E911 Accuracy Assurance

Rosum
Nashua NH

July 2, 2007

Rosum TV-GPS provides accurate, reliable location indoors, outdoors and in dense urban locations.

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1 Introduction

1.1 4G Communications, Inc. Overview

4G Communications is a Small Disable Veteran Owned Business **(SDVOB)** dedicated to providing critical communications solutions to those entities requiring time sensitive delivery of critical information. 4G communications also provides Professional Services including project management, systems solutions and system integration into turnkey solutions.

4G Communications has many years of combined experience providing critical communications and project management to both government and commercial providers. 4G Communications background stems from a Military Special Operations background as well as experience working within Department of Defense, Joint Special Operations, Special Forces, as well as other federal government agencies communications.

The 4G Communications team has extensive experience implementing Enhanced 911 service for numerous carriers across the US working with Mobile Position Centers as well as third party vendors.

1.2 Executive Overview

This report, commissioned at the request of Rosum, provides a county-level analysis of E911 Phase II Accuracy Validation testing performed for the test area defined as 'Nashua NH'. The location finding systems within the Nashua NH area are analyzed with respect to the OET Bulletin No. 71 guidelines for E911 Phase II compliance testing. In addition to the accuracy analysis results, this report documents the testing environment, data collection methods and analysis techniques.

1.3 Scope of Effort

4G performed an E911 Validation Test upon the Rosum location finding system in the 'test area' defined as Nashua NH. Validation testing includes a system analysis of the carrier's network for the purpose of characterizing the expected performance of the E911 Location Determining Techniques (LDT) implemented in the area under test. Specifically, 4G follows an efficient procedure designed to meet and exceed the guidelines outlined in the OET Bulletin No. 71. An overview of the testing methodology is included in the report as Appendix C. 4G Communications followed the guidelines as prescribed by ATIS 0500011in order to identify the specific parameters for testing Nashua NH as a suburban environment which led to the selection of sites.

Due to the random nature of test point selection, the indoor test calls will be distributed throughout the various categories of usage environments. The usage environment for the one-time performance report may include an aggregate of the location estimate for all of the test calls that occur within that usage environment. Wireless carriers may, optionally, state indoor versus outdoor test point accuracy estimates as subcategories under each usage environment.

The indoor test calls include each of these four usage environments should, when possible to identify from existing data, reflect the typical nature of indoor usage in each environment.

A. Indoor calls in a rural environment should generally be in settings that create low penetration loss.
B. Indoor calls in a suburban environment should have a mix of indoor calls in settings with low and moderate penetration losses. N The exact ratio is up to the body that performs the tests and would reflect the nature of the network under test and its typical usage in the given test environment. However, a reasonable guideline is 25% moderate loss and 75% low penetration loss.
C. Indoor calls in a urban environment should have a mix of indoor calls in settings with low, moderate and high penetration losses. The exact ratio is up to the body that performs the tests, however a reasonable guideline is this case would be 15% high penetration loss, 50% moderate loss and 35% low penetration loss.
D. Indoor calls in a dense urban environment should also have a mix of indoor calls in settings with low, moderate and high penetration losses. The exact ratio is again up to the body that performs the tests; however a reasonable guideline in this case would be 25% high penetration loss, 50% moderate loss and 25% low penetration loss.

1.4 Summary of Results

This report concludes that: “the Rosum LDT deployed in Nashua is compliant with the FCC Phase II objectives”. Furthermore, the analysis shows a 67% error distance of **30 meters** and a 95% error distance of **63 meters**. The joint 67%, 95% error distance confidence pair is **(31 m, 66 m)** with a confidence interval of **90.01 %**.

2 Nashua Test Call Analysis

This section is divided into three components. First, test call results are analyzed for the un-weighted FCC compliance metrics as specified in OET Bulletin No. 71. Second, the network performance is analyzed for test calls including call yield, solution source results and indoor vs. outdoor accuracy. Finally, the test call geographic distribution is analyzed to ensure the empirical sampling of Nashua does not create a 'land-use' bias in the accuracy results.

2.1 Accuracy Analysis

This portion of the report presents the un-weighted FCC compliance results achieved during the E911 Validation Test.

The first step in processing test call data is rounding error values to the nearest meter as interpreted through OET Bulletin No. 71 and following Best Engineering Practices (BEP) regarding significant digits. Following this rounding, the individual call samples are organized into an ordered list and the 67% and 95% error distances are calculated. The following table presents the FCC compliance statistics for errors observed between 1) the PDE log results and 2) the matched test calls' GPS 'Ground Truth' locations.

FCC Compliance Error Distances	67% Error Distance (m)	95% Error Distance (m)	Test Call Count
Un-Weighted	30	63	1,828
FCC Mandate (handset solution)	≤ 50	≤ 150	90.00 % Confidence

Table 1: Un-Weighted FCC Compliance Metrics for Nashua

Empirical test calls results are required to achieve a 90% confidence interval pair of 67% and 95% error distances that are within the FCC Mandate. The table below presents the confidence interval results for the un-weighted test calls.

Confidence Interval Results	Test Call Count	67% Conf. Int. Error (m)	95% Conf. Int. Error (m)	Confidence Interval
Un-Weighted	1,828	31	66	90.01 %
FCC Mandate	N/A	≤ 50	≤ 150	≥ 90.00 %

Table 2: Un-Weighted Confidence Interval Results for Nashua

A chart depicting the Cumulative Distribution Function (CDF) of the PDE accuracy results is shown below.

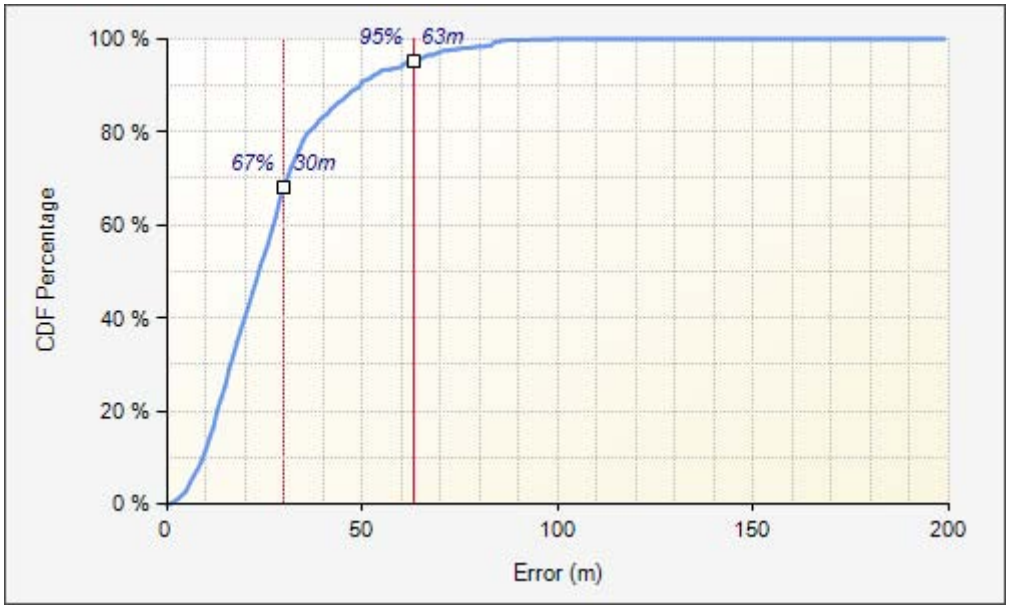


Figure 1: CDF of Un-Weighted PDE Call Statistics for Nashua

2.2 Network Performance

This portion of the report provides details on the network performance observed by the test calls.

The next table shows the test call yield, or the percentage of test calls that were successfully matched to the PDE logs, and thus the yield of calls that would return a location result to the PSAP operator.

Test Call Yield	Test Calls Placed	Test Calls Matched	Yield
Un-Weighted	1,828	1,828	100.00 %

Table 3: Test Call Yield for Nashua

The table below shows the 67th and 95th percentile error for indoor and outdoor test call types. No distribution is shown with respect to solution source in this table.

Call Type	Count	Percent	67% Error (m)	95% Error (m)
Indoor	929	50.82 %	39	71
Outdoor	899	49.18 %	22	35

Table 4: PDE Accuracy by Call Type for Nashua

2.3 Land-Use Analysis

This portion of the report analyzes the distribution of test call locations and produces FCC compliance metrics from a 'weighted' data set.

Test call locations are classified according to land-use type using the 'ground truth' information and a set of processed satellite imagery. A complete set of land-use types used in this report are defined in Appendix C.

The next table shows the accuracy achieved within each of the tested land-use types within Nashua. The final column indicates the proportions of each land-use type within the 'test area'.

Land-Use Type	Num. of Fixes	67% Error (m)	95% Error (m)	LU % of Test Area
Transportation	0	0	0	NaN
Dense Forest	61	10	19	NaN
Light Forest	0	0	0	NaN
Open – Vegetated	61	24	46	NaN
Open, Non-Vegetated	164	43	60	NaN
Urban, Low Density	306	32	70	NaN
Urban, Med Density	430	25	40	NaN
Urban, High Density	0	0	0	NaN
Commercial/Industrial	806	32	69	NaN
Airports	0	0	0	NaN
Water	0	0	0	NaN

Table 5: PDE Accuracy by Land-Use Type for Nashua

3 Nashua Testing Environment

This section is divided into three components. The first part explicitly defines the 'area under test'. The second provides background material on the testing logistics while the final portion lists functional issues encountered, if any, during testing.

3.1 Definition of the 'Area Under Test'

Nashua is defined as containing all of the following Public Service Answering Points (PSAP) shown below.

PSAP Number	PSAP Name
4670	New Hampshire Bureau of Emergency Management Services

Table 6: List of PSAPs within Test Area

3.2 Testing Logistics

Test Points were selected for Nashua NH using a random point generator and filtering to ensure an appropriate mix of land-use types. Field test teams were then deployed to the pre-determined test point locations and location attempts were conducted. For each "test call", the field test team logged a 'ground truth' position using a DGPS unit and simultaneously logged the handset data.

The table below contains information on the testing dates and test call volume.

Testing Logistic	Values
Time of First Test Call	6/26/2007 1:01:57 PM
Time of Final Test Call	6/28/2007 12:57:17 AM
Number of Test Points	30
Average Number of Calls per Test Point	60.93

Table 7: Nashua Testing Dates and Test Call Volume

The following figure shows the test area location with land-use types represented by various colors as explained in Appendix C. Test call locations are represented as red circles and BSA entries as black triangles.

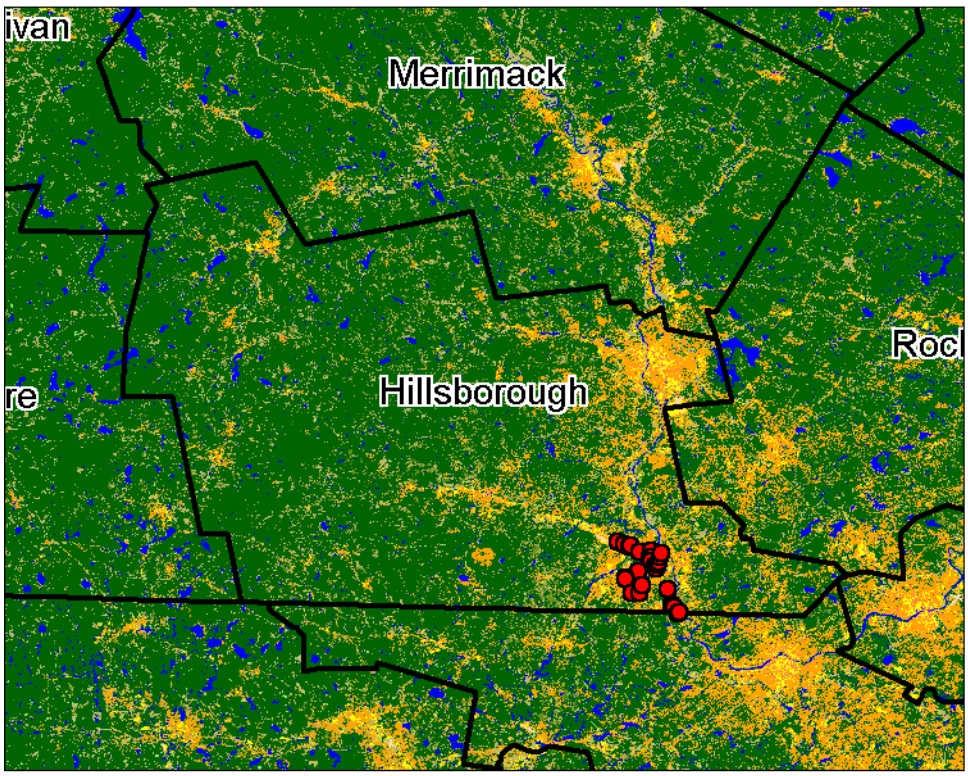


Figure 2: Test Calls Locations for Nashua

The figure below shows the distribution of test calls among land use types.

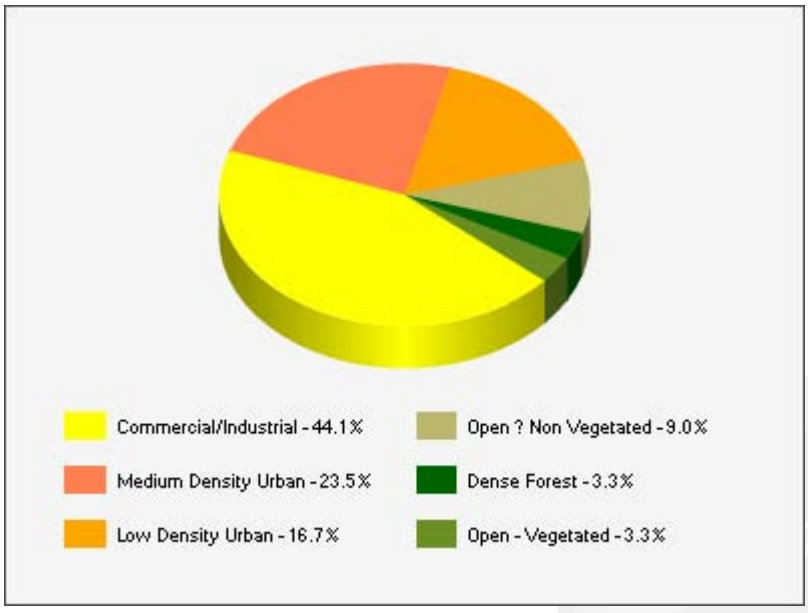


Figure 3: Distribution of Test Calls among Land-Use Types for Nashua

3.2.1 Site Selection Objective

The aim of site selection is to make sure that random test points are identified within the Nashua NH coverage area ensuring that all wireless usage environments within that PSAP are being tested.

3.2.2 Site Selection Process

- A Shape file of the PSAP was used to determine the boundaries of the Nashua NH PSAP coverage area.
- The Random Generator was used to identify random points within the PSAP area. 30 Random points were generated and identified as potential test sites.
- Fifteen (15) of the random sites were identified as outdoor candidates making sure that the wireless Usage Environment methodologies were being used
- Fifteen (15) of the random sites were identified as indoor candidates making sure that the wireless Usage Environment methodologies were being used.

3.2.3 Survey Methodology

4G Communications Inc surveyed indoor sites via the following process. First, permission was obtained by the local management to test within their facility. Next, 4G personnel identified a DGPS reference point within close proximity of the desired test location. Finally, a distance and bearing measurement from the DGPS reference point was utilized to determine the ground truth of the test location.

- Location: GPS 76 WAAS and differential capable handheld unit (within 3 meters)
- Distance: Laser Range Finder (plus or minus 3 feet)
- Azimuth: Silva magnetic with 15 West degrees declination (plus or minus 10 degrees)

The fifteen (15) outdoor test locations were determined by using the GPS 76 with an external antenna. Location was calculated at the location in which the equipment was setup for data collection.

The indoor test point locations were randomly selected to ensure that the testing entity may encounter the following types of indoor settings:

- Low penetration loss: 1 or 2 story house or building made of wood or brick surrounded by similar buildings.
- Moderate penetration loss: First or second floor of 4 to 8 story concrete building with metal frame surround with ample separation by similar or shorter buildings. Locations away from the outer walls and windows are selected.
- High penetration loss: Underground parking lots of shopping center, inside elevators, inner offices of high rise buildings.

Due to the random nature of test point selection, the indoor test calls were distributed throughout the various categories of usage environments. The usage environment for the one-time performance report included an aggregate of the location estimate for all of the test calls that occurred within that usage environment.

3.3 Functional Issues Encountered During Testing

No functional issues were encountered during the test.

Appendix A: References

[1] **Cellular Radio-telecommunications Intersystem Operations**
ANSI/TIA/EIA-41-D, Revision D, 1997

[2] **Enhanced Wireless 9-1-1 Phase 2**
TR-45 J-STD-036, Revision AD-2 v5, July 2001

[3] **Guidelines for Testing and Verifying the Accuracy of Wireless E-911 Location Systems**
OET Bulletin 71, April 12, 2000

[4] **Define Topologies & Data Collection Methodologies**
ATIS-0500011, 2006

Appendix B: Nashua Validation Points

This Appendix contains detailed figures of test locations for each of the sub areas tested in Nashua.

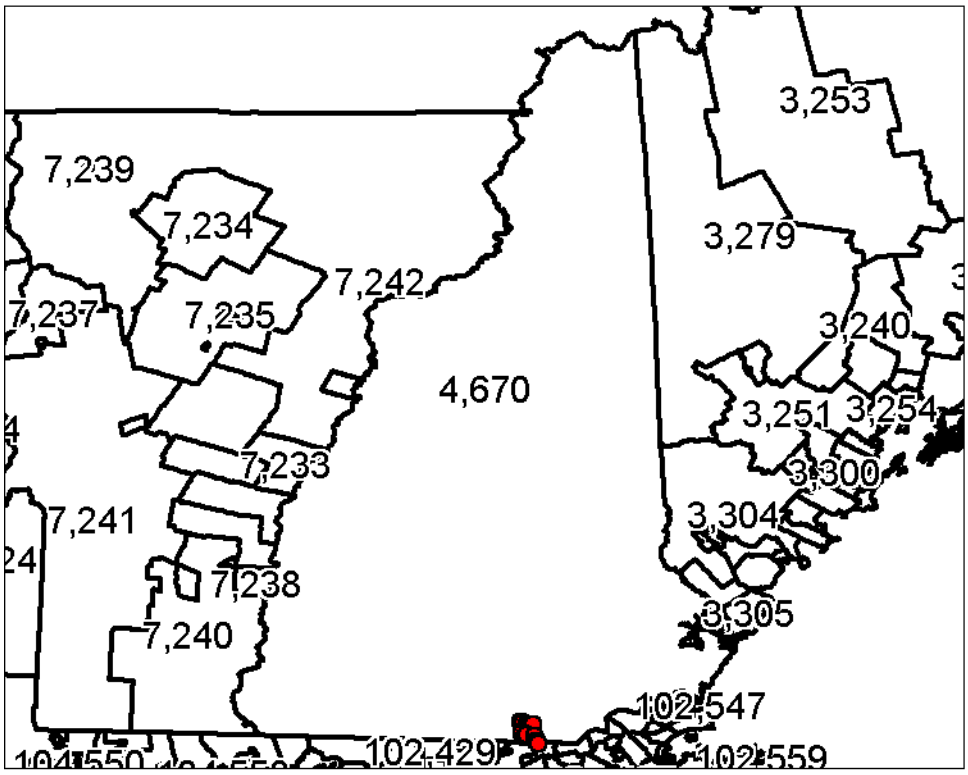


Figure 4: Test locations for (4670) New Hampshire Bureau of Emergency Management Services

Appendix C: Land-Use Type Definitions

Transportation
Includes areas of major transportation, primarily interstate highways.

Dense Forest
Includes areas of forest with at least 70% crown closure. Found in urban as well as rural areas.

Light Forest - Shrub/Scrub Vegetation
Includes areas of forest with 25%-70% crown closure and may lie in close proximity to open-vegetated regions. Found in urban as well as rural areas.

Open - Vegetated
Includes agricultural land, rangeland, grassland, golf courses, major parks where significant forested areas are not present, but some level of vegetation exists.

Open – Non Vegetated
Includes agricultural land, rangeland, grassland, strip mines, disturbed land, and some paved areas.

Low Density Urban
Mainly residential with homes on large lots. Includes areas where 10-20% of the region is covered by buildings.

Medium Density Urban
Mainly residential with homes on medium or small lots. Includes areas where 20-35% of the region is covered by buildings.

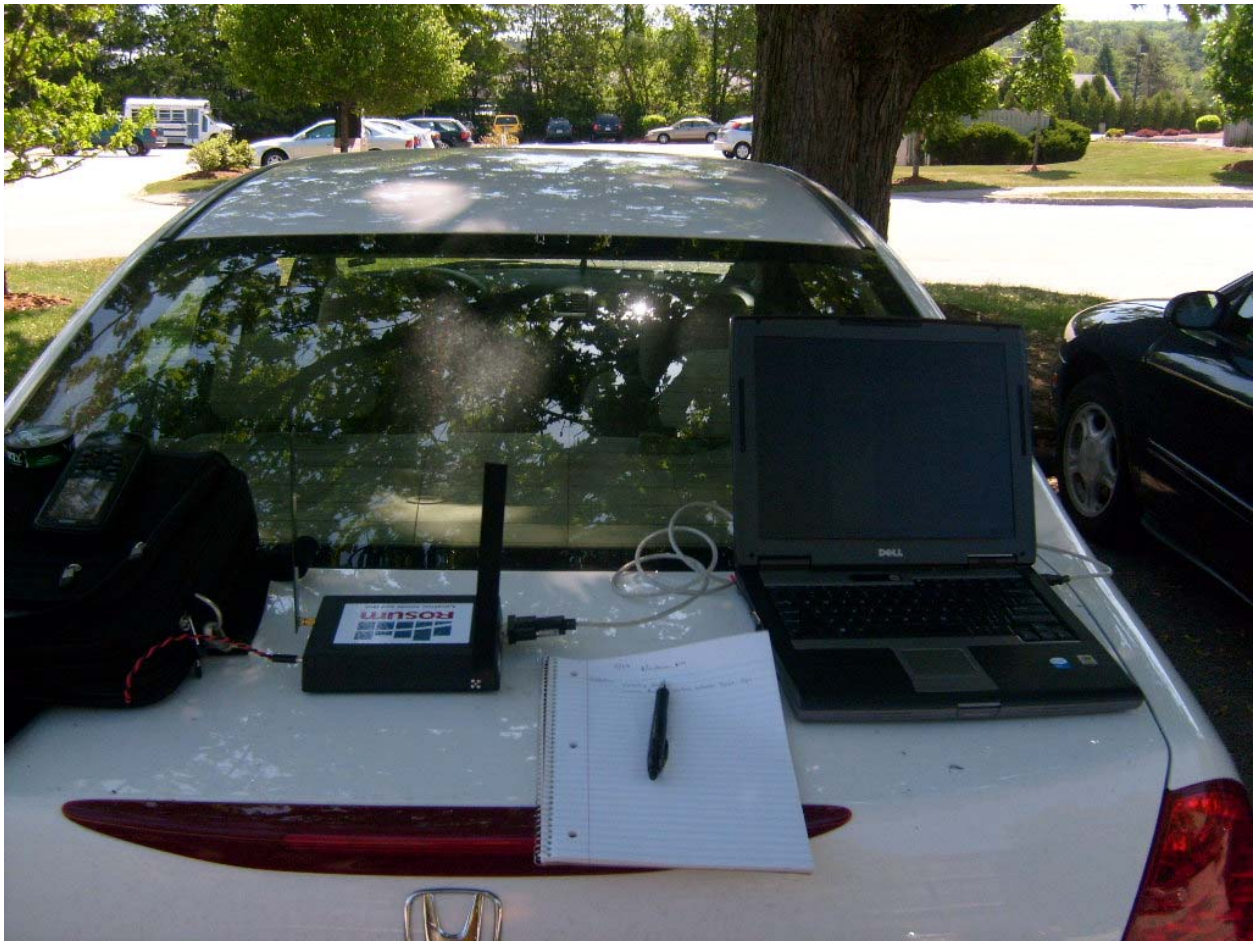
High Density Urban – City Center
Residential and commercial areas, including row houses, apartments, and/or homes on small lots. Includes areas where 35%-60% of the region is covered by buildings. Also includes the central business districts within major metropolitan areas, primarily consisting of tall buildings.

Commercial/Industrial
Consists of areas of medium to heavy industry, medium to large-sized shopping malls, or major business parks.

Airports
Includes airports, minor runway facilities, and runways.

Water
Consists of lakes, large rivers and streams, and canals.

Appendix D: Photographs



Site 1_9_Northeastern Blvd.JPG

Site 1

Site 2_Lockness Dr and Langholm Dr.JPG

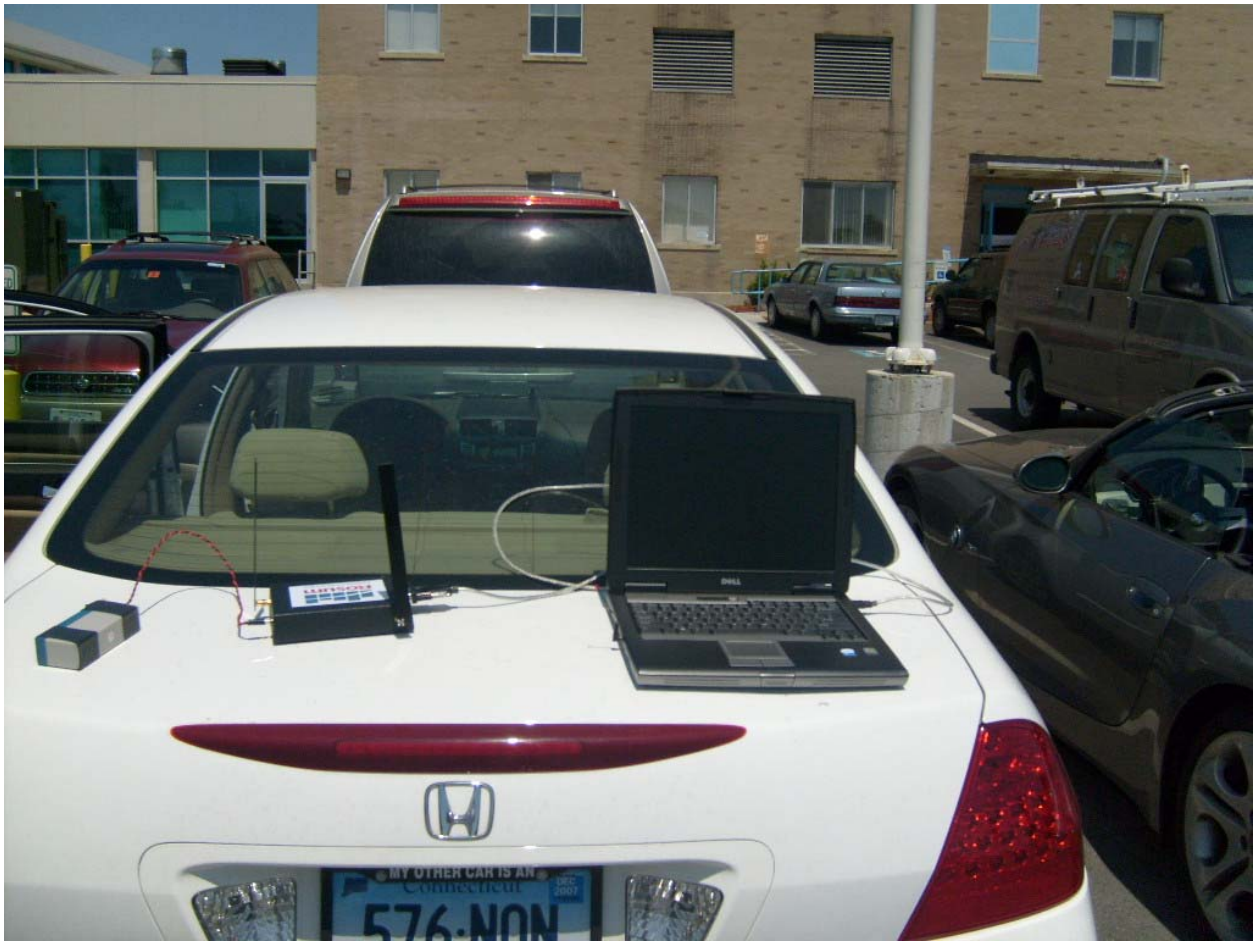
Site 2

Site 3_Kirkpatrick Park.JPG

Site 3

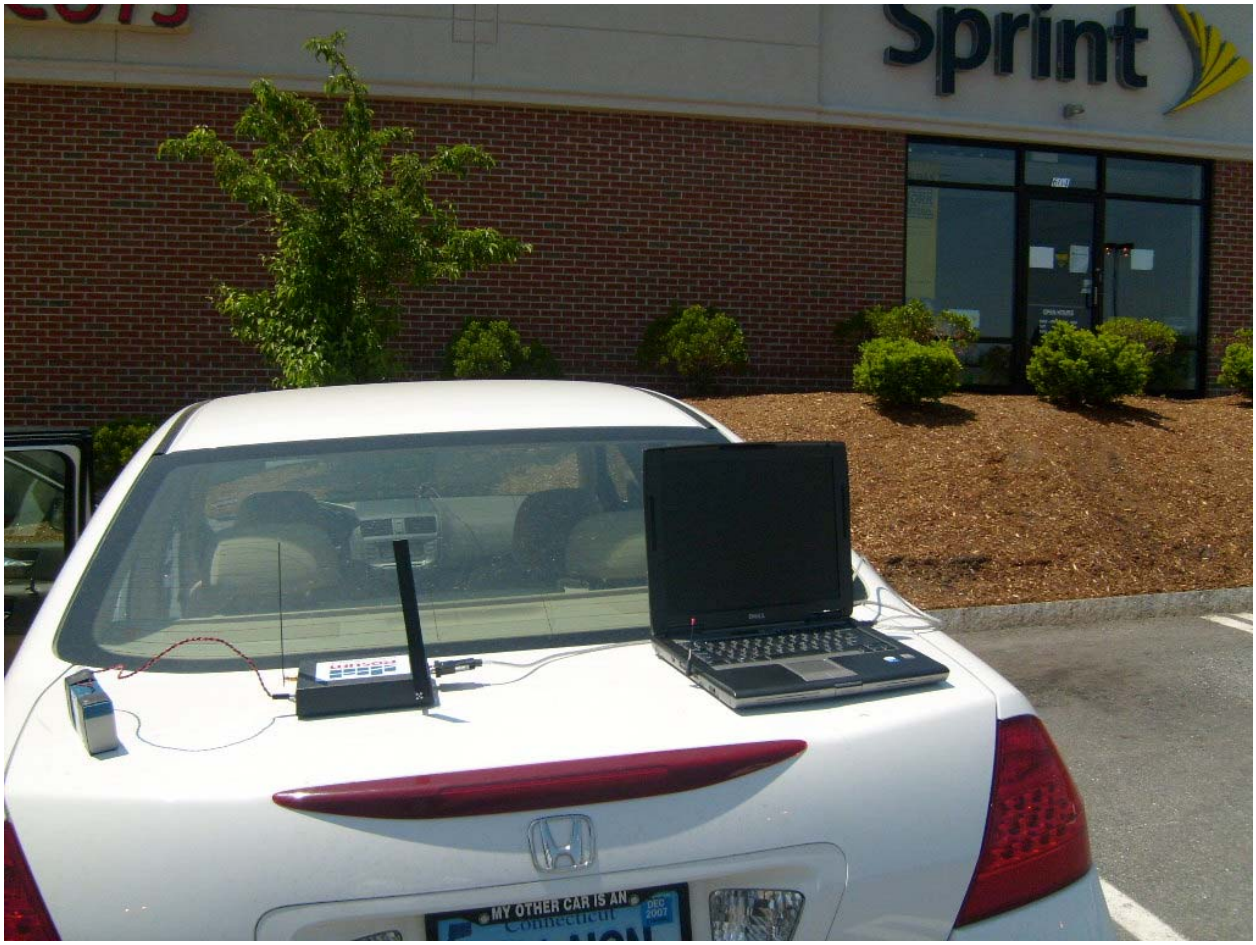
Site 4_122 Northeastern Blvd.JPG

Site 4



Site 5_1980_Kinsley St.JPG

Site 5



Site 6_604_Daniel Webster Hwy.JPG

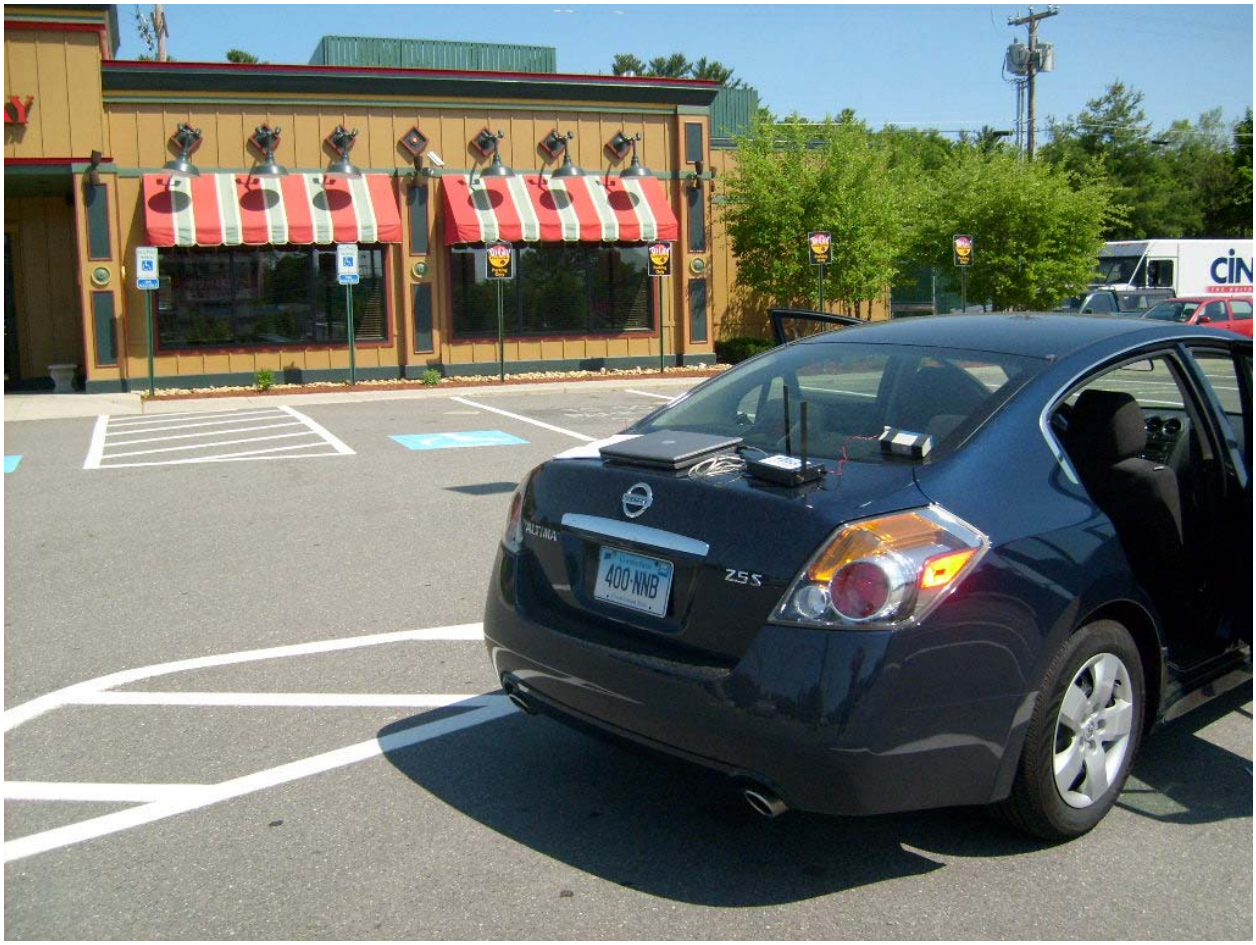
Site 6

Site 7_109 Daniel Webster Hwy.JPG

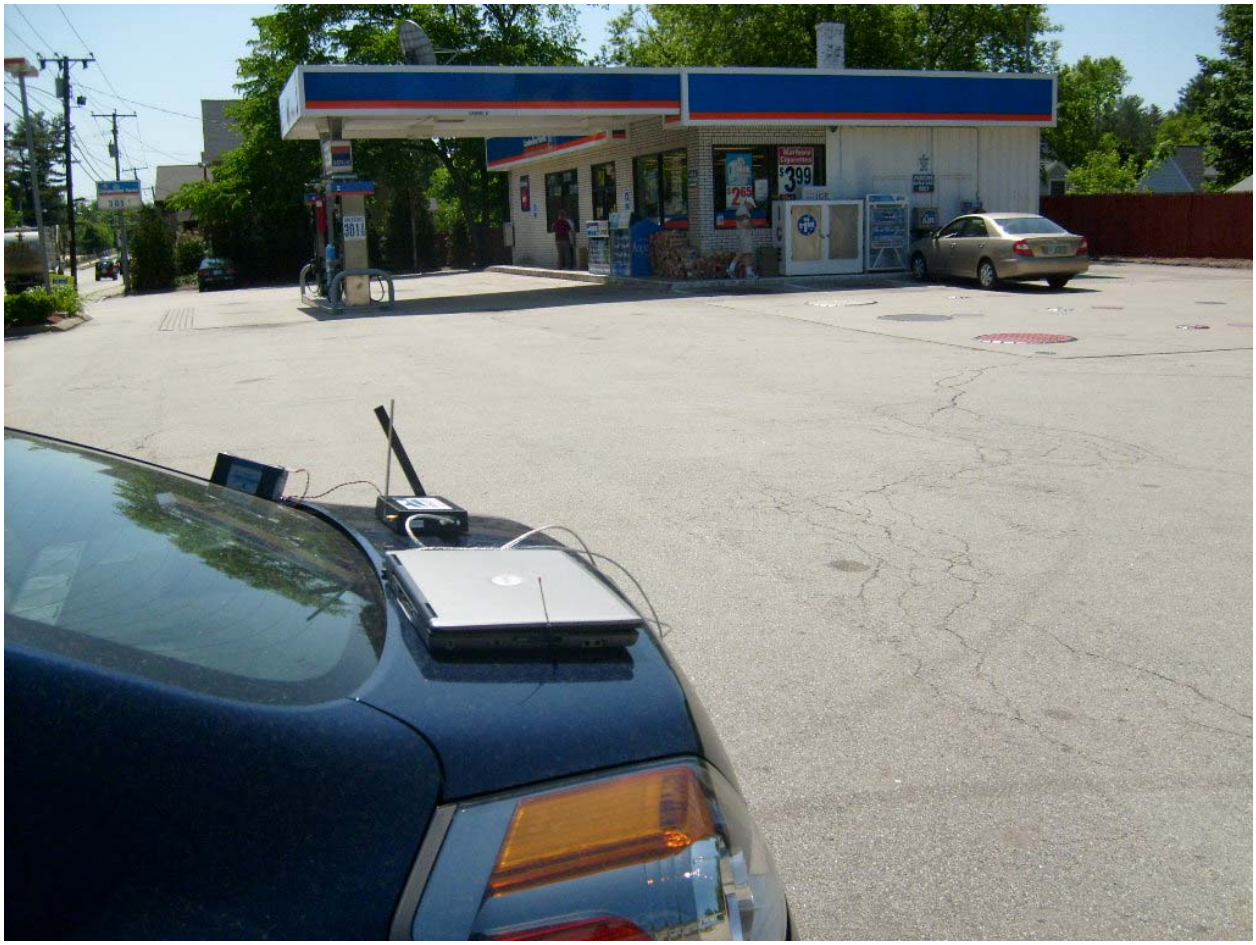
Site 7

Site 8_10 Saint Laurent St_05302007.JPG

Site 8



Site 9_275 Amhurst St_05302007.JPG
Site 9



Site 10_106 Amhurst_05302007.JPG

Site 10

Site 11_Corner of Concord St & Courland St_05302007.JPG

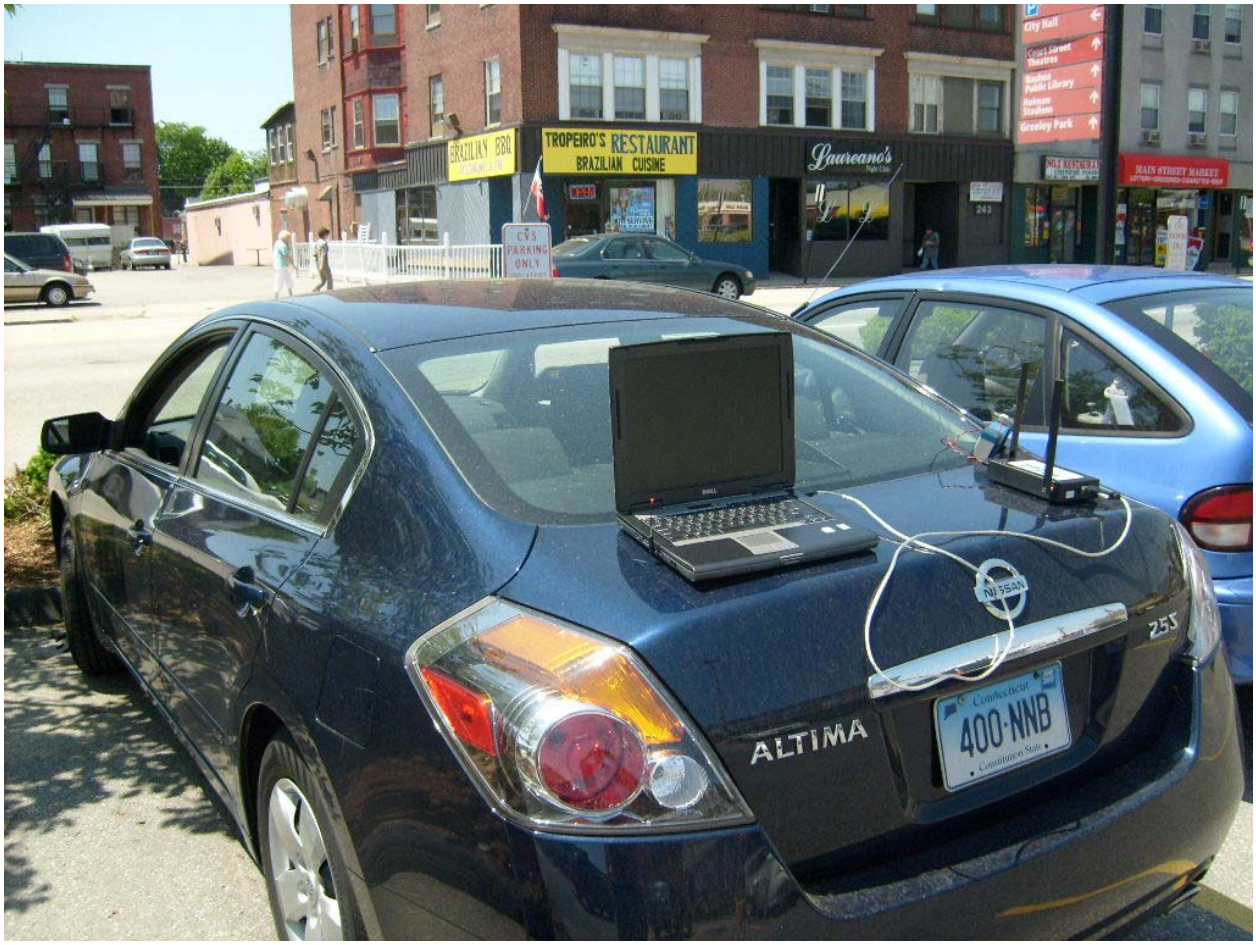
Site 11

Site 12_the park_ Atherton Ave_05302007.JPG

Site 12

Site 13_104 Canal St_05302007.JPG

Site 13



Site 14_254 Daniel Webster Hwy_05302007.JPG

Site 14

Site 15_Nashau Mall_05302007.JPG

Site 15

Site 16_Nashua Mall_Reference Point.JPG

Site 16

Site 16_Nashua Mall_Facility.JPG
Site 16

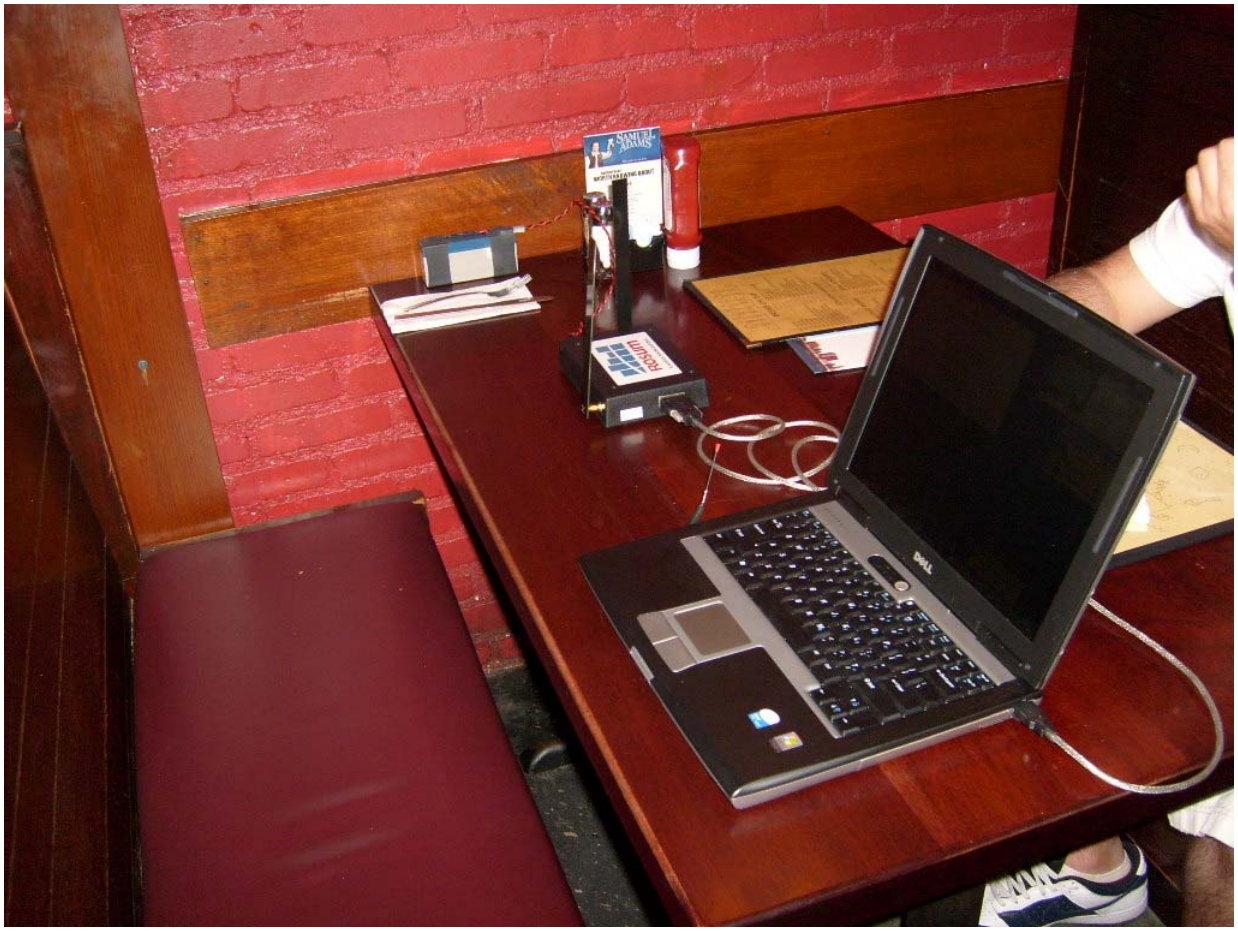
Site 16_Nashua Mall_Test Point.JPG

Site 16

Site 17_1667 Massachusetts Ave_5222007_Reference Point.JPG

Site 17

Site 17_1667 Massachusetts Ave_5222007_Facility.JPG
Site 17



Site 17_1667 Massachusetts Ave_5222007_Test Point.JPG

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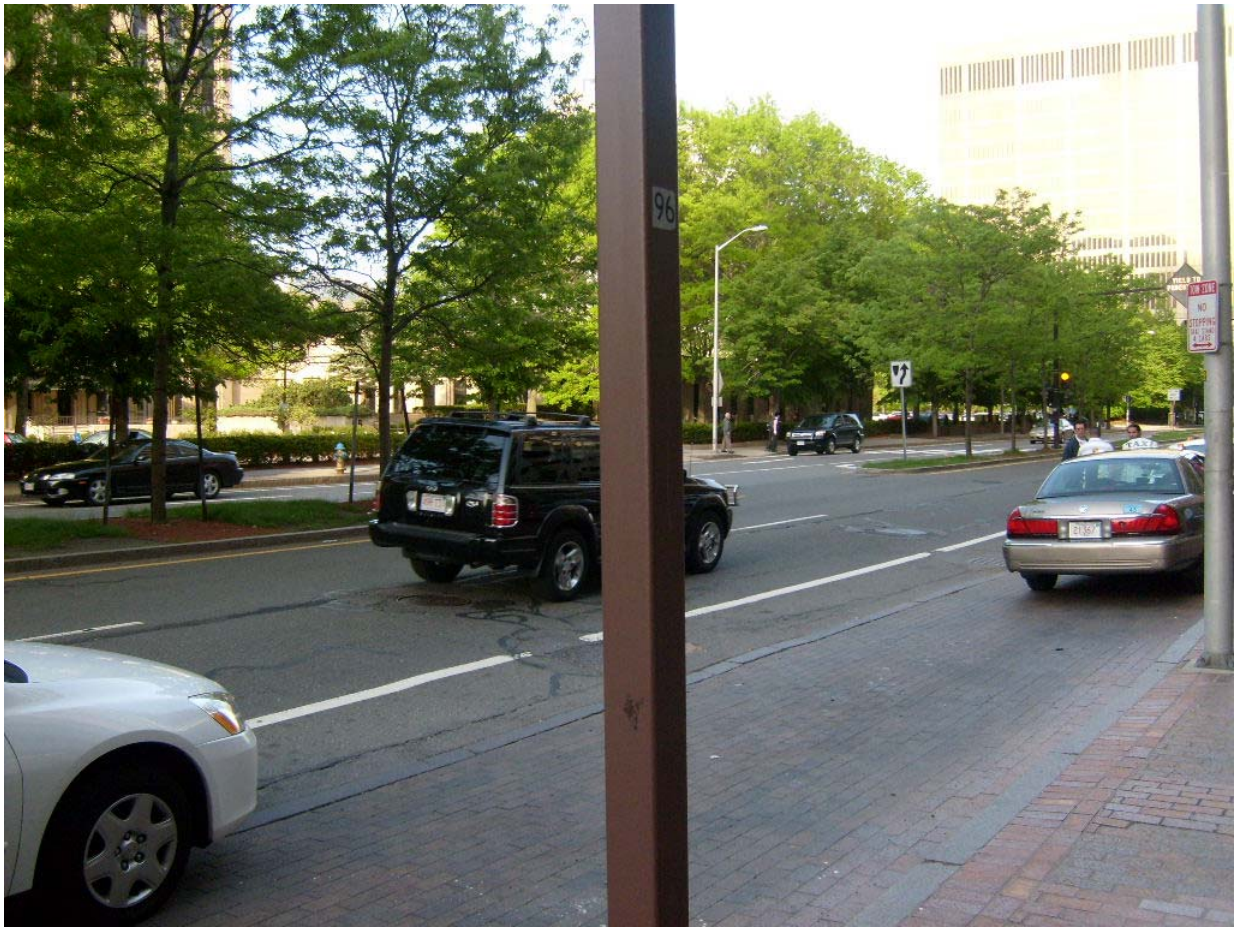

Site 18_55 Broadway St_5222007_Reference Point.JPG

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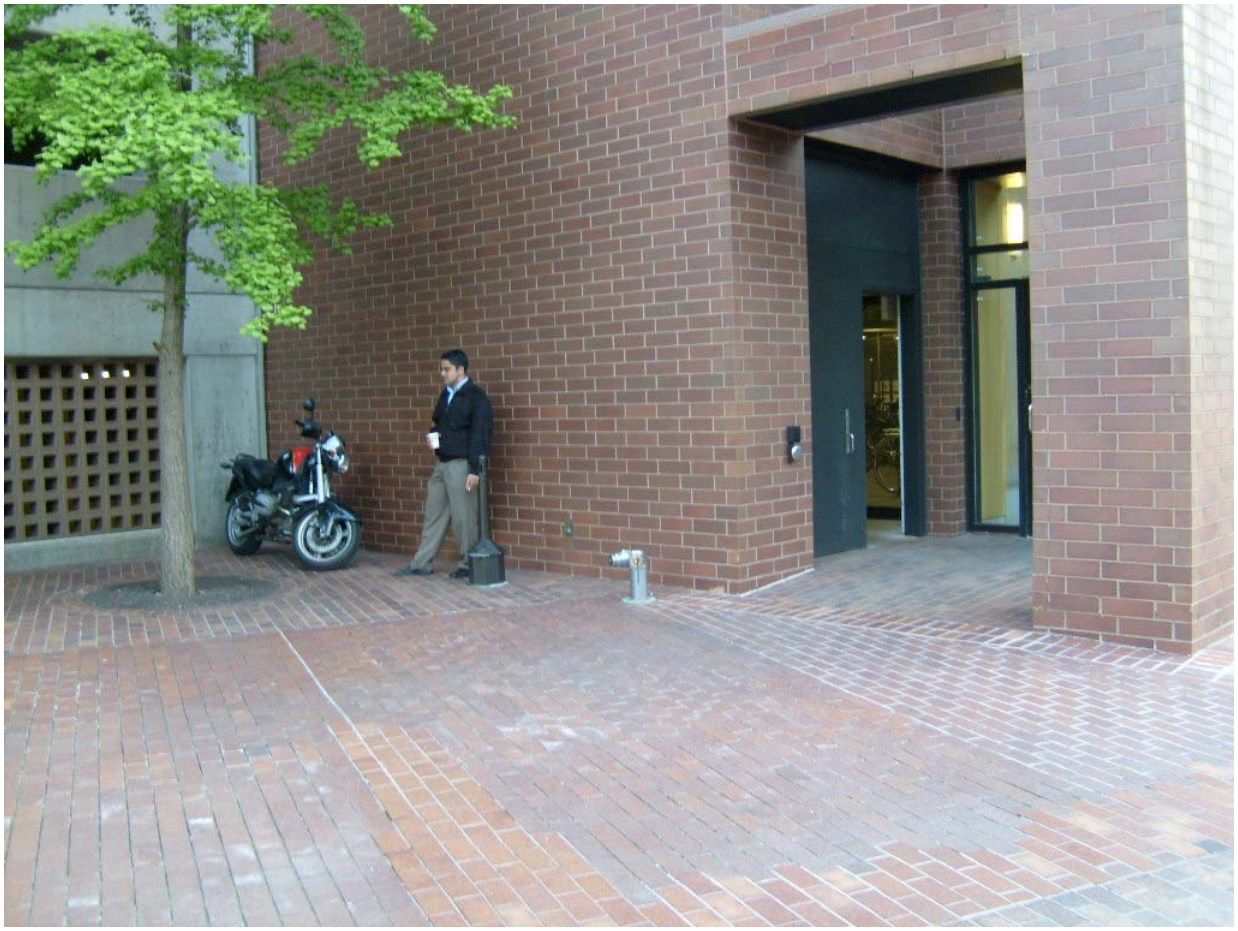
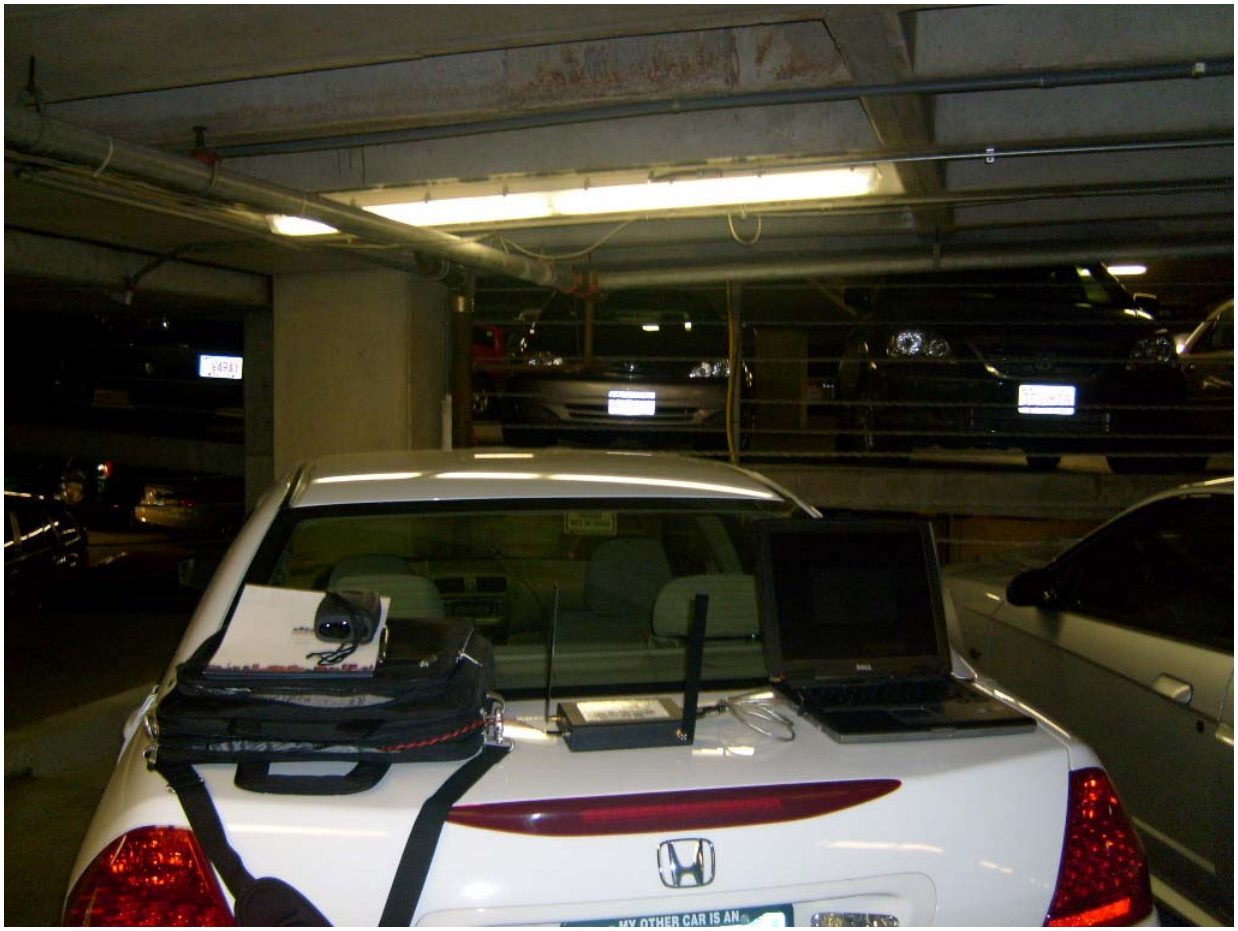


Site 18_55 Broadway St_5222007_Facility.JPG

Site 18



Site 18_55 Broadway St_5222007_Test Point.JPG

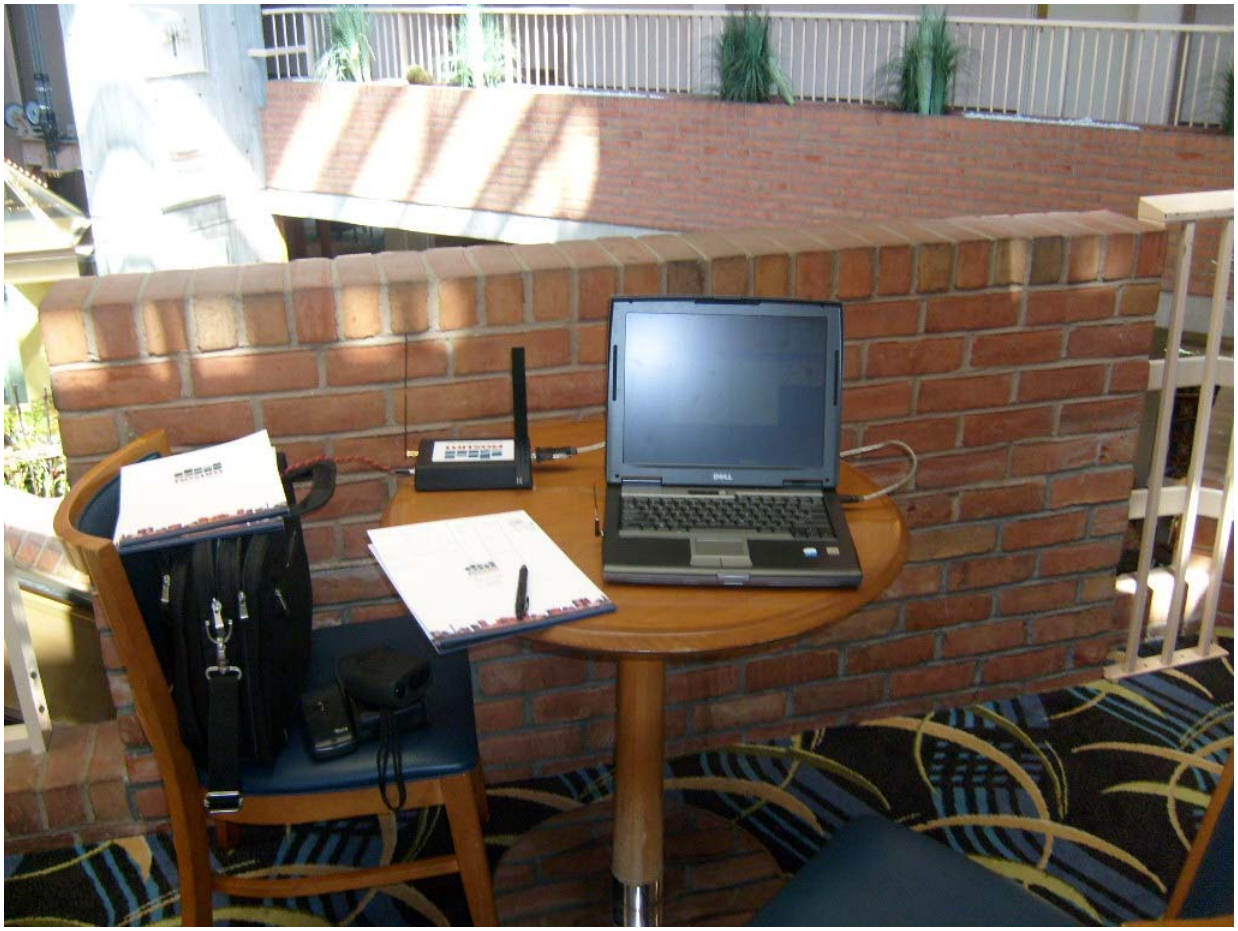
Site 18

Site 19_575 Memorial Dr_5222007_Reference Point.JPG

Site 19

Site 19_575 Memorial Dr_5222007_Facility.JPG

Site 19



1345 Coleman Rd_Test Point.jpg

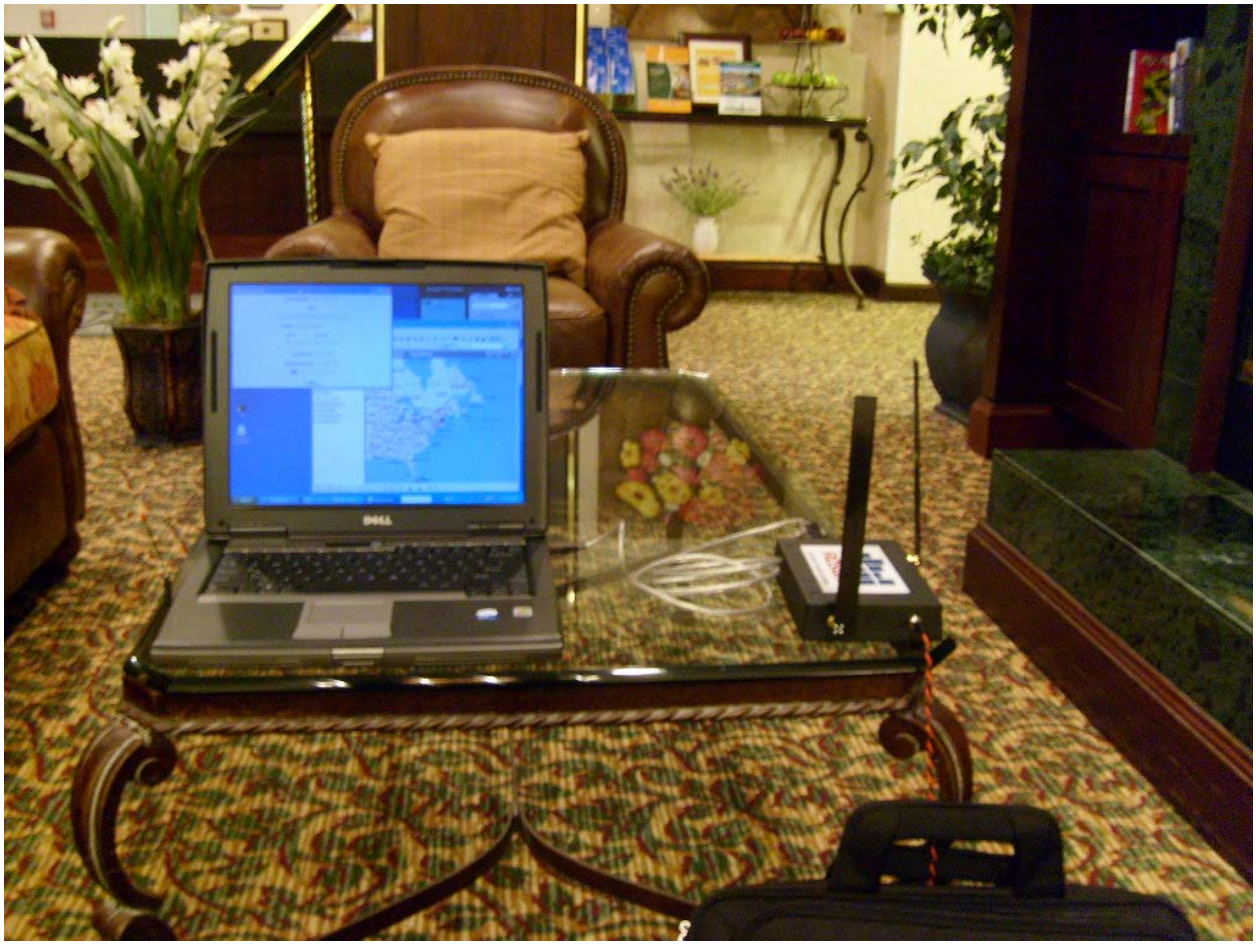
Site 19

Site 20_9_Northeastern_Reference Point.JPG

Site 20

Site 20_9_Northeastern_Facility.JPG

Site 20



Site 20_9_Northeastern_Test Point.JPG

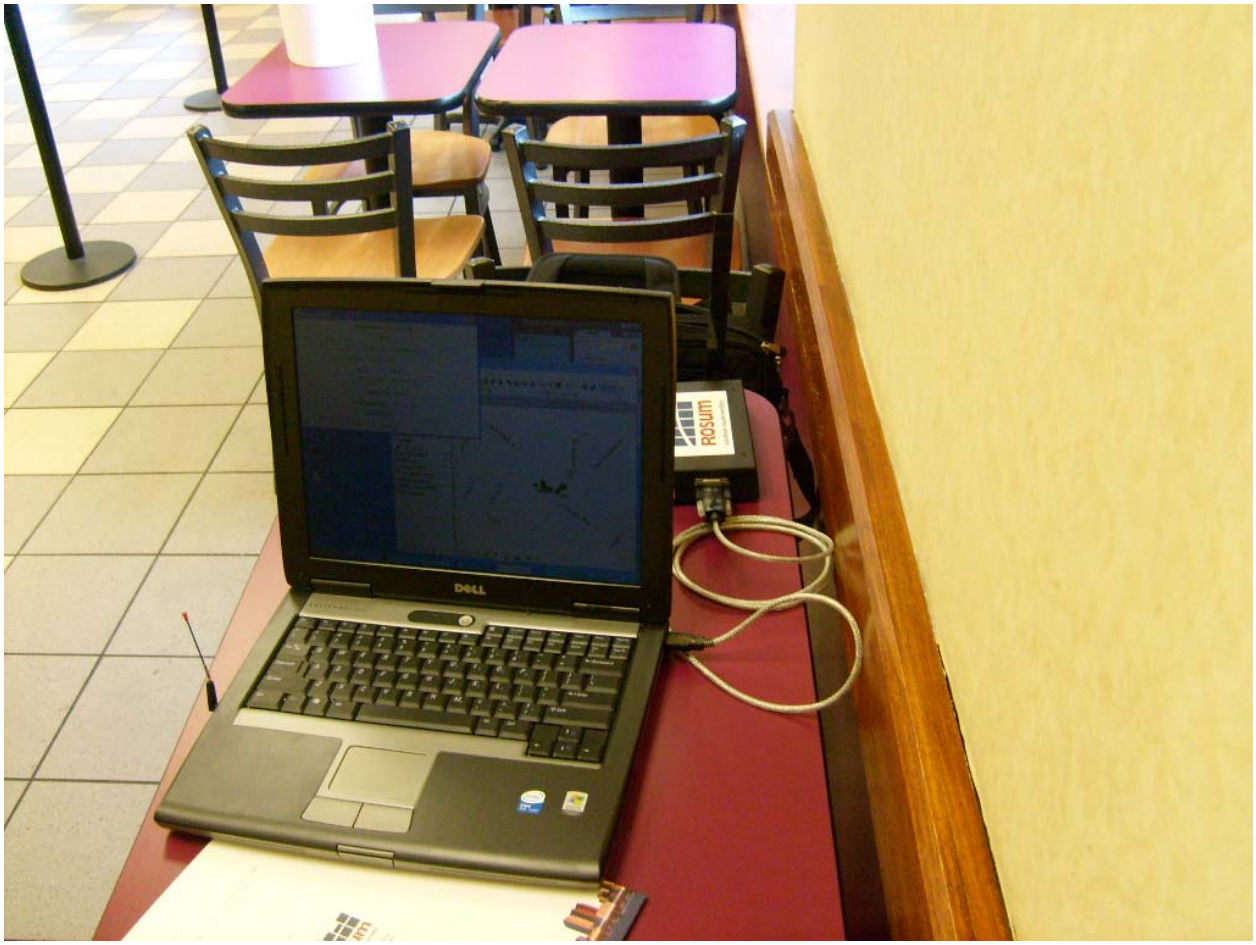
Site 20

Site 21_268 Main Dunstable Rd_Reference Point.JPG

Site 21

Site 21_268 Main Dunstable Rd_Facility.JPG

Site 21



Site 21_268 Main Dunstable Rd_Test Point.JPG

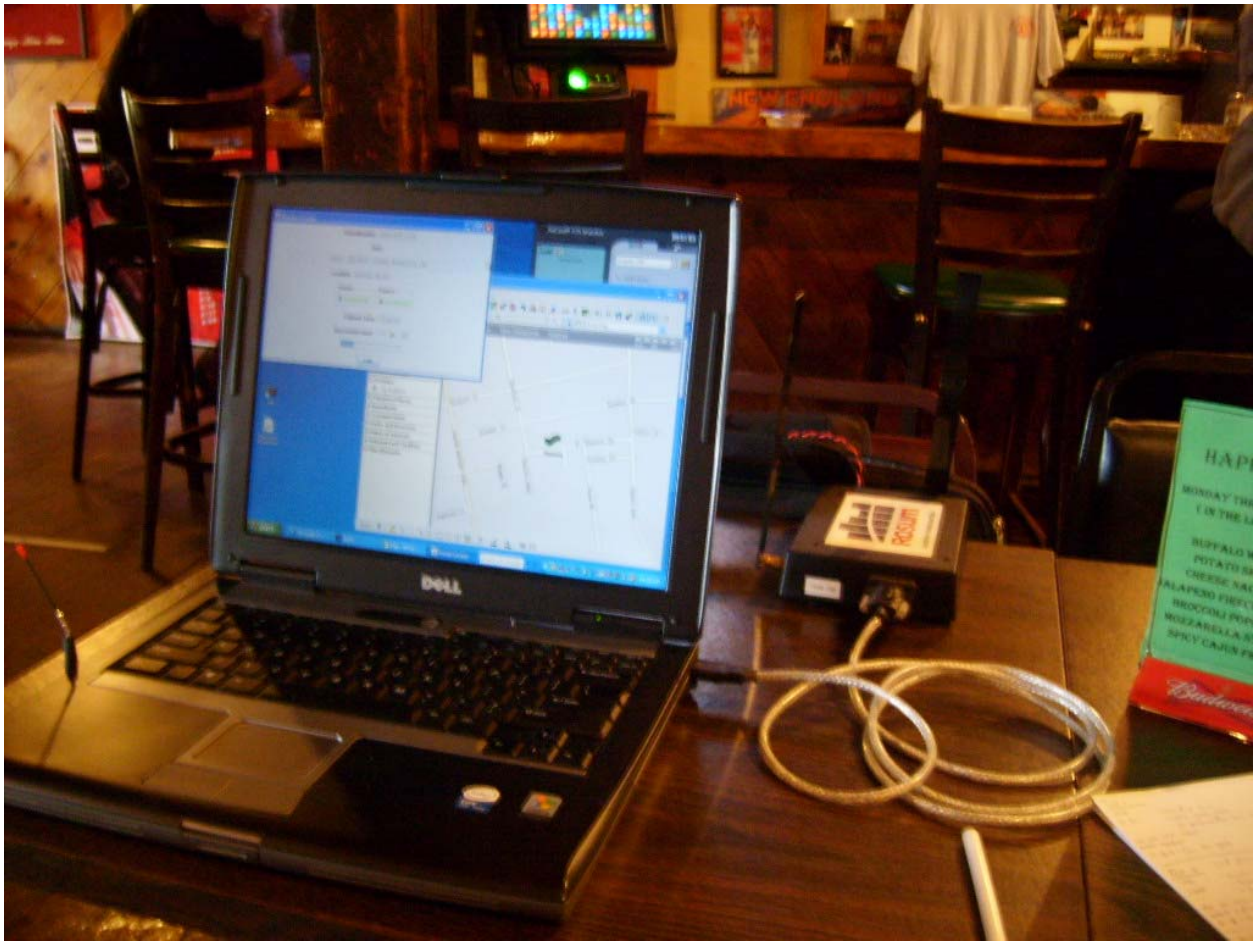
Site 21

Site 22_36 Otterman St_Reference Point.JPG

Site 22

Site 22_36 Otterman St_Facility.JPG

Site 22



Site 22_36 Otterman St_Test Point.JPG

Site 22

Site 23_Elm St Municipal parking garage_Reference Point.JPG

Site 23

Site 23_Elm St Municipal parking garage_Facility.JPG

Site 23

Site 23_Elm St Municipal parking garage_Test Point.JPG

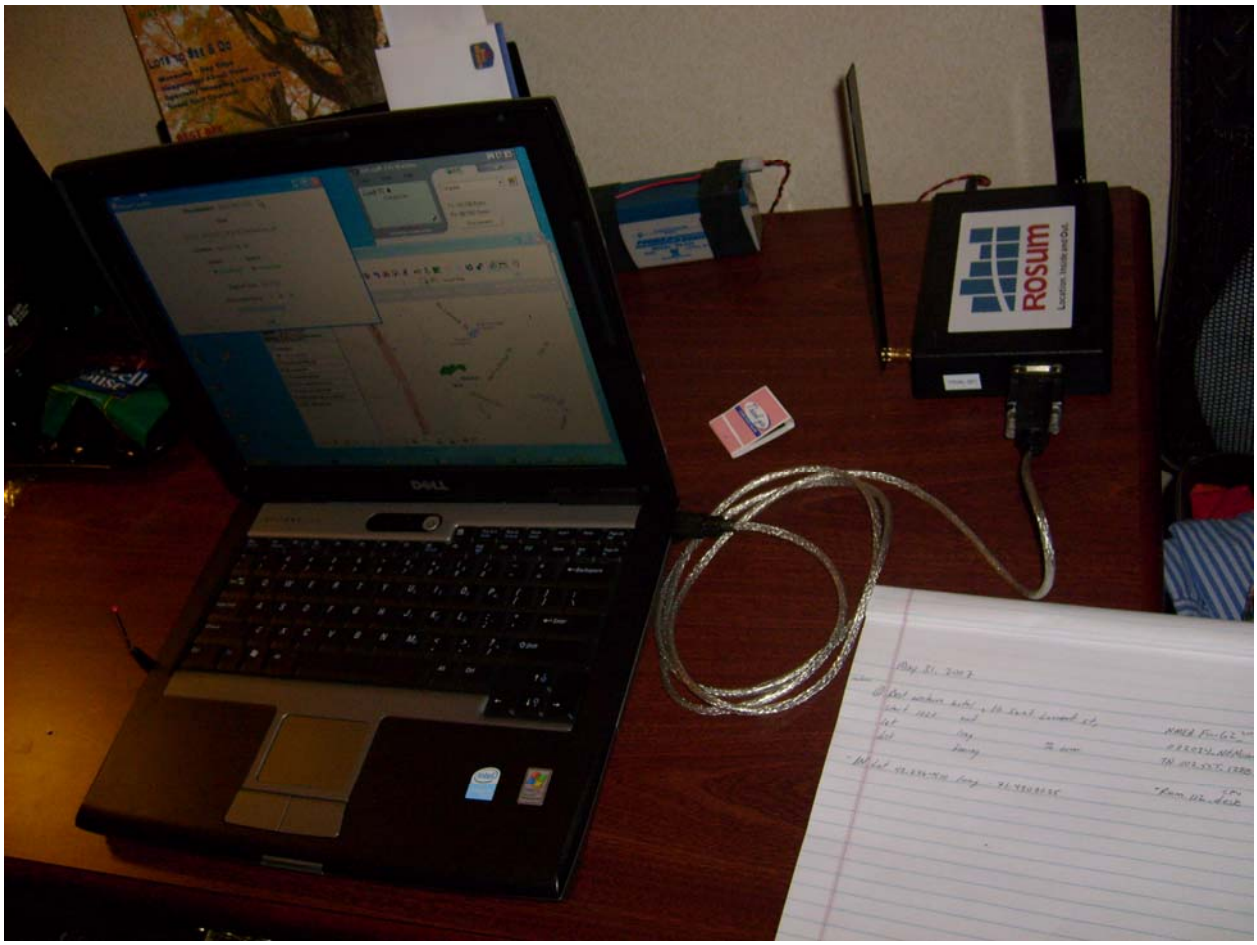
Site 23

Site 24_10 Saint Laurent St_05312007_Reference Point.JPG

Site 24

Site 24_10 Saint Laurent St_05312007_Facility.JPG

Site 24



Site 24_10 Saint Laurent St_05312007_Test Point.JPG

Site 24

Site 25_340 Amhurst St_05312007_Reference Point.JPG

Site 25

Site 25_340 Amhurst St_05312007_Facility.JPG

Site 25

Site 25_340 Amhurst St_05312007_Test Point.JPG

Site 25

Site 26_260 Amhurst st_05312007_Reference Point.JPG
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Site 26

Site 26_260 Amhurst St_05312007_Facility.JPG

Site 26

Site 26_260 Amhurst St_05312007_Test Point.JPG

Site 26

Site 27_23 Main St_05312007_Reference Point.JPG

Site 27

Site 27_23 Main St_05312007_Facility.JPG

Site 27

Site 27_23 Main St_05312007_Test Point.JPG

Site 27

Site 28_48 Main St_05312007_Refernce Point.JPG

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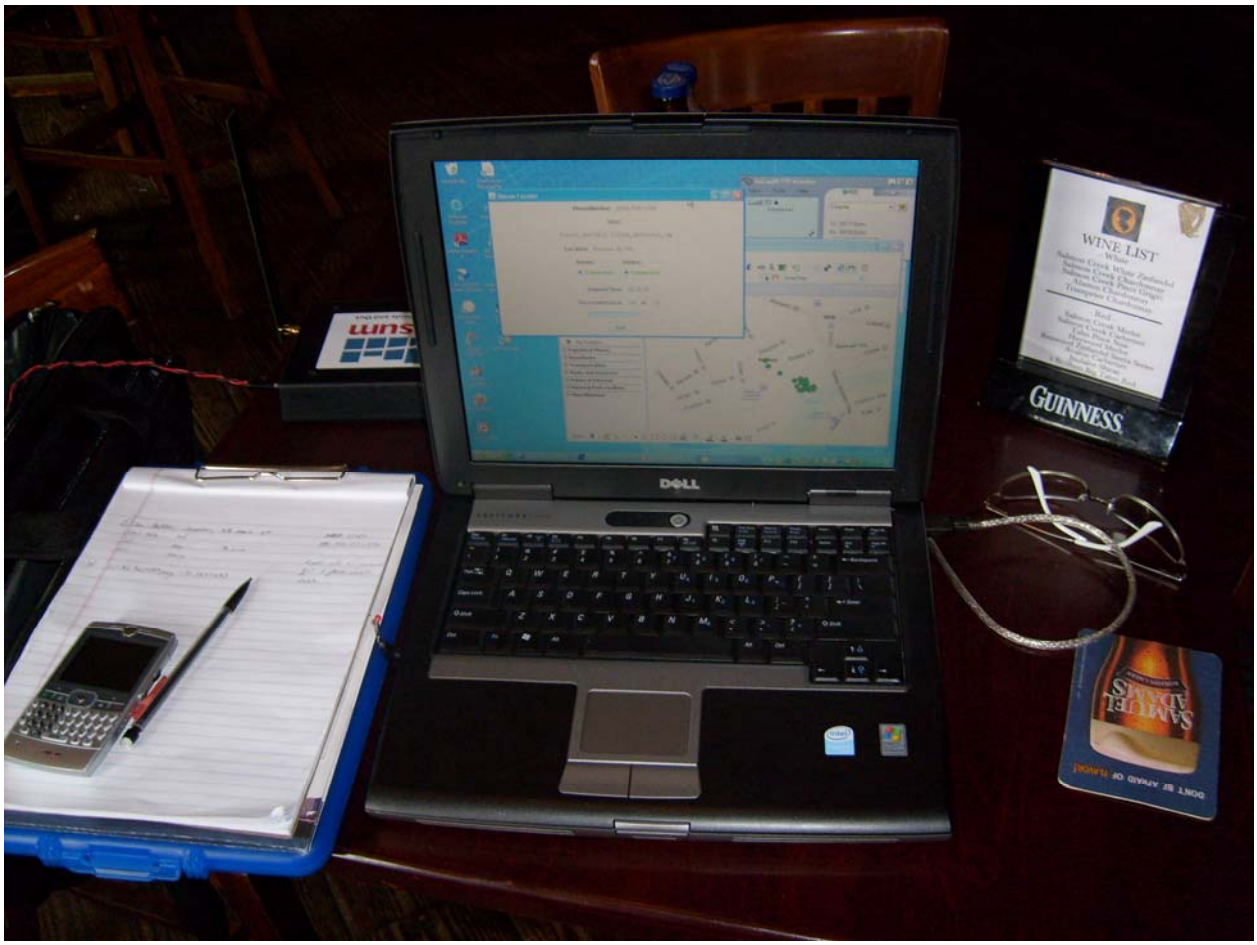
Site 28_48 Main St_05312007_Facility.JPG

Site 28



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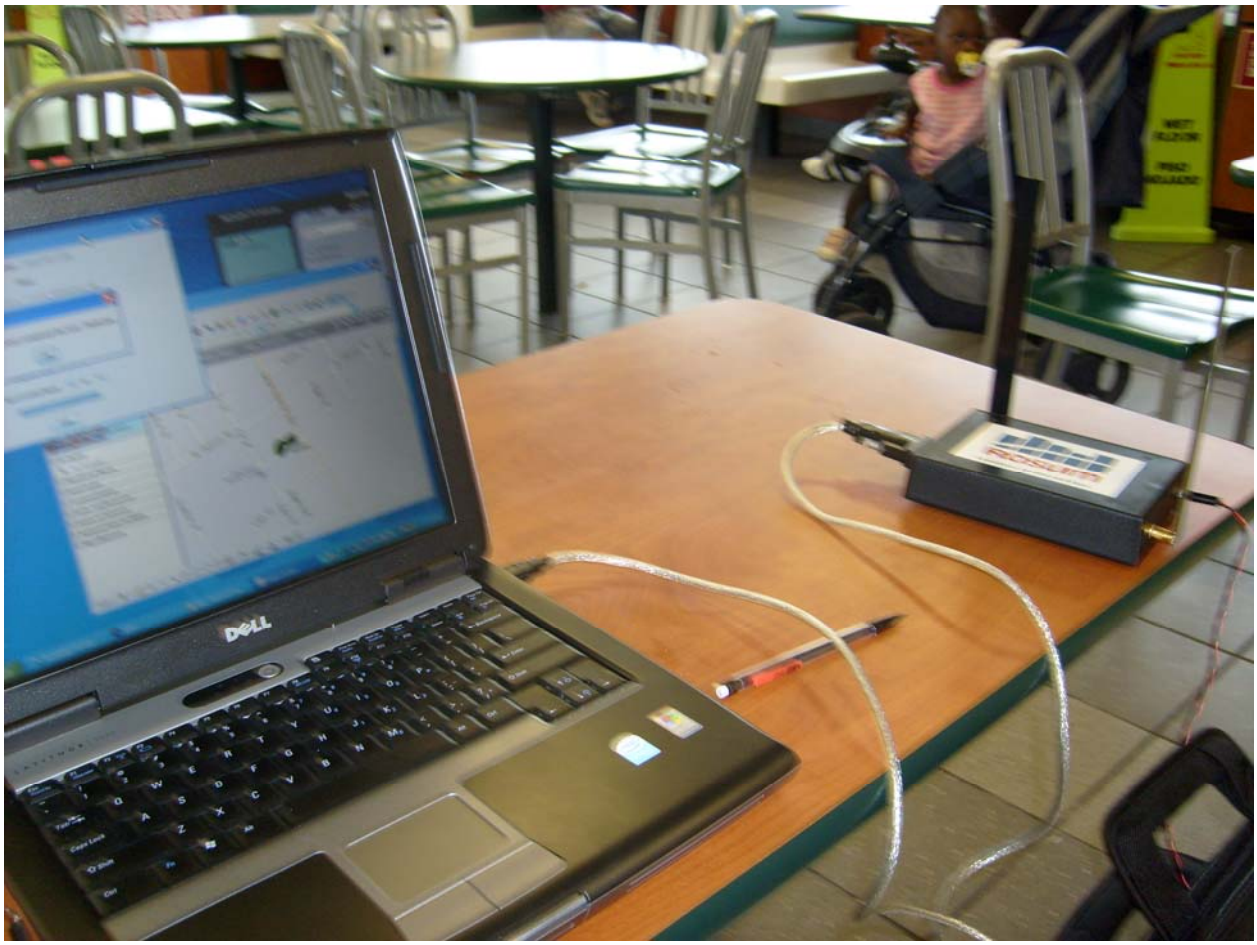
Site 29



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Site 29

Site 30_Elm St Municipal parking garage_Reference Point.JPG

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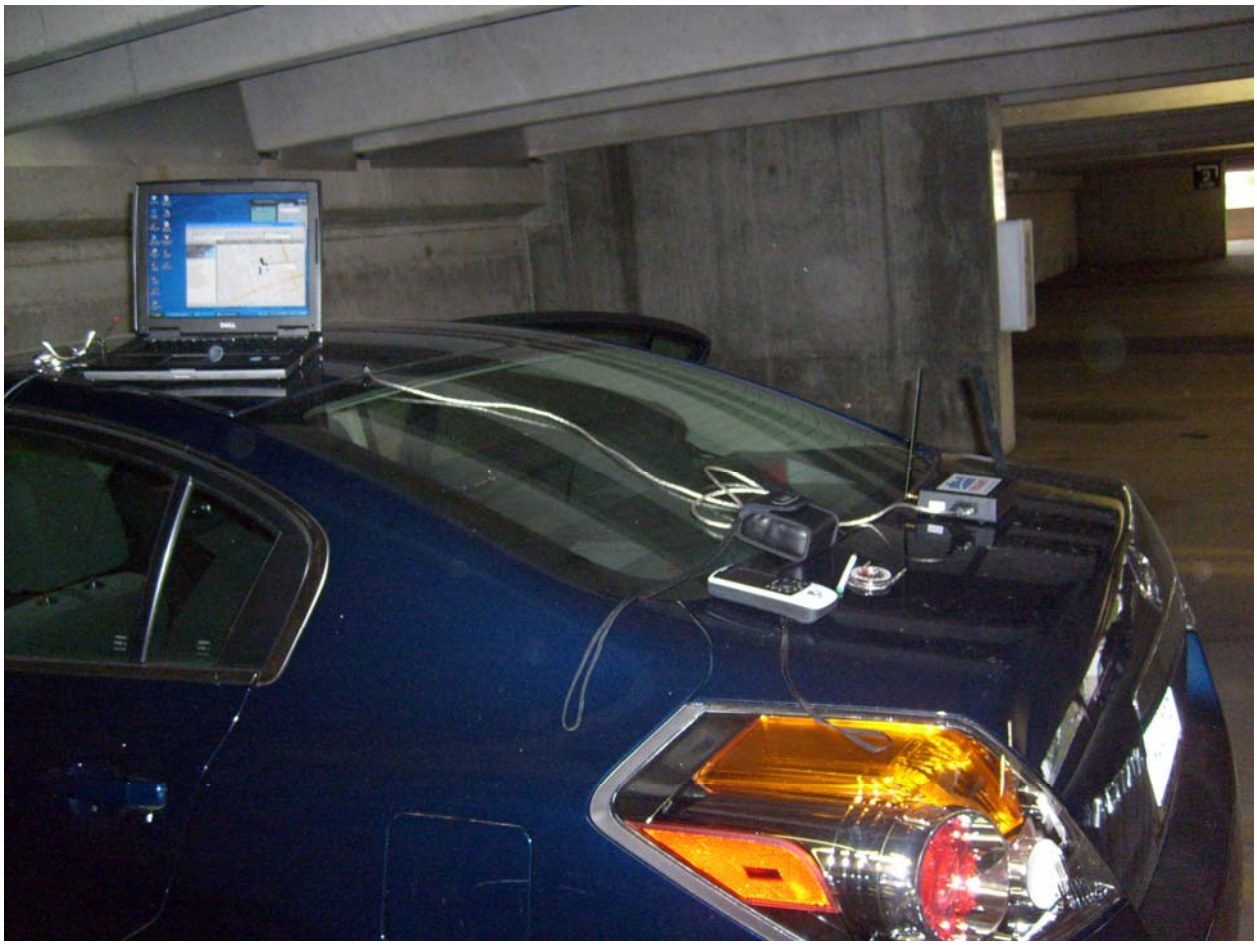
Site 30_Elm St Municipal parking garage_Facility.JPG

Site 30



Site 30_Elm St Municipal parking garage_Test Point.JPG

Site 30