment on whether we should apply the z-axis requirement to only a subset of those environments where we apply the horizontal indoor location requirements, or otherwise apply the z-axis requirement in a manner that is independent from the application of horizontal indoor location requirements."*

Effective z-axis determination will likely use barometric pressure sensors and, as such, there is no need to for a geographic restriction. While some technologies also require the presence of and sufficient density of beacons, the availability of barometric pressure sensors in smartphones removes this dependency.

If the Commission (or CMRS provider) mandates barometric sensors in all smartphones, this will provide for z-axis compliance without exemptions being required, without the need to install dedicated beacons to address the z-axis, and removes the need to separate z-axis from the x- and y-axis indoor requirement.

*[97] "Finally, we seek comment on any other alternative approaches that would enable us to focus the application of indoor location requirements in the most effective and cost-efficient way possible."*

We wish to restate our opinion that use of existing technology, specifically smartphones equipped with GNSS, Wi-Fi, cellular, and sensors, configured at factory per mandated specifications from the CMRS providers, will provide cost effective crowd sourcing of location inputs and will also help mitigate otherwise network-intensive location determination.

*[107] "We seek comment on ways in which we can take steps towards achieving our long-term indoor location objectives by leveraging measures that CMRS providers are already taking to expand and enhance their networks…. CMRS providers are already deploying both small cells and DAS…. CSRIC noted that '[a]s cell sizes shrink, the location of the serving cell itself may suffice for a position estimate….'"*

We agree with the CSRIC statement and would add that the same could be said for Wi-Fi APs in the vicinity of any call. That is, by nature of their small signal range, APs, when properly geotagged [see 108 below] are accurate aids in determining location.

*[108] "…we seek comment on whether, as part of a long-term indoor location solution, CMRS providers should be subject to a requirement to program all small cell and geographically identifiable DAS extensions of their CMRS networks with address information at the time of installation and/or prior to the commencement of commercial service…."*

It is our view that programming the location of such devices (as well as Wi-Fi APs under the control of CMRS providers) is highly desirable, but that doing so manually risks human error (incorrect entries, unclear abbreviations, risk during moves or changes). CMRS providers have indicated to Rx Networks that human error is a concern even regarding their primary network infrastructure (the cellular transceivers). CMRS providers also want to manage these assets to ensure they are not used where they are not licensed for use. We propose that self-locating technology be deployed on all small cells and enterprise APs (if under the management of a CMRS provider) to ensure reliable location. The manual entry of addresses could also be performed, but the self-locating capability of the devices will facilitate an automated location and/or location audit.

*[109] "We seek comment on the technical feasibility of programming both small cells and DAS with location information, as well as the feasibility of installing A-GPS chips within small cell nodes and DAS antennae…. Finally, we seek comment on whether CMRS providers could retroactively program existing small cells, DAS, and industrial signal boosters to contain specific address information."*

As per our response to paragraph 108, Rx Networks has technology that will enable such devices to self-locate. Using A-GPS chips is helpful, but even greater indoor performance can be achieved by using an RF receiver to capture any GNSS satellite data that is available, even over several hours, along with other signals of opportunity and processing the information with high power servers in the cloud. Rx Networks' product XYBRID Cloud does this, enabling GNSS fixes of devices that are deep indoors. Regarding retroactive programming, Rx Networks offers external dongles that can be installed in, or collocated with, the small cells, DAS systems, or Wi-Fi APs to perform the location function.

*[121] "…almost all smartphones sold today are equipped with multiple sensors that can determine acceleration, magnetic fields (compass direction) and movement (gyroscope), which also provide a means of determining the operating environment. In addition, a number of large mobile device vendors have started to include barometric pressure sensors in their devices, which can calculate z-axis information. Moreover, the performance reached by such indoor location technologies has now surpassed GPS for the outdoors…. We seek comment on these developments and on how they may relate to potential location accuracy requirements."*

The proliferation of smartphones and their increasingly complex array of radios and sensors has two impacts: (1) they provide an ability to crowd source useful information to improve location accuracy; and (2) they can perform hybrid location fixes without requiring upgrades to the CMRS provider's network.

Rx Networks has conducted tests using A-GNSS (single, dual, and tri-constellation), Wi-Fi positioning, Cell-ID positioning, sensor navigation and detection (including barometric pressure) and found that each, or combinations of each, can contribute to the overall yield depending on the use-case. Assumptions cannot necessarily be made that GPS (GNSS) is the best outdoor solution, nor non-GPS/GNSS solutions the best indoor solutions. We have seen cases where the opposite applies (for example, in dense urban environments where multipath interference degrades GNSS positioning accuracy, making Wi-Fi positioning more accurate even outdoors).

The best approach to determining location is to use several technologies concurrently and select the best result at the time for the first and successive fixes. For example, a first fix may be achieved using Cell-ID positioning followed by an A-GNSS fix two seconds later. In some cases, multiple inputs will be used at once (e.g. a Wi-Fi position may help determine which of two possible GNSS fixes is most accurate).

In order to make full use of these capabilities, the phone manufacturers need to expose the necessary radio and sensor outputs. **Of notable concern is Apple's and Microsoft's blocking of access to the radio interface layer which makes it impossible for third parties to scan for Wi-Fi AP and Cellular ID parameters necessary to query a the location database. We recommend the Commission require all OEMs make this information available in their APIs, if not for general use, at least for E911 purposes.**

[122] *"Could smart phones be programmed in such a manner that, when the phone initiates a voice call to 911, a separate and additional query within the handset is made for information on the device's last known location, with all location information then being sent to the provider's location information center?"*

Most smart phones cache last known location so that it can be used to assist the next GNSS fix, however, use of this information for E911 may not be advisable because the user may have travelled considerable distance since last caching location (e.g. when getting off a plane in Los Angeles, having last cached a location in New York). For this reason, it would be advisable to design in an expiry date exclusion or an exclusion based on a sensed, but unknown rapid velocity.

There may also be privacy concerns if someone's now-inaccurate, but last known location becomes a matter of public record.

It is assumed the statement in paragraph 122 is trying to address achieving the fastest possible location fix in the absence of, or while waiting for, other methods to determine the fix. Given the state of today's technology, where location can be determined typically within 2 to 3 seconds, we suggest this is not necessary. If, however, the Commission feels otherwise, there are solutions from Rx Networks that will provide almost instant location fixes using regional copies of cellular and Wi-Fi base station almanacs stored on the smartphone. Location requests are simply made by a call to the device's memory, resulting a fix in less than one second. It is not necessary to have a large database on the phone. A regional database can be easily abstracted and sent to the phone and seldom needs updating given that most subscribers work/travel/live in the same region most days. There are also the cases of devices that engage in persistent location, where the cached position may be only a few minutes old and may be as accurate as a newly requested location fix.

*[125] "We also seek comment on how institutional and enterprise location systems could be leveraged to provide location data for E911. For example, Cisco Systems has presented possible use cases for its location technologies for hotels, hospitals, higher education campuses, and large enterprise settings."*

E911 Phase II drove advancements in technology that collaterally benefited consumer LBS [ref. 115-118] and industrial/institutional location use-cases. Our statement is supported by the relative lack of mobile operator LBS infrastructure implemented outside of North America and, prior to E911 Phase II, in North America as well.

We suggest that for nation-wide coverage it is important that CMRS providers adopt a more consistent approach to the technology as there is no standard (defacto or official) when it comes to LBS and enterprise location technologies. Notwithstanding OEM's desire to develop intellectual property as an asset, if CMRS providers require OEMs to implement the self-locating technology suggested by Rx Networks this will provide a foundational level of location capability to serve not only E911 indoor location requirements but also the majority of LBS and industrial use cases. That is, the OEMs should not be adverse to such a recommendation and it will still leave room for proprietary innovation where the LBS or industrial location requirements are more stringent.

*[126] "What modifications to Wi-Fi hotspots, location beacons, or devices with location information would be necessary to enable the transmission of location information to CMRS providers?"*

This will require the establishment of a standard for transmitting the location information so that devices can uniformly decode the location information and assign an uncertainty factor to it (radius of coverage) based on the type and power of the device.

*[127] "We seek comment on how Bluetooth or Wi-Fi-enabled home security systems, door locks, thermostats, lighted exit signs, security systems, and other residential 'smart building' technologies could be registered with dispatchable address information and, if so, how it could be achieved."*

While we recommend that ubiquitous infrastructure (those employing Wi-Fi for example) be made self-locating, we also recommend that it only be used as an input to the handset that is making the wireless 911 call, not as the asserted location of the call.

In addition to technologies directly under control of the CMRS provider (the cellular network, including small cells), we recommend that the inclusion of additional infrastructure elements focus on Wi-Fi for reasons of efficiency and effectiveness. Wi-Fi is widely deployed and should remain so for the foreseeable future. The systems can be made self-locating with relative ease, even retroactively with an after-market dongle.

The proliferation of Wi-Fi enabled devices such as door locks, thermostats, security systems, and light bulbs will increase the density of indoor Wi-Fi devices thereby providing a greater number of points that can be located (either through self-location or crowd sourcing the location) which will result in improved multilateration fixes.

*[131] "We propose that, as part of our existing Phase II E911 requirements as well as our proposed indoor requirements, CMRS providers must deliver E911 location information, with the specified degree of accuracy, within a maximum period of 30 seconds to the location information center."*

Low latency determination and transmission of location is mentioned in several places in the Notice. We wish to comment that use of predicted A-GNSS (a/k/a extended ephemeris), as opposed to real-time A-GNSS, plays a critical role in ensuring the minimum possible time to first fix. Mandating of extended ephemeris on devices has been already been included in some CMRS provider's marketing requirement documents that they issue to device OEMs. We recommend such a mandate be considered on a broad scale to help ensure the TTFF goals of the Commission.

We also recommend a concurrent hybrid technology approach [see comments to paragraph 132].

We also note that the increasing use of persistent location on smartphones will provide location fixes contemporaneously with the establishment of a 911 call.

*[132] "As CMRS providers refine and deploy hybrid technologies to achieve better location accuracy indoors, is it technically feasible for providers to leverage those hybrid developments for wireless 911 calls from outdoor environments to achieve improved yield and TTFF? ...Will hybrid technologies, complemented by beacon technologies, DAS networks, and small cells, make it possible to achieve improvements in TTFF in challenging environments?"*

Yes. It is essential that hybrid techniques be used. The term "hybrid" has been defined in various ways within the industry. Paragraph 132 of the Notice refers to "fall-back" techniques. Rx Networks considers the best hybrid location practice to be the simultaneous use of multiple inputs (for example, A-GNSS and Wi-Fi positioning). Sequential fall-back approaches, by design, introduce delays in TTFF.

However, a simultaneous approach does not mean that the device should wait for all components to achieve their task if there is already a useful fix. An example of a potent hybrid approach would be a location request that uses on-board extended ephemeris (A-GNSS) concurrently with a Wi-Fi scan. It is likely the Wi-Fi request will determine an acceptable fix within two to three seconds which can be updated with what will likely be a more accurate A-GNSS fix shortly after that. Should the A-GNSS fix not be possible, due to the challenging indoor environment, time has not been wasted determining this and then falling back to a Wi-Fi location request.

*[134] "We seek comment on whether 10 seconds is the right cut-off for an exclusion for short calls."*

We cannot speak for network-related contributions to call setup time, but most hybrid location technology will derive a location within this time frame, typically two to three seconds.

*[141] "We also seek comment on NextNav's suggestion to incorporate ESIF's recommended 90 percent confidence level as a requirement. Is it important that all CMRS providers subject to Commission's E911 requirements use the same confidence level when calculating C/U data? If a standard confidence level is desirable across Phase II data, is 90 percent the correct level? Why or why not? Moreover, if not, should the Commission nevertheless still require CMRS providers to use the same confidence level? If so, what should that level be and why? What potential costs would be associated with implementing this requirement? In the event we establish a uniform confidence level, should CMRS providers be required to demonstrate compliance with that confidence level to the FCC, and if so, how?"*

We believe that: (1) all CMRS providers should be required to use the same confidence level when calculating C/U data, particularly given the varying confidence levels in use across the industry today; (2) a 90% confidence level is a good level to use – anything higher will result in unnecessarily large reported uncertainties; (3) the cost of implementing this requirement is low given the technology available today; and (4) CMRS providers must be required to demonstrate compliance with a uniform confidence level as part of the test bed.

All accurate positioning techniques, whether based on A-GNSS, Wi-Fi or Cell-ID, involve a great deal of statistical analysis. C/U data is a byproduct of this analysis. However, the quality of this analysis can vary and CMRS providers must be required to demonstrate compliance so that PSAPs can come to trust the reported data. The same test bed which validates accuracy claims can be used for this purpose.

*[143] "Is there any reason why the format of C/U requirements should differ for indoor versus outdoor calls? We seek comment on this issue as well."*

The format of C/U requirements for both indoor and outdoor calls should be identical. This is the only way for PSAPs to develop confidence in reported uncertainty values.

*[146] "…we seek comment on whether to require CMRS providers to identify the technology used to determine a location fix and to provide this information to PSAPs that have the capability to receive this information."*

Ultimately, the PSAP needs to know how accurate the fix is in order to understand the size of the search ring. Transmitting the technology used to the PSAP adds complexity, cost, potential delays in providing the location, and distraction to the PSAP operator. It also assumes that technologies are uniform in their performance across environments and manufacturers, and also that they evolve equally (in terms of accuracy) over time. A properly adhered to confidence/uncertainty standard should be the common frame of reference.

*[147] "Could CPE be programmed to automatically rebid if it receives Phase II location information from a fall-back technology?"*

With regard to the concept of rebidding, we suggest that a rebid based on the technology that was used is less advisable than doing so based on a threshold confidence/uncertainty level.

For example, using the hybrid location technologies described in our comments and outlined in response to paragraph 132 of the Notice, an initial, relatively coarse location derived from non-A-GNSS source may be received that has some use but presents a high degree of uncertainty. This might be followed by a rebid that results in an A-GNSS fix. However, it is not the technology that determines the need for the rebid but the uncertainty level.

*[149] "We seek comment on whether there have been sufficient advancements in technology and a sufficient number of handsets with A-GPS capabilities in the consumer subscriber base to warrant modification of our existing Phase II requirements as they apply to outdoor calls."*

We defer to the CMRS providers with regard to the full context of paragraph 149, but wish to comment that we are not aware of any smartphone on the market in North America without some form of handset based A-GPS using either real-time A-GPS methods or predicted methods (offered variously as Qualcomm XTRA, Broadcom LTO, CSR InstantFix, and Rx Networks GPStream PGPS). Certain smartphones even make use of autonomous prediction methods (including Rx Networks' GPStream PGPS product) if the subscriber does not have a data plan to receive A-GNSS assistance data.

*[151] "We seek comment on whether all CMRS providers reasonably could comply with a 50-meter accuracy/67 percent reliability requirement within two years, such that we could adopt a unitary requirement for both indoor and outdoor calls. …Is there a benefit in continuing to allow a dual search ring requirement?"*

Please see comments to paragraphs 4 and 45.

*[164-166] "Roaming Issues"*

Rx Networks agrees that roaming issues have been largely addressed in the current CMRS networks. By introducing indoor accuracy requirements with corresponding changes that will need to be made in devices and/or CMRS networks, further roaming issues could be created, but would be greatly mitigated through a standardized approach that makes use of pervasive handset technologies.

= End of Submission =