Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Wireless E911 Location Accuracy Requirements	)	PS Docket No. 07-114
	)	
	)	

COMMENTS OF POLARIS WIRELESS, INC.

Polaris Wireless, Inc. ("Polaris")[1] hereby submits these Comments in response to the Public Safety and Homeland Security Bureau's March 28, 2014 Public Notice requesting comment on the Third Further Notice of Proposed Rulemaking ("NPRM") in the E911 location accuracy proceeding.[2] Polaris strongly supports the Commission's ongoing efforts to improve the accuracy and reliability of E911 Phase II systems, and offers these comments to describe the technology model Polaris has developed to meet the need for wireless indoor location accuracy identified in the NPRM.

I. Introduction

The continual effort to improve emergency call response, particularly for wireless calls placed from indoor locations, has motivated the Commission to propose an indoor location accuracy mandate for wireless 911 calls, in a manner similar to what the Commission previously

[1] With over 49 global deployments, Polaris is a leader in high accuracy, software-based wireless location solutions for location services, including E911 Phase II.

[2] *Wireless E911 Location Accuracy Requirements*, Third Further Notice of Proposed Rulemaking, PS Docket No. 07-114 (rel. Feb. 21, 2014) ("*NPRM*").

had done for outdoor wireless 911 calls.[3] Polaris Wireless wholeheartedly supports these efforts, which will enhance the safety of the general public when wireless callers seek emergency assistance over both licensed and unlicensed federally-regulated wireless spectrum. Recognizing that wireless and mobile ecosystems continue to evolve, Polaris is confident that, when deployed as a hybrid with Assisted-GPS (A-GPS) and other network/handset-based technologies, its field proven Wireless Location Signatures (WLS™) technology based on the 3GPP[4]-standardized RF Pattern-Matching (RFPM) approach and integrating multiple tiers of location data as described below will be compliant with the Commission's indoor location requirements.

Polaris seeks to draw attention to two factors of particular importance among the many critical components of the Commission's proposed rulemaking. The first is the expectation that *all wireless callers* will receive an appropriate level of location estimation accuracy, and that consumers will not be marginalized based on their choice of wireless carrier, where they live, or which user equipment they possess.[5] The second is that, to the extent practicable, *new technologies and location solutions* are pursued (and motivated through the Commission's rulemaking) so that continued wireless network and user equipment refresh cycles drive a corresponding evolution of best-in-class indoor wireless location accuracy performance.[6]

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[3] *NPRM* ¶ 2.

[4] 3GPP, or the 3rd Generation Partnership Project, unites six telecommunications international standard development organizations and provides a stable environment to produce the Reports and Specifications that define cellular telecommunications network technologies such as LTE, HSPA, and GSM. *See* www.3gpp.org.

[5] *NPRM* ¶¶ 38-39.

[6] *See, e.g.*, *NPRM* ¶ 47.

Our experience, and that of other members of the wireless location industry, shows that no single technology can meet the aggressive accuracy benchmarks entertained in the proposed rulemaking. It also is clear, however, how vitally important it is to public safety that industry responds with practicable and cost-effective solutions. Therefore, Polaris expects that *all* viable solutions deployed to meet the proposed accuracy benchmarks will necessarily incorporate a mix of technologies and interfaces – particularly since fundamentally different sensor modalities are likely to be required in order to meet the Commission's floor-level vertical accuracy benchmark.[7]

II. Polaris's Proposed Model

Consistent with our deployed E911 platform and technology development roadmap, Polaris proposes a model which represents a layered approach of ever-more-precise location ingredients. At the base level are location technologies that are capable of serving all handsets across all wireless air interfaces – specifically, we propose our highly-optimized software-based wireless location platform, WLS™, which is a high-accuracy hybrid solution fusing cellular-derived location estimates with estimates produced by an assisted-GPS chip across 2G, 3G, and 4G air interfaces; WLS™ also leverages Observed Time Difference of Arrival (O-TDOA) measurements on LTE and standardized inter-Radio Access Technology (inter-RAT) measurements based on our sponsored 3GPP Work Items. To further enhance location accuracy, Polaris' hybrid model includes additional layers above the base layer, such as location data derived from Distributed Antenna Systems (DAS), metro cells and pico cells, data derived from WiFi access points, and finally data derived from sensors. Collectively, this stack of location

[7] *See NPRM* ¶ 73-74.

accuracy capabilities will allow network operators to comply with the Commission's proposed location accuracy standards within the proposed timeframe.

a. Horizontal Accuracy Compliance

For those callers seeking emergency assistance while outdoors, the Polaris hybrid solution has repeatedly been shown to deliver horizontal accuracy which meets a 50m compliance target at the 67th percentile at the county/PSAP level across all environmental morphologies – from dense-urban to rural. Furthermore, since GPS signals do penetrate to a limited extent into many single-story buildings and lightly-framed wooden structures, Polaris's hybrid location technology also serves users in these indoor environments as well. Finally, this hybrid high-accuracy system serves to help calibrate and maintain horizontal location accuracy derived from the short-range radio technologies which comprise the upper layers of this tiered capabilities model.

We note the increasing presence of short-range cellular network infrastructure deployed to keep pace with the ever-growing demand for wireless network data bandwidth. This short-range infrastructure includes Distributed Antenna Systems (DAS), metro cells, and pico cells – all systems which find their most compelling use-cases where subscriber populations are densest, such as frequently visited indoor areas. Consequently, it is becoming critical to incorporate these network elements into the highest-accuracy indoor location solutions. By employing carefully constructed radio map prediction databases, continuously and automatically calibrated and maintained by collecting measurements from the subscribers who inhabit these spaces, Polaris has repeatedly demonstrated indoor location accuracies of approximately 30-40m across a variety of indoor morphologies.

We emphasize that Polaris's wireless location platform today supports all air interface technologies, from 2G/GSM and 3G/UMTS through the evolving 4G/LTE standards. Furthermore, Polaris is confident that this high-performance hybrid combination of 3GPP-standardized RF pattern-matching, augmented by A-GPS, and further augmented in LTE with O-TDOA measurements, will meet the Commission's proposed horizontal indoor location accuracy requirement within the proposed timeframe. Finally, Polaris expects horizontal accuracy performance to continue to improve with (1) protocol standardization of inter-RAT measurements, (2) increased convergence to 3G and 4G technologies (particularly with the emergence of voice-over-LTE), (3) build-out of short-range wireless infrastructure (e.g., DAS, metro cells, pico cells, and Wi-Fi) and (4) inclusion of the sensor measurements available in smart devices.

b. Vertical Accuracy Compliance

The latest capability added to the Polaris platform is directly responsive to the Commission's stated objective of providing vertical resolution of emergency calls.[8] The addition of 3-dimensional radio prediction maps and new 3D RF Pattern Matching location algorithms offers an initial capability today which ultimately will pave the way to floor-level vertical discrimination in the immediate future.

For indoor wireless subscribers, the sensing and observation of nearby Wi-Fi 802.11 access points has become increasingly important for location-discovery and context-awareness. The Polaris solution can access this information either over a data session with a suitably-equipped smartphone, or by exposing the Polaris location server to an interface of the Wi-Fi

[8] *See NPRM* ¶ 73-80.

network management and user access/control system. In the former case, an app-equipped mobile device provides to the Polaris location server the identity, signal strength, and other parameters of the Wi-Fi access points in its vicinity. In the latter case, all Wi-Fi access points receiving probe requests from a particular mobile device report this data to the Polaris location server. The accuracy of this system depends critically on calibration intensity, access point coverage density, and the self-healing algorithms in the Polaris Wi-Fi access point database system. The best performance achieved to-date has been in the 8-12m range at the 90th percentile – although this is based on freshly-calibrated and optimally provisioned Wi-Fi access point networks. In comparison, with sparser calibration coverage in heavily-trafficked retail venues, performance of the Polaris system has consistently been in the 18-25m range.

The utmost performance in mobile location accuracy comes from accessing sensor measurements available on the most recent generations of high-end mobile devices. This includes not only receiving data from micro-electro-mechanical systems (MEMS) sensors such as accelerometers, gyroscopes, magnetometers, and barometric pressure sensors, but also processing this data in a navigation filter in order to perform pedestrian dead-reckoning (accurate to several percent of distance travelled) as well as elevation estimation (i.e., the vertical or z-axis). The Polaris approach is to provision this capability in an on-device ("client-side") application, make available aiding information from an external server, and then export as needed the final position solution and/or location context to other mobile applications and services.

With regard to vertical estimation, we emphasize that there are substantial challenges to meeting the accuracy and reliability targets the Commission proposes. Our work, and that of

others in the industry, shows the significant negative impact to vertical accuracy caused by wind and weather induced pressure phenomena, particularly the stack effect caused by temperature differentials between high-rise buildings and the outdoor environment. These challenges motivate our strategy of *hybrid vertical estimation*, combining barometric pressure readings (corrected by assistance data from a terrestrial reference network) with 3D RF fingerprinting. This combination approach not only optimizes accuracy but also detects, isolates, and rejects large errors. In light of the significant penetration of sensors across subscriber devices, Polaris is confident that this hybrid vertical estimation solution will meet the Commission's proposed vertical location accuracy requirement within the proposed timeframe. Finally, the Commission will find it increasingly important to ensure that emergency call operators and PSAPs are able to exploit this additional vertical information in order to improve dispatch response and other measurable outcomes of success within the specified time period.

The benefits of exploiting this upper-most tier of the location capabilities stack are substantial: when integrated into the full capabilities stack, sub-10m horizontal accuracy and floor-level vertical accuracy are available virtually continuously while the system is activated, and convergence upon warm-start to re-capture this level of accuracy takes only 10-20 seconds. In this way, the requirements of data usage, network resource utilization, and device energy consumption are balanced to achieve optimal and pervasive indoor and outdoor location accuracy performance.

III. Benefits for E911 and Beyond

In addition to providing best-in-class indoor location accuracy performance for emergency 9-1-1 callers, Polaris's hybrid location accuracy solution opens the door to further

beneficial location-based applications for users. Given that virtually all modern mobile devices can be located (while also maintaining subscriber anonymity), the two location technologies in the base layer of the Polaris tiered capabilities indoor location deployment model (RFPM and A-GPS) will serve other applications as well, over both control-plane as well as user-plane implementations. For example, some relevant potentially beneficial applications include retail analytics, mobility modeling, and pedestrian preferred route discovery. Importantly, potential applications like these may also allow wireless operators to amortize their expenses between revenue-generating uses of the underlying mobile location platform and the vital emergency call-response mission – potentially reducing the costs to subscribers. Furthermore, as mentioned previously, greater utilization of these multiple layers permits calibration and maintenance of the higher-accuracy tiers that substantially differentiate the capabilities of Polaris's solution from other systems – for the benefit of both public safety and non-public safety users.

As a further example of beneficial applications beyond public safety, fundamental advances in cooperative positioning, crowd-sourcing, and population modeling for the purposes of indoor mobile location estimation have resulted from Polaris's active, multi-year university outreach and collaboration partnerships. The cooperative positioning research is of particular relevance since 3GPP currently is defining requirements for Device to Device (D2D) communications, and our advances in this domain could become an important ingredient in Polaris's strategy to meet evolving location accuracy requirements.

IV. Conclusion

We summarize that Polaris's hybrid solution, with a layered approach of network-based technologies, handset-based technologies, and evolving network infrastructure will help achieve

the Commission's proposed horizontal and vertical location accuracy mandate. Many of these performance metrics are achievable today or in the near future, and Polaris looks forward to demonstrating indoor location accuracy performance consistent with the Commission's proposed requirements in the next Phase-II round of testing currently being facilitated under the auspices of CSRIC-IV.

Polaris commends the Commission for examining horizontal and vertical location accuracy simultaneously in this proceeding, since precise and reliable horizontal location performance is critical for the successful determination and effective use of the vertical location component. Polaris is thankful for the opportunity to share with the Commission its perspective on developing technologies for improving wireless indoor location accuracy, and on the particular capabilities of emerging solutions like its tiered hybrid solution to meet the Commission's proposed location accuracy benchmarks.

Respectfully submitted,

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May 12, 2014