7.0 TECHNICAL OUTPUTS
THE FINDINGS

7.1 QUANTITIVE DATA PHASE

Approximately 20,000 total wireless calls were logged between June 1, 1998 and November 30th of 1998. Of the 20,000 total calls, approximately 10,000 were developmental – of these calls, approximately 5,200 were calibration and exactly 4,870 were controlled. During this controlled phase, a test calibration procedure was developed and a special key sequence (9999) was used to identify those Automated Call Location Database (ACLD) logged calls within the test. The final data sets covered 92 distinct test locations and 4,870 controlled wireless calls. **Figure 7-1** provides a sample of the call control logs used in the trial.

The data collected was:

- Reported Latitude
- Reported Longitude
- GPS time of fix
- Type of Phone and system
- Location of call by benchmark
- Data Validity flag

Additional data logged at ACLD[1]:

- Record #
- Time of day call was made
- Day, date
- Real time SA error measured
- Real time correction values
- Number of "pings" to acquire the data
- Process time for the data exchange

Record #	Location ID	Phone	Latitude	Longitude
2734	91	11	4736.1233	12219.5862
2735	91	11	4736.1323	12219.5871
2736	73	13	4728.4733	12146.4372
2737	74	13	4728.3896	12146.4915

Corrected Latitude	Corrected Longitude	Latitude Correction	Longitude Correction	Time Stamp
4736.1038	12219.5976	0.0195	-0.0114	240
4736.1035	12219.5970	0.0288	-0.0099	309
4728.4771	12146.4542	-0.0038	-0.0170	80630
4728.4764	12146.4548	-0.0868	0.0367	750

Time	Date	Location Valid	Time	Pings
8/14/98 9:23	7/31/98 0:00	TRUE	2.00	1
8/14/98 9:25	7/31/98 0:00	TRUE	2.00	1
8/16/98 11:27	7/31/98 0:00	FALSE	2.00	1
8/16/98 11:38	7/31/98 0:00	TRUE	4.00	2

Figure 7-1. Sample Call Logs for Call Records 2734 - 2737

[1] Appendix E contains a larger population sample of this information.

During this data phase, data was collected across 6 environmentally diverse areas as follows:

- Downtown Seattle (Urban venue): 1,073 total calls
- Mercer Island, Washington (Suburban and Waterborne Venue): 1,533 total calls
- The Arboretum (Heavily Forested – Rural venue): 452 total calls
- North Bend, Washington (Rural venue): 1,136 total calls
- Snoqualmie Pass (Mountainous venue): 161 total calls
- Washington Department of Transportation monuments (Highway venue): 515 total calls
- **Total of 4,870 calls**

For the trial, 10 different wireless handsets were used across four air interfaces (AMPS, NAMPS, CDMA, and iDEN), with both digital and analog modes utilized when available from that specific carrier.

7.2 QUALITATIVE DATA PHASE

IDC conducted 109 test calls in actual Public Safety Answering Point (PSAP) environment – with existing equipment modified with IDC technology. IDC sent out test personnel into a variety of areas and environments, totally unknown to the call taker. Calls were then made to the call taker, and results were tallied. Of the 109 calls:

- **105 (96.3%)** of the calls were mapped at the call taker station.
- **101 (96%)** were found to within the FCC Phase III requirement of 406 feet.
- **69 (65.7%)** were found to within 100 feet of the actual location.

This test proved the viability of IDC's technology within an actual PSAP call taker station. It also proved (in addition to the quantitative phase) that IDC's technology can consistently exceed the FCC requirement (FCC: 406 ft., 67% of the time vs. King County: 406ft., 96% of the time). *Moreover, over 1/3 of the calls during this phase were made within difficult urban canyon calling environments – often the most challenging for GPS-supported, location-based systems.*

During this actual PSAP test, below are actual, verbatim excerpts were recorded from King County, Washington user reaction to the functionality of the system (with some suggested enhancements). These unabridged comments clearly demonstrate that the Public Safety user understands what information is immediately helpful for effective dispatching of emergency services.

- "Amazing"
- "Very cool. Could use a displayed direction indication on each location request."
- "Very nice. Could use a N-S-E-W display overlaid on the actual map"
- "Would like to see actual directions (N-S-E-W) on the map and a more detailed map."
- "A reference scale – e.g. 1" = 1000 feet – would be helpful"

- "Would like to see a more detailed map"
- "Color of the first circle of location different from the most current/last circle of location".

It should be noted that these anecdotal and unabridged reactions are predominantly focused on direction, which is not a FCC Phase II requirement (but is clearly needed by the PSAP). IDC was able to provide 8 "directionals" in its user interface implementation to help the dispatch user. This directional information is an additional need of this specific group of PSAPs. Mapping suggestions will be made part of the further enhancements to the IDC technology in future system releases.

7.3 DYNAMIC ROUTING PHASE

As part of those performance requirements set forth by Marlys Davis, King County's E-911 Program Manager, a handset-based solution is to be capable of selectively routing a call to a destination PSAP based upon the caller's location. This dynamic routing test took place at the end of the trial period. A caller's location is to be reported to a network-based, Phase I routing service. The routing service would then apply the location data to a geo-database query, which would then return an upgraded (from Phase I) PSAP routing number. The routing numbers were assigned to jurisdictional regions and boundaries, which were drawn up based on statistical data from King County call centers. Boundary criteria addressed issues such as volume vs. location, call transfers to presiding jurisdiction, and call congestion management. The jurisdictions were divided into four major geographic regions: Downtown Seattle, Mercer Island, North Bend, and Snoqualmie Pass. Each region represented a variety of demanding geographic and environmental challenges. The regions were assigned the following jurisdictional assignments:

- **Downtown Seattle** is an "Urban Canyon" environment, and represents the most challenging test for any wireless E-911 technology. This region was routed to Seattle Police Department in both default Phase 1 routes, and Phase II determinations where the caller's position was reported within the region.

- **Mercer Island** is a "Suburban" environment, and is predominately characterized by low-level commercial structures, residential housing, and light to moderate foliage canopy. This region was routed to King County Sheriff's Office in both Phase I and Phase II tests.

- **North Bend** is a "Rural" environment, having very few commercial-type structures, and widely scattered clusters of residential housing. Roads may not be well marked, and landmarks tend to be hard to find and provide little help in establishing a frame of reference for a location. Foliage can range from non-existent to heavy canopy (multi-layered, or >75% sky coverage). This region was routed to the Washington State Patrol (WSP) for Phase I and Phase II tests.

- **Snoqualmie Pass** is a "Mountainous" environment, characterized by few, if any, commercial and residential structures. Roads are scarce and tend to be poorly marked. Landmarks are only discernable by identification of major geographic features (i.e. Pass names, mountain names, rivers, etc.), and only then if the names are known by the caller. Emergency response to this region can be measured in minutes, hours, or even days (depending on terrain, environmental conditions, and season). This region was routed to WSP for Phase I and Phase II tests.

Within each major geographic jurisdiction, a sub-jurisdiction boundary was defined to distinguish calls originating from Interstates 5 and 90 (Washington State Police or WSP jurisdiction); from calls originating within a regional jurisdiction (Downtown Seattle: Seattle Police Department or SPD), or Mercer Island: (King County Sheriff's Office or KCS), excluding North Bend and Snoqualmie Pass. All calls whose location fell within the sub-jurisdiction boundaries were routed to Washington State Patrol; calls outside of these boundaries were routed to the appropriate regional PSAP.

Appendix G, Figures G-1 through G-3, documents actual calls routed correctly to the WSP's PSAP based upon the caller's location falling within the bounds of WSP's jurisdictional boundary. The logs were recorded on November 10, 1998 on Interstate 5 in the downtown Seattle regional jurisdiction. Topography found in this series varies from open freeway in the lower three, to multi-story, overhead, and concrete structures in the upper two boundaries. Multiple passes were taken over a two-hour period, both inside and outside of the I-5 boundaries. In all cases where the caller's location was reported within the WSP boundary, the correct routing of the call to Washington State Patrol resulted. In all cases where the caller's location was reported outside the WSP jurisdictional boundary, the call correctly routed to the regional jurisdiction.

Because the jurisdictional boundaries are fixed reference points (see Appendix G, Figure G-1 - "WSP Boundaries") in the routing equation, it is imperative that the geo-reference data sets have been validated for accuracy and corrected of errors. The process of "rubber sheeting" uses field reference data, which has been corrected via post-processing, to match geo-reference data against "real world" data. Key points are precisely matched between the two data sources. The remaining points in the geo-reference data are then interpolated on the matched points, therefore skewing the erroneous data to closely reflect the "real world". The ideal solution to the issue of erroneous geo-reference files is to map the entire region of interest using the field reference data. This task, though impractical for trial purposes, will prove to be a key factor in the success of any wireless E-911 solution.

It was observed on numerous occasions that the caller's location was 25 feet inside of the jurisdictional boundary. *(Note: see Appendix G, Figure G-3, which validates the correct P-ANI. In this case, the call was released to SPD).* In some instances, the caller's location was within 50 feet of the centerline of an overhead city street; however, placement within the WSP boundaries ensured the call was routed to the correct PSAP.

In every test call using the Proctor Cell-Link for the routing test, calls were routed to the appropriate PSAP.

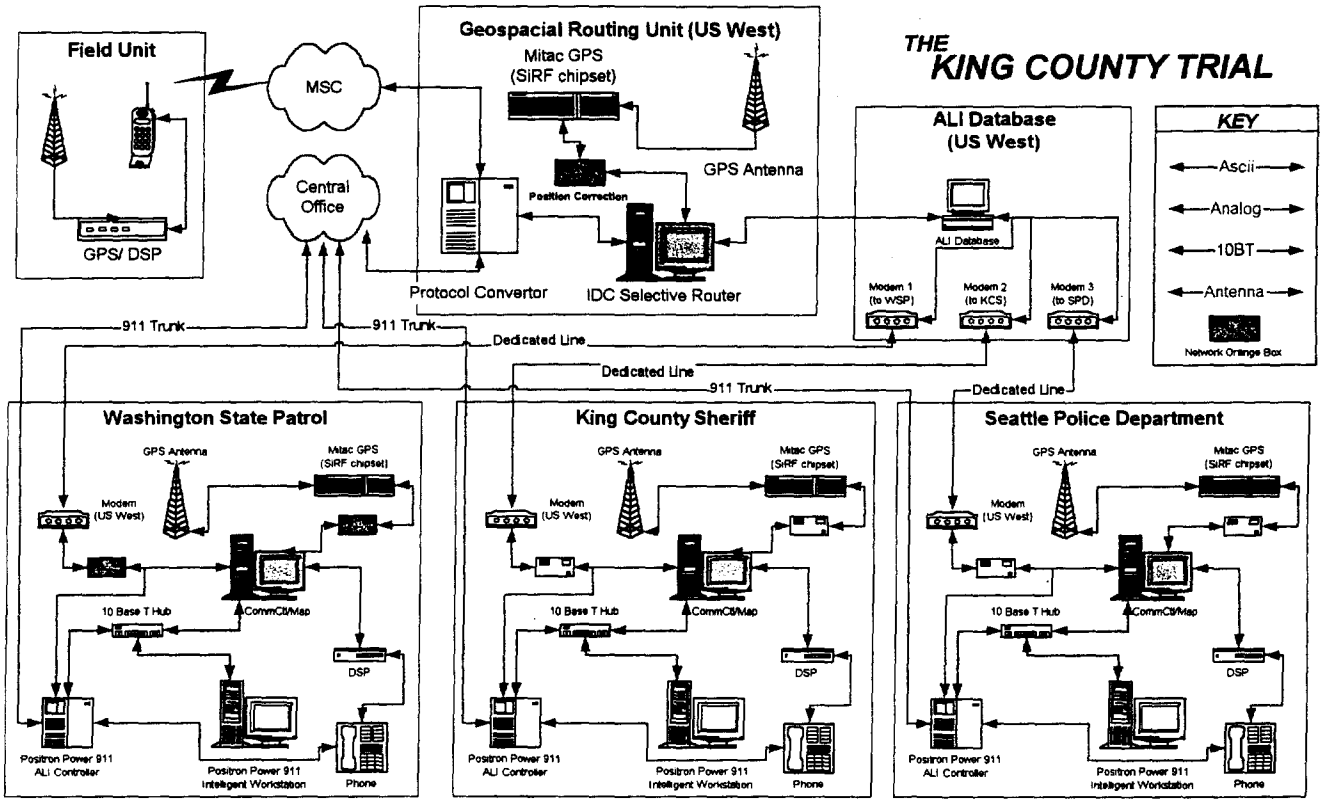


Figure 7-2 Component Representation of the King County Washington E911 Trial

7.4 NETWORK MONITORING

IDC deployed a network monitoring system for use during the trial (see **Figure 7-2** above). The system deployed was the Network Orange p/TAM Analyzer which is a remotely controlled "probe" that was installed at all three PSAPs by US West. US West was responsible for the maintenance of customer premise equipment (CPE) and the circuits carrying voice and data to the PSAP.

The p/TAM Analyzer monitors and records Automatic Location Identifier (ALI) and Computer-Aided Dispatch (CAD) data, and is used to control various vendors' ANI/ALI controllers. It is also used to monitor discrete alarms from Uninterrupted Power Supplies (UPS's), printers, doors, etc.

When the p/TAM Analyzer detects protocol or data problems on the ALI links, it generates alarms that are reported to the service provider's control center. Technicians can then connect to the Analyzer, examine the data in real time, and review events associated with the alarm. Often, the condition causing the alarm can be resolved by the control center technician without dispatching a field technician.

The Network Orange Manta Server, located at the control center (US West Labs), receives alarms from the p/TAM Analyzers and allows multiple technicians to access the database of reported alarms. Technicians can establish real-time connections to the p/TAM Analyzers.

7.5 BETA PHASES

7.5.1 Description

The test apparatus contained two (2) elements: 1) The Global Positioning System (GPS) receiver, and 2) the Automated Call Location Database (ACLD). Three (3) GPS receivers were deployed during the trial. However, only one was used throughout the data collection phase. This receiver was the SiRF Technology-based Mitac receiver.

The ACLD deployed during the trial was constantly improved throughout the course of the testing – from version 1 to version 5. The last revision was deployed on August 14th, 1998, and was used for the balance of the test period. This version corrected several errors discovered during the logging phase. The Beta nomenclature 1.5 represented GPS receiver 1/ACLD version 5, and Beta 3.5 represented GPS receiver 3/ACLD version 5.

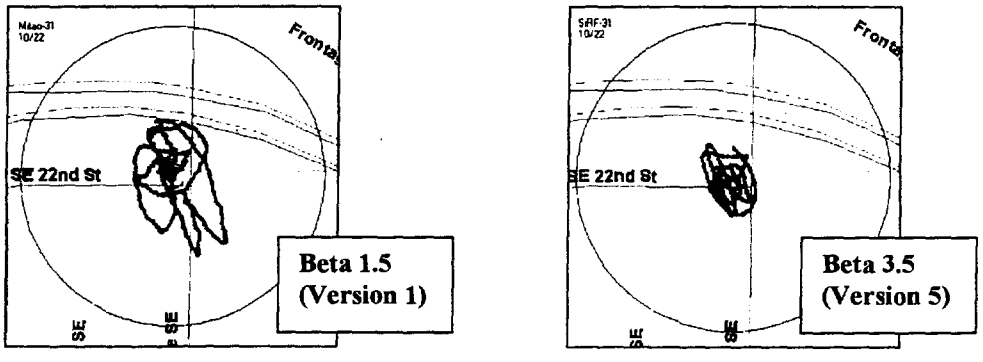


Figure 7-3 SiRF Technology chip set accuracy improvement

7.5.2 GPS Improvements

The trial participants observed a continuous improvement and evolution in GPS product from SiRF Technology. In "side by side" testing, Version 1.5 against Version 3.5 demonstrated a 245% increase in accuracy (see **Figure 7-3** above). IDC expects to test with SiRF Technology's Beta 4.6 against the trial baseline, in similar "side-by-side" studies, during the first half of 1999.

7.6 UNOFFICIAL PARTICIPANTS IN THE STUDY: AT&T WIRELESS SERVICS AND SPRINT PCS

One of the major goals of this study was to test as many air interface protocols as possible, as well as cellular phone handset models. The simple nature of IDC's solution allows for a Phase II implementation with minimum impact on the wireless carriers infrastructure. Drawing "unofficial" participants into the Study was necessary – and these participants were highly willing team players.

AT&T Wireless Services offered IDC the chance to study the TDMA environment, dual band service, as well as the NOKIA handset. The phone model used was the NOKIA 2160 and 6160. These were purchased over the counter, activated and put into the Study group with the Study phones. The NOKIA in digital and analog mode performed well. It was later discovered that the TDMA and iDEN have similar characteristics (as iDEN is a TDMA-like format), and the NOKIA performed much like the Motorola i600 iDEN phone from Nextel Communications.

While the study included two other CDMA participants, a Sprint PCS SONY phone purchased over the counter was added to the trial set. Again, no modification to the Sprint PCS (CDMA) network was needed.

7.7 ROAMING DIGITAL TO ANALOG

On a TDMA NOKIA 2160, a call was placed to a call taker from a static location. The position was transmitted and the location mapped. After the call was terminated, the same phone was manually "locked" into the analog mode. With no change to the GPS controller a call was placed to the call taker and the location was requested and transmitted. Again the caller was mapped. This procedure was repeated numerous times with an Ericsson DF388 and NOKIA 2180 CDMA. The results were the same. IDC proved that GPS can work flexibly and dynamically with dual-mode phones.

7.8 ENTERING A BUILDING

A large building was identified in downtown Seattle. A call was placed from the outside of the building and the caller was accurately located and mapped. After the call was terminated, the caller entered the building and placed the call again. The GPS sent an invalid data flag and reported the position of the front door of the building, north side. The procedure was repeated on all sides of the building. The results were the same in each instance. It is assumed that finding the front door of a building is at least equal to receiving a static ALI address for the same front door.

7.9 GPS IN STRUCTURES

One of the major issues with GPS-based solutions is the acquisition of satellite signals in buildings, tunnels, overpasses, and other structures. Expectations at the outset were very low for the acquisition of GPS signals in these areas for the study.
However, additional testing of a SiRF Technology receiver with an extended "Weak Signal" processing may demonstrate a significant indoor capability. This testing is beyond the scope

of this Study but will be conducted in the first half of 1999 against the established trial baseline.

7.10 DISCOVERY/ANOMALIES/GENERAL COMMENTS

7.10.1 Inner City Canyons And Multipath GPS

IDC experienced a high frequency of reflected GPS signals while in the canyons of the inner city. These reflections are attributed to the structures. Although the deflections failed to acquire the needed 40 foot King County requirement, it did meet the FCC Phase II requirement of 406 feet. The calling distribution for downtown Seattle in Figure 7-7 of Section 7 demonstrates the accuracies achieved in this challenging venue.

7.10.2 Parking Structures With Repeaters

IDC implemented WR's GPS repeaters into a multi-level concrete parking structure of Seattle's inner city. Within close proximity to the repeater, the signal acquisition was excellent – acquisition in the middle of the structure was also very good. As a test caller moved towards the outer edge of the structure (near windows or other open areas), the free GPS signals interfered with the interior repeater GPS, thereby decreasing the overall accuracy. While the 40-foot accuracy goal was not met (100-ft accuracy was made over 50% of the time in this instance), the 406-foot FCC requirement was still attained.

7.10.3 High - Gain Antennas

The use of high-gain antennas made a large difference in acquisition in most environments, except in the inner city canyons, under bridges, and inside tunnels. These were also areas that experienced low cellular signals, resulting in marginal to non-existent call paths available to send a call to the call taker's station.

7.10.4 Underpass Deflection

It is assumed that GPS signals bounced as a function of the system geometry. These signals were not received well and contributed to a smaller percentage of acquisitions. However, by buffering[2] the last good fix, the call taker knew the call was in the vicinity of the overpass.

7.10.5 GPS With No Cellular Coverage

On occasion (in buildings, etc.), cellular coverage was either poor or non-existent in the test area. In these cases, IDC was not able to transmit the location data. This was not restricted to a single carrier, but rather to all wireless systems. Ubiquitous coverage has not been achieved by any wireless carrier, and is a major issue for handset-based or network-based location technologies.

[2] As part of the control system architecture, IDC incorporated an external logic at the GPS where the last good fix was buffered and not over written by an invalid data string. This later proved to be valuable for the call taker, in the sample data set above, note the 5 digit time stamp and the validity flag. This information was presented to the call taker as part of the confidence algorithm as well as notification to the call taker the location data was not valid.

7.10.6 Time Continuous When GPS Stops Acquiring Data

During the trial, IDC observed that the time stamp of the cellular call to the PSAP continued, when GPS signal did not. This was the case when the caller would pass through long tunnels that have been re-radiated with wireless signals for specific carriers. The ACLD version corrected this anomaly by not applying correction to data that had an invalid time stamp.

7.10.7 Speed Over Ground Error

Speed over ground error was found to be the result of speedometer error due to improper calibration or incorrect tire sizing. There will always be a variable between the vehicle speedometer and the GPS. It is assumed that GPS will be the most accurate of the two.

7.11 GPS ERROR

There are several types of errors that must be processed when obtaining and using GPS data. The following section discusses these errors, and the process that is used to correct and/or minimize them.

7.11.1 Built-In Error (Selective Availability)

The government has a built-in error (Selective Availability) that makes extracting data difficult without utilizing some correction factor (e.g. Differential GPS, or DGPS). DGPS is used in surveying and draws data from a fixed position (e.g. Coast Guard Buoy or other reference receiver). IDC created a protocol which uses the information from a known position on a second GPS receiver. The correction increased the percentage of caller locations that fell within the King County, WA requirement.

7.11.2 Atmospheric Error

A natural phenomenon can occur in the upper atmosphere which can attenuate GPS signals. Although these appear to have a minimal effect on the data, they probably incrementally induced additional error for a small percentage of locations.

7.11.3 Water Molecule Error

Water molecules reflect microwaves. It is apparent that satellite acquisition is effected during a rainy day; however, the water in the atmosphere was not found to substantially change the location accuracy. Presumably, enough signals find their way through the water molecules to show a reasonably accurate location. Acquisition is also improved with the use of a high gain antenna (26 dB - active).

7.11.4 Building Reflection Error

IDC observed GPS signals reflecting off buildings (multi-path) in the inner city. However, this signal reflection worked to the caller's advantage. GPS reflection placed a good percentage of locations within the 125-meter requirement where acquisition would normally not be acquirable (i.e. alleys and doorways).

7.11.5 GPS Firmware Error

In early August, a reasonably significant error was detected in the Version 1 GPS receiver. The problem was a boot timing error of 12 seconds in the handset GPS. When the GPS system was turned on for field testing (depending on how long it had been off), the system was reporting location with a 12 second error. In Version 4 of the ACLD, IDC did not account for this type of error during the correction process. This 12-second delay not only caused an error in the correction process, but also in some cases induced additional location error.

On August 14th of the trial, a new administrative procedure was put into place for the call maker to "warm" the GPS up for 30 minutes to ensure it was transmitting the right time. A second corrective action was implemented in the ACLD version 4. If the reported time was greater then 5 seconds off of the reference receiver clock, no correction was applied and the database was annotated. Data collected prior to August 14th had a time variable error that could not be captured during the data reduction phase. However, even with the error corrected late in the trial, the requirements over the course of the entire were still met.

7.12 SUMMARY FINDINGS

7.12.1 Did IDC technology send latitude/longitude?
Yes

7.12.2 Was latitude/longitude sent via wireless phone?
Yes

7.12.3 Was the FCC Phase II requirement of 125 meters (406 feet) met?
Yes – for 94% of the calls

7.12.4 Was the trial requirement of 90% at 40 feet met?
No*. See Section 7.13 for specific results regarding the 40-ft. benchmark.

7.12.5 Is the new technology capable of meeting the trial requirements today?
Yes

7.12.6 Was a caller's altitude measured?
Yes

7.12.7 Was a caller's altitude displayed as feet above the ground?
No – Displayed as Altitude Above Mean Sea Level

7.12.8 Were floors in building expressed as floor numbers?
No

7.12.9 Were any buildings enabled to display floor location?
No

7.12.10 Were any buildings enabled with GPS repeaters?
Yes

7.12.11 Did an enabled building produce accurate caller location?
Yes

7.12.12 Was it possible to display caller's speed in miles per hour?
Yes

7.12.13 Was it possible to display caller's direction of travel in "8-point" directionals?
Yes

7.12.14 Were data requests and responses emulated?
Yes

7.12.15 Was caller's ALI text and location map integrated and displayed on a Positron E-911 Intelligent Workstation at each PSAP?
Yes

7.12.16 Did the IDC/Valor/NDE MapCad Workstation provide in-band wireless phone communication (bi-directional)?
Yes

7.12.17 Did the IDC/Valor/NDE MapCad Workstation provide received GPS coordinate correction?
Yes

7.12.18 Did applied correction result in correction 100% of the time?
Yes

7.12.19 Did the IDC/Valor/NDE MapCad Workstation provide a caller location mapping display application?
Yes

7.12.20 Did the IDC/Valor/NDE MapCad Workstation provide an external mapping display application?
Yes

7.12.21 Did the IDC/Valor/NDE MapCad Workstation provide an external mapping display support (to Positron Power 911)?
Yes

7.12.22 Did the IDC/Valor/NDE MapCad Workstation provide an ALI data service emulation (SCC specification)?
Yes

7.12.23 Was the technical evaluation project system originally designed to meet the 2-second budget?
Yes

7.12.24 Was the 2-second budget met?
Yes

7.12.25 Was information updated every 15 seconds (if desired by the call taker).
Yes

7.12.26 Did updated information displace original call information?
Yes

7.12.27 Were technical evaluation project calls routed based on latitude/longitude of original call (selective routing)?
Yes

7.12.28 Was voice and data routed on existing E-911 network, through existing E-911 telephone and PSAP equipment?
Yes

7.12.29 Were "Customer Name", "Customer Billing Address", and "Calling Party Number" displayed at the PSAP for each call?
Yes

7.13 FIELD TRIAL RESULTS AND BREAKDOWN

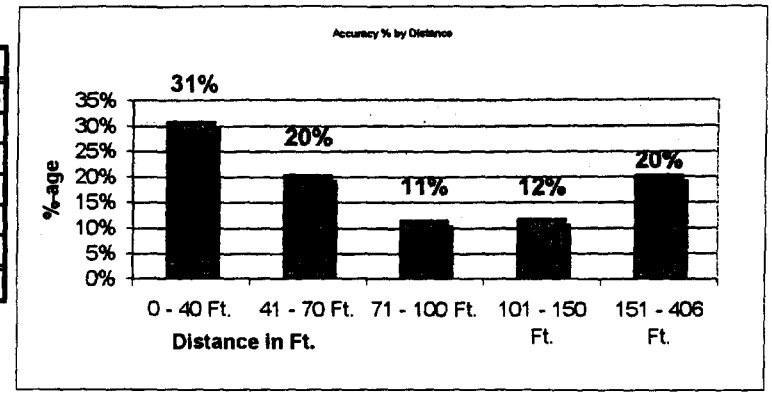
In addition to the proving the key objectives of routing, roaming from digital to analog, and other performance results noted throughout Section 7, the following pages depict in graphical and tabular form the key quantitative results from the trial. The summary findings listed below are contained in the Figures 7-4 through 7-10 for the balance of this Section.

- **The IDC technology found the caller, at a given distance, 100% of the time**
- 31% of the total calls were found to within 40 feet or less.
- 20% of the total calls were found between 41 feet and 70 feet; therefore, **51% - or a majority of all of the calls – were found within 70 feet.**
- 11% of the total calls were found between 71 feet and 100 feet; therefore, 62% of the calls were found within 100 feet.
- 12% of the total calls were found between 101 feet and 150 feet; therefore, 74% of the calls were found within 150 feet.
- 20% of the calls were found between 151 feet and 406 feet; **therefore, 94% of all callers were found within 406 feet (the FCC Phase II mandate).**

Breakdown of these findings are contained in the following figures:

- Figure 7-4. Calling Venue Breakdown, Incremental Accuracy by Distance, and Summary Call Distribution
- Figure 7-5. Call Distribution – By Venue (Cumulative and Incremental), and Cumulative Accuracy of All Calls
- Figure 7-6. Tabular Depiction of All Calls – Accuracy and Summary to Increments of 10 feet (2 pages)
- Figure 7-7. Downtown Seattle Venue Calling Distribution. Mercer Island Venue Calling Distribution (in increments of 10 feet).
- Figure 7-8. Arboretum Venue Calling Distribution. North Bend Venue Calling Distribution (in increments of 10 feet).
- Figure 7-9. Snoqualmie Pass Venue Calling Distribution. Washington State DOT Monuments Venue Calling Distribution (in increments of 10 feet).
- Figure 7-10. Breakdown of Calls by Phone Model Type. Breakdown of Calls by Air Interface.

Calling Venue	# of Calls
Mercer Island- Suburban	1,533
Snoqualmie Pass - Rural/Mnts.	161
Downtown Seattle - Urban	1,073
North Bend - Rural	1,136
Arboretum - Heavy Forest	452
DOT Monuments - Various	515
Total Calls	4,870



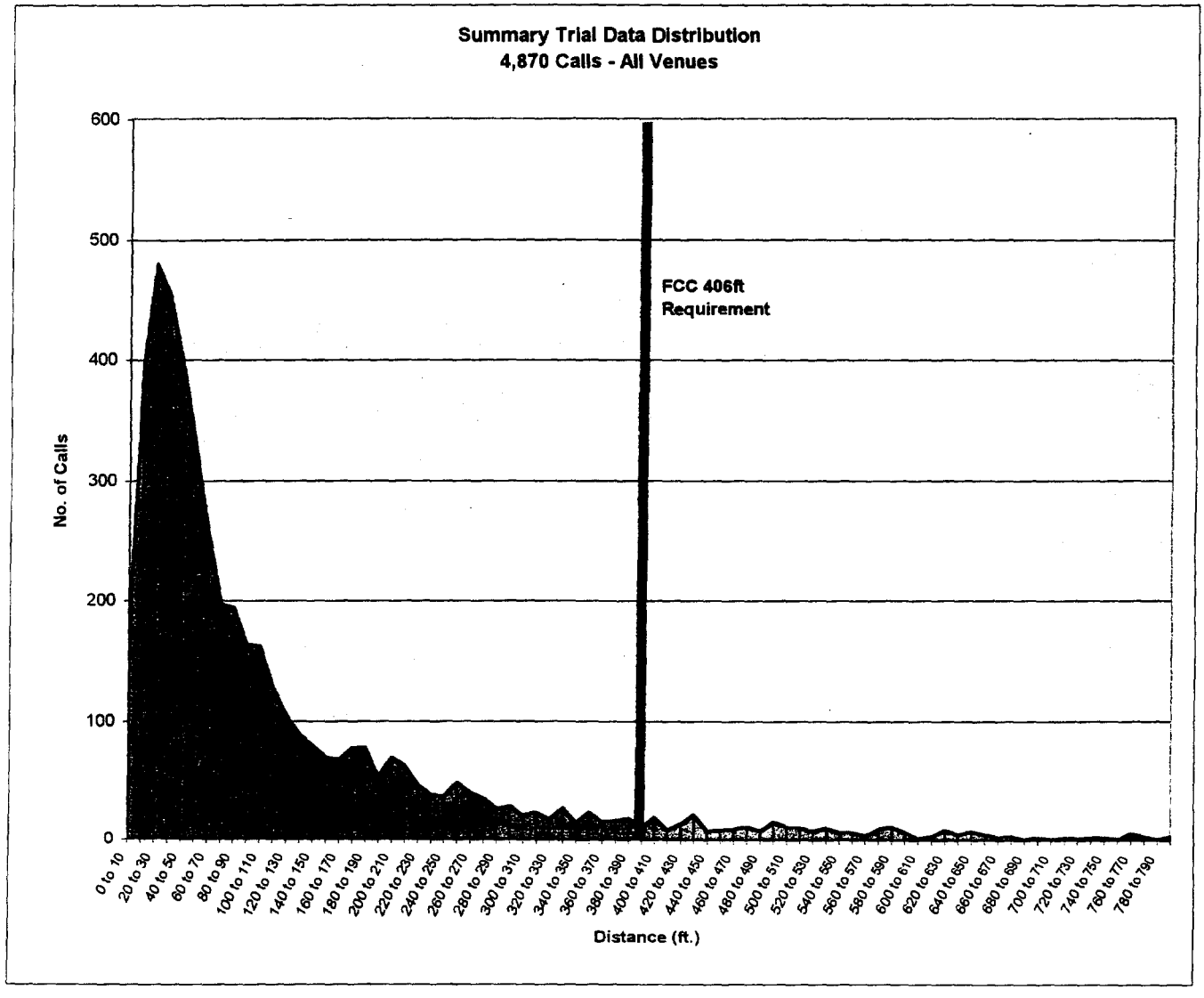
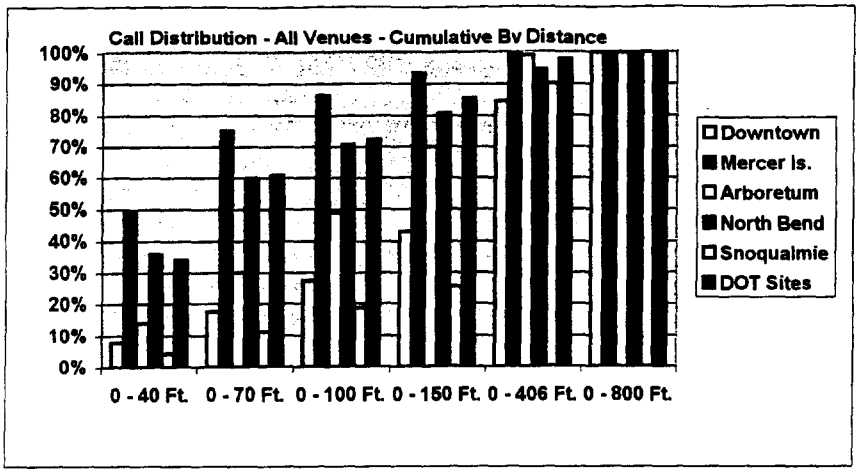
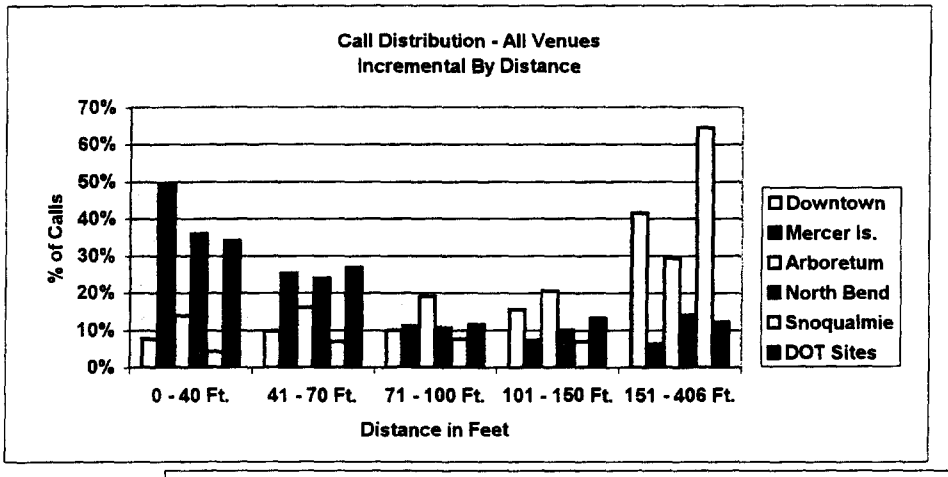


Figure 7-4. Calling Venue Breakdown, Incremental Accuracy by Distance, and Summary Call Distribution





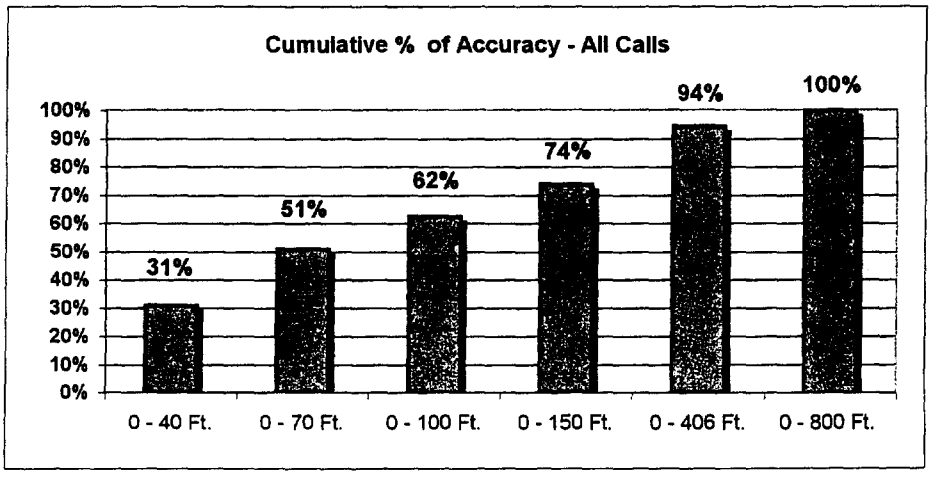


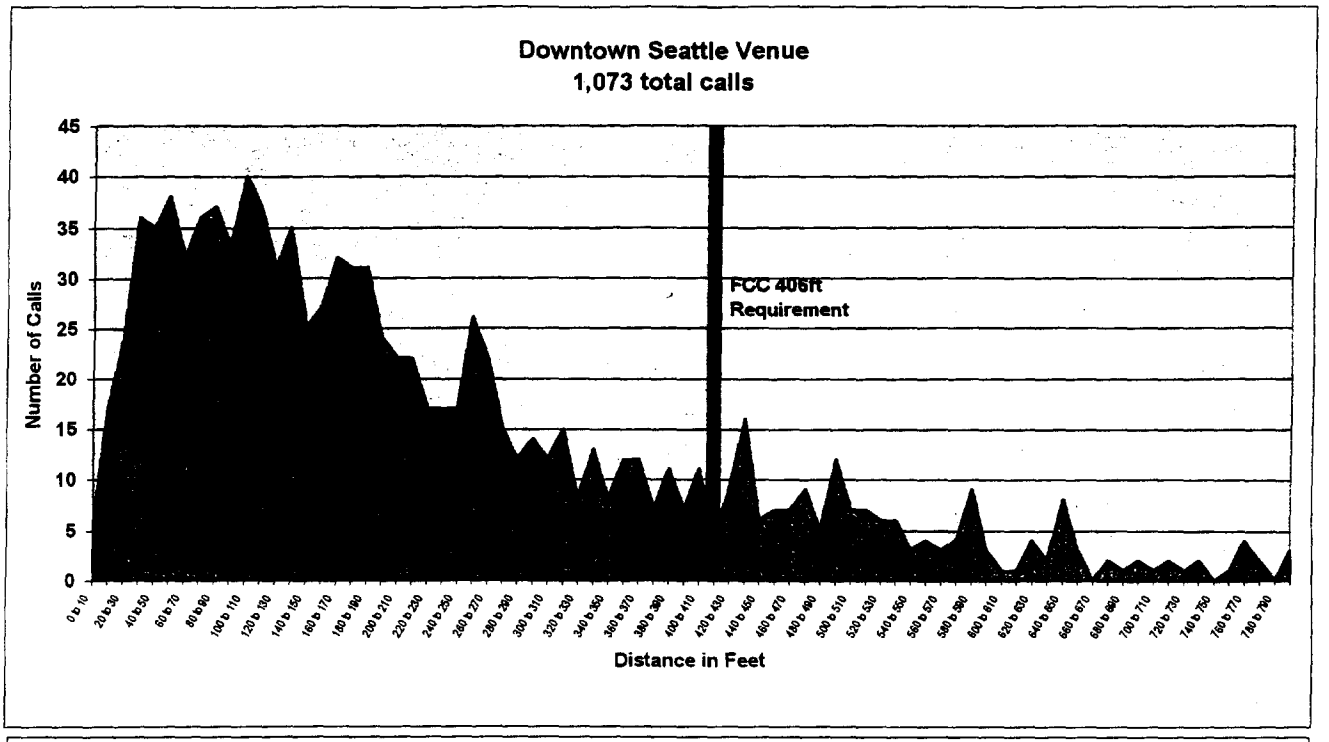
Figure 7-5. Call Distribution - By Venue (Cumulative and Incremental) and Cumulative Accuracy of all Calls

DOWNTOWN VENUE			MERCER ISLAND			ARBORETUM		
Distance	# of Calls	Subtotal	Distance	# of Calls	Subtotal	Distance	# of Calls	Subtotal
0 to 10	5		0 to 10	92		0 to 10	2	
10 to 20	17		10 to 20	221		10 to 20	5	
20 to 30	24		20 to 30	263		20 to 30	20	
30 to 40	36	82	30 to 40	186	762	30 to 40	36	63
40 to 50	35		40 to 50	148		40 to 50	24	
50 to 60	38		50 to 60	140		50 to 60	22	
60 to 70	32	167	60 to 70	100	1150	60 to 70	27	136
70 to 80	36		70 to 80	53		70 to 80	36	
80 to 90	37		80 to 90	67		80 to 90	24	
90 to 100	33	293	90 to 100	51	1321	90 to 100	26	222
100 to 110	40		100 to 110	37		100 to 110	32	
110 to 120	37		110 to 120	23		110 to 120	22	
120 to 130	31		120 to 130	21		120 to 130	16	
130 to 140	35		130 to 140	18		130 to 140	10	
140 to 150	25	461	140 to 150	12	1432	140 to 150	13	315
150 to 160	27		150 to 160	12		150 to 160	10	
160 to 170	32		160 to 170	4		160 to 170	15	
170 to 180	31		170 to 180	13		170 to 180	10	
180 to 190	31		180 to 190	6		180 to 190	18	
190 to 200	24		190 to 200	4		190 to 200	8	
200 to 210	22		200 to 210	3		200 to 210	13	
210 to 220	22		210 to 220	7		210 to 220	12	
220 to 230	17		220 to 230	4		220 to 230	6	
230 to 240	17		230 to 240	6		230 to 240	7	
240 to 250	17		240 to 250	3		240 to 250	5	
250 to 260	26		250 to 260	5		250 to 260	3	
260 to 270	22		260 to 270	6		260 to 270	5	
270 to 280	15		270 to 280	5		270 to 280	4	
280 to 290	12		280 to 290	2		280 to 290	2	
290 to 300	14		290 to 300	3		290 to 300	2	
300 to 310	12		300 to 310	0		300 to 310	2	
310 to 320	15		310 to 320	2		310 to 320	1	
320 to 330	8		320 to 330	0		320 to 330	1	
330 to 340	13		330 to 340	3		330 to 340	1	
340 to 350	8		340 to 350	0		340 to 350	3	
350 to 360	12		350 to 360	1		350 to 360	1	
360 to 370	12		360 to 370	1		360 to 370	0	
370 to 380	7		370 to 380	1		370 to 380	0	
380 to 390	11		380 to 390	1		380 to 390	0	
390 to 400	7		390 to 400	1		390 to 400	0	
400 to 410	11	906	400 to 410	1	1526	400 to 410	3	447
410 to 420	4		410 to 420	1		410 to 420	0	
420 to 430	9		420 to 430	0		420 to 430	0	
430 to 440	16		430 to 440	1		430 to 440	0	
440 to 450	6		440 to 450	0		440 to 450	1	
450 to 460	7		450 to 460	0		450 to 460	0	
460 to 470	7		460 to 470	0		460 to 470	0	
470 to 480	9		470 to 480	0		470 to 480	0	
480 to 490	5		480 to 490	1		480 to 490	1	
490 to 500	12		490 to 500	0		490 to 500	0	
500 to 510	7		500 to 510	0		500 to 510	0	
510 to 520	7		510 to 520	0		510 to 520	0	
520 to 530	6		520 to 530	0		520 to 530	1	
530 to 540	6		530 to 540	0		530 to 540	1	
540 to 550	3		540 to 550	0		540 to 550	1	
550 to 560	4		550 to 560	0		550 to 560	0	
560 to 570	3		560 to 570	0		560 to 570	0	
570 to 580	4		570 to 580	0		570 to 580	0	
580 to 590	9		580 to 590	0		580 to 590	0	
590 to 600	3		590 to 600	0		590 to 600	0	
600 to 610	1		600 to 610	0		600 to 610	0	
610 to 620	1		610 to 620	0		610 to 620	0	
620 to 630	4		620 to 630	0		620 to 630	0	
630 to 640	2		630 to 640	0		630 to 640	0	
640 to 650	8		640 to 650	0		640 to 650	0	
650 to 660	3		650 to 660	0		650 to 660	0	
660 to 670	0		660 to 670	1		660 to 670	0	
670 to 680	2		670 to 680	0		670 to 680	0	
680 to 690	1		680 to 690	0		680 to 690	0	
690 to 700	2		690 to 700	0		690 to 700	0	
700 to 710	1		700 to 710	0		700 to 710	0	
710 to 720	2		710 to 720	0		710 to 720	0	
720 to 730	1		720 to 730	0		720 to 730	0	
730 to 740	2		730 to 740	1		730 to 740	0	
740 to 750	0		740 to 750	1		740 to 750	0	
750 to 760	1		750 to 760	0		750 to 760	0	
760 to 770	4		760 to 770	0		760 to 770	0	
770 to 780	2		770 to 780	0		770 to 780	0	
780 to 790	0		780 to 790	1		780 to 790	0	
790 to 800	3		790 to 800	0		790 to 800	0	
Total Calls	1073		Total Calls	1533		Total Calls	452	

Figure 7-6. Tabular Depiction of all calls - Accuracy and Summary to Increments of 10 feet

NORTH BEND			SNOQUALMIE PASS			DOT MONUMENTS		
Distance	# of Calls	Subtotal	Distance	# of Calls	Subtotal	Distance	# of Calls	Subtotal
0 to 10	44		0 to 10	1		0 to 10	23	
10 to 20	113		10 to 20	1		10 to 20	39	
20 to 30	122		20 to 30	2		20 to 30	49	
30 to 40	129	408	30 to 40	3	7	30 to 40	64	175
40 to 50	120		40 to 50	8		40 to 50	63	
50 to 60	90		50 to 60	1		50 to 60	39	
60 to 70	62	680	60 to 70	1	18	60 to 70	36	313
70 to 80	49		70 to 80	4		70 to 80	19	
80 to 90	43		80 to 90	5		80 to 90	18	
90 to 100	29	901	90 to 100	3	30	90 to 100	22	372
100 to 110	37		100 to 110	0		100 to 110	16	
110 to 120	18		110 to 120	4		110 to 120	24	
120 to 130	22		120 to 130	3		120 to 130	12	
130 to 140	19		130 to 140	3		130 to 140	4	
140 to 150	17	914	140 to 150	1	41	140 to 150	12	440
150 to 160	12		150 to 160	0		150 to 160	9	
160 to 170	8		160 to 170	2		160 to 170	7	
170 to 180	13		170 to 180	4		170 to 180	7	
180 to 190	11		180 to 190	5		180 to 190	7	
190 to 200	10		190 to 200	4		190 to 200	3	
200 to 210	11		200 to 210	16		200 to 210	5	
210 to 220	12		210 to 220	10		210 to 220	0	
220 to 230	7		220 to 230	12		220 to 230	1	
230 to 240	6		230 to 240	1		230 to 240	2	
240 to 250	9		240 to 250	2		240 to 250	1	
250 to 260	9		250 to 260	3		250 to 260	3	
260 to 270	5		260 to 270	2		260 to 270	1	
270 to 280	7		270 to 280	3		270 to 280	2	
280 to 290	5		280 to 290	5		280 to 290	1	
290 to 300	4		290 to 300	3		290 to 300	3	
300 to 310	3		300 to 310	1		300 to 310	3	
310 to 320	4		310 to 320	1		310 to 320	1	
320 to 330	3		320 to 330	3		320 to 330	3	
330 to 340	5		330 to 340	3		330 to 340	3	
340 to 350	1		340 to 350	3		340 to 350	0	
350 to 360	4		350 to 360	6		350 to 360	0	
360 to 370	1		360 to 370	1		360 to 370	1	
370 to 380	3		370 to 380	6		370 to 380	0	
380 to 390	4		380 to 390	3		380 to 390	0	
390 to 400	1		390 to 400	2		390 to 400	0	
400 to 410	2	1074	400 to 410	3	145	400 to 410	0	503
410 to 420	2		410 to 420	2		410 to 420	0	
420 to 430	3		420 to 430	2		420 to 430	0	
430 to 440	2		430 to 440	2		430 to 440	1	
440 to 450	0		440 to 450	1		440 to 450	0	
450 to 460	1		450 to 460	1		450 to 460	0	
460 to 470	1		460 to 470	1		460 to 470	1	
470 to 480	3		470 to 480	0		470 to 480	0	
480 to 490	1		480 to 490	0		480 to 490	0	
490 to 500	2		490 to 500	1		490 to 500	1	
500 to 510	4		500 to 510	1		500 to 510	0	
510 to 520	3		510 to 520	0		510 to 520	1	
520 to 530	0		520 to 530	1		520 to 530	0	
530 to 540	3		530 to 540	1		530 to 540	0	
540 to 550	2		540 to 550	1		540 to 550	0	
550 to 560	1		550 to 560	2		550 to 560	0	
560 to 570	1		560 to 570	0		560 to 570	0	
570 to 580	6		570 to 580	0		570 to 580	0	
580 to 590	3		580 to 590	0		580 to 590	0	
590 to 600	3		590 to 600	0		590 to 600	1	
600 to 610	1		600 to 610	0		600 to 610	0	
610 to 620	3		610 to 620	0		610 to 620	0	
620 to 630	3		620 to 630	0		620 to 630	2	
630 to 640	2		630 to 640	0		630 to 640	1	
640 to 650	0		640 to 650	0		640 to 650	0	
650 to 660	2		650 to 660	0		650 to 660	0	
660 to 670	1		660 to 670	0		660 to 670	1	
670 to 680	1		670 to 680	0		670 to 680	1	
680 to 690	0		680 to 690	0		680 to 690	0	
690 to 700	1		690 to 700	0		690 to 700	0	
700 to 710	0		700 to 710	0		700 to 710	0	
710 to 720	1		710 to 720	0		710 to 720	0	
720 to 730	0		720 to 730	0		720 to 730	1	
730 to 740	0		730 to 740	0		730 to 740	0	
740 to 750	1		740 to 750	0		740 to 750	1	
750 to 760	0		750 to 760	0		750 to 760	0	
760 to 770	2		760 to 770	0		760 to 770	0	
770 to 780	2		770 to 780	0		770 to 780	0	
780 to 790	0		780 to 790	0		780 to 790	0	
790 to 800	1		790 to 800	0		790 to 800	0	
Total Calls	1136		Total Calls	161		Total Calls	515	

Figure 7-6. Tabular Depiction of all calls - Accuracy and Summary to Increments of 10 feet



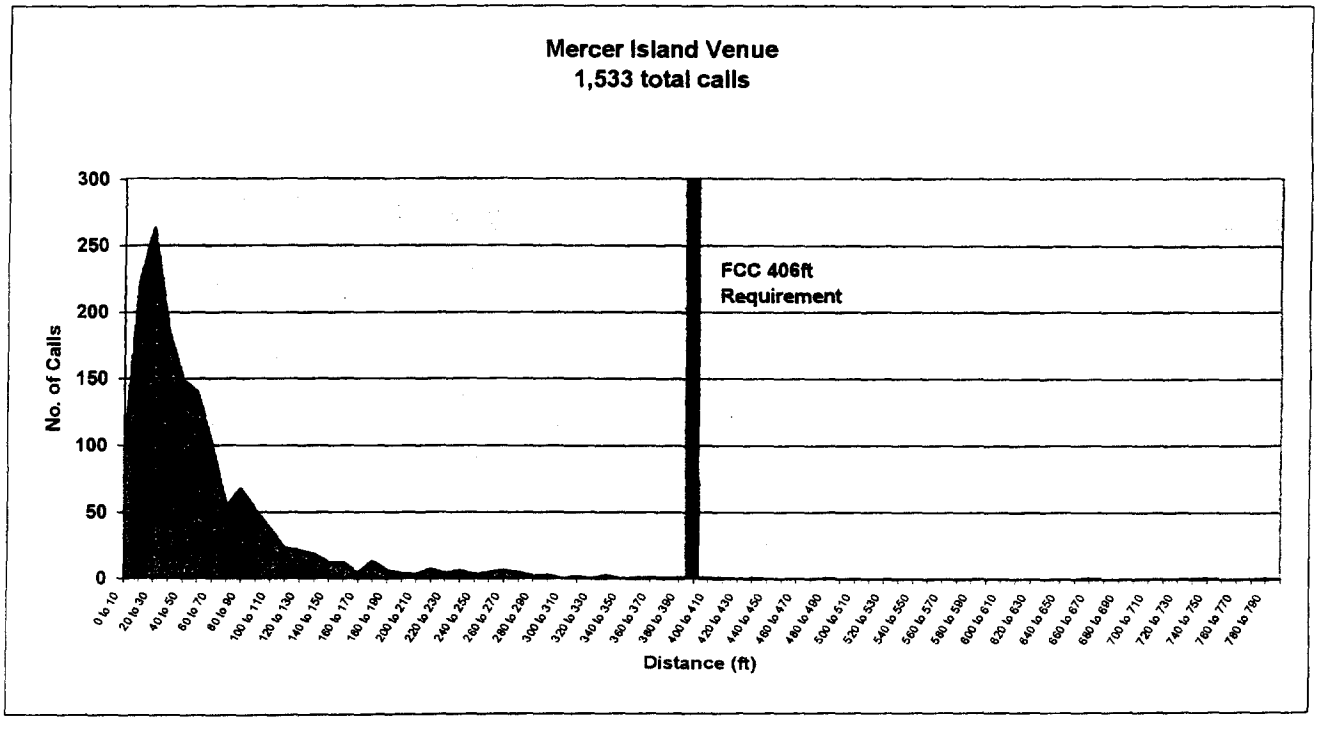
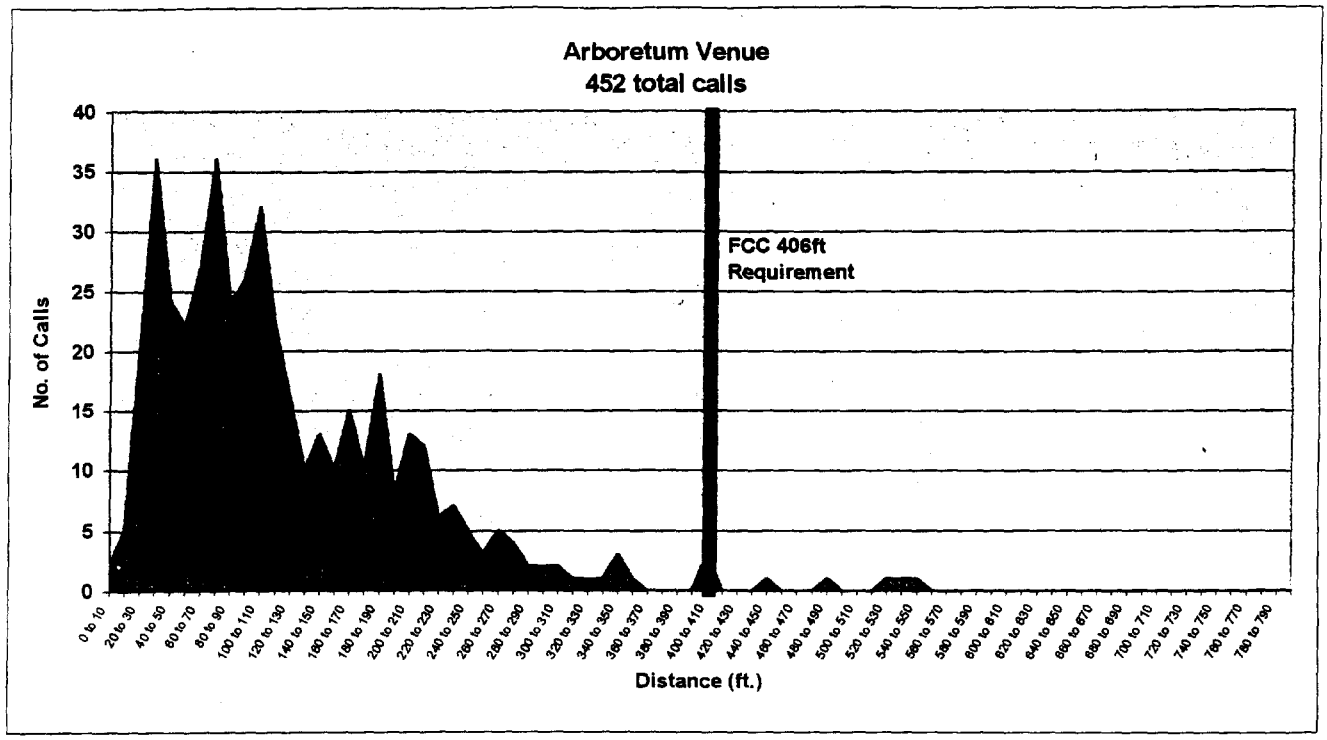


Figure 7-7. Downtown Seattle Venue Calling Distribution. Mercer Island Venue Calling Distribution



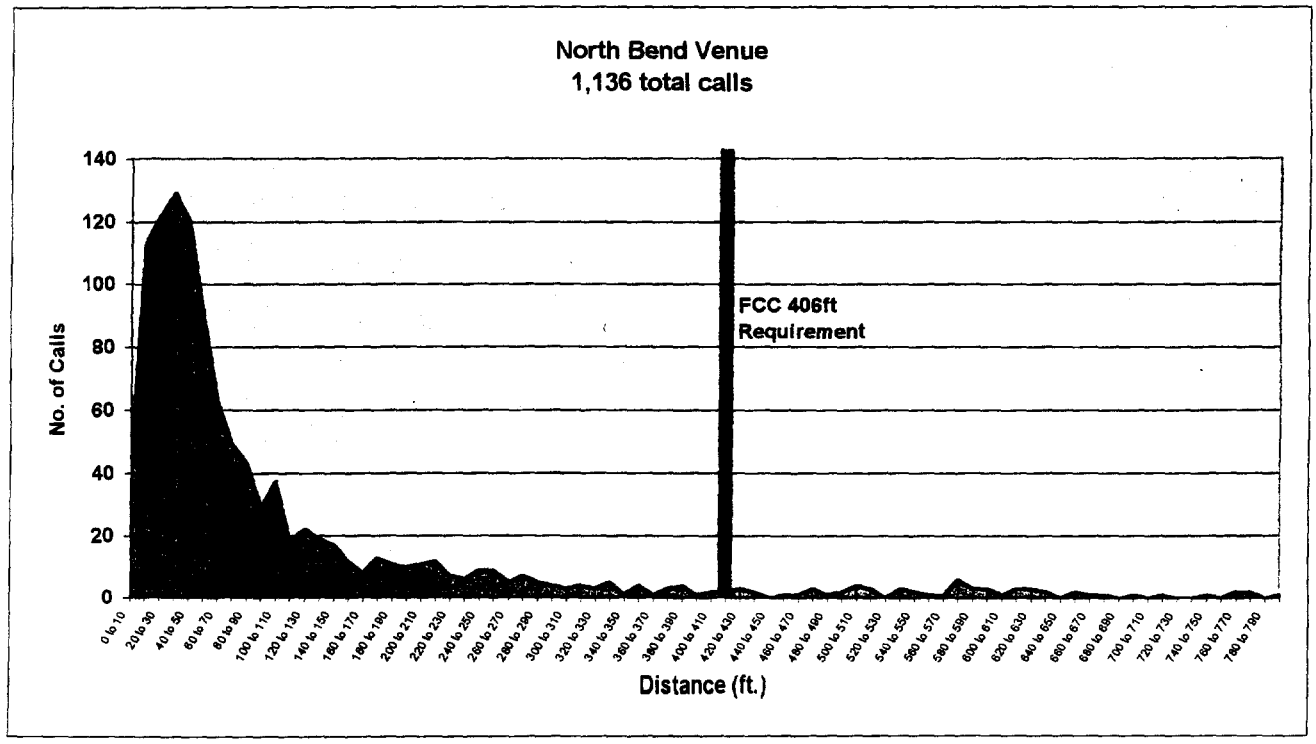
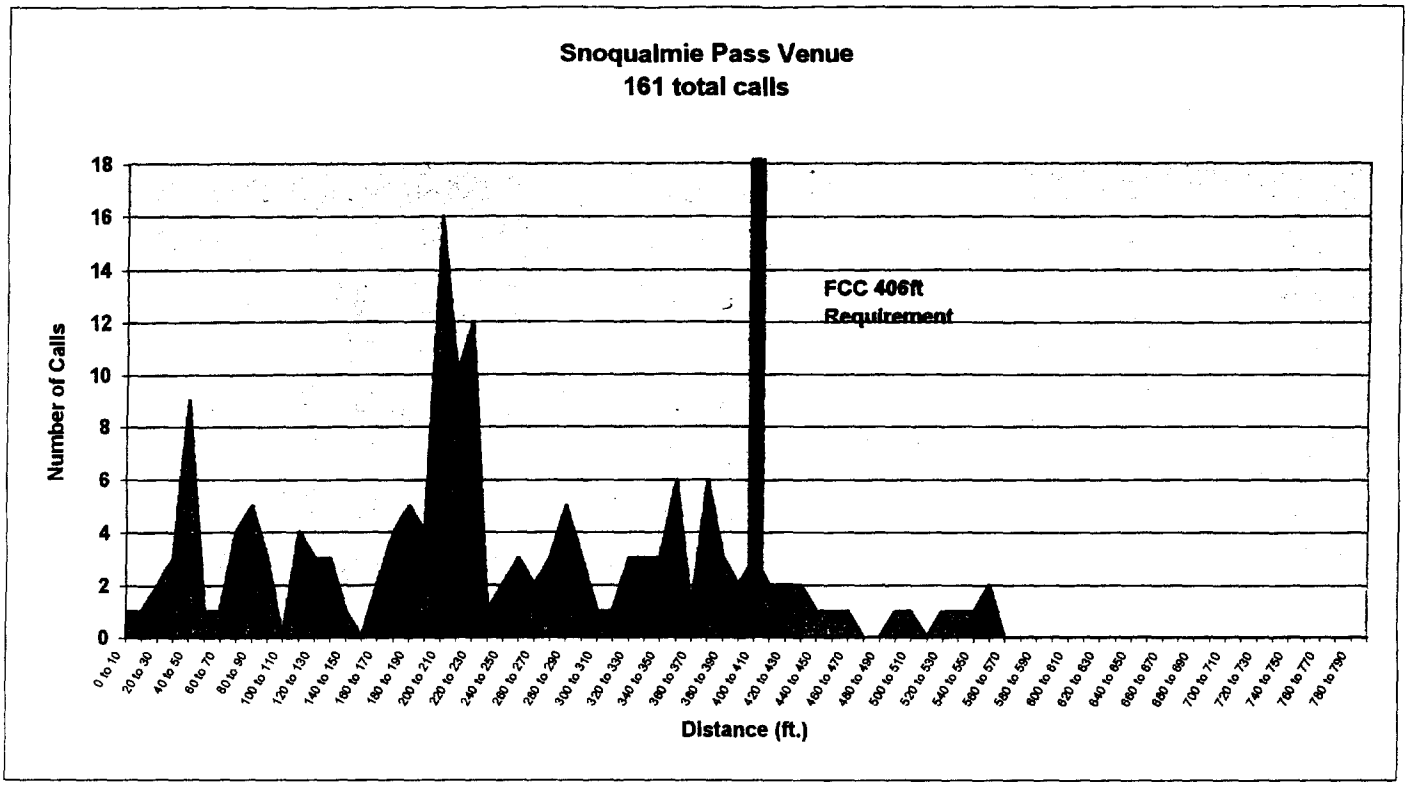


Figure 7-8. Arboretum Venue Calling Distribution. North Bend Venue Calling Distribution



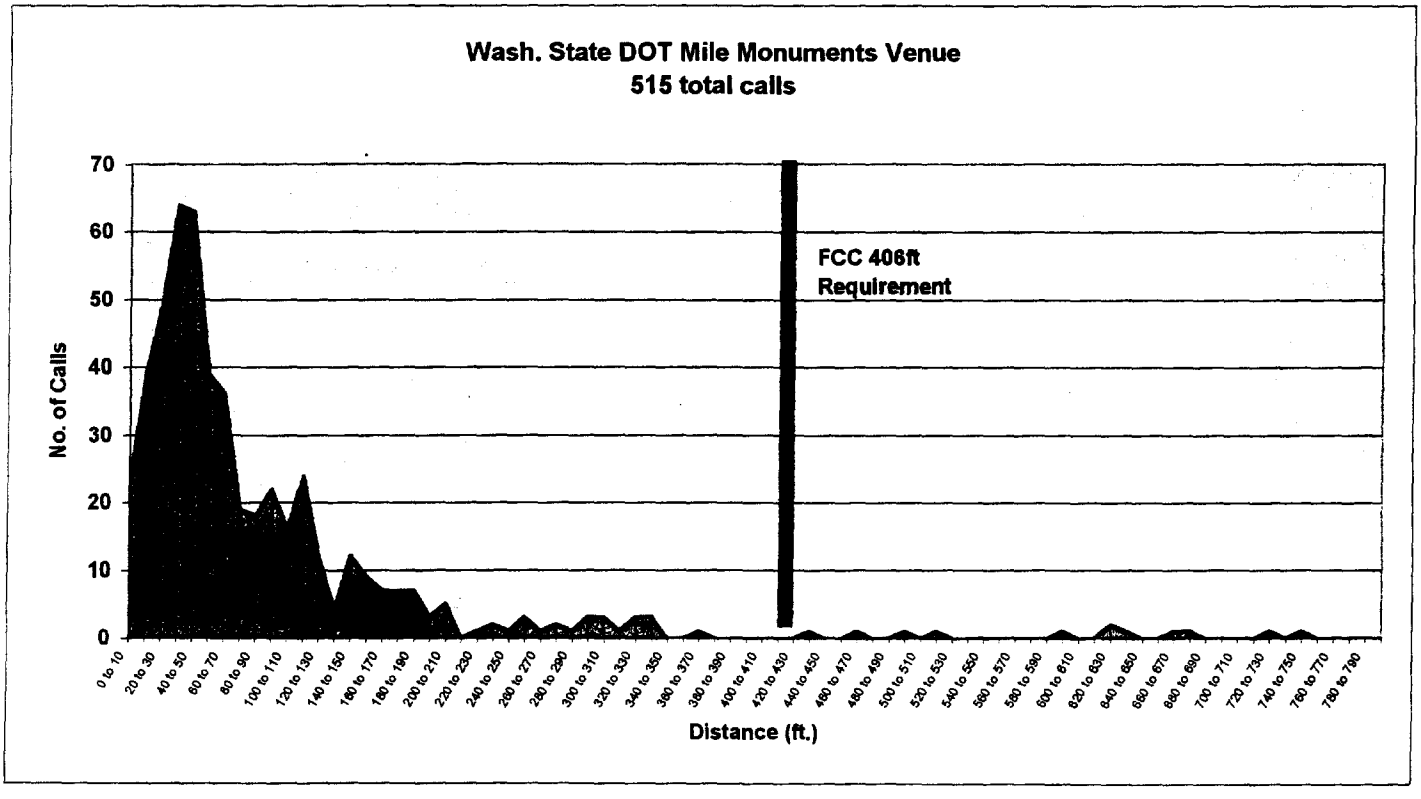
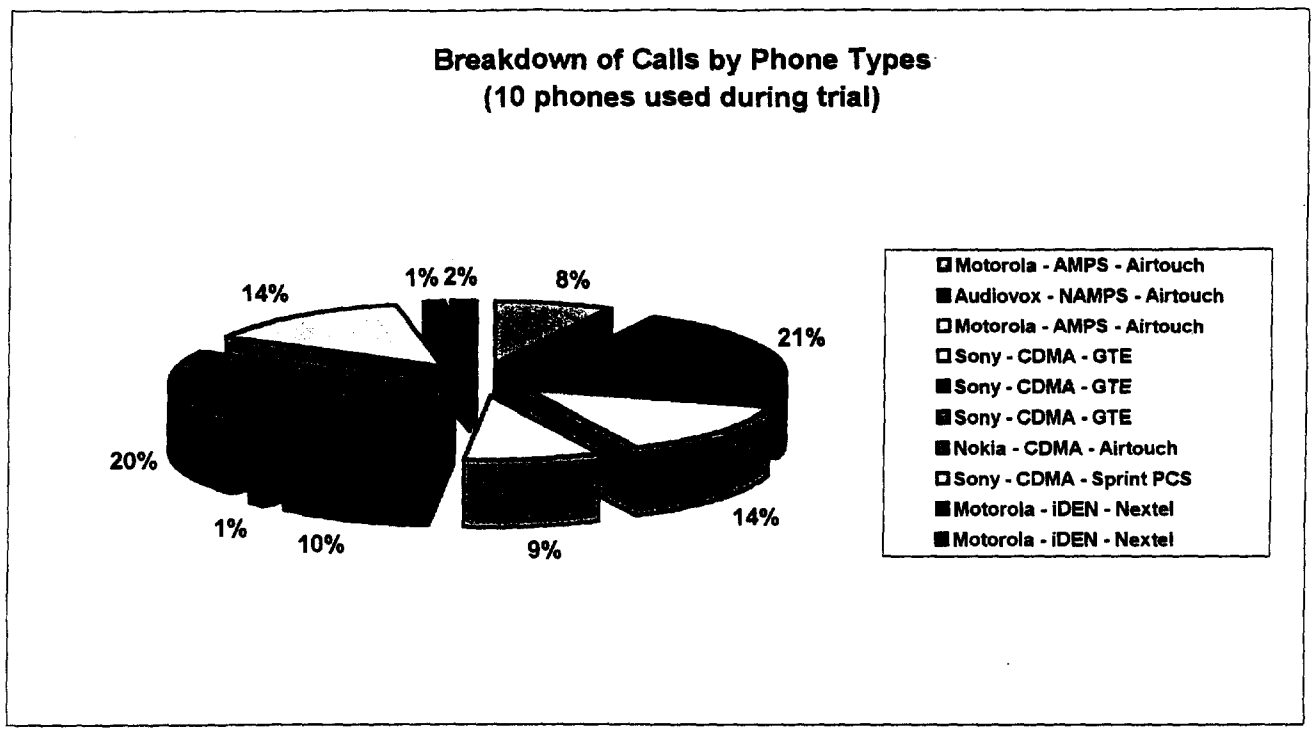


Figure 7-9. Snoqualmie Pass Venue Calling Distribution. DOT Monuments Venue Calling Distribution



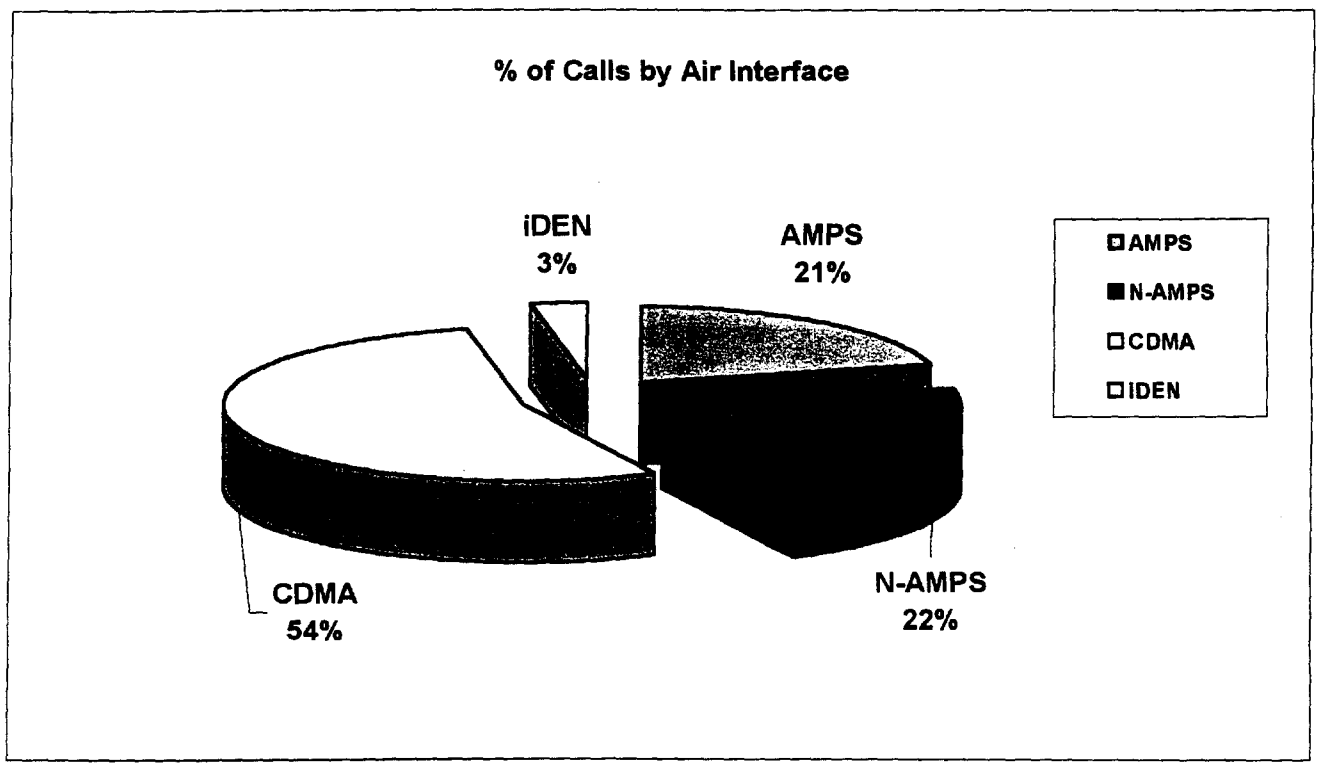


Figure 7-10. Breakdown of Calls by Phone Model Type. Breakdown of Calls by Air Interface Type

8.0 CONCLUSIONS

8.1 CONCLUSION SUMMARY

A stand-alone Global Positioning System (GPS) location technology at the handset, coupled with a call path signaling method to an enabled call taker's station, meets the published requirements of the Federal Communications Commission (FCC's) Phase II mandate, and is an effective method for location of wireless calls for Public Safety. The trial was conclusive in proving:

- GPS data can be communicated through a tested wireless phone's voice channel;
- Calls can be routed by latitude and longitude to the appropriate Public Safety Answering Point (PSAP);
- Location information can be received and made useful by the PSAP;
- The caller's location can be displayed with confidence on a geo-corrected map, accompanied by altitude, speed, direction, time, and caller's vital information, which can be displayed on the same computer monitor automatically.
- And that the call taker, at their discretion, can request additional data to refresh the caller's location, or can transfer the call (and accompanying location information) to another call taker station or PSAP.

8.2 GPS-ENABLED HANDSETS CAN PRODUCE HIGHLY ACCURATE LOCATION INFORMATION.

4,870 calls were placed and logged from 92 different locations, each one benchmarked to within one meter with a differentially-corrected GPS Survey grade system. *Utilizing the FCC-recommended Root Mean Square (RMS) measurement methodology as further refined by IDC, and based on certain assumptions, the trial's results demonstrate that callers can be found a majority of the time (51%) to within 70 feet. For more rural and suburban areas (such as North Bend and Mercer Island), accuracy to 40 feet or less was documented and can be expected from this solution.*

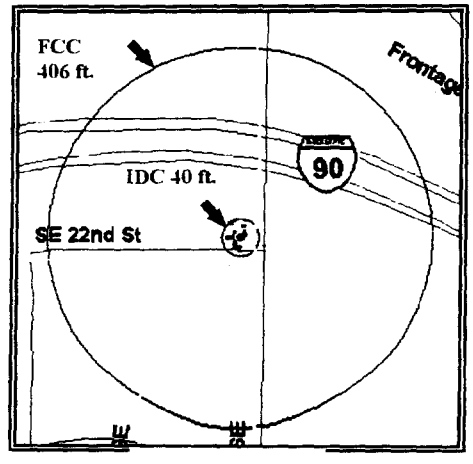


Figure 8-1 (left) shows a series of sample calls made and logged. The dots in the smaller circle represent calls that were found using IDC's location technology. The small circle with green dots represents 12.3 meters (40 feet) and the larger is the FCC Phase II mandated 125 meters (406 feet).

IDC proved during the trial that accuracy of 40-ft.or less is achievable – and proved it for **31%** of the total 4,870 calls.

Figure 8-1. Comparison of IDC technology and FCC mandate

In **Figure 8-2** (below) this call taker display screen illustrates the caller's position on the highway, and provides information regarding speed and direction. In this example, he caller is in the westbound lane of I-90, traveling NW at 61 MPH. This example proves that IDC was able to obtain, transport, and display location information on the existing Customer Premise Equipment at the Public Safety Answering Point (PSAP). Altitude, speed, and heading were also obtained and displayed on the call taker maps.

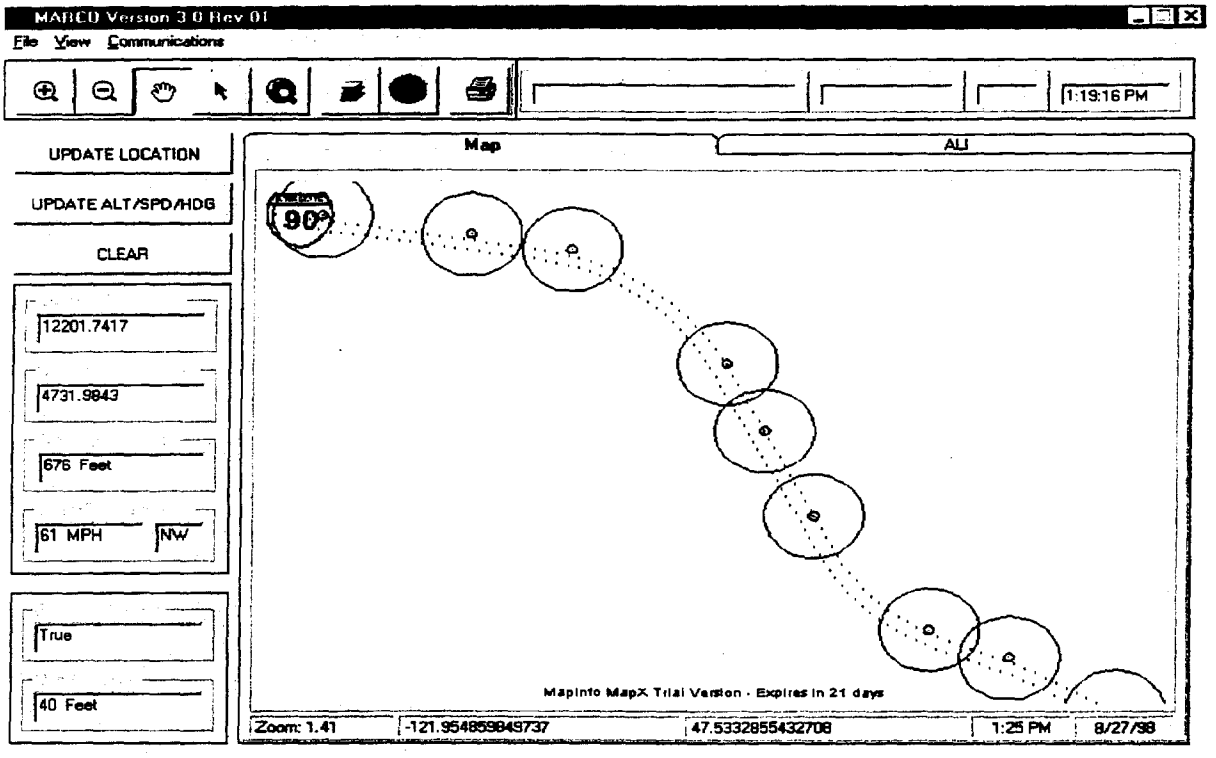


Figure 8-2. Screen Capture to Demonstrate Call Tracking Ability

8.3 CALL PATH SIGNALING: A VIABLE APPROACH

Testing the components individually was a necessary step to:

- Identify "Best in Class" suppliers;
- Help identify the system variables; and
- Control the variables in the data gathering/logging phase.

When IDC integrated the entire system in a live "511" environment[1], we objectively demonstrated and documented that call path signaling across all wireless carrier protocols in

[1] GTE-Wireless, US West and King County set up a 511 system to parallel the existing 911 service so that testing would be as close to actual PSAP environment as possible.

a live environment was technically achievable. It further validated the system reference model and proved the practicality of the IDC technology.

IDC believes the answers to the primary questions driving this trial is that location, both accurate and reliable, is important to everyone. This trial has demonstrated, through validation of a reference model, that a handset-based solution is accurate and can be made available today. Additionally, the FCC requirements can be met (and exceeded) within cost-recovery bounds and that a solution can include the embedded base of wireless phones. Finally, Public Safety drove the FCC requirements and IDC has proven that this solution can not only meet the mandate of October 2001, but can achieve Public Safety's needs today as well as its goals of tomorrow.

8.4 A CHURN-BASED TRANSITION: A VIABLE APPROACH

Immediately after the conclusion of this study on December 24, 1998, the FCC published Public Notice 98-2631 entitled "*Wireless Telecommunications Bureau outlines Guidelines for Wireless E911 Rule Waivers for Handset Based Approaches for Phase II ALI Requirements*". A complete text of this ruling is included in Appendix H. This ruling has provided the wireless carriers an option of requesting a waiver for meeting the Phase II E911 mandate if the proposed request includes either/both of the following two components:

- While the wireless carrier may not achieve 100% of the FCC Phase II guidelines of 125 meters/67% of the time by October 2001, the carrier can request a waiver for Phase II compliance <u>if the proposed solution exceeds the mandated accuracy and availability requirements.</u>

- The wireless carrier can propose a <u>churn-based transition</u> approach which demonstrates an "over-time" achievement of the Phase II mandate through the carriers historical annual churn and gross additions to the installed base.

- The carrier also can commit to an <u>early adoption</u> (prior to October, 2001) in its request for waiver.

Depending upon the annual churn of the carrier's installed base, the beginning number of subscribers, and incremental net additions into the future, a carrier can prove a complete "turnover" of the existing phone base in a matter of months.

Figure 8-3 (next page) provides a sample model of a churn-based transition approach. Using sample data of 2.8 million beginning subscribers, 2 million gross adds/year, and 24% annual churn, *units covered with handset-based location technology can achieve nearly 70% compliance by October 2001 – and 100% compliance by mid-year 2002 (shown by the* ●) . Employing IDC's technology within this approach can provide higher accuracy than required by the FCC Phase II mandate and achieve compliance over time - with no additional cost to the network infrastructure.

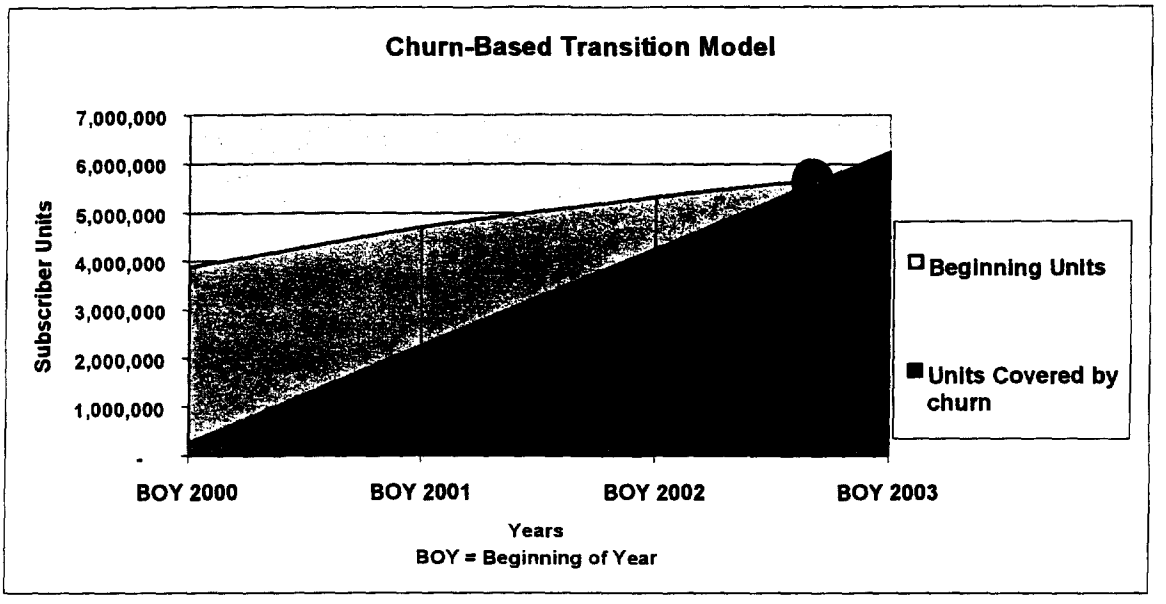


Figure 8-3. Sample Churn Based Transition achieving 100% compliance by Mid-Year 2002

This approach does not take into account additional "retrofitting" of the installed wireless phone base through the use of battery packs or other add-on devices; a campaign of providing installed unit retrofits to the customer base during this phased approach can achieve compliance months earlier than the chart depicted above.