EXHIBIT 4

July 11, 2001

Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
445 12th Street, N.W.
Washington, DC 20554

EX PARTE
IN THE MATTER OF CC DOCKET NO. 94-102
Comments of U.S. Wireless Corporation on Performance, Viability, and Application of the Mobile-Assisted Network Location System

Dear Ms. Salas:

U.S. Wireless Corporation ("U.S. Wireless") hereby submits the following *ex parte* comments on the performance, viability, and application of the Mobile-Assisted Network Location System ("MNLS"), as related to AT&T Wireless Services, Inc.'s ("AT&T") request for waiver.

U.S. Wireless' comments are intended to clarify issues related to MNLS performance and the role MNLS technology can play in meeting the E-911 Phase II mandate. We believe that with proper design and implementation, MNLS can serve as the foundation for providing a timely and effective location solution. With continued development and the combined use of complementary location technologies, such as the RadioCamera™ System, the performance of the location platform can be improved over time to achieve the performance objectives of the mandate.

If we can be of further assistance to the Commission in this matter, please do not hesitate to contact the undersigned.

Sincerely yours,

Patricia A. Murphy
Senior Corporate Counsel
U. S. Wireless Corporation

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Wireless E9-1-1 Phase II Automatic Location Identification Requirements	)	**CC Docket No. 94-102**
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To the Commission:

EX PARTE COMMENTS OF U.S. WIRELESS CORPORATION
On Performance, Viability, and Application of the Mobile-Assisted Network Location System (MNLS)

1 INTRODUCTION

U.S. Wireless Corporation ("U.S. Wireless") submits these *Ex Parte* comments for the purpose of assisting the Commission in its evaluation of an April 4, 2001 request by AT&T Wireless Services ("AT&T Wireless") for a waiver[1]. In its April 4 request, AT&T Wireless proposed the use of Mobile-Assisted Network Location System ("MNLS") technology to meet the E-911 Phase II mandate for its TDMA network.

On May 10, the FCC ordered AT&T Wireless to produce, by May 30, the test data which led to its conclusions and supported its April 4 request to use MNLS technology as its location solution[2].

On May 30, AT&T Wireless, in a partial response to the FCC's May 10 order, submitted documentation in support of its request for waiver[3].

[1] AT&T Wireless Services, Inc. Request for Waiver of the E911 Phase II Location Technology Implementation Rules, CC Docket No. 94-102, filed April 4, 2001.
[2] *Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems*, CC Docket No. 94-102, Order, DA 01-1188, released May 10, 2001.
[3] Partial Response of AT&T Wireless Services, Inc. to Order of the Wireless Telecommunications Bureau, CC Docket No. 94-102, filed May 30, 2001.

On June 8 and 14, SigmaOne Communications Corporation ("SigmaOne") submitted comments urging the Commission to deny AT&T's waiver request for its TDMA and AMPS networks[4,5]. The SigmaOne submission was a detailed response to AT&T's April 4 and May 30 submissions filed in support of its request for waiver.

U.S. Wireless's comments are intended to clarify issues related to MNLS performance and the role MNLS technology can play in meeting the E-911 Phase II mandate. U.S. Wireless believes that with proper design and implementation, MNLS can play a key role in providing a timely and effective location solution. With continued development and the combined use of complementary location technologies, such as the RadioCamera™ System, the performance of the location platform can be improved over time in order to achieve the Commission's performance objectives as stated in the E911 Phase II mandate.

2 BACKGROUND AND TECHNICAL FOUNDATION

In its June 8 submission, SigmaOne challenged the viability of employing MNLS technology as a means for meeting the E911 Phase II FCC mandate. In particular, the SigmaOne report ("SigmaOne Report") presented a number of claims suggesting that MNLS was an immature technology[6], impractical to implement[7], and with limited theoretical basis[8] for achieving the accuracy goals as stated by AT&T Wireless. In this submission, U.S. Wireless will address each of these claims based upon our extensive experience in the development and deployment of wireless location technologies closely related to MNLS, as well as our more recent investigation of MNLS technology directly.

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[4] Comments of SigmaOne in Response to Request for Waiver of AT&T Wireless Services, Inc., CC Docket 94-102, filed June 8, 2001 ("SigmaOne Report").
[5] SigmaOne Ex Parte Comments, CC Docket 94-102, filed June 14, 2001 ("SigmaOne Briefing").
[6] SigmaOne Briefing, p. 12.
[7] SigmaOne Report, Exhibit A, Detailed Comments by SigmaOne in Response to AT&T's Waiver Request, p. 6.
[8] SigmaOne Briefing, p. 11.

2.1 Relevant U.S. Wireless Experience

U.S. Wireless has been developing wireless location technology since 1996. Our principal product, the RadioCamera™ System, is a network-based location solution employing our patented location pattern matching ("LPM") technology. The LPM technology is based on the principle that as wireless signals propagate from a handset to a receiving device, the signals will be distorted due to obstacles in the propagation path (*e.g.,* buildings and mountains) as well as other transmission phenomena. Using a calibration training process, the RadioCamera™ System is taught to recognize these "RF signatures" and to associate them with specific points of origin within the coverage area. In this manner, the RadioCamera™ System is able to effectively determine the location of a mobile subscriber.

U.S. Wireless has successfully deployed, operated and evaluated the RadioCamera™ System in multiple markets throughout the country. The RadioCamera™ performance has been evaluated and documented in numerous audited trials conducted for wireless carriers as well as public safety agencies such as the National Emergency Number Association ("NENA") and the Montana E911 Program Office. The most recent comprehensive system evaluation was conducted by NENA from March 6 through March 16, 2001, in Seattle, WA[9,10]. In this evaluation, over 16,000 location fixes were computed for a wide variety of test conditions, yielding an overall accuracy of 61 meters for 67% of the cases and 295 meters for 95% of the cases. The performance demonstrated in this trial was fully compliant with the requirements established by the FCC for E911 Phase II network-based location solutions.

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9 Ex Parte Supplemental Report of U.S. Wireless Corporation Regarding Network-Based Enhanced Services, CC Docket 94-102, filed April 10, 2001.

10 Comments of APCO and NENA, as Public Safety Organizations, in Response to Request for Waiver of AT&T Wireless Services, Inc., CC Docket 94-102, filed May 7, 2001, pp. 9-10.

2.1.1 U.S. Wireless Power Based Location Methods

In addition to employing our LPM technology, U.S. Wireless has recognized the value in incorporating additional complementary location capabilities in order to supplement and enhance overall system performance. In particular, U.S. Wireless has successfully developed and evaluated two such techniques to date: (1) Serving Cell Localization, and (2) Power Calibration[11]. Serving Cell Localization uses knowledge of the carrier's serving cell sector coverage in order to constrain the search region used in the Location Pattern Matching process. This technique also ensures that only those RadioCamera™ sites within the immediate vicinity are tasked to locate the caller. Through this technique, U.S. Wireless has been able to successfully reduce location processing time (thereby reducing the time-to-first-fix) and has minimized the incidence of co-channel interference. This in turn has improved the 95th percentile accuracy performance of the system substantially, by eliminating those outliers falling outside of the known or probable search region.

The second approach, referred to as Power Calibration, is a family of proprietary U.S. Wireless techniques that have been under development for the past two years and are based on concepts very similar to those of the proposed MNLS technology. The Power Calibration techniques utilize the same principles as LPM technology, but rely solely on the characterization of uplink power measurements. For these techniques, the system must also be calibrated using a drive test procedure to create a library of power signatures – each associated with a unique geographic location. The primary motivation for developing Power Calibration technology is to provide a more precise localization of the caller, with accuracy superior to that of simply knowing the serving cell sector coverage. This information can be used to further reduce the location pattern matching search area and restrict statistical outliers.

[11] The Serving Cell Localization technique has been fully integrated within the RadioCamera™ System while the Power Calibration techniques are still in development.

2.1.2 Power Calibration Performance Results

To provide a feel for the performance capabilities of the Power Calibration methods, trial performance results are shown for an audit conducted in Rosslyn, VA over the two-day period, October 19-20, 2000. The test region was approximately two square miles and included a variety of operating environments including light urban, residential, highway, and waterfront. The U.S. Wireless test system was comprised of six collection sites deployed throughout the test region. Prior to the evaluation, a series of drive tests was performed to create the power calibration database used during testing.

Test procedures involved placing a series of AMPS and IS-136 TDMA calls at a variety of locations throughout the test region, including both mobile and stationary calls, as well as indoor and outdoor calls. During each call, a set of simultaneous power measurements, referred to as a "power snapshot," was collected at all six RadioCamera™ sites. These measurements were repeated every three seconds throughout the duration of the call. Since each site employed a six-element antenna array, each power snapshot contained 36 unique power measurements.

Two candidate Power Calibration techniques were evaluated. The first was a straightforward technique that combined the six antenna power measurements at each site to create a single combined, or total power measurement per site. In this manner, the snapshot was reduced to only six absolute power measurements (one per site). The second technique retained all 36 measurements per snapshot, and created a power signature that was based on exploiting the relative power levels between all pair-wise combinations of antennas. Approximately 300 test calls were placed and 6000 location fixes were computed. All mobile testing was completed on the first day and stationary testing was performed on the second day. Complete results for these tests are shown in Tables 1 and 2.

Note that even though both Power Calibration techniques employed the same calibration database information and were given identical raw power measurements, the overall location performance differences were dramatic. The first technique, based only on total power measurements, performed relatively poorly and achieved accuracies of 1373 meters and 510 meters for 67% of the mobile and stationary calls respectively, when two or more sites were able to adequately receive the signal. In contrast, the second technique, which used a more sophisticated approach, was able to achieve accuracies of 440 meters and 323 meters for 67% of the mobile and stationary cases respectively, for the same set of test calls and conditions. Note that neither of these techniques incorporated any special post-processing or location tracking capabilities. It is reasonable to assume that with additional processing, the location accuracy could be even further improved.

Table 1: Power Calibration performance – mobile testing.

Technique 1: Total Site Power Matching			
# of Sites Reporting	**Fixes**	**67%**	**95%**
2 or more	3110	1373	4772
2	200	1787	4040
3	452	1649	4020
4	909	1188	4262
5	979	1187	6443
6	570	1172	5363
Technique 2: Relative Power Matching			
# of Sites Reporting	**Fixes**	**67%**	**95%**
2 or more	3110	440	4194
2	200	847	3727
3	452	546	2590
4	909	382	2816
5	979	334	4644
6	570	465	5883

Table 2: Power Calibration performance – stationary testing.

Technique 1: Total Site Power Matching			
# of Sites Reporting	Fixes	67%	95%
2 or more	2689	510	3666
2	146	1874	3839
3	258	1364	3953
4	469	1749	4523
5	1378	314	2610
6	438	286	2834
Technique 2: Relative Power Matching			
# of Sites Reporting	**Fixes**	**67%**	**95%**
2 or more	2689	323	2723
2	146	1988	6328
3	258	749	3697
4	469	487	4232
5	1378	265	569
6	438	259	981

2.1.3 MNLS Technology

AT&T Wireless has recently proposed an alternative power-based location technique in its FCC waiver request dated April 4, 2001. The proposed solution, Mobile-Assisted Network Location System (MNLS), is based upon the use of Mobile-Assisted Hand-Off (MAHO) received signal strength measurements to determine the caller's location. In its waiver request, AT&T Wireless has proposed an MNLS performance goal of 250 meters for 67% of the cases and 750 meters for 95% of the cases.

The underlying principles of MNLS are closely related to those of the U.S. Wireless location pattern matching technology, and in particular, to the Power Calibration methods. Both techniques seek to "train" their systems by first creating a database of location-dependent "signatures" - each representing a set of signal measurements anticipated at a particular location within the service area. In the event of a 911 call, the appropriate signal measurements are obtained and a signature is created. This signature is then compared to the set of signatures in the database, and the caller's position is determined based on the closest match.

While the proposed MNLS approach differs from Power Calibration in certain aspects,[12] the performance that has been achieved with the Power Calibration techniques clearly demonstrates the viability of exploiting power measurements to locate a subscriber. For both approaches the power measurements will be subjected to similar propagation channel effects and corruption (*e.g.,* multipath fading, path-loss, shadowing, antenna polarization, and interference). As such, both techniques must be properly designed and implemented in order to mitigate these effects and produce accurate and repeatable results. Given the similarities between the U.S. Wireless LPM technology and MNLS technology, U.S. Wireless has been independently investigating the use of MAHO-based power calibration as part of our broader location platform offering. Based on our extensive experience with location pattern matching and power calibration technology, as well as our understanding of the MAHO system, U.S. Wireless believes that MNLS can indeed provide a useful location capability.

2.2 LPM-Based Location System Design

Prior to addressing the specific issues raised in the SigmaOne Report, it is helpful to first review some fundamentals associated with the design and implementation of a location system based on location pattern matching principles. These fundamentals are briefly discussed in the following sections.

2.2.1 Data Pre-Processing

In the design of any location system, it is necessary to ensure that the basic input data measurements provided to the system are accurate and of the highest quality. Therefore, all systems must include some form of data pre-processing to ensure that "noisy" or corrupted input data is either corrected, or removed. Note that this corruption may occur due to a number of causes, including distortion due to the propagation channel (the path between the mobile handset and the location system receiver), interfering signals, or even defects within the data collection system itself. There are many standard signal processing techniques that can be applied to filter or correct corrupted input measurements; the specific techniques chosen are typically dependent upon the nature of the location system and the type of corruption to be mitigated. In the U.S. Wireless RadioCamera™ System, the data pre-processing subsystem utilizes proprietary techniques to detect and eliminate samples that have been corrupted by interference or are determined to be too weak to be of use in the location pattern matching process. Techniques for Time Difference of Arrival ("TDOA") and Angle of Arrival ("AOA") location methods would employ similar techniques, as well as additional methods to perhaps mitigate the effects of multipath distortion.

2.2.2 System Modeling

A critical step in the design of a wireless location system is the development of an accurate mathematical model to characterize the expected behavior of the end-to-end system. That is, a model must be defined that describes the statistical behavior of signals as they emanate from a handset, pass through the propagation channel, the measurement (or sensor) system, and any signal processing operations or transformations performed as part of the core location technology. These models are then used in both the design and implementation stages of development.

For location systems, one of the most significant components of the system model is the accurate characterization of the propagation environment effects – including models for

[12] The most significant difference between the Power Calibration and MNLS technologies is that Power Calibration makes measurements on a single uplink channel using multiple RadioCamera™ receivers, while MNLS makes measurements on multiple downlink channels using a single handset receiver.

multipath fading, shadowing, and diffraction. There are two basic approaches toward establishing models for the propagation channel – one is to use theoretical models (*e.g.*, the Hata-Okumura model as described in the SigmaOne Report[13]) while another is to construct empirical models based on "probing" the environment through drive test methods or channel-sounding techniques. Combinations of these approaches are also used extensively, to effectively "tune" theoretical propagation models based on a limited set of empirical data. This latter technique has been used widely in the wireless industry to optimize performance of communication networks.

In the case of the U.S Wireless RadioCamera™ and Power Calibration systems, experience has shown that while theoretical models have been useful during the design and early development phases, comprehensive empirical modeling is required in order to achieve the desired performance goals.

2.2.3 Optimization

Once the statistical system model has been established, an appropriate optimization criterion must be selected and implemented. This optimization criterion typically seeks to minimize or maximize certain internal system metrics in order to achieve the desired goal. For example, within the RadioCamera™ system, a fairly sophisticated optimization approach is used to transform the measured signal data (after data pre-processing) into an RF signature which is then compared with a stored database in order to find the "closest" signature, and hence, the location of the transmitter. The optimization criterion is to select the database signature that exhibits the minimum statistical distance from the measured signature. A detailed description of this optimization process can be found in the published set of U.S. Wireless patents. There are a large number of candidate optimization criteria that can be employed in location systems; the appropriateness of any specific criterion is highly dependent upon the nature of the location technology, its implementation, and performance objectives.

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[13] SigmaOne Report, pp. 34-35.

2.2.4 Data Post-Processing

A final key component of the location system is the data post-processing stage. Post-processing techniques are used to further improve system accuracy and reliability once an initial location estimate or set of estimates has been made. Post-processing techniques can range from very simple to very complex algorithms. A simple example is one in which a location estimate is made, but found to be unreasonable (*e.g.,* the location estimate is determined to be outside of the range of the known serving cell site) in which case the estimate is either reprocessed or simply discarded. More complex techniques may involve advanced signal processing techniques such as Kalman filtering, that can be used to continuously track a moving transmitter based on a series of consecutive location estimates and knowledge of the motion dynamics (*e.g.,* maximum velocity, acceleration, etc.). Both of these types of approaches have been successfully applied in the U.S. Wireless RadioCamera™ system, as well as those of other location technology vendors.

3 COMMENTS ON THE SIGMAONE REPORT CLAIMS

Given this background and technical foundation, a number of the more relevant and specific issues raised in the SigmaOne Report can now be discussed.

3.1 SigmaOne Report Claim: *"MNLS accuracy claims have limited theoretical basis."*[14]

The MNLS performance results described in the SigmaOne Report represent those achieved with a specific MNLS implementation. It is incorrect to assume that the reported performance can be extrapolated to other MNLS approaches or that the results represent a fundamental theoretical performance bound. It is likely that alternative implementations would significantly improve accuracy performance over that described in the SigmaOne Report.

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[14] SigmaOne Briefing, p. 11.

While the implementation described in the SigmaOne Report is a valid MNLS approach, it incorporates a relatively simplistic system model and employs a very basic optimization strategy that, by design, inherently limits its performance. Note that there is not sufficient detail provided in the SigmaOne Report to fully understand the methodology used, but based on the theoretical analysis provided, the approach appeared to be relatively straightforward. In particular, we can now examine the proposed MNLS implementation described in the SigmaOne Report in terms of the four basic system components previously discussed:

1. *Data Pre-Processing*: In the SigmaOne Report there is no evidence or discussion of the use of any substantial data pre-processing techniques. As such, the basic input measurements may have been unnecessarily corrupted or of lower quality than desired. Several straightforward techniques could have been applied to ensure the integrity of the input measurements. For example, averaging of multiple consecutive MAHO measurements over several seconds would have helped mitigate the variability induced by the various propagation channel effects and measurement errors[15]. An initial coarse ranging technique could also have been applied to remove those large outliers that were clearly not within the coverage of the primary server.

2. *System Modeling*: The propagation theory presented in the SigmaOne Report provides a very thorough and accurate description of multipath effects, path-loss, and other propagation channel phenomena. However, the propagation model that was used in the specific MNLS implementation appears to have been restricted to a simple theoretical model only. It is unclear if this model was additionally tuned through the use of drive test data or was further "corrected" through the incorporation of terrain or high-resolution clutter data (a database that describes the specific buildings and structures in a region), however, it appears that this was

[15] This fact is acknowledged in the SigmaOne Report, Appendix A, p. 5: "Statistically speaking, over many averages and many positions, the mean signal strength has some degree of repeatability."

not the case. The use of a propagation model derived from extensive drive testing would have substantially improved performance.

3. *Optimization*: The MNLS technique described in the SigmaOne report was based upon a weighted least-squares optimization criterion. This criterion seeks to minimize the weighted sum of the range errors associated with the signals received from each cell site. This optimization approach has a fundamental drawback, in that it is extremely sensitive to errors in the range measurements. This is further exacerbated by the fact that the propagation model employed – a simplified theoretical model – is itself prone to creating such range errors. Together, this combined model and optimization would have fairly severe limits on achievable location performance. A more robust optimization approach might seek to jointly exploit the relative power relationships between subsets of measurements from two or more cell sites. It is this type of approach that has been successfully employed in the U.S. Wireless RadioCamera™ System, and would be equally applicable in an MNLS implementation.

4. *Post-Processing*: The MNLS technique described in the SigmaOne Report does not appear to make use of any post-processing techniques to enhance accuracy or eliminate outliers. As previously described, a number of straightforward techniques could be applied, such as simply eliminating those location estimates known to lie far outside the serving site coverage region. More advanced tracking techniques would also substantially enhance the reported performance.

Given the limitations of the specific MNLS approach described in the SigmaOne Report, it is clear that its performance (both empirical and theoretical) is not representative of the broader class of MNLS techniques, nor does it represent a theoretical performance bound.

3.2 SigmaOne Report Claim: *"[MNLS] technology is not mature – and will require 2-3 years of development effort."*[16]

U.S. Wireless has been perfecting location pattern matching technology for over 5 years. The theory and implementation are very mature – as reflected in the numerous field trials and demonstrations previously described. This technology can be readily applied to MNLS, with minimum modification. U.S. Wireless believes that the MNLS PDE can be developed and deployed on a large scale within a time frame of 6 to 9 months. Note that this implementation assumes that the MSC and MPC vendors are compliant with the proposed J-STD-036 modifications as required to support MNLS.

3.3 SigmaOne Report Claim: *"Path loss errors can be caused by antenna polarization, seasonal effects, fading caused by scattering rays from both near and far reflective objects, elevation above terrain, and interference from other signals in same or near-by cells."*[17]

U.S. Wireless does not dispute this claim - the SigmaOne Report has very accurately represented the various well-known propagation channel effects that can impact wireless communication systems. However, it is important to clarify the perhaps false impression that the mere presence of these effects in some way *precludes* the ability for a location system to accurately locate a wireless subscriber. In the case of the U.S. Wireless RadioCamera™ system, the impact can be exactly the opposite. In particular, the presence of fading, shadowing, and scattering phenomena creates a richness and variety to the environment that enables a system, particularly one based on trained pattern matching principles, to effectively discriminate between RF signatures in order to associate each with a unique location. An MNLS technique that has been properly designed and trained through drive test calibration can similarly benefit by exploiting this phenomenon.

[16] SigmaOne Briefing, p. 12.
[17] SigmaOne Briefing, p. 14.

3.4 **SigmaOne Claim: "*... location mapping is extremely impractical due to the requirement of periodic re-calibration over potentially huge geographic areas. A comprehensive database should include all areas from which 911 calls can be made, including sidewalks, parks, alleys, parking lots, garages, access roads, inside buildings, etc. Additionally such activity requires three dimensional and seasonal mappings. Elevation changes and foliage conditions can present large variations in signal path loss. Also, this approach is highly ineffective for slow-moving or stationary mobiles due to fading.*"**[18]

U.S. Wireless has extensive practical experience and understanding of calibration requirements and logistics. The primary objective of the calibration process is to accurately measure and model the propagation effects within a specific operating environment. This process is essentially independent of the location technology to be used, but is highly dependent upon the structures, clutter, and topography in the environment, and the rate at which these might significantly change. In this respect, the calibration process for the U.S. Wireless RadioCamera™ system and an MNLS system would be very similar. Based on our experience with RadioCamera™ system calibration, we make the following key observations:

1. *Geographic Coverage*: The calibration process will not require that data be collected at all points within the coverage area. A variety of interpolation and modeling techniques can be applied to "fill in" or predict missing calibration data. These techniques have been used successfully in the U.S. Wireless RadioCamera™ system for several years. Therefore, it will not be necessary to perform drive test calibration in every parking lot, alley, or sidewalk.

2. *Level of Effort*: For MNLS, it is expected that driving 10% of the roadways in a given market would be sufficient to tune the basic MNLS propagation model (similar to standard wireless network model tuning). For greater accuracy,

[18] SigmaOne Report, Exhibit A, Detailed Comments by SigmaOne in Response to AT&T's Waiver Request, p. 6.

additional drive test calibration should be performed to supplement the model data. The specific amount of additional drive test data required would be dependent upon the performance goals and the nature of the propagation environment for the target market. To provide perspective on the potential scope of the calibration effort, a summary of drive test mileage is provided in Table 3, for the top 400 urbanized markets[19].

Table 3: MNLS calibration mileage required in the Top 400 urbanized markets[20].

Calibration Objective	Interstates	Freeways / Expressways	Principal Arterials	Minor Arterials	Collector	Local	Totals
10% Model Tuning	1,170	795	4,098	7,018	6,715	48,078	67,874
100% Major Roadways	11,700	7,950	40,982	0	0	0	60,632
25% Secondary Roadways	0	0	0	17,545	16,788	120,196	154,529
50% Secondary Roadways	0	0	0	35,090	33,577	240,392	309,059

3. *Re-Calibration Interval*: Based on U.S. Wireless experience, "re-calibration" of the MNLS system can be implemented as an on-going process in which the system will continually "learn" as the propagation model is continuously adjusted. To accommodate straightforward carrier network changes (such as modifications to cell site transmit power, neighbor lists, or the network frequency plan) the signature database can be updated with no additional drive testing, by simply updating the propagation model with the new network parameters and recomputing the calibration table. To accommodate more substantial network and environmental changes, it is our experience that drive testing is required approximately twice per year in the affected regions, in order to maintain performance levels.

[19] *Urbanized Areas – 1999 Miles and Daily Vehicle–Miles of Travel*, U.S. Department of Transportation Federal Highway Administration, October 2000.

[20] An urbanized market is an area with 50,000 or more persons that at a minimum encompasses the land area delineated as the urbanized area by Bureau of the Census.

4. *Mobility*: A single calibration table can be created that effectively characterizes measurements for both stationary and mobile subscribers. For the U.S. Wireless RadioCamera™ system this has been accomplished by creating a general calibration table based on mobile measurements, that inherently includes stationary calibration signatures as a subset, or special case. The MNLS calibration can be similarly constructed to yield comparable performance.

Given these observations, and based upon U.S. Wireless' experience in calibrating and maintaining operations for several years in multiple markets (*e.g.,* Oakland, CA; Seattle, WA; Baltimore, MD; Billings, MT; and Washington, DC), the calibration of an MNLS system can be executed in a practical manner, and should not present a significant financial or operational obstacle.

4 MEETING THE FCC MANDATE

U.S. Wireless believes that it is the intent of the FCC mandate to promote the development and implementation of a timely, accurate, and ubiquitous wireless location capability to support the needs of the nation's wireless E911 callers. Since the mandate's inception, location technology vendors, wireless carriers, and public safety organizations have expended significant effort and resources to develop and evaluate a variety of proposed location technology solutions. U.S. Wireless believes that while many of these technologies, including our own RadioCamera™ System, have demonstrated accuracy performance that is in compliance with FCC requirements, the relative cost-effectiveness and timeliness of deploying and operating any particular technology within a given market is highly dependent upon the nature of that market and the technology itself. As such, it is unlikely that any single location technology will simultaneously meet the competing needs for a ubiquitous, accurate, timely, and cost-effective solution for all markets and wireless operating environments.

Therefore, it is reasonable to expect that it is a combination of these technologies that will ultimately provide the complete solution; thereby meeting the immediate needs of public safety while addressing the practical and engineering constraints of deploying a nationwide location technology. U.S. Wireless believes that MNLS technology can play a critical role in such a solution. In particular, the MNLS technology can provide two key capabilities:

- *Rapid Deployment*: MNLS can be deployed in an extremely rapid and efficient manner. Because MNLS is based on capabilities already available in TDMA handsets, no additional network infrastructure is required beyond that deployed for E911 Phase I service.

- *Ubiquitous Coverage*: Due to its rapid deployment capability, MNLS will be capable of quickly providing comprehensive geographic coverage.

In this manner, MNLS can provide a rapid initial location capability for a broad geographic area – establishing a nationwide safety net for wireless E911 service. Building upon this initial capability, the overall system can then be improved over time in order to achieve the performance objectives of the Phase II mandate. U.S. Wireless believes that these improvements can be achieved by two methods:

1. *Advanced MNLS Development*: In order to achieve its performance goals, the initial performance and functionality of the MNLS system can be systematically improved through the development and implementation of advanced processing and calibration techniques. For example, the MAHO drive test measurements can be optimally combined with the RF-propagation model data to create a hybrid calibration table that is superior to the use of either technique alone. In addition, one of the more promising means for improving MNLS performance is to incorporate the use of additional channel quality measurements readily available from the wireless network. Such data includes bit error rates, uplink signal strength, and frame error rate measurements. By exploiting this available data the

MNLS system could be made significantly more robust (particularly with respect to interference) and accurate. Note that to support this capability, an addendum to the J-STD-036 standard must be approved.

2. *Hybrid Location Technology*: In order to achieve accuracy beyond the proposed MNLS goals of 250 meter – 67% and 750 meter – 95%, the MNLS system should be supplemented by a higher-resolution location solution such as the RadioCamera™ System or any other FCC compliant solution. Such systems could initially be deployed in the dense population centers and high-traffic areas to provide enhanced accuracy where it is most needed, and would serve the broadest number of subscribers. The exact deployment strategy and mixture of complementary technologies would be dependent upon the specific markets, overall performance objectives, and methodology for assessing performance compliance.

5 CONCLUSION

In conclusion, U.S. Wireless believes that with proper design and implementation, MNLS can serve as an integral part of a timely and effective location solution. With continued development and the combined use of complementary location technologies, such as the RadioCamera™ System, the performance of the location platform can be improved over time in order to achieve the Commission's performance objectives as stated in the E911 Phase II mandate.

Furthermore, U.S. Wireless remains committed to working with the carrier community, public safety, the FCC, and the location technology vendor community to ensure that such a solution can quickly become a reality.

Respectfully Submitted,

U.S. Wireless Corporation

By: ________________________

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July 11, 2001

EXHIBIT 5

EUS/RK/BB-01:073
June 27, 2001

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Executive Director- Intelligent Networks Products and Services
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Cc:
Kris Rinne
Bill Clift
Steve Hardin

Re: Ericsson Support for MNLS Technology for E911 Phase 2 compliance

Dear Mr. Adams,

This letter responds to your request that Ericsson provide Cingular with general information regarding MNLS (Mobile Assisted Location System) positioning technology that we are developing as an alternative to support the E911 Phase 2 function.

The Ericsson MPS-T1.2 will have a general availability of Q-4-2001

The MNLS technique makes use of an existing mechanism of TDMA IS-136 and IS-54B handsets, in which the mobile handset makes measurements to assist the wireless system in determining the best cell site to handoff the mobile. In this technique, often referred to as MAHO (mobile-assisted handoff) the mobile is commanded by the wireless system to make signal strength measurements of up to 24 neighboring base stations. The mobile makes these measurements on the continually transmitting strong control channel broadcast from each base station sector to the mobile. In TDMA, the MAHO list is controlled by the operator, and makes measurement on every MAHO candidate channel regardless of signal strength. This provides a list of the broadcast power from multiple cell sectors to a mobile in its current position. Since the MAHO measurements can be made down to the minimum sensitivity level of the phone (-113 dBm), the mobile is able to "hear" sites within a large radius.

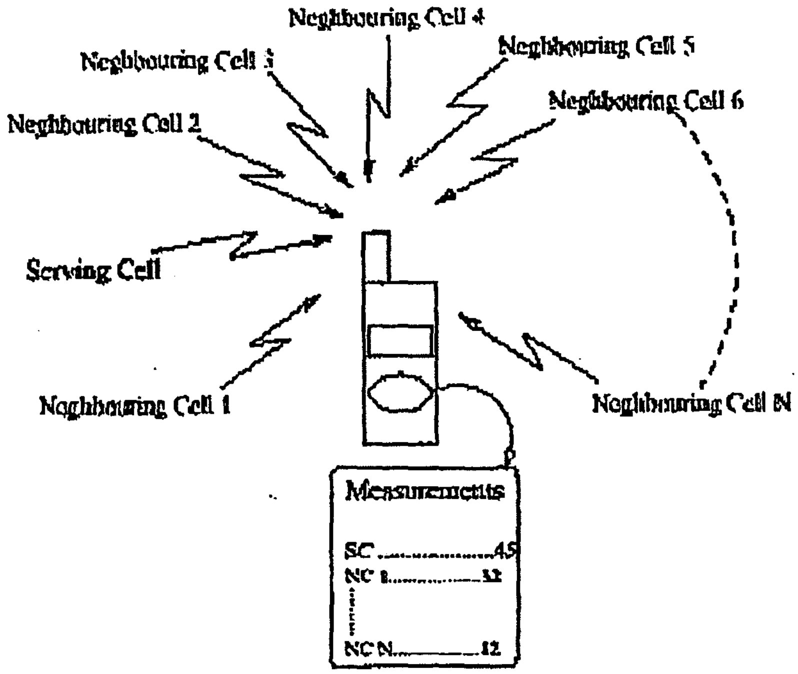

Figure 1: Mobile measures neighboring base stations signal strength

After making these signal strength measurements, the mobile will transmit these reports back to the wireless system. These reports will be sent while the 911 voice call is being setup to the PSAP. (Note: The 911 call is not held or delayed prior to call setup.) Unlike some other network solutions, an advantage of the MNLS system, is that MAHO reports are transmitted from the phone every 1 second during a TDMA call, consequently, this technology could provide the ability to track the 911 call, rather than just an initial location at call setup.

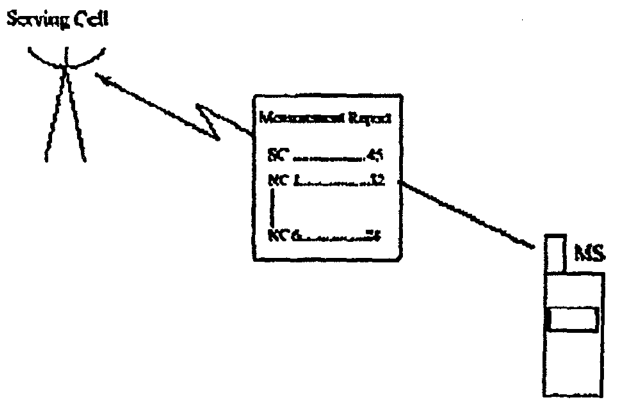

Figure 2: Mobile reports the measurements it made back to the wireless system

The MAHO lists and cell site information are delivered to a processor that can determine mobile location with either, or a combination, of two techniques: the first one called "triangulation", and the second one known as "contour matching".

In the first technique, termed "triangulation", the signal strength from multiple MAHO channels is associated to their cell site location. This then produces a geometric triangulation mathematical problem that can be solved to determine the mobile's location.

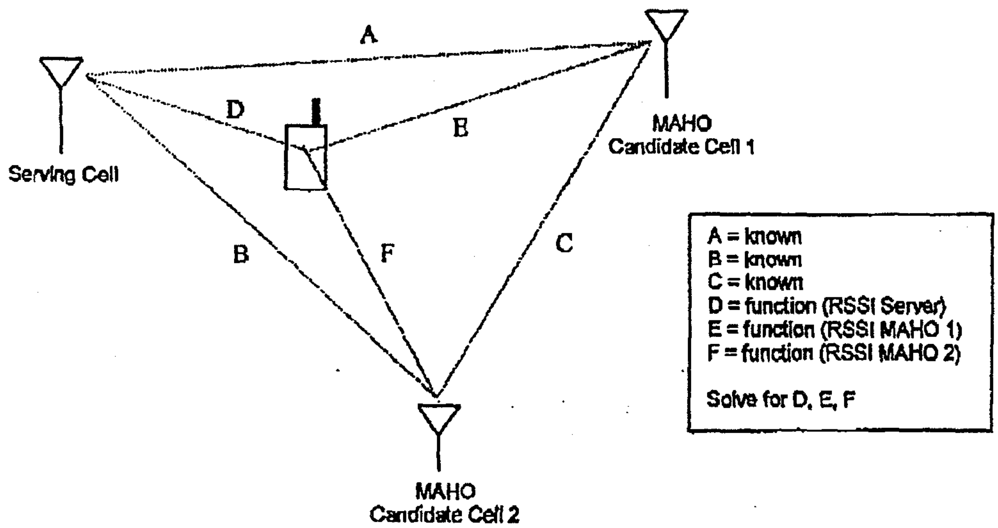

Figure 3: Example of "triangulation" to determine location, 3 sites example.

In the second technique, termed "contour matching", the wireless system receives these measurements and compares these relative signal strength measurements to a specially developed database of stored relative signal strength measurements within the cell serving the call. The wireless system will then determine the location of the mobile by matching it to one of these predetermined grid locations in the database.

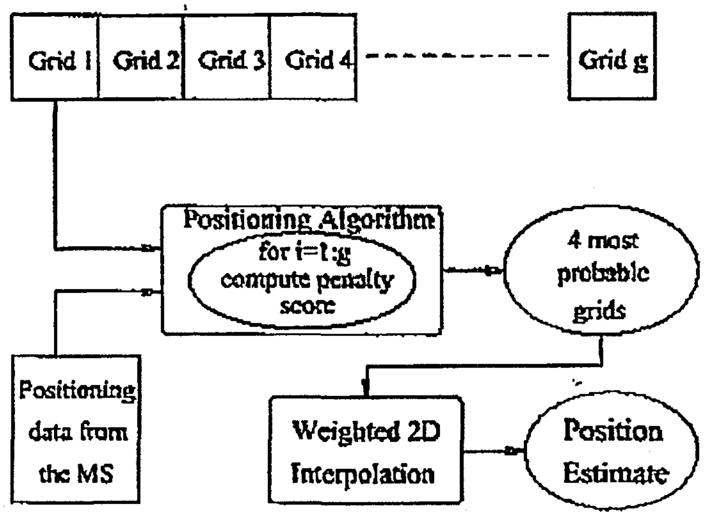

Figure 4: Wireless system determines location by matching DB grids to mobile report

The database for the grid measurements can be created in several different methods. The best method is to use available RF engineering tools to predict the expected received signal strength (RSS) measurements within grids as small as 50 meters. These engineering tools take into account antenna height and type, down-tilt, beam width, effective radiated power, and ground clutter. These predictive measurements can then also be augmented with real world measurements to increase accuracy in difficult areas.

It is possible to use both the triangulation and contour match techniques in combination. In combination, it would allow for the most flexibility.

Status of Standards Efforts:

MNLS is a fully standards-compliant solution that is currently being adopted by TR45.2 AHES (Ad-Hoc on Emergency Services), the industry-PSAP body overseeing wireless E911 standards.

Advantages:

The MNLS has many advantages over other alternate solutions investigated. These advantages include:

1. Legacy handsets – The systems works with all TDMA handsets in the ANSI-41 network. No changes, upgrades or replacements are necessary to these handsets.
2. Roaming support – MNLS will support all TDMA handsets roaming into our network.
3. Non-valid/uninitialized handsets – MNLS will support TDMA phones that do not have a valid account or phone number.
4. High Reliability – MNLS is using the same functionality normally required by the network. Therefore, if problems arise, they will be detected immediately. The integral nature of the MNLS solution to the overall network dramatically increases the reliability of the system.
5. Standards compliant – MNLS is a fully standards compliant (see above).
6. Updated Location – One of the advantages of the MNLS system is the fact that locates can be completed repeatedly on the same 911 call, in order to allow PSAPs additional information, such as direction of travel, etc.
7. Improvement – The accuracy of the system can most likely be improved with ongoing enhancements to the algorithms, and to the location grid database.
8. One of the advantages of the MNLS system is the fact that locates can be completed repeatedly on the same 911 call, in order to allow PSAPs additional information, such as direction of travel, etc.

Accuracy:

The following are the approximate accuracies expected:

All Environments	67%	95%
All Calls	Approx. 250 meters	Approx. 750 meters

Please let me know if we can address any further questions.

Sincerely,

Mikael Stromquist
Vice President and Chief Technical Officer
Ericsson

EXHIBIT 6

AT&T Wireless Services, Inc.

Redmond Mobile Drive Trial of MNLS

Phase 2: E911 Location Technology Trial

Document Number	**10934**
Revision	**1.0**
Revision Date	**06/09/01**

Technology Development Group
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1. Purpose

The FCC specifies an October 2001 deadline for providing location-based capability for wireless services. That time limit—for Phase II of the FCC's enhanced 911 (E911) order of 1996—requires that each wireless telecommunications company doing business in the United States must offer either handset- or network-based location detection capability. The FCC requires that network-based systems must be accurate within 100 meters for 67 percent of calls and within 300 meters for 95 percent of calls.

This document provides a technical summary of the drive-test efforts and analysis performed for the E911 Mobile Network Location System (MNLS) trial in Redmond, Washington performed in 2001.

2. Overview

2.1. Introduction

Positioning technologies for cellular systems may be differentiated based on the types of measurements made. The most common measurements involve analysis of the radio signal transmitted or received by the mobile terminal to be positioned. These analyses are:

- Time of arrival (TOA)
- Time difference of arrival (TDOA)
- Angle of arrival (AOA)
- Received signal strength (RSS)

An RSS-based positioning technique referred to as Mobile Network Location System (MNLS) has been proposed for positioning in TDMA networks. In this technique, RSS measurements are made by the mobile terminal on downlink channels from the serving and neighboring base stations. These RSS measurements are then used by the Position Determining Equipment (PDE) in the cellular network to compute the position of the mobile terminal, given knowledge of the transmitted powers from the base stations, the locations of the base stations, and the sector layout in the coverage area.

In TDMA systems, the mobile terminal can be ordered to make RSS measurements when it is camping on the control channel and when it is on a traffic channel. In the former case, RSS measurements are used for mobile-assisted channel allocation (MACA); in the latter case, RSS measurements are used for mobile-assisted handoff (MAHO). The advantage of MNLS is that TDMA digital cellular standards already call for the mobile terminal to make RSS measurements for network management reasons; therefore the MNLS method has minimal impact on TDMA digital cellular standards.

This document describes the performance of the MNLS method in a TDMA network. Measurements were made near AT&T Wireless headquarters in the Seattle/Redmond area.

First, a set of measurements was used to construct a database of the RSS on downlink channels at different positions within the coverage area. A second set of measurements was then used to test positioning performance of MNLS in the test area.

The Section 2.2 describes the measurement and prediction data in greater detail. Section 3 discusses the MNLS performance. Conclusions are presented in Section 4.

2.2. Field Measurements

Field measurements were conducted by AT&T Wireless in the Seattle/Redmond area using a mobile terminal, a computer with software for aggregating measurement data from the phone, and a GPS receiver.

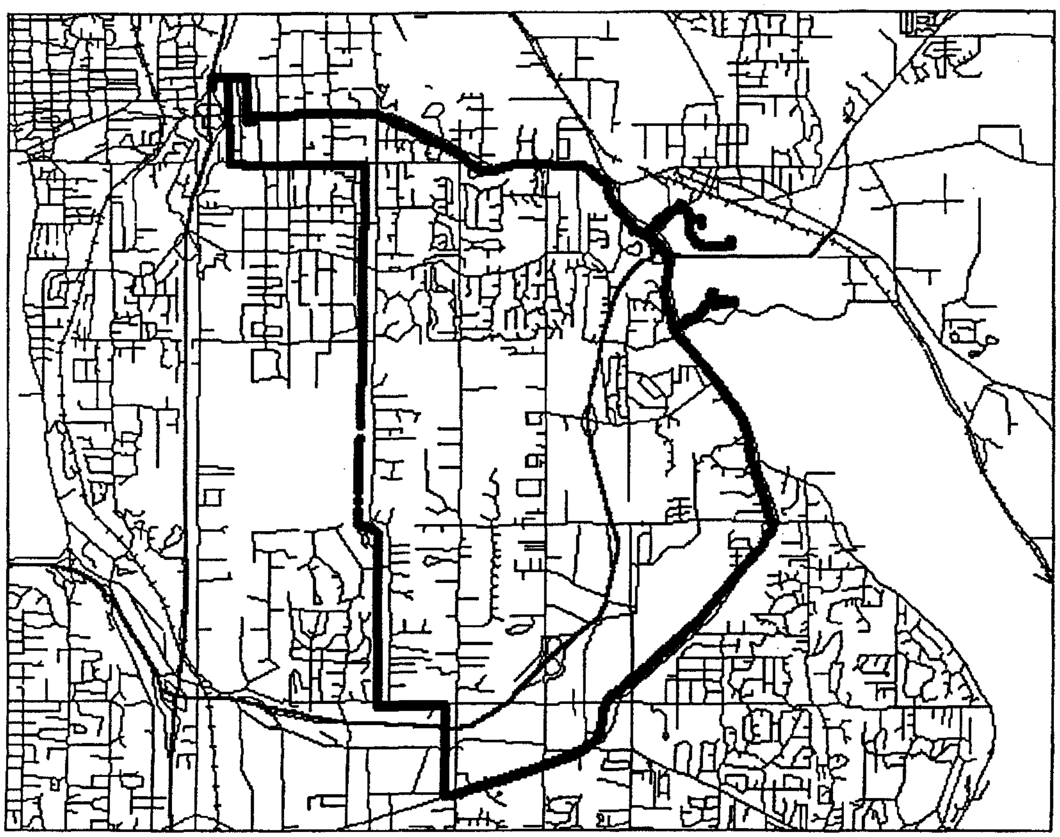
Initially, a database was constructed recording RSS measurements from neighbor channels along with the corresponding position of the mobile as recorded by the GPS receiver while driving through the coverage area. Later, measurements were made at test points in a smaller part of the area covered by the drive test.

The RSS/GPS database measurements were collated with sector, frequency plan, and antenna information for serving and neighboring base stations within the coverage area.

The coverage area was section into a approximately 50-meter grid. RSS data was predicted for channels in the coverage area then compared with actual RSS measurements from the mobile to estimate mobile location within the grid.

Figure 1 shows locations where measurements were recorded in Redmond area.

Figure 1 Route where mobile measurements were recorded in the lesser Redmond area.



3. MNLS Performance

Using the RSS/GPS database, a set of predictive measurement was obtained to estimate the performance of the MNLS method. A position estimate was obtained for each measurement entry by comparing the measurements to the entries in the RSS/GPS database. The position estimate was computed by comparing the measured RSS profile to the stored RSS profiles in the database corresponding to positions in the coverage area, then generating metrics for each location. The locations of the serving and neighboring base station were also used in computing the position estimate.

MNLS performance was obtained using RSS measurements made when the mobile was camping on a control channel. The measurements were averaged over a time period of approximately five seconds.

Figure 22 shows the performance of the MNLS method for locations calculated from 261 RSS measurements using roads common to the drives of both Figure 1. This graph of actual result is an example of 50-meter grid location predictions expected from a database correlated with actual drive test data.

Figure 2 MNLS Results using common roads

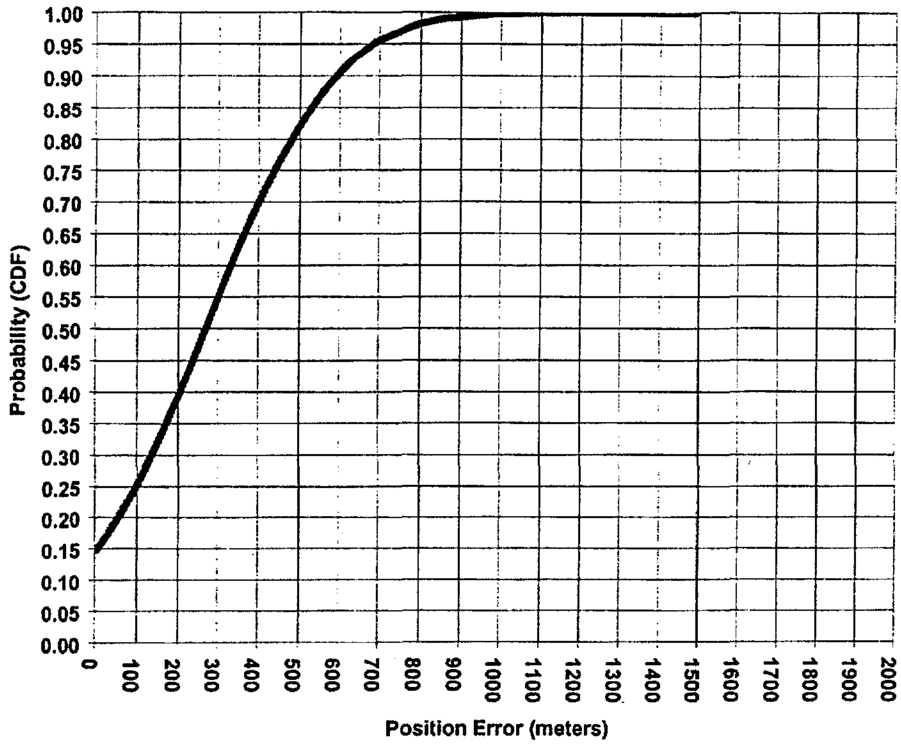


Table 1 summarizes MNLS position errors measured in this trial (expressed as percentages).

Table 1 MNLS Measured Position Errors

	Probability	
	67%	**95%**
MNLS Position Error (meters)	290 m	606 m

3.1. Performance Improvements

3.1.1. Grid Size

MNLS performance was also evaluated with the distance between locations in the database (grid size) increased to 100 meters, resulting in a minor degradation in performance. The degradation was in part due to a slight worsening of the RSS standard deviation metric, but was minor since the performance was dominated by the quality of the database.

In general, smaller grid sizes are expected to provide better performance and the choice of grid size should be based on the expected performance with a certain database. In order to ensure the best possible performance with a given database, a grid size in the range of 50 meters is recommended.

3.1.2. Database Quality

In order to improve the performance of MNLS in the future, the main factor to be targeted is the quality of the database. Database quality may be improved in the following ways:

- More accurate RF propagation models will improve the quality of the prediction data.
- Measurement data over the whole coverage area is expected to have better quality than prediction data and, if available, could be used to build the database.
- Periodic testing of a database built from prediction data could be used to determine which regions and/or channels have the poorest quality, and the corresponding data can be replaced or augmented with measurement data. That is, a hybrid database that includes both prediction data and measured data can be used.
- A smaller grid size can be used for regions in the densely-populated coverage areas.
- Extra information, such as map data for the coverage area, may be used to reduce the number of possible location estimates and thus improve performance.

Note: The databases used to generate results in this were generated for the purpose of a field trial only. The database generated from measurements could have been enhanced with measurements gathered with more density while the database generated with prediction data could have had data for more neighboring control channels. Having a more complete database in both respects should result in better performance in a practical implementation.

4. Conclusions

The performance of the MNLS method (as described in Section 3, "MNLS Performance") was evaluated based on measurement and prediction data provided by AT&T Wireless. The results using prediction data could be improved with enhancements in the quality of the database. It may also be desirable in practice to use a prediction database that is augmented with measured data for channels and for areas where the predicted data is known to be weak. An averaging time of approximately five seconds was used for processing measurements. This averaging time was chosen considering the tradeoff between the delay incurred in calculating position and the quality of the measurement sample used. A grid size of 50 meters was found to provide the best results with the given data.