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

In the Matter of	)	
	)	
Wireless E911 Location Accuracy Requirements	)	PS Docket No. 07-114
	)	
Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems	)	CC Docket No. 94-102
	)	
Association of Public-Safety Communications Officials-International, Inc. Request for Declaratory Ruling	)	
	)	
911 Requirements for IP-Enabled Service Providers	)	WC Docket No. 05-196

To: The Commission

COMMENTS OF POLARIS WIRELESS, INC.

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COMMENTS OF POLARIS WIRELESS, INC.

Polaris Wireless, Inc. ("Polaris"), through its attorneys, hereby submits its Comments in response to Section III.B of the Federal Communications Commission's Notice of Proposed Rulemaking in the above-captioned proceeding.[1]

SUMMARY

Polaris reiterates its support for the Commission's efforts to improve the performance of public safety E911 systems in general and to achieve greater location accuracy in particular. The goals outlined in the *NPRM* represent objectives that the entire wireless industry should strive to achieve in the interest of delivering the best possible information to the nation's first responders in emergency call scenarios. The lines of inquiry raised by the Commission in the *NPRM* Section III.B, such as accuracy standards, location technologies, testing methods and

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[1] *See Wireless E911 Location Accuracy Requirements*, PS Docket 07-114, *Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems*, *Association of Public-Safety Communications Officials-International, Inc. Request for Declaratory Ruling*, CC Docket No. 94-102, *911 Requirements for IP-Enabled Service Providers*, WC Docket No. 05-196, Notice of Proposed Rulemaking, 22 FCC Rcd 10609 (rel. Jun. 1, 2007) ("*NPRM*").

enforcement time frames, represent many of the difficult, practical challenges that must be addressed to achieve these goals. Based on its E911 Phase II research, development, deployment and testing experience, Polaris is in a unique position to comment on the important questions raised by the Commission in Section III.B of the *NPRM*, particularly those related to hybrid location technologies. By hybrid, Polaris means those systems that combine handset-based technology (typically GPS) with network-based technology (such as received signal strength measurements).

Based on Polaris's experience, hybrid systems can play a significant role in improving accuracy as a step toward meeting the Commission's stated goals in the *NPRM*. Hybrid approaches have the potential of providing more consistent accuracy performance across the wide range of environments encountered with E911 calls. This is because of the diversity benefit achieved from combining network-based technologies, which typically work best in high cell density environments (*e.g.*, dense urban), with handset-based technologies that tend to work best in open sky environments. As noted by other commenters, hybrid systems are not a panacea,[2] but based on Polaris's test results, hybrid systems can most certainly improve accuracy beyond current levels. The necessity to adopt hybrid approaches underpins Polaris's positions on many of the *NPRM* Section III.B issues and questions raised by the Commission.

In the overall context of the *NPRM*, the Commission should consider carefully the appropriate geographic scope of its location accuracy rules, as addressed in Section III.A, in direct relation to the accuracy standards, location technologies and testing issues raised in Section III.B. As Polaris and other commenters pointed out,[3] the geographic scope, location technology and testing considerations are inextricably linked to the question of meeting Phase II

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[2] *See* Comments of QUALCOMM Inc., PS Docket No. 07-114, at 6-7 (filed Jul. 5, 2007) ("QUALCOMM Comments").

[3] *See* Reply Comments of Polaris Wireless, Inc., PS Docket No. 07-114, at 3 (filed Jul. 11, 2007); Comments of Verizon Wireless, PS Docket No. 07-114, at 17-20 (filed Jul. 5, 2007) ("Verizon Wireless Comments"); QUALCOMM Comments at 5-6.

accuracy requirements at the PSAP service area level. The record being created on Section III.B should inform the Commission's future decisions with regard to Section III.A.

About Polaris. Founded in 1999, Polaris is a privately held company that has developed and commercialized a wireless location software technology for the delivery of location services, including E911 Phase II public safety applications. Polaris's software products have been deployed extensively since 2003 by eleven U.S. wireless carriers in sixteen TDMA IS-136 and GSM networks to meet E911 Phase II emergency call location requirements and enhance their customers' safety. Currently, Polaris's location systems provide E911 Phase II services to about 900 PSAPs nationwide and process approximately 10,000 emergency call locates daily.

Polaris's Wireless Location Signatures (WLS) technology has several key advantages over alternative technologies: no modifications are required in the handset, as opposed to GPS/A-GPS technologies; and the location algorithms are implemented on a standard computer server, which requires no hardware additions to the base stations, as opposed to other network-based technologies such as U-TDOA (uplink time-difference-of-arrival) or AOA (angle-of-arrival) that require new radio hardware. In addition, the WLS system achieves high accuracy and reliability results due to its reliance on measurements that are made as a part of normal wireless network operations.

Because the WLS system uses serving and neighbor cell measurement information to estimate location, it is most accurate in high cell density environments where many measurements are often reported, such as dense urban and many indoor settings. Unlike other technologies, such as TDOA and AOA, WLS does not rely on line-of-sight paths between the base stations and handset, so performance can actually be improved in heavily cluttered, multipath environments. Moreover, due to its ability to leverage existing infrastructure, the initial investment to deploy an E911 solution with WLS is a fraction of the cost of alternate technologies, and deployment times are significantly faster than what is necessary to install new radio network equipment or to replace the installed base of wireless handsets in the marketplace.

The Polaris WLS technology is based on the observation that the radio environment varies from location to location due to features such as terrain, buildings, foliage and cellular signal coverage. If enough elements of the radio environment can be measured with sufficient accuracy, each set of measured values provides a radio signature that uniquely identifies a particular location. Because the control channels of a wireless network are broadcast at a constant power (*i.e.*, the power does not vary over time), they provide a signature that is predictable and repeatable. In typical cellular networks, handsets measure the signal strengths (or signal-to-interference ratios) of serving and neighbor sector broadcast control channels for normal handover operations. These measurements form the basis of the radio signatures used to locate the handsets.

WLS is a pattern-matching technique in which the measured radio signatures from the handset are compared against a Predicted Signature Database (PSD) to estimate the user's location. The location algorithms use the predicted signal strength values in the PSD and the time series of measurements from the handset to calculate the probability distribution of the handset's location. Polaris has implemented a location algorithm primarily based on relative signal strength that mitigates the effects of any biases that are common to all channels. When the algorithm has processed the time series of measurements currently available, it will have calculated the probability that the handset is at each point in the array of possible locations. When a new measurement becomes available, the algorithm uses its knowledge of the possible motions of the handset during the time period between the last measurement and the new measurement to predict a new location probability distribution.

WLS is well-suited to provide high accuracy in urban and indoor situations because of its unique ability to take advantage of shadowing conditions that can degrade other approaches that rely on line-of-sight circumstances, such as TDOA, AOA and GPS. First, urban areas typically contain extremely high cell densities because of the large concentrations of wireless users; therefore, many neighbor measurements are reported in the signatures, enabling especially accurate location estimation. Second, through use of radio propagation modeling, geographical information system data and measurements, the PSD contains information about local shadow fading conditions, which is particularly critical in urban areas where non-line-of-sight conditions are predominant due to extensive building obstructions and clutter. As Professor Henry Bertoni, a noted radiowave propagation researcher at Polytechnic University, observed for pattern-matching location-signature approaches (using the terminology Power Signature), "[a]nother urban location technology gaining attention is known as the Power Signature (PS) method. . . Power signatures contain information about the shadowing of the signals by the buildings surrounding the mobile. To the extent that this shadowing is unique to each mobile location the shadowing information can serve to locate the mobile."[4]

In addition, the PSD contains information about predicted radio signal penetration into local buildings that can be used for indoor location estimation. As Professor Gregory Durgin from the Georgia Institute of Technology observed from his research and field testing, "[t]he [received signal strength method] technique is particularly powerful for locating and discriminating indoor users, which is not possible for other triangulation techniques."[5] He further noted that, "[a]n extensive measurement campaign conducted on the Georgia Tech campus indicates that RSS [received signal strength] location techniques can locate handset calls

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4 *See* H. L. Bertoni and J. W. Suh, "Simulation of Location Accuracies Obtainable from Different Methods," Institute for Electrical and Electronics Engineers 62nd Vehicular Technology Conference, Sept. 25-28, 2005, Proceedings Volume 4 at 2196-2200.

5 *See* J. Zhu and G. D. Durgin, "Indoor / Outdoor Location of Cellular Handsets Based on Received Signal Strength," *Electronics Letters*, Jan. 6, 2005, Volume 41, Number 1.

within 100 meter error distance to its ground truth 78% of the time for a network with a majority of indoor users."[6]

I. THE OVERALL ACCURACY AND CONSISTENCY OF E911 PHASE II SYSTEMS CAN BEST BE ACHIEVED THROUGH THE APPLICATION OF HYBRID TECHNOLOGIES

Fundamentally, Polaris's experience indicates that the overall accuracy and consistency[7] of E911 Phase II systems can be improved through the application of hybrid technologies, combining network-based and handset-based elements. As the record on this *NPRM* demonstrates, hybrid systems cannot solve all of the complex and varied challenges associated with achieving PSAP-level accuracy compliance. However, Polaris believes that the Commission's overarching goal of improving E911 Phase II accuracy can best be achieved by adopting hybrid approaches. Therefore, the evolution to hybrid systems underpins Polaris's viewpoints on the fundamental questions raised in the *NPRM*'s Section III.B, such as deferred enforcement, accuracy standards, and compliance time frames.

Polaris does not believe that it is possible to meet the Commission's goals of improving E911 Phase II accuracy within short time frames by using new and unproven handset-based technologies. For example, approaches using other GPS-alternative satellite systems (*e.g.,* GLONASS), future satellite proposals (*e.g.,* Galileo), unlicensed band wireless local networks (*e.g.,* WiFi IEEE 802.11a/b/g), or other terrestrial signal sources (*e.g.,* broadcast TV stations) all require significant handset changes. None of these handset-based approaches solves all the issues raised in the *NPRM*. For example, the availability of more satellites does not address problems with urban multipath reflections and deep indoor scenarios, unlicensed band networks are uncoordinated and ever-changing, and broadcast signals do not always provide the geometric

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6 *Id.*

7 Both location estimation accuracy and consistency are critical to providing reliable and trustworthy E911 Phase II location information to PSAPs. Approaches that reduce gross errors (*i.e.*, outliers) can be extremely valuable.

diversity needed for accurate location measurements. In order to enter commercial service, these approaches would need to be tested, proven practical, standardized in industry bodies, built into commercial handsets, and then rolled out to the mass market. These steps would take a number of years, resulting in a much longer time needed to positively impact public safety accuracy. In contrast, hybrid systems represent a faster, more orderly and efficient evolution to increased accuracy for E911 Phase II systems.

New developments in state-of-the-art satellite navigation deserve particular comment. Galileo, an ambitious and admirable undertaking being developed by the European Union,[8] represents a particularly high-risk path to a reliable E911 service. Indeed, this year the European Union made fundamental changes to Galileo's plans to recover costs.[9] Up until this summer, Galileo sought to realize a Public-Private Partnership (PPP), in which the general tax fund would pay for the deployment of the system, and users would pay for the operation and maintenance of the system (at a cost of several hundred million dollars per year). No suitable business arrangement could be made, however, and the European Transport Ministers recently scrapped this approach and called for a re-planning to realize a navigation system wholly funded by the public. In view of this recent sea change, the Galileo operational date of 2010 seems optimistic. Indeed, closer followers of Galileo are hinting that 2014 would be the earliest possible operational date.

GLONASS, the satellite navigation system operated by Russia, also suffers from appreciable financial uncertainty.[10] Indeed, GLONASS dwindled from a 25-satellite constellation in December 1995 to fewer than six satellites in November 2002. Today,

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8 *See, e.g.*, "Galileo: European Satellite Navigation System," *at http://ec.europa.eu/dgs/energy_transport/galileo/index_en.htm*.

9 *See, e.g.*, "Europe to Fund Galileo Satellite Navigation System; Junks Private Consortium," SatNews Daily, May 18, 2007, *available at* http://www.satnews.com/stories2007/4472/.

10 *See, e.g.*, "Radical Change in the Air for GLONASS," GPS World, January 22, 2007, *at http://www.gpsworld.com/gpsworld/article/articleDetail.jsp?id=399504*.

GLONASS has 12 satellites in orbit, and the probability of achieving a successful position fix using GLONASS is approximately 33% (even under open sky). GLONASS may be enjoying a resurgence, however, as its planners claim that 18 satellites will be in orbit by the end of 2007 and that the constellation will utilize a full 24 satellites by the end of 2009. Unfortunately, GLONASS employs a multiple-access scheme that differs markedly from that used by GPS or proposed for Galileo. Thus, the handset receiver implementations will be appreciably different than that required for GPS, and the costs would reflect this serious complication.

GPS itself is being modernized. New GPS satellites carry a second civil signal at the so-called L2 frequency. In fact, three such satellites are included in the current constellation of 30 GPS satellites. Commencing in 2008, new GPS satellites will broadcast three civil signals. However, the constellation will not be fully populated with this new capability until 2016 at the earliest.

Even if all of these new satellite resources are deployed and combined (*e.g.,* creating a future handset-based system that used GPS, GLONASS and Galileo satellite signals together), the aggregation of signal power across three frequencies and three constellations will only result in a 10 dB improvement in signal power. Perhaps advanced signal processing of the so-called data-free components in the new satellite signals will provide another 6 dB of gain. While helpful, this potential gain of 16 dB is less than the loss experienced due to a single floor, exterior wall or tinted glass window in a modern office building, and will provide little improvement in the probability that the satellite signals will reach the distressed user of E911 calling from inside a building. Thus, Polaris strongly believes that some of the improved E911 capability must come from both space-borne and terrestrial sources working in concert together as a hybrid system.

Other handset-based approaches using terrestrial signal sources, such as WiFi IEEE 802.11 Wireless Local Area Networks (WLANs) or broadcast TV stations, are constrained by time-to-market and technical limitations. For example, WiFi WLANs for consumers, enterprises and public entities operate in a shared manner using unlicensed bands. These networks are unplanned (*i.e.*, deployment and placement of access points are not coordinated, managed or catalogued by a single source). On the other hand, cellular networks are planned by wireless service providers operating in licensed bands; therefore, base station information (*e.g.,* location, height, antenna type, transmit power, channels) is known and controlled. Estimating position, particularly indoors, based on WiFi WLAN signals is problematic because of the unknown, changing and transitory nature of WiFi access points in unplanned networks. In addition, there are battery life, cost and time-to-market constraints associated with adding WiFi capabilities to commercial handsets on the mass scale required for E911.

Approaches using broadcast TV signals face similar challenges with integrating new TV tuner functionality into handsets, since broadcast TV services operate at different frequency bands than CMRS networks, necessitating radio hardware (*e.g.* filters, antennas, low noise amplifiers) and signal processing changes in handsets. In many markets, broadcast TV station towers are not geometrically diverse because the transmitter sites tend to be congregated near each other at geographically high locations. Without geometric diversity of TV signal sources, position estimation accuracy is degraded due to the well-known effects of geometric dilution of precision. Therefore, Polaris believes the best hybrid approach to improve E911 Phase II accuracy in practical timeframes combines information from network-based (terrestrial cellular networks) with handset-based (satellite A-GPS) systems.

As noted in Polaris's prior comments, currently deployed E911 Phase II location technologies cannot practically and economically meet the Commission's goal of compliance at the PSAP level in some cases, and it will take time for wireless carriers and location system vendors to develop new technologies, such as hybrid approaches. There are numerous and considerable challenges that wireless carriers must still overcome to achieve PSAP-level accuracy in their networks, including those faced by network-based technologies in sparse rural areas and handset-based technologies in dense urban and indoor areas.

II. THE COMMISSION SHOULD ONLY REQUIRE A SINGLE LOCATION ACCURACY REQUIREMENT IF IT IS A HYBRID SOLUTION

Although the Commission tentatively concluded in paragraph 9 of the *NPRM* that a single location accuracy requirement would best serve the public interest, Polaris finds that this is only appropriate as part of a hybrid solution. The prior record before the Commission on E911 Phase II clearly established the fundamental physics differences between handset-based technologies using satellites and network-based systems using terrestrial networks.[11] These underlying differences and their impact on accuracy have not changed in the intervening years and remain true today. Although some underlying technologies, such as signal processing algorithms, have improved, they have tended to do so for both handset-based and network-based technologies. Accordingly, should the current network-based and handset-based paradigm remain in place, a single accuracy requirement is not appropriate. Once hybrid systems are widely available in the marketplace, however, the distinction between handset-based and network-based solutions will effectively dissolve. Only at that point would it be appropriate for the Commission to adopt a single location accuracy requirement.

Because of the numerous challenges and uncertainty of success identified in the record with regard to achieving PSAP-level accuracy compliance,[12] Polaris believes it is best to first address the accuracy improvement mechanisms under the current bifurcated approach before the Commission considers introducing additional complexity by unifying the accuracy requirements.

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[11] *See, e.g.*, Verizon Wireless Comments at 3, 16.

[12] *See* Comments of Polaris Wireless, Inc., PS Docket No. 07-114, at 6-8 (filed Jul. 5, 2007); QUALCOMM Comments at 5-6.

III. THE IDEAL HYBRID SOLUTION IS TO PAIR A NETWORK-BASED AND A HANDSET-BASED TECHNOLOGY

Polaris has much to add to the record in response to the *NPRM*'s questions regarding location technologies (paragraph 11), including current performance and future improvements possible with hybrid systems. Polaris views a hybrid solution as the best long-term approach to improve location accuracy and consistency. Although there are many conceivable hybrid combinations of different technologies to improve accuracy, Polaris considers the ideal hybrid solution to be the pairing of a network-based and a handset-based technology. The foundation for improving location accuracy in a hybrid system is the introduction of measurement diversity, which reduces the detrimental impacts of errors (particularly large outliers). The best diversity is achieved when the measurements are derived from systems in which the errors are not correlated. For example, combining one network-based technology with another would not optimally improve location accuracy because the errors would tend to be correlated. Network-based technologies have errors that vary based on terrestrial cell site densities and geometries (among other factors), so different network-based technologies may tend to experience large errors in similar locations. However, handset-based technologies have errors that vary based on satellite densities and geometries (among other factors). Thus, combining a network-based technology with a handset-based technology results in better accuracy benefits because the terrestrial cell site and satellite configurations are independent of one another (*i.e.*, not correlated).

The hybrid solution leverages the strengths of two highly complementary technologies, particularly when combining handset-based A-GPS with a network-based pattern-matching technology such as Polaris's WLS approach. Polaris's WLS location information is less correlated with handset-based A-GPS than other network-based technologies, such as U-TDOA or AOA, in urban environments. Urban shadowing that leads to multipath conditions can cause location errors in A-GPS systems, as well as in U-TDOA or AOA systems; however, urban shadowing improves the location accuracy of Polaris's WLS.

In hybrid systems, pattern-matching technologies, such as Polaris’s WLS method, can produce accuracy improvements with potential advantages in performance, without the cost and complexity of U-TDOA or AOA. Both U-TDOA and WLS are network-based technologies with accuracies that depend on cell tower (base station) densities and geometries, so they typically perform best in high cell density scenarios. TDOA methods, such as U-TDOA, depend on direct line-of-sight propagation from the base stations to the handsets to estimate the differences in times-of-flight. This means that they can be impacted negatively by obstructions that block or shadow the line-of-sight paths, such as buildings in urban scenarios. On the other hand, pattern-matching technologies such as WLS can take advantage of shadowing effects to improve accuracy (rather than be degraded by them). Therefore, WLS represents a better network-based approach for combining with handset-based methods in a hybrid combination to produce accuracy improvements.

The Polaris WLS pattern matching system achieves its best accuracy in high cell density and cluttered environments, such as urban outdoor and indoor locations. In contrast, A-GPS achieves its best performance in open sky conditions, such as outdoor suburban and rural settings, where several satellites are visible in line-of-sight to the handset. Polaris’s hybrid system uses information from both WLS and A-GPS to provide more consistent accuracy across the range of environments.

Polaris has conducted a number of field tests to assess the potential performance improvements of hybrid systems, compared to existing handset-based systems (commercial A-GPS systems which fallback to Cell-ID or Advanced Forward Link Trilateration [AFLT] technologies). These tests have been conducted predominantly in dense urban, urban, and indoor areas, where satellite-based systems may experience challenges with obstructions. The results from several of these trials are consolidated in the bar chart of Figure 1 and illustrate the percent improvement expected from a hybrid system using WLS at the 67^{th} and 95^{th} percentiles. The percentage improvements in accuracy vary from about 30% to over 65%, depending upon the type of existing network and A-GPS system; these numbers represent significant performance gains that could be harnessed to drive accuracy and consistency improvements.

Separate bar chart entries in Figure 1 are shown for hybrid systems on asynchronous networks (cellular networks where the base stations are not synchronized in time) and synchronous networks (cellular networks where the base stations are synchronized in time using a precise reference clock). Performance of A-GPS is expected to be better (in terms of accuracy, time to fix, and location yield) in synchronous networks, where the cellular network's time reference information can be used to aid the handset in acquiring the satellite signals. Currently deployed CDMA2000 networks are synchronous networks, where the A-GPS system uses AFLT for the position fix fallback. Many asynchronous networks, such as GSM, UMTS/WCDMA and iDEN, use Cell-ID or similar network technologies as fallbacks when A-GPS position fixes are not available. In general, AFLT provides better accuracy performance than Cell-ID. As Figure 1 shows, the improvements of hybrid systems using WLS are expected to be higher on asynchronous networks using A-GPS with Cell-ID than for synchronous networks using A-GPS with AFLT; these measured differences are believed to be caused by the reasons outlined above.

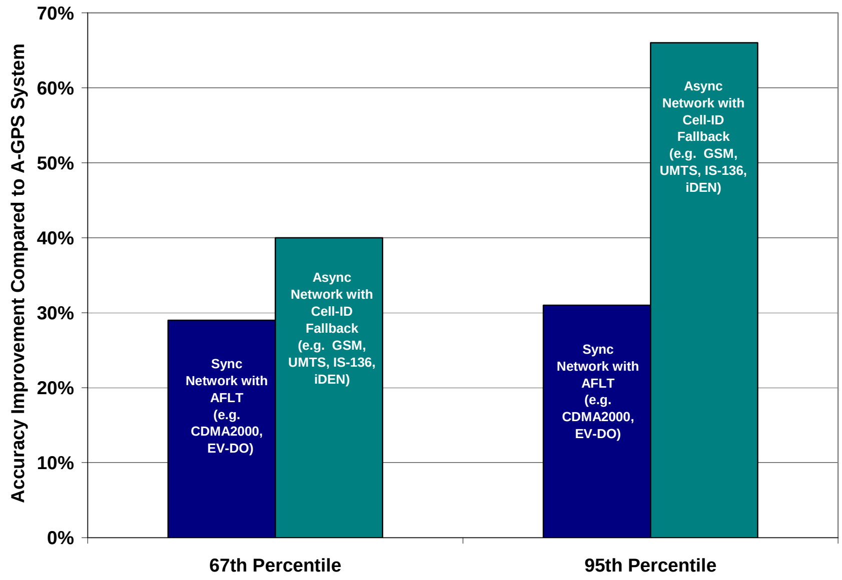

Figure 1. Expected Accuracy Improvement of Hybrid System using WLS Compared to Existing A-GPS Systems from Field Tests in Dense Urban, Urban and Indoor Areas

While the expected performance improvement of hybrid systems with WLS, based on these test results, is promising and significant, further testing is required in different environments and conditions. The evolution to hybrid systems does not guarantee that PSAP-level accuracy will be achieved in each and every case, but it is critical that the industry seize the major improvements that are available. Industry stakeholder groups, such as the E911 Technical Advisory Group (ETAG) proposed by AT&T,[13] would be excellent forums to exchange test data and compare test methodologies, since different systems need to be compared on a level playing field and across a broad range of scenarios.

On the performance of handset-based systems, the record in this proceeding contains assessments from several commenters with expertise and experience using the technology. For example, Qualcomm, the pioneer of A-GPS technology, stated unequivocally that "AGPS cannot

13 *See* Comments of AT&T, PS Docket No. 07-114, at i (filed Jul. 5, 2007).

today, nor in the foreseeable future, meet the E911 Phase II accuracy requirements in each and every PSAP on a PSAP-by-PSAP basis."[14]

Verizon noted that due to the limitations of GPS technology, PSAP level accuracy is technically infeasible. It stated that "because of the physical limitations on satellite signal propagation where there are ground-based obstructions, there are PSAPs where compliance with 150 meter/95% threshold is infeasible."[15] Adding further clarification, Verizon stated, "GPS solutions are generally challenged, however, in situations where satellite visibility is poor, such as dense forest, medium and high density urban areas and indoor permanent structures."[16] "GPS satellite transmission signals at 1.5 GHz are low power and do not penetrate structures or dense forest areas as well as signals lower in the frequency spectrum, resulting in loss of GPS signals from in-building callers and remote users areas."[17] Finally, Verizon noted that, "a clear view of the sky is critical for achieving the Commission's accuracy requirement for handset solutions."[18]

For indoor scenarios, Verizon has stated that "[i]ndoor GPS solutions generally only have the ability to travel through a single sheetrock wall, with the most advanced GPS techniques only providing an extra 6-10 feet of penetration within a building."[19] In relation to outdoor accuracy in urban areas, Verizon stated that "dense urban areas with many buildings will preclude test calls from assessing a sufficient number of GPS satellites. Test calls made on sidewalks and street corners will 'see' only portions of the sky. Depending on the slice of the sky that is visible, accuracy within 150 meters may not be possible . . . Even parts of the cities away from buildings

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14 *See* Qualcomm Comments at 4.

15 *See* Verizon Wireless Comments at 14.

16 *Id.* at 17.

17 *Id.* at 18.

18 *Id.*

19 *Id.*

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will not be able to achieve accuracy due to tree cover, overpasses, and other obstacles."[20] Verizon added that "For AGPS solutions, concentrations [of calls] in dense urban areas (with poor satellite visibility and multipathing) will make meeting the 95% accuracy level very difficult."[21]

Verizon's real-world findings are wholly consistent with what would be concluded from a first principles engineering analysis. A-GPS provides two varieties of assistance (*i.e.*, the 'assist' part of Assisted-GPS). First, A-GPS provides an alternate delivery of the contents of the navigation message normally provided by the GPS satellite signals. This assistance is valuable, because the satellite uses a very low transmission rate of only 50 bps. Thus, the entire message can consume 30 seconds while transmitting all the needed data. Needless to say, an uninterrupted 30-second window is unlikely in an urban canyon. Second, A-GPS provides data to extend the averaging time of the roving receiver. This data includes the Doppler shifts for the satellites in view, and/or the actual navigation bits that are currently being broadcast.

This second variety of assistance allows GPS receivers to operate in more challenging radio environments, but the improvement is not large compared to the losses introduced by the floors, walls or tinted glass windows of buildings (or combinations of other typical obstructions encountered inside buildings, such as partitions, pillars, soft walls, furniture, and cabinets). Under open skies, GPS signal-to-noise ratios are typically 40 dB-Hz. With A-GPS assistance, GPS receivers can tolerate signal-to-noise ratios of 14 to 16 dB-Hz.[22] However, a single floor, exterior wall or tinted glass window in a modern office building may introduce 20 dB or more of loss, so that the building structure quickly overcomes the gain provided by A-GPS.

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20 *Id.* at 21.

21 *Id.* at 20.

22 *See* Misra and Enge, "Global Positioning Systems: Signals, Measurements and Performance," Ganga-Jamuna Press, 2006

Sprint Nextel stated that for their handset-based A-GPS location systems, "[t]he ability to obtain a location fix can be affected by numerous factors outside the carrier's control, including, but not limited to: time of day, time of year, weather, geographic features, the proximity of buildings, the speed at which the handset is moving, whether the handset is inside a building, under a tree canopy, inside an automobile, the quality of voice coverage (which impacts the delivery of data), the number of towers available, etc. Once one or more of these factors comes into play, the accuracy of the solution can begin to vary widely."[23]

To be balanced, it should be pointed out that while handset-based systems face challenges predominantly in urban and indoor areas, network-based systems face equally difficult challenges in low cell density environments, such as sparse rural areas. The record also contains many comments in this regard. As previously noted, handset-based systems could benefit from hybrid elements in urban and indoor situations, while network-based systems could benefit from hybrid features in rural and low cell density scenarios. Neither system alone is likely to meet the Commission's objectives of improving accuracy performance, particularly to the PSAP-level.

The public domain industry literature also contains some assessments of A-GPS performance. Location yield and accuracy are factors to consider in evaluating performance of a system, but another critical consideration is the time latency of the location fixes. The E911 Phase II application requires location fixes within a 30-second time window. In challenging urban and indoor environments, A-GPS can take an unacceptably long time to obtain a position estimate. This is illustrated in the bar chart in Figure 2 from Helios Technologies, based on its testing of A-GPS systems in Tokyo, Japan.[24] The horizontal axis is the time required for the handset to produce a position fix. The colored bars show the frequency of calls where an A-GPS

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23 *See* Comments of Sprint Nextel, PS Docket No. 07-114, at 11 (filed Jul. 5, 2007).

24 *See* A. Sage, "The Practical Reality of Today's Positioning Systems and Their Implications for E112," Helios Technologies Ltd., EENA Conference, Brussels (Dec. 2, 2004).

fix was achieved (magenta), network-based AFLT fall back was used (tan), Cell ID fall back was used (light blue), and failure to produce any estimate (blue). In these outdoor urban tests, the time for A-GPS to produce a position estimate from a cold start was often more than 30 seconds, with some calls taking as long as 40 seconds to locate.

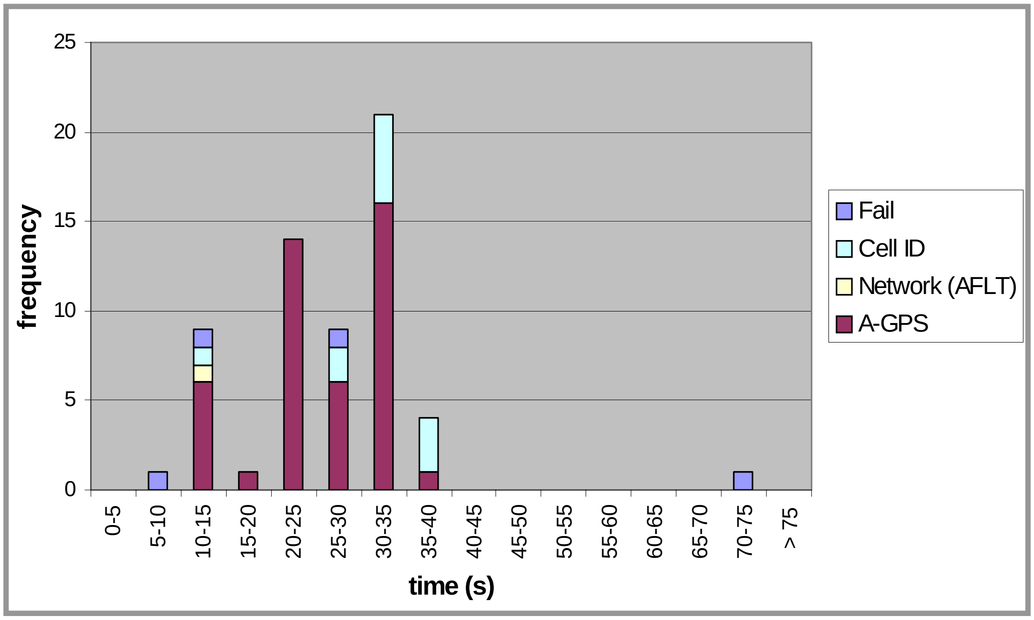

Figure 2. Time Latency of A-GPS Location Fixes in Tokyo, Japan Field Testing[25]

In addition to the location fix time delays noted in the outdoor latency results above, the Helios indoor tests in Tokyo, Japan, obtained results reflecting "virtually 0% A-GPS yield across a range of indoor scenarios." In separate indoor testing done by Polaris in New York City (Manhattan), the WLS system was able to locate 100% of indoor calls, with the resulting accuracy within 30% of that obtained outdoors.

In urban and indoor settings, even when A-GPS can produce a position estimate, it may not be of sufficient accuracy. In obstructed situations, the signals measured by the A-GPS handset may be corrupted by multipath reflections from distant buildings or walls. The result is

25 *See id* at 19.

potentially large A-GPS errors. This is illustrated in the scatter plot of Figure 3 from the same Helios Technologies EENA conference presentation. The plot shows the position accuracy variation over time for a specific outdoor urban Tokyo, Japan test location where numerous test calls were located. The magenta squares show the A-GPS position estimate, where the center crosshair (0,0 meters) represents the ground truth location. The horizontal and vertical axes depict North-South and East-West errors, respectively, in meters. One can see that the A-GPS errors vary widely, with maximum errors of over 350 meters. The large error variations over time presumably were due to the ever-changing satellite geometries, handset movements and other factors affecting the local multipath reflections and signal levels. These are precisely the types of location estimation inconsistencies that potentially could be addressed by adopting hybrid systems.

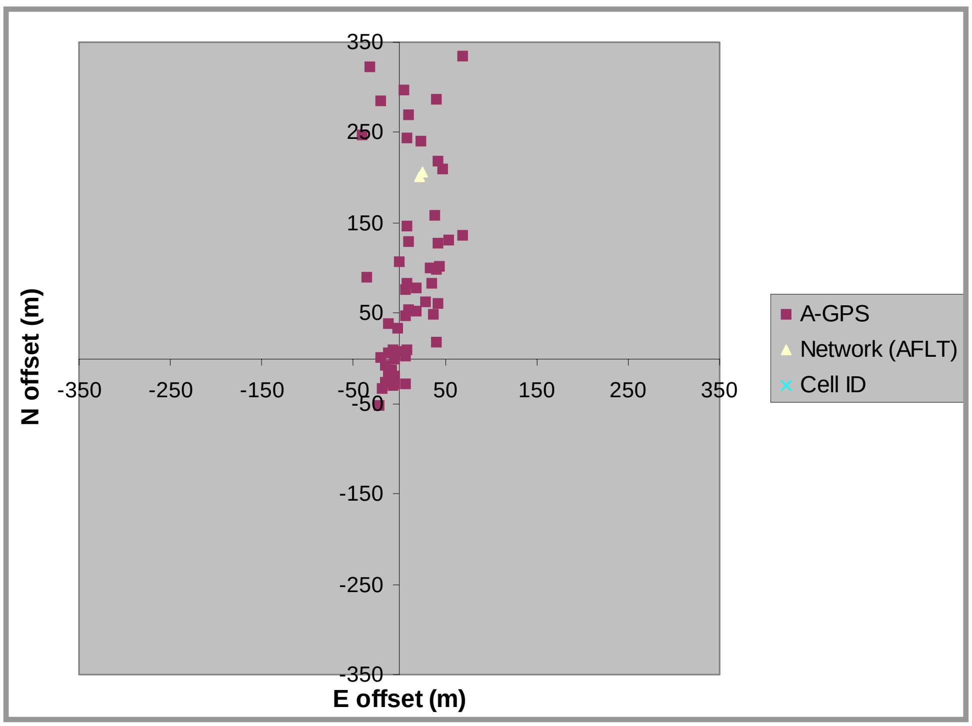

Figure 3. Accuracy of A-GPS Location Fixes in Tokyo, Japan Field Testing[26]

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26 *See id* at 18.

IV. NOTHING IN THE RECORD INDICATES THAT TECHNOLOGIES EXIST TO SUPPORT A STRICTER STANDARD THAN THE CURRENT HANDSET-BASED STANDARD

Regarding the *NPRM*'s questions on accuracy standards (paragraph 12), nothing in the record indicates that practical technologies exist to support a standard tighter than the current handset-based level of 50 meters for 67% of calls and 150 meters for 95% of calls. As the Commission pointed out, wireless location technology has advanced since the current location accuracy standards were adopted in 1999. However, it is important to recognize that views on testing methods and compliance measures have also changed considerably. This is readily evident from the current debate regarding PSAP-level accuracy performance. Indoor testing is another area that was not clearly identified or defined in 1999, but has grown in relative importance due to wireless substitution of wireline communications. Finally, in the 1999 time frame the industry did not have real-world experience with the location technologies across the broad range of environments and call scenarios. Therefore, Polaris does not find justification for adopting accuracy standards more stringent than current levels; there is no indication that more stringent standards are technically or economically feasible.

On the question of including additional information, such as elevation, Polaris does not know of a practical and economical solution to estimate elevation accurately at this time. Polaris is actively researching the issue and conducting field tests. There are fundamental physics limitations (including geometrical dilution of precision) associated with accurately estimating elevation using typical terrestrial cellular network and satellite approaches. We are aware of methods using barometric pressure sensors such as altimeters to estimate elevation, but these methods run into practicality, reliability and accuracy issues when contemplated for widespread use in consumer wireless E911 applications. For example, significant air pressure variations exist within typical buildings, which could result in erroneous altitude readings, particularly in elevators. In addition, accuracy requirements for elevation may be different than for horizontal (latitude, longitude) location, as might be needed to identify from which floor within a multistory building an emergency call was placed. The Commission, along with industry stakeholders' groups, should first consider whether new accuracy requirements are necessary for the vertical elements. Tackling the vertical dimension will require significant research prior to identifying and testing feasible solutions. Therefore, Polaris believes that including additional information, such as elevation, into the Commission's E911 standard would be extremely premature.

V. THE COMMISSION SHOULD INCORPORATE PREVIOUS WORK PRODUCT ON E911 TESTING METHODS AND PROCEDURES INTO THE E911 ACCURACY IMPROVEMENT PROCESS

To answer the *NPRM*'s compliance testing questions in paragraph 14, it should be noted that significant industry effort has already gone into E911 compliance testing methods and procedures, such as the work done by the Emergency Services Interconnect Forum[27] and the National Reliability & Interoperability Council.[28] To make rapid and efficient progress, the Commission should also incorporate these previous work products into the overall E911 accuracy improvement process. For example, the ESIF E911 Test Methodologies document contains a strong section on achieving statistical significance in testing, which could help to answer the Commission's question on the required numbers of test points.[29] The NRIC Focus Group 1A recommendations provide guidance on the percentage of indoor calls, which could inform the Commission's question on the level of indoor versus outdoor testing.[30] Polaris

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[27] *See* Emergency Services Interconnect Forum Technical Report, ATIS 0500001, *High Level Requirements for Accuracy Testing Methodologies*, (Jul. 23, 2004) *available at* http://www.atis.org/esif/docs.asp ("ESIF E911 Test Methodologies Report").

[28] *See* National Reliability Interoperability Council VII, Focus Group 1A Near Term Issues for Emergency/E911 Services, Final Report (Dec. 2005), *available at* http://www.nric.org/fg/index.html ("NRIC Focus Group 1A Report").

[29] *See* ESIF E911 Test Methodologies Report at 7-11.

[30] *See* NRIC Focus Group 1A Report at 24.

believes that the foundation for compliance testing has already been laid through a combination of OET 71, ESIF E911 Test Methodologies, and the NRIC Focus Group 1A Report. The Commission should rely on these excellent resources as the starting point to avoid "reinventing the wheel." Industry stakeholders groups, including possibly ETAG, ESIF and NRIC, would be the forums to evaluate and propose any changes.

VI. THE COMMISSION SHOULD DEFER ENFORCEMENT OR THE EFFECTIVE DATE OF ANY NEW COMPLIANCE RULES FOR FIVE YEARS

On the questions raised in the *NPRM* on deferred enforcement (paragraph 8) and on the appropriate compliance time frame (paragraph 13), Polaris believes that any new compliance rules adopted by the Commission must be accompanied by a deferral period (or a stay of the effective date). Because accuracy needs to be improved beyond current levels, and hybrid systems are the best solution to provide reliable accuracy performance, network-based operators will be required to deploy complementary handset-based solutions and *vice versa*. For wireless carriers that are currently using network-based approaches, the availability of A-GPS capable handset devices then becomes a major factor to consider. Some radio air interface technologies, such as GSM, do not currently have a wide variety of A-GPS handsets on the market at reasonable prices for most consumers. While Polaris is not a handset vendor and cannot comment on handset development times and market availabilities, historical examples would indicate that it takes one or more years for added technologies, such as A-GPS, Bluetooth and WiFi, to be deployed in commercial devices and available in large quantities. To reach the desired customer penetration rates, numerous different terminal device models must be available to suit the widely varied tastes and price points in the marketplace. After the handsets reach the marketplace, it will take significant time for the carriers' distribution channels and market forces to diffuse large numbers of devices into the customer populations, as was seen with the rollout of handset-based E911 Phase II systems.

Historical precedent from the experiences of wireless carriers that have deployed E911 Phase II handsets indicates that five years from the effective date of new rules would be required for this process to achieve a high level of penetration.[31] Currently, wireless carriers that are using handset-based solutions for E911 Phase II would have to deploy network-based complementary technologies for hybrid technologies. Although it is expected that the amount of time necessary for this rollout or upgrade would be less than for rolling out new handset-based technologies, it still would require significant time, the amount of which would depend on the network-based technology selected. Accordingly, Polaris believes that five years from the effective date is a reasonable amount of time for the Commission to permit network-based carriers to implement hybrid technologies; less time, perhaps two or three years, could be required for current handset-based carriers.

CONCLUSION

Polaris appreciates the Commission's efforts in the *NPRM* to seek public comment on these crucial E911 Phase II matters and strongly believes that the hybrid solution combining network-based and handset-based technologies is by far the best approach to achieve the desired outcome of consistent accuracy across urban, suburban, rural, outdoor, and indoor scenarios. Any rules resulting from the *NPRM* should drive the wireless industry toward the most efficient methods of directly implementing hybrid systems without wasting resources on interim methods that do not achieve the Commission's ultimate objectives. Based on these intimate technology linkages, the compliance issues raised in *NPRM* Section III.A cannot be evaluated separately

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[31] *See, e.g.*, *Revision of the Commission's Rules To Ensure Compatibility with Enhanced 911 Emergency Calling Systems, Phase II Compliance Deadlines for Non-Nationwide CMRS Carriers*, Order to Stay, CC Docket No. 94-102, 17 FCC Rcd 14841, 14842 ¶ 5 (2002) (the Commission "recognized that the E911 deployment schedule was aggressive in light of the need for further technological advancement..."); *Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems*, Fourth Memorandum Opinion and Order, CC Docket No. 94-102, 15 FCC Rcd 17442 (2000); *Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems*, Third Memorandum Opinion and Order, CC Docket No. 94-102, 14 FCC 17388 (1999).

from the technology and testing lines of inquiry in Section III.B, and the Commission should determine the appropriate geographic area for E911 Phase II accuracy and testing requirements in the context of the broader proceeding.

Due to the fact that currently deployed E911 Phase II location technologies cannot practically and economically meet the Commission's goal of geographical service area compliance at the PSAP level in some cases, it will take time for wireless carriers to bring new technologies, such as hybrid approaches, to bear on the problem at hand. Therefore, if the Commission determines that Section 20.18(h) requires E911 measuring and testing at the PSAP service area level, it should defer enforcement or stay the effective date of the PSAP-level accuracy requirements until carriers have an opportunity to deploy hybrid networks. A deferral or stay of approximately five years from the Commission's adoption of new rules would be appropriate for current network-based carriers, because currently deployed E911 location technologies will require time to be upgraded to hybrid systems. The Commission should also facilitate stakeholder meetings to discuss location accuracy issues and assess the best methods of improving accuracy and promoting public safety and homeland security.

Respectfully submitted,

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