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AT&T

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July 10, 2001

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

Re: AT&T Wireless Services, Inc. - Request for Waiver of the E911 Phase II Location Technology Implementation Rules
CC Docket No. 94-102

Dear Ms. Salas:

Transmitted herewith on behalf of AT&T Wireless Services, Inc. ("AWS") are an original and four copies of the results of AWS's third MNLS field trial in Denver, Colorado, which was referenced in AWS's Partial Response to the Order of the Wireless Telecommunications Bureau filed on May 31, 2001.

Like AWS's Redmond and Bellevue MNLS trials, the Denver trial was designed to test the performance of MNLS technology under the most challenging, real-world conditions, using mobile drive tests and over 2,600 location data points. The report provides a breakdown of both the mobile and stationary performance of MNLS. In conducting the MNLS trial, AWS used the same service footprint as in the Grayson TDOA/AOA trial described in Exhibit E of AWS's April 4 waiver request. The overall accuracy performance for MNLS in the Denver trial was 299 meters 67 percent of the time and 703 meters 95 percent of the time.

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

Respectfully submitted,

Douglas I. Brandon BTB

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AT&T Wireless Services, Inc.

Denver MNLS Trial Technical Summary

Phase 2: E911 Location Technology Trial

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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 performed in Redmond, WA in 2001.

1. Overview

1.1. 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

calculate 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 the Denver, CO market.

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.

Section 1.2 describes the measurement and prediction data in greater detail. Section 2 discusses the MNLS performance. Conclusions are presented in Section 3.

1.2. Field Measurements

Field measurements were conducted by AT&T Wireless in the Denver market using an Ericsson T-18D TEMS (Test Mobile System) mobile phone, a computer with TEMS software for logging phone measurement data, and a GPS (Global Positioning System) receiver.

Measurements were made in idle mode of the RSS downlink channels 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 database grid size was 50 meters.

Similar measurements were then made in idle mode of the RSS downlink channels of the serving and neighbor cells. Typically the measurements would have been made on an active call. However, due to the use of Forward Power Control (FPC) and Mobile Switching Center (MSC) software that currently allows 12 neighbors, collecting active call information was not possible.

When the MSC software in the Denver market is upgraded in the near future to allow 24 neighbors, the serving site's control channel can be included in the neighbor list. This allows measurements to be made on the serving cell without any power reduction due to FPC. Control channels are not included in FPC, as any power reduction would negatively impact call setup.

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

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

Figure 1 through Figure 4 show the results of each of the drive routes. Figure 5 shows the results of the six stationary test points.

Figure 1 Measurements Made on Freeway Routes I-70 and I-25

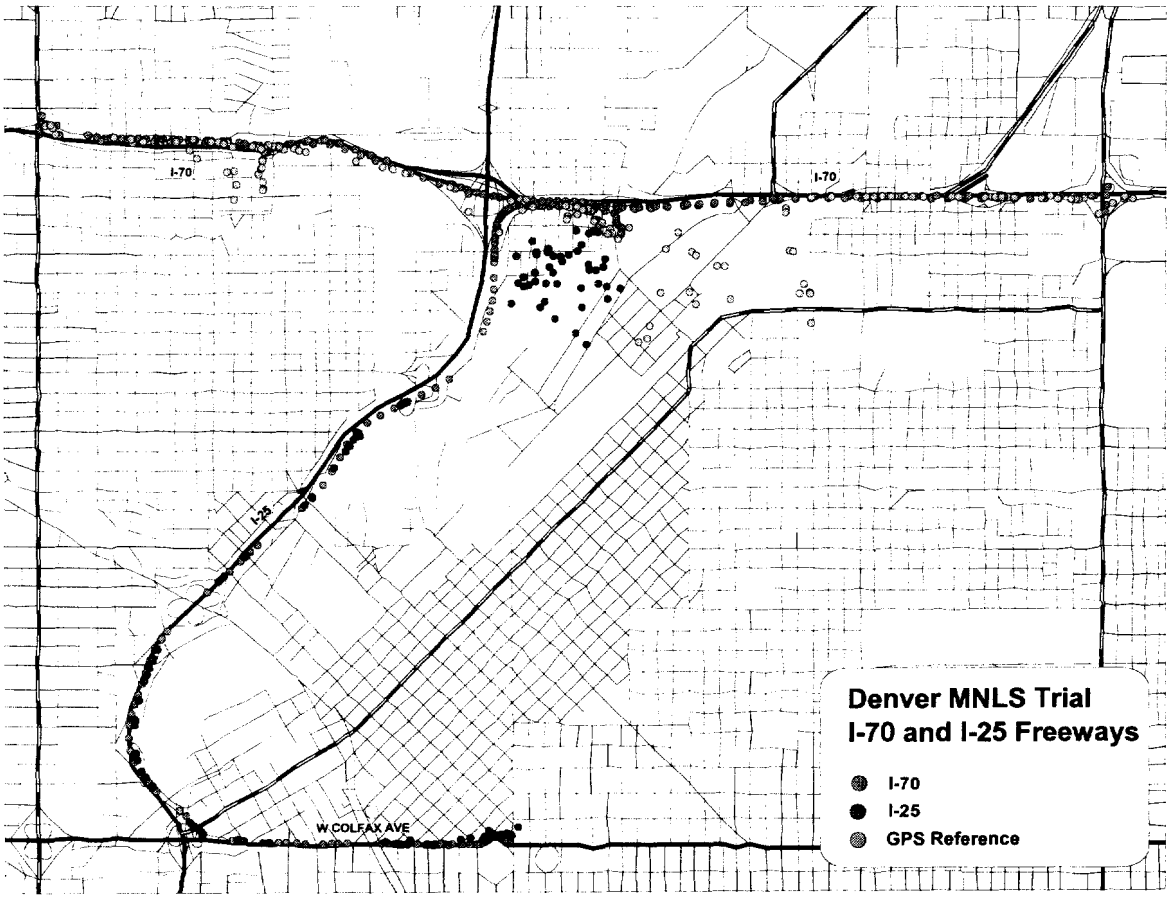


Figure 2 Dense Urban Route 1

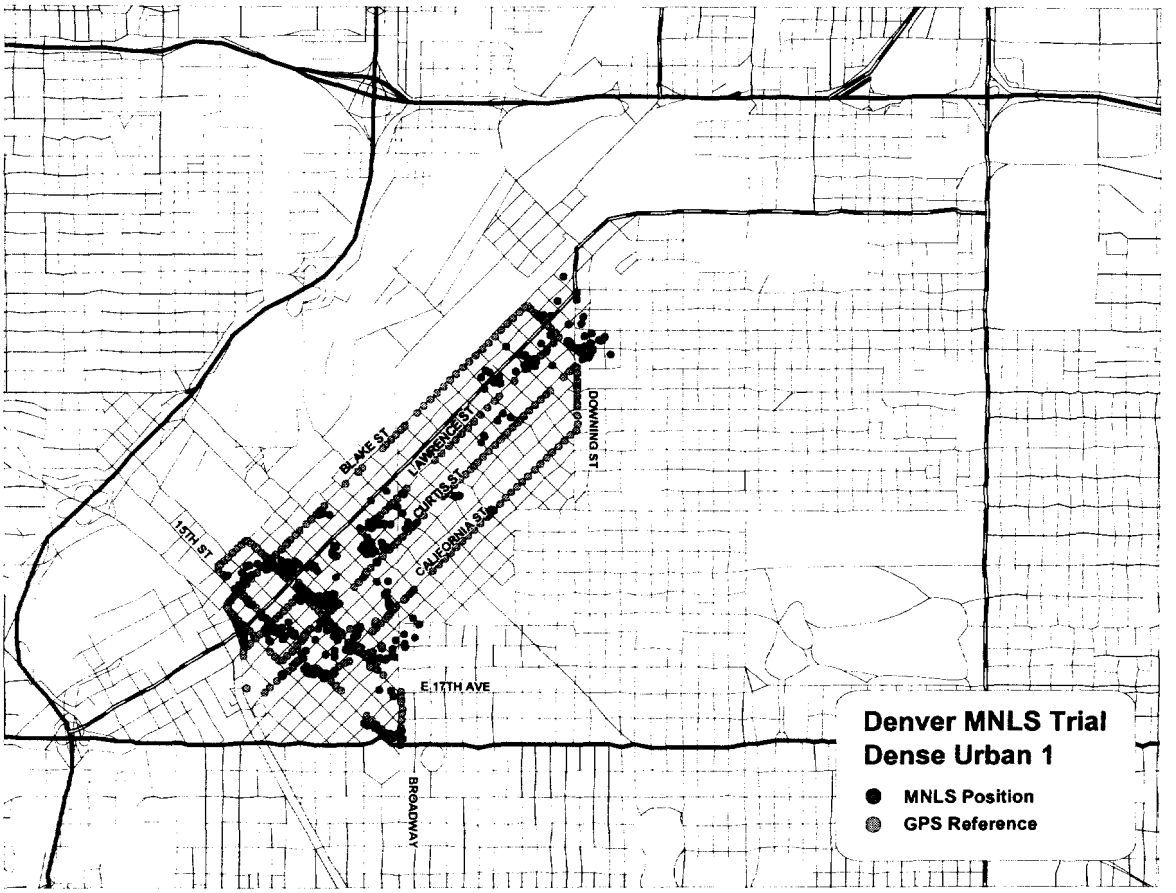


Figure 3 Dense Urban Route 2

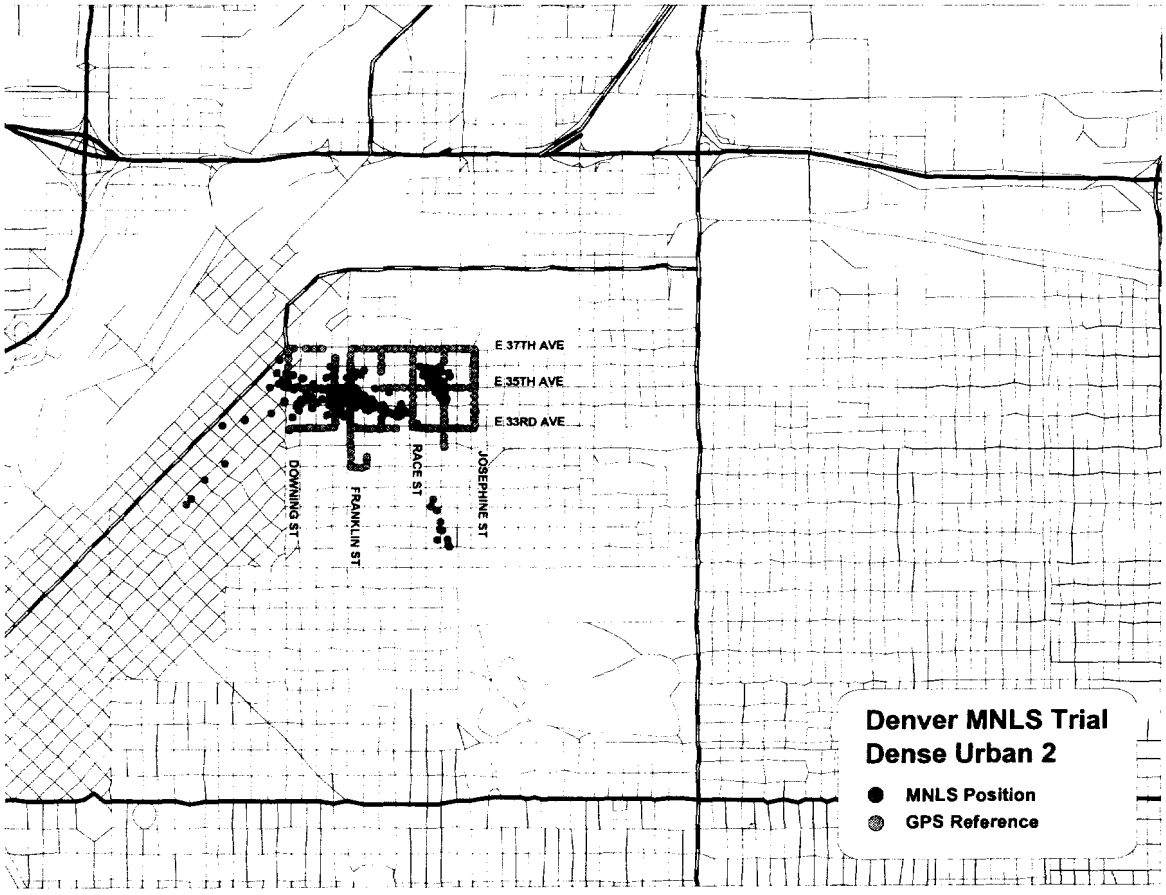


Figure 4 Dense Urban Route 3

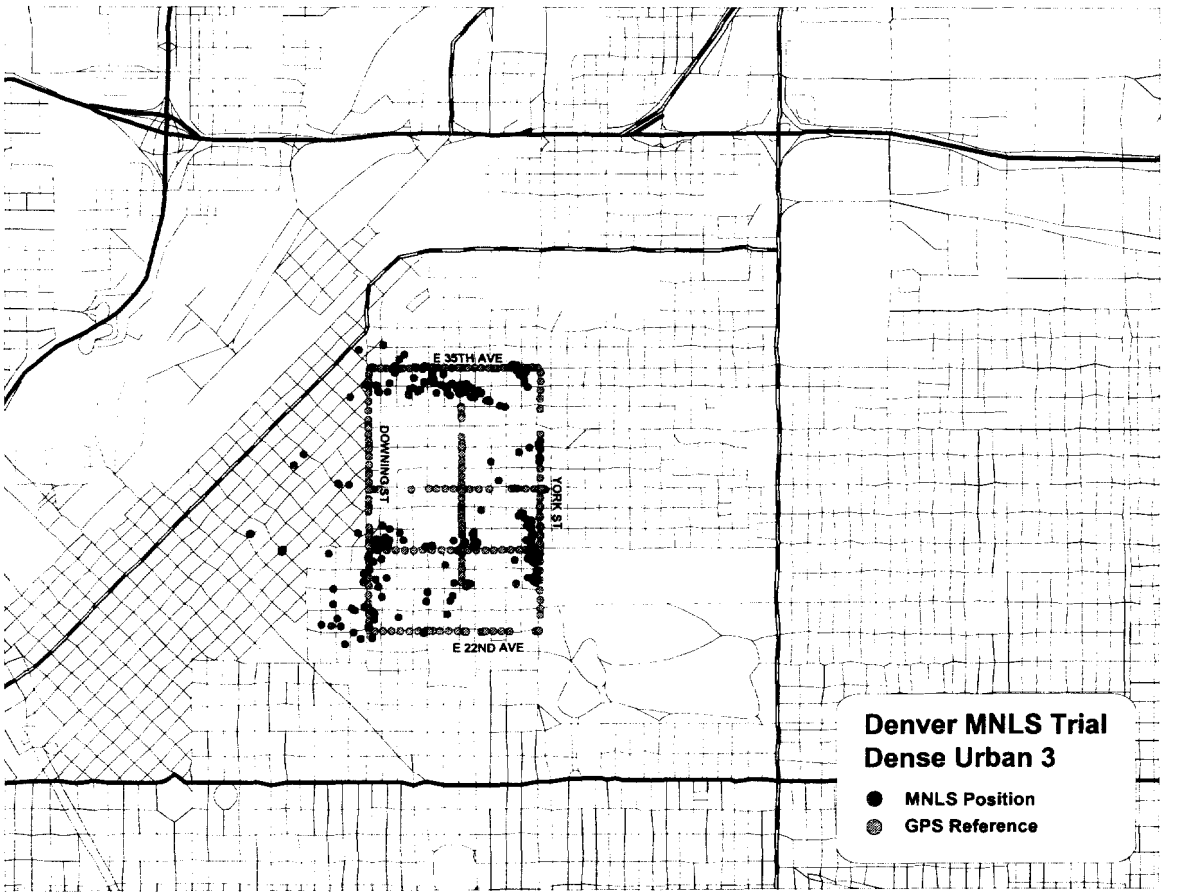


Figure 5 Urban Route

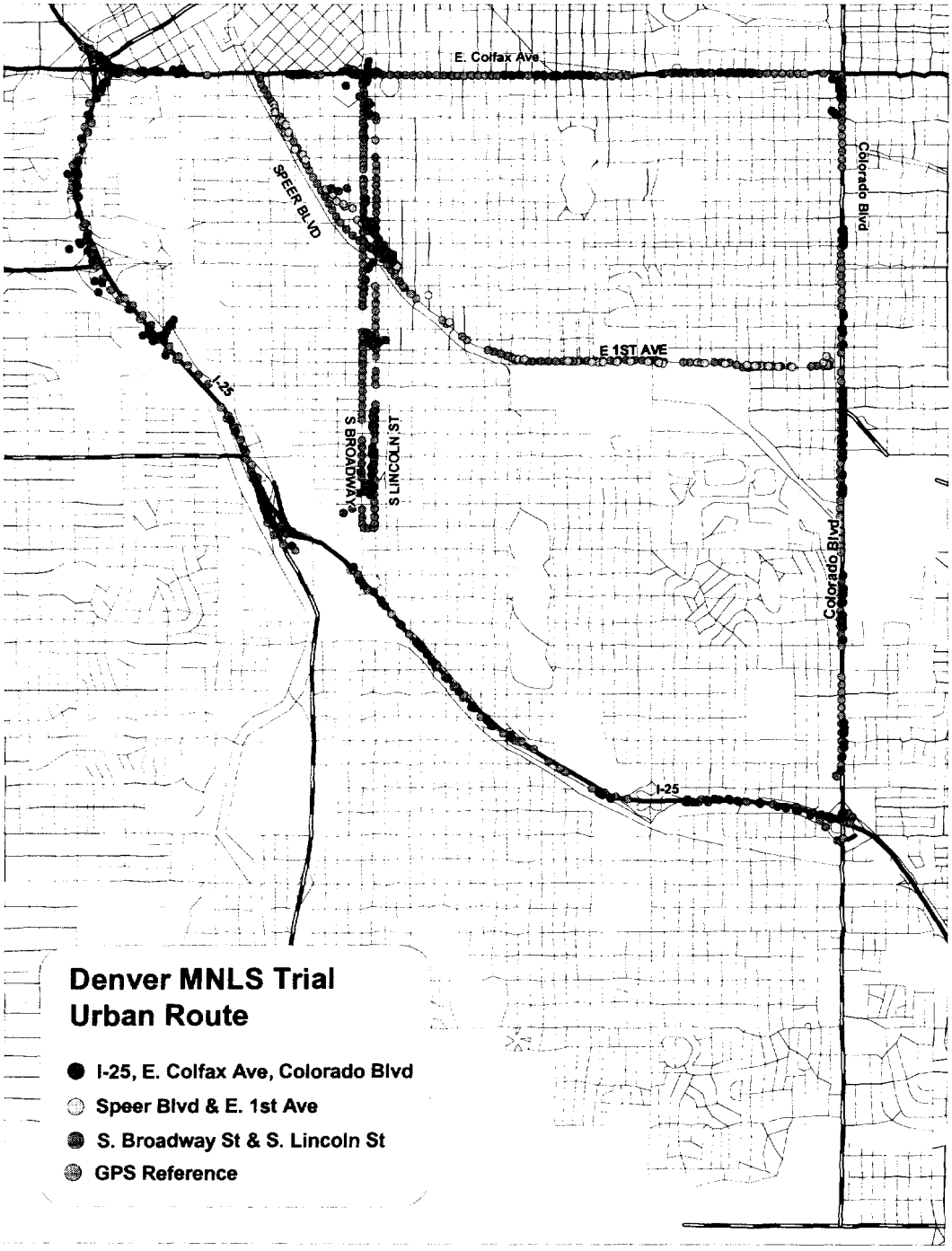


Figure 6 Suburban Route

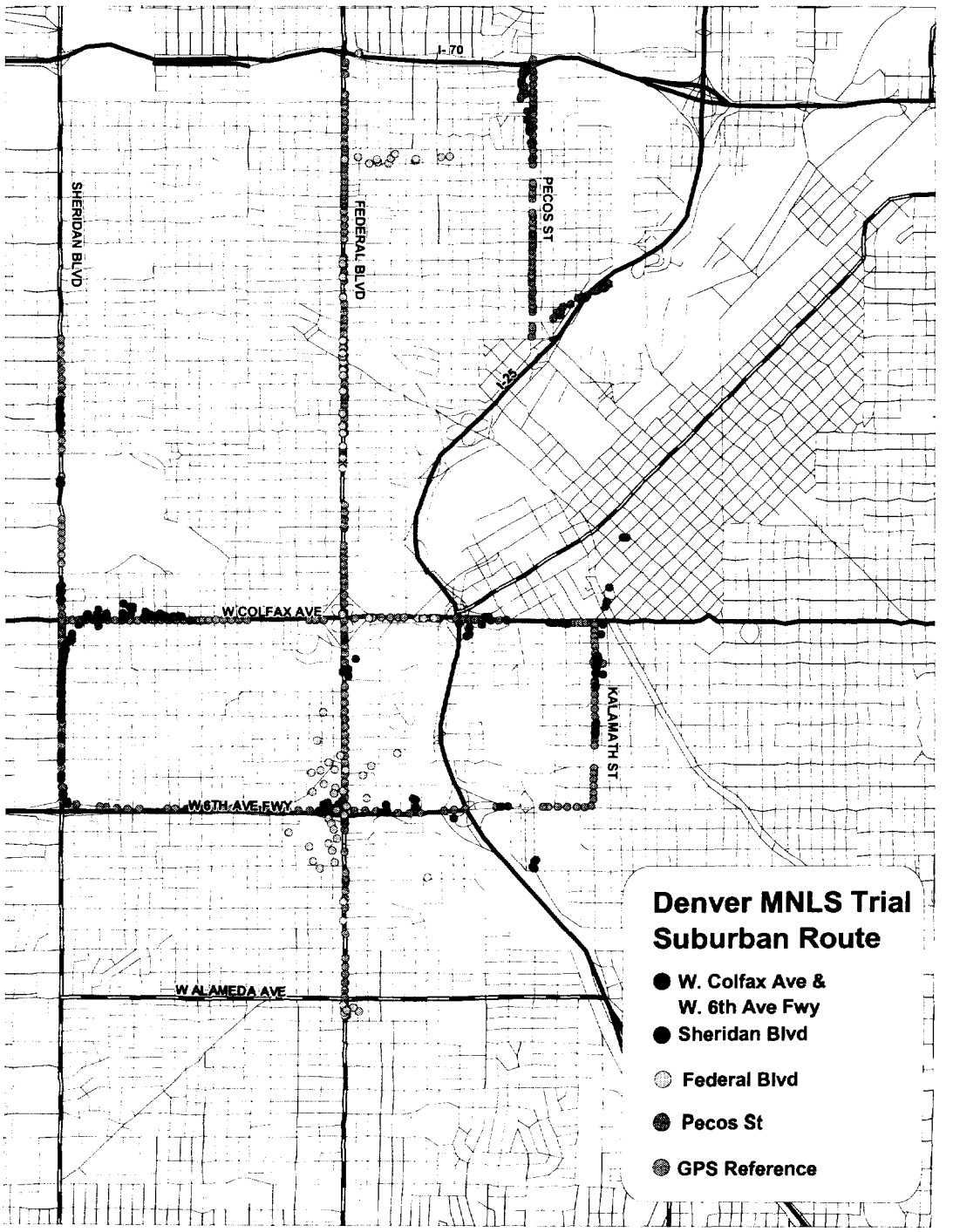
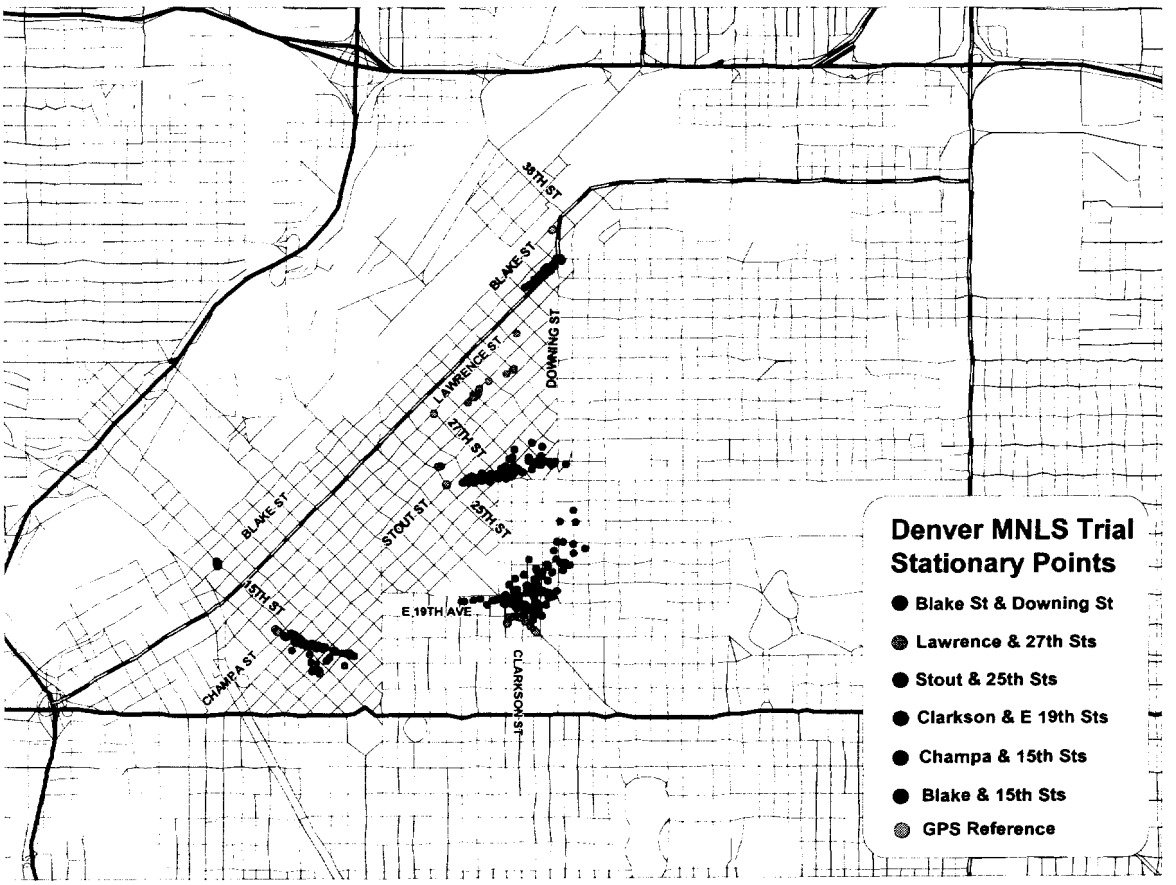


Figure 7 Stationary Test Points



2. MNLS Performance

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

Table 1 Denver MNLS Trial Position Errors

Trial Position Location	Probability		Number of Measurements
	67%	95%	
Total Aggregate Position Error	299 m	703 m	2611
Total Aggregate Drive Position Error	285 m	716 m	2244
Total Aggregate Stationary Position Error	351 m	650 m	367

2.1. Performance Improvements

2.1.1. 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.

2.1.2. 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.
- Use of a dead reckoning positioning system would improve measurements collected in poor GPS reception areas.

Note: The databases used to generate results in this document 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.

3. Conclusions

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 used to provide the best results with the given data. See Table 1 for overall results.