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June 12, 2001

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

By Hand

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

Re: REDACTED--FOR PUBLIC INSPECTION

Supplemental Response of AT&T Wireless Services, Inc. to Order of the Wireless Telecommunications Bureau

Dear Ms. Salas:

Transmitted herewith on behalf of AT&T Wireless Services, Inc ("AT&T") is an original and four copies of the above-referenced supplemental response to the May 10, 2001 order of the Wireless Telecommunications Bureau ("Supplemental Response"). Pursuant to Section 0.459 of the Commission's rules, 47 C.F.R. § 0.459, AT&T seeks confidential treatment of the following exhibits attached to the Supplemental Response: Exhibit A, "MNLS for E911 Phase 2 on TDMA," AT&T TDG Design Document (June 5, 2001), and Exhibit B, "ECGI Simulations and Performance Analysis," Ericsson Report (April 20, 2001).

Exhibit A contains detailed technical information regarding how the MNLS location technology would be integrated into, and its impact upon, AT&T's wireless network. This information is privileged, confidential, and commercially sensitive. Its disclosure is likely to cause substantial harm to AT&T's competitive position because it would provide details about the capacity and configuration of AT&T's network that could be used by other commercial entities to compete directly with AT&T. AT&T is voluntarily submitting this document to the Commission, but would otherwise not make such detailed information about its network available to the public. Because the information submitted consists entirely of materials protected from public disclosure under Section 0.457(d), AT&T respectfully requests confidential treatment as set forth herein. 47 C.F.R. § 0.459(b).

Exhibit B was provided to AT&T by Ericsson for filing with the Commission on the condition that AT&T request confidential treatment of the document. AT&T also respectfully requests confidential treatment of this document under 47 C.F.R. § 0.459(b).

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The confidential version of the Supplemental Response is being filed in a sealed envelope. Accordingly, this document should not be placed in the public record of this proceeding. In the event that this request is denied, AT&T requests notification and immediate return of the enclosed information, as provided for in the Commission's rules. 47 C.F.R. § 0.459(e).

A copy of the public version of AT&T's Supplemental Response without the confidential exhibits is being filed simultaneously herewith for inclusion in the public record; the confidential exhibits have been redacted in whole from the public filing. All confidential exhibits bear a legend identifying them as confidential.

If you have any questions concerning this filing, please do not hesitate to contact the undersigned.

Respectfully submitted,

Douglas I. Brandon BTB

Douglas I. Brandon

Enclosures

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

In the Matter of	)	
	)	
Revision of the Commission's	)	
Rules To Ensure Compatibility	)	CC Docket No. 94-102
with Enhanced 911 Emergency	)	
Calling Systems	)	
	)	

SUPPLEMENTAL RESPONSE OF AT&T WIRELESS SERVICES, INC. TO ORDER OF THE WIRELESS TELECOMMUNICATIONS BUREAU

AT&T Wireless Services, Inc. ("AT&T") hereby responds to the Bureau's request for additional information supporting its selection of the Mobile-Assisted Network Location System ("MNLS") location solution for its TDMA network.[1/] On May 30, 2001, AT&T provided a partial response to the Wireless Telecommunications Bureau's May 10 Order and indicated that it would submit additional information at a later date.[2/] Attached is that additional information, including the results of the Redmond and Bellevue MNLS field trials, a confidential AT&T Design Document for MNLS, a confidential Ericsson report on Enhanced Cell Global Identity ("ECGI") technology (Ericsson's term for MNLS), and other information responsive to question one of the Bureau's May 10 Order.

1. Information Supporting AT&T's Selection of MNLS for its TDMA Network

In the May 10 Order, the Bureau directed AT&T to provide additional information regarding its selection of the MNLS technology for its TDMA network, including the results of

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1/ 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) ("May 10 Order").

MNLS field trials and other information documenting the accuracy of MNLS, documents supporting the claim that the accuracy of MNLS will improve over time, and evidence establishing AT&T's willingness to commit to improvements.[3/] In response to this request, AT&T has attached as Exhibits A and B two documents that provide additional information on the MNLS location solution. Exhibit A is the most current draft of AT&T's Technical Design Group Design Document for MNLS.[4/] This detailed design analysis, which AT&T will continue to update and revise over time, is the company's "big picture" review of the MNLS technology and its overall impact on AT&T's network. The document includes information regarding the technology's design (including architecture and call flows), implementation, network impacts, operational impacts, performance, and reliability. AT&T is seeking confidential treatment of this document.

Exhibit B is an April 2001 report by Ericsson on ECGI Simulations and Performance Analysis.[5/] Ericsson has provided this document to AT&T for filing with the Commission on the condition that AT&T request confidential treatment of it. This document demonstrates that the concepts underlying AT&T's proposal to utilize the MNLS location technology for its TDMA network are neither new nor unexamined. Rather, MNLS-type technologies have been reviewed and evaluated by many carriers and infrastructure vendors in other countries. While AT&T has been unable to secure the permission of international carriers to file the results of their field trials with the Commission, the Ericsson report is an example of the analyses that have been performed

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2/ See Partial Response of AT&T Wireless Services, Inc. to Order of the Wireless Telecommunications Bureau, CC Docket No. 94-102, filed May 30, 2001 ("AT&T Partial Response").

3/ May 10 Order at 2-3.

4/ See "MNLS for E911 Phase 2 on TDMA," AT&T TDG Design Document (June 5, 2001), attached hereto as Exhibit A.

of MNLS-type technology for Phase II E911 compliance. Please note that Ericsson uses the term "enhanced cell global identity" or "ECGI" to refer to the same MNLS technology that AT&T has selected for its TDMA network. Please also note that this study is based upon use of ECGI technology for GSM, the air interface used in Europe, rather than TDMA.

MNLS Technology Trials. Also attached as Exhibits C and D are the results of two field trials of the MNLS technology that AT&T conducted in Redmond and Bellevue, Washington.[6/] Both trials were designed to test the performance of MNLS technology under the most challenging conditions, i.e. utilizing mobile drive tests, which are also the same type of tests to which the TruePosition and Grayson solutions were subjected. (Stationary test results are expected to be equivalent or better.) The Redmond trial was conducted in the same approximate area as the trials AT&T conducted with TruePosition and Grayson Wireless. The Bellevue trial covered a diverse footprint, including freeways, urban areas with high-rise buildings, suburban areas, and rural areas. Both trials incorporated large numbers of locates. For example, the Bellevue trial alone utilized 1,900 measurements.

The results from the Redmond and Bellevue trials support AT&T's earlier claims that the accuracy of MNLS is comparable to that of other network-overlay solutions, as tested by AT&T field trials.[7/] In Redmond, test results were 290 meters for 67 percent of all drive-test calls and

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5/ See "ECGI Simulations and Performance Analysis," Ericsson Report (April 20, 2001), attached hereto as Exhibit B.

6/ See "Redmond Mobile Drive Trial of MNLS," AT&T TDG Report (June 9, 2001) ("Redmond Trial Report"), attached hereto as Exhibit C and "Bellevue MNLS Trial," AT&T TDG Report (June 11, 2001) ("Bellevue Trial Report"), attached hereto as Exhibit D. As AT&T indicated in its partial response, AT&T is conducting a third trial of the MNLS technology in Denver, Colorado and expects to be able to provide the results of that trial to the Bureau by the end of June.

7/ The results of AT&T's field trials of various network-based Phase II solutions are now a matter of public record. See Memorandum from Wireless Telecommunications Bureau Policy Division to Magalie Roman Salas (May 31, 2001) (submitting partially unredacted version of AT&T's waiver request for the record). Those field trials included a trial of TruePosition's Time

606 meters for 95 percent of all drive-test calls.[8/] In Bellevue, test results were 301 meters for 67 percent of all drive-test calls and 708 meters for 95 percent of all drive-test calls.[9/]

NENA and APCO indicate in their comments on AT&T's waiver request that NENA observed a trial of US Wireless's RadioCamera™ location solution in Seattle in March 2001.[10/] AT&T is pleased that NENA had an opportunity to see the RadioCamera™ location solution in action because the RF Fingerprint technology used by US Wireless is very similar to AT&T's MNLS technology. Both are pattern-matching techniques and locate callers by comparing signal characteristics from the handset against a sophisticated database of stored RF signals. Contrary to NENA's assertion that the results of the RadioCamera trial in Seattle undermine AT&T's decision to use MNLS, the positive attention RF Fingerprint technology is receiving validates AT&T's belief in the viability and benefits of MNLS.[11/]

AT&T acknowledges that RF Fingerprint could be a possible route to improved accuracy, in some areas, in the future. There are, however, a few key differences between MNLS and RF

Difference of Arrival ("TDOA") technology in Redmond, Washington, a trial of Grayson Wireless's TDOA technology in Redmond, and an expanded field trial with Grayson Wireless in Denver, Colorado. AT&T also observed a demonstration of US Wireless Corporation's RadioCamera™ location system in Seattle, Washington.

8/ Redmond Trial Report, Exh. C at 7.

9/ Bellevue Trial Report, Exh. D at 7.

10/ APCO and NENA Comments at 9-10.

11/ APCO's and NENA's claim that MNLS is "more than six times less accurate" than the FCC's rules require is also incorrect. APCO and NENA Comments at 5. The FCC's accuracy requirements are stated in terms of radial measurements. For example, network-based solutions must locate 67% of callers within 100 meters, a radial measurement. APCO and NENA, however, use area measurements rather than radial measurements to evaluate the accuracy of MNLS. If the FCC's accuracy requirements were stated in terms of area measurements, the 100 meter radial requirement would be 31,415.9 square meters (the radius, 100, squared, multiplied by Pi, 3.14159). By using area measurements rather than radial measurements to evaluate the accuracy of MNLS, NENA and APCO are comparing apples to oranges. If radial values are consistently used, as the FCC has done, the accuracy of MNLS accuracy is only 2.5 times worse than the accuracy requirement for network-based solutions (250 meters versus 100 meters), not 6.25 times worse as APCO and NENA claim.

Fingerprint that AT&T believes make MNLS a more viable route to compliance with the Commission's Phase II rules. First, MNLS combines existing network and handset functionality with new network-based software, resulting in a location determination system that is fully integrated with AT&T's existing wireless network (often referred to as "mainstreaming"). RF Fingerprint, by contrast, uses a network-overlay system that is independent from the network's normal call flow. As AT&T explained in its waiver request, there are fundamental problems with network-overlay solutions that are not present with network-integrated solutions like MNLS. For example, these overlays are cumbersome, maintenance-intensive, and cause problems from a zoning and community relations perspective.[12/]

Because MNLS is integrated with AT&T's overall network, as described above, it is easier to monitor and vastly more reliable than a network-overlay system. AT&T's trials of network-overlay systems demonstrate that because such systems carry low volumes of traffic (911 calls only vs. all traffic on network), they are by definition less reliable and far more challenging to monitor than location solutions that are fundamentally integrated in the overall network. MNLS technology also can be deployed rapidly system wide, while deployment of the RF Fingerprint technology would be a very slow, jurisdiction-by-jurisdiction process.[13/]

AT&T's and Lockheed's reviews of the US Wireless demonstrations (in both Seattle and Montana) also indicate that RF Fingerprint, unlike MNLS, is heavily dependent upon the existence of a multi-path environment (i.e., an environment with large quantities of reflected RF radio signals caused by the existence of reflective surfaces such as metallic buildings, mountains,

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12/ AT&T Waiver Request at 12-14.

13/ US Wireless has promoted a business model under which it would develop a national Phase II network and then sell it to multiple carriers. If that model were used, there is no chance that the FCC's timetables would be met because the national deployment of an overlay technology is a complex process that would take years to complete, as the results of AT&T's Grayson Trial in Denver demonstrate. See AT&T Waiver Request at 9-10, Exh. E.

water towers, etc.). RF Fingerprint uses a "radio camera" to detect the multi-path "signature" of an incoming call. As explained above, the signature is then compared to those in the database until a probable match is found.[14/] MNLS uses received signal strength indication ("RSSI"), which essentially allows the handset to determine how strong a signal it is receiving from any particular cell site, and is not dependent upon a multi-path environment.[15/]

Another drawback of the RF Fingerprint technology is its reliance on measured data, i.e. the actual data collected during drive tests. MNLS, by contrast, can use both measured and predictive data, i.e. estimated measurements obtained by using RF propagation tools. While the performance of MNLS is optimized if measured data is used, AT&T can deploy MNLS more rapidly by loading the database with predictive data initially and then adding measured data as it is gathered over time.[16/] Most importantly, predictive data can be used in conjunction with measured data to fill in areas where measured data is never likely to be available, such as cornfields or lakes.

Improved Accuracy Over Time. The very nature of the MNLS location solution -- a network-based technology that utilizes the core functionality of the existing wireless network and handsets -- lends itself to continuous improvement over time. As Ericsson explained in its comments on AT&T's waiver request:

> Initially, MNLS, through a combination of the MAHO functionality and a network database, collects, analyzes, and compares signal strength measurements. At first the network signal database is populated with complex and accepted mathematical

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14/ See US Wireless Location System Field Evaluation at 2, attached to AT&T Waiver Request as Exh. F.

15/ APCO and NENA assert in their comments on AT&T's waiver request that MNLS must "hear" three cell sites to work. Comments of APCO and NENA at 6. This is not accurate. MNLS is able to locate a caller using only one cell site, although the accuracy of the technology improves as the number of cell sites a handset "hears" increases.

16/ The addition of measured data will also improve the accuracy of the MNLS technology. See discussion infra at 7.

> predictions of network signal strength, which are used to locate a mobile user. Over time, the database is supplemented with actual field data on signal strength throughout the service area. The supplemental information provides more precise and detailed data for inclusion in the mobile database and improves the level of accuracy of the system. Therefore, MNLS offers an immediately available location solution that becomes increasingly more accurate as it is utilized.[17/]

As AT&T explained above, the ability of MNLS to use measured data, predictive data, or a combination of both will allow AT&T to speed the deployment of Phase II service to its TDMA customers by using predictive data initially. Over time, however, the MNLS database will be populated with an ever-larger percentage of measured data, which should lead to continually increasing accuracy. Automated drive testing tools are being developed that could maximize the amount of measured data in the database. More accurate RF propagation models are also being developed, which will improve the quality of the predictive data that is in the database.[18/] In addition, new and more intelligent generations of the algorithms used to generate "locates" are continually being developed. As numerous vendors of network-based Phase II solutions have explained, these and other advances should improve the accuracy of the locates in the future.[19/]

While MNLS field trials to date have indicated that a 50-meter grid produces the best location results, one of the issues AT&T is investigating in its ongoing trials is whether accuracy can be improved even further by using alternate grid sizes, particularly in densely populated

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17/ Ericsson Comments at 9.

18/ See Redmond Trial Report at 10. Even though the MNLS database will be populated with an ever-larger percentage of measured data over time, one of the advantages of MNLS is its ability to utilize predictive data when measured data cannot be used. For example, drive-test measurements may never be taken in the middle of a lake or a cornfield.

19/ See Opposition of Grayson Wireless to Nextel Request for Waiver, CC Docket No. 94-102, filed January 5, 2001; TruePosition, Inc., Ex Parte Presentation in CC Docket No. 94-102, filed July 24, 2000.

areas.[20/] AT&T is also investigating whether there are other methods for narrowing down grid choices that can improve accuracy. As AT&T explained in the MNLS overview attached to its waiver request as Exhibit H, AT&T initially will deploy MNLS using the "contour matching" technique, one of two methods by which MNLS narrows down grid choices. AT&T is also investigating whether the use of the "triangulation" technique, either alone or in combination with contour matching, improves the accuracy of MNLS. AT&T will continue to review the possibility of using other supplemental technologies as a route to improved accuracy, if necessary, in the future.

20/ See Redmond Trial Report at 10.

CONCLUSION

AT&T provides this information pursuant to the Bureau's May 10 Order and will continue to provide additional relevant information when it becomes available.

Respectfully submitted,

AT&T WIRELESS SERVICES, INC.

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Of Counsel

June 12, 2001

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Confidential Material

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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**

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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.

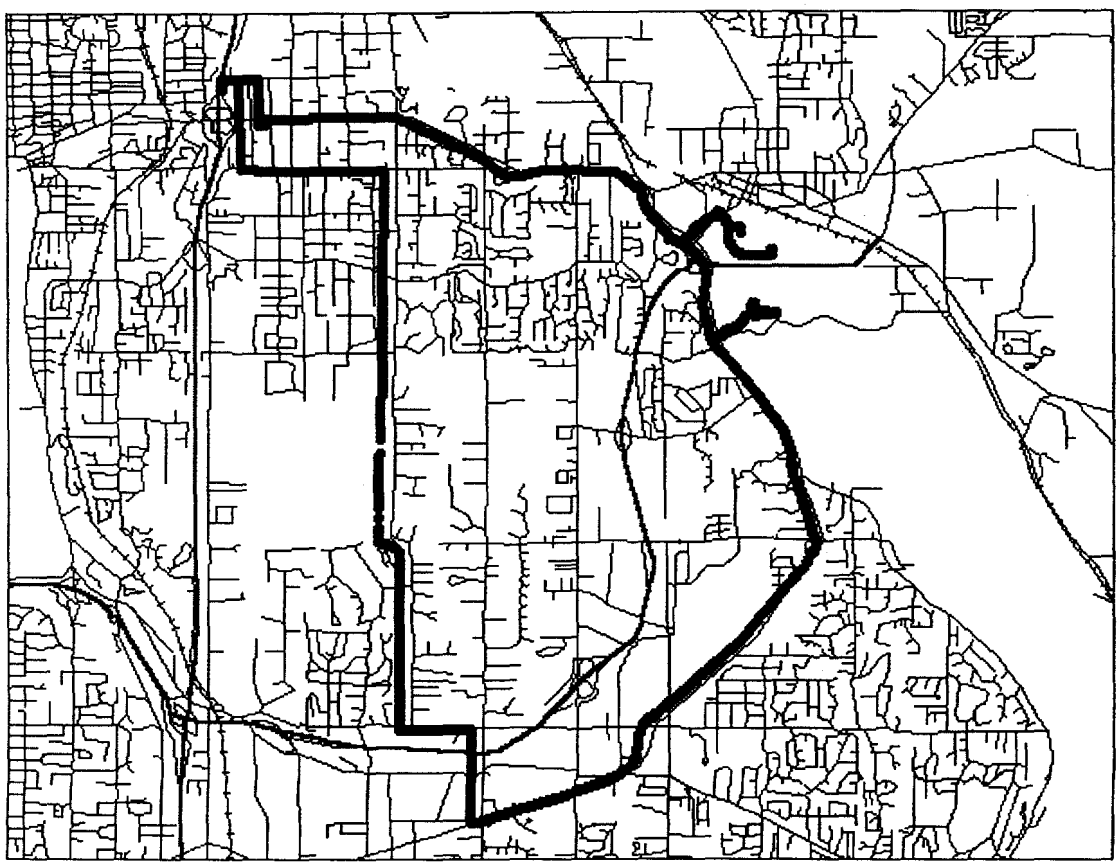
Initially, a database was constructed recording RSS measurements from neighbor channels along with the corresponding position of the mobile as recorded by the GPS receiver while driving through the coverage area. Later, measurements were made at test points in a smaller part of the area covered by the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

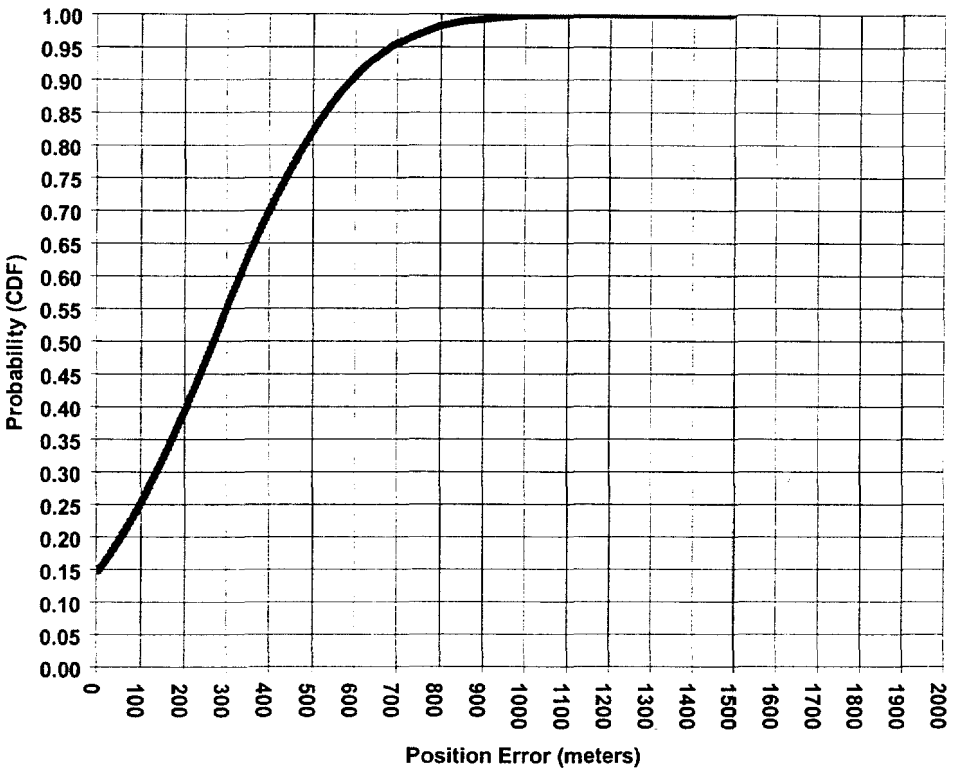


Table 1 summarizes MNLS position errors measured in this trial (expressed as percentages).

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.

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AT&T Wireless Services, Inc.

Bellevue MNLS Trial

Phase 2: E911 Location Technology Trial

Document Number	
Revision	**0.1**
Revision Date	**06/11/01**

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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 Bellevue, 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)
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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 in Bellevue, WA.

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

2.2. Field Measurements

Field measurements were conducted by AT&T Wireless in the Bellevue area using an Ericsson T-18D TEMS mobile phone, a computer with TEMS software for logging measurement data from the phone, and a GPS receiver.

Figure 1 is a map of the roads used for the Bellevue MNLS Trial. For collection and display purposes, the measurements were broken into separate drive routes or loops.

Measurements were made in idle mode of the RSS downlink measurements of the serving and neighbor cells. The TEMS software logged both the RSS measurements and GPS position data.

The RSS/GPS measurements were then used to create a database for the coverage area. The grid size of the database was 50 meters.

Similar measurements were then made in active mode of the RSS downlink measurements of the serving and neighbor cells. The active mode measurements were made by calling a test number that played a local radio station.

MNLS position was calculated using the database created from the idle mode measurements. Every 5 measurements were used together for MNLS calculation purposes. The TEMS mobile phone reports MAHO scans every 1.28 seconds. Therefore, a MNLS position was provided every 6.4 seconds.

Position error was determined using the first of the five GPS positions. Care was taken to verify all 5 of the GPS/RSS measurements were within 50m of each other.

Figure 1. Map of the roads used for the Bellevue MNLS Trial.

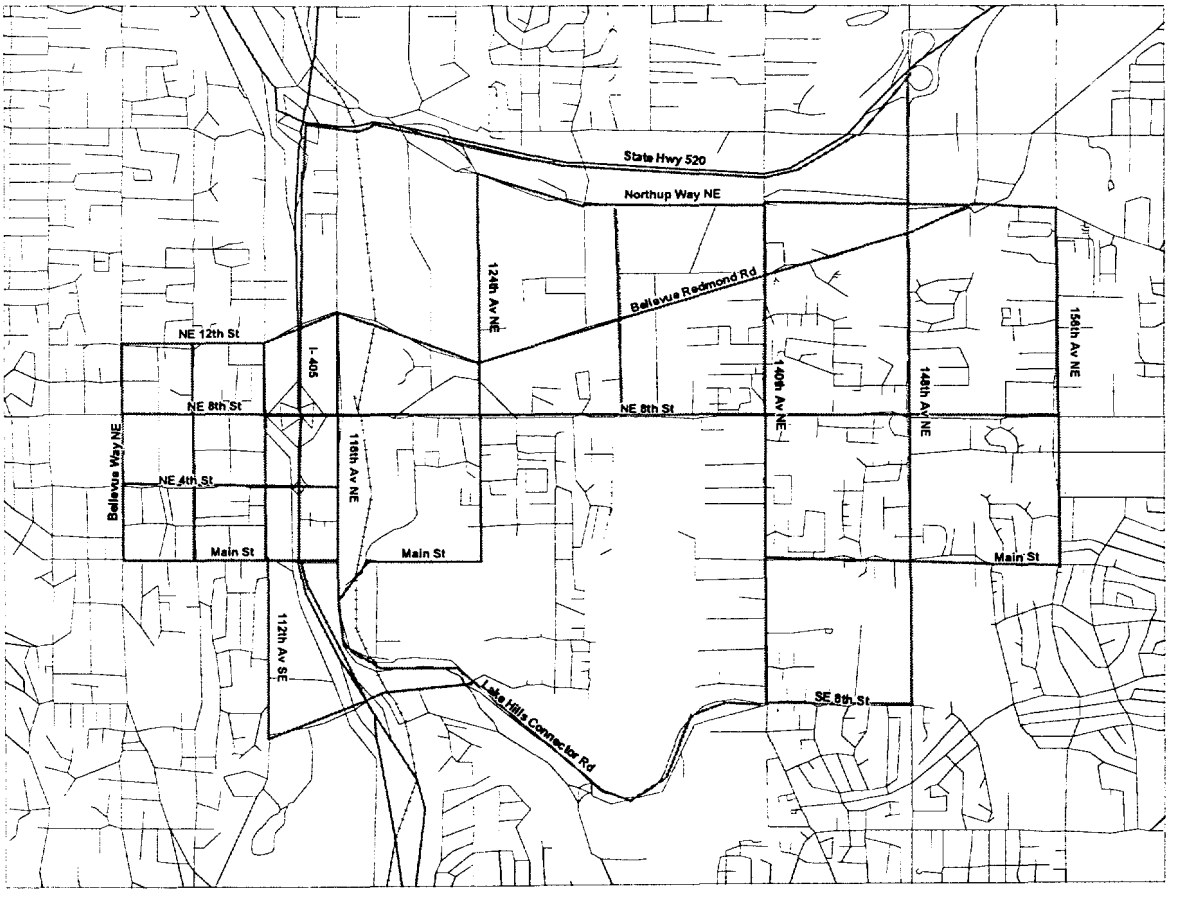
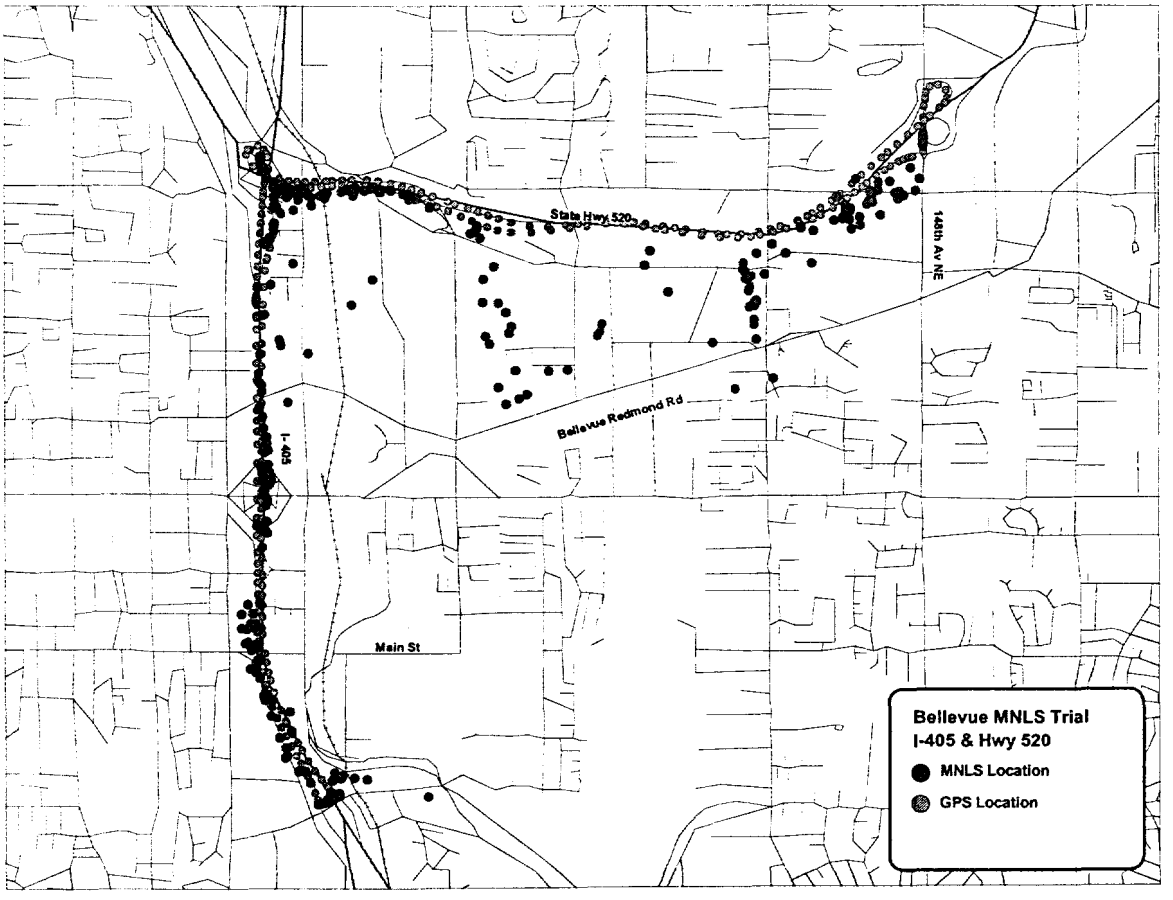


Figure 2. Freeway Loop. Measurements were made on Hwy 520 (east and west), and I-405 (north and south).



3. MNLS Performance

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

Table 1. Bellevue MNLS Trial Position Errors.

	Probability		
	67%	95%	Number of Measurements
Total Aggregate Position Error	301 m	708 m	1935
Freeway Loop (Figure 2)	232 m	785 m	263
Loop 1 (Suburban)	338 m	998 m	429
Loop 2 (Sub/Rural)	324 m	704 m	528
Loop 3 (Urban)	254 m	582 m	162
Loop 4 (Urban)	289 m	585 m	235
Loop 5 (Dense Urban)	345 m	527 m	196
Loop 6 (Urban)	195 m	339 m	122

3.1. Performance Improvements

3.1.1. Grid Size

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.

CERTIFICATE OF SERVICE

I, Andrea Willis, hereby certify that on this 12th day of June 2001, I caused copies of the foregoing "Supplemental Response of AT&T Wireless Services, Inc. to Order of the Wireless Telecommunications Bureau" to be sent to the following by hand delivery:

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