# Using GIS to Improve the Daily Drive Route Evaluation Process for Mobile Test Operations

Francisco F. Morrow[1,2]
[1]*Department of Resource Analysis, Saint Mary's University of Minnesota, Winona, MN 55987;*
[2]*Telephia, Inc. 101 Green Street, San Francisco, CA 94118*

*Keywords:* Cell Phone, Wireless, Mobile Test, Network Performance, Drive Test, MapInfo, GIS

## Abstract

Everyday, millions of people worldwide call a friend, check email, send text messages, watch TV, download music, and surf the web over a wireless network. Regardless of cell phone carrier, each network is often subject to ridicule by end users due to poor coverage and lack of connectivity. Telephia, an independent market research firm for the wireless industry, seeks ways to improve network performance using Mobile Test. The Mobile Test division of Telephia creates drive routes, drives the route to measure network performance, and sends data back to the Telephia office team which then generates a report for the client. This paper demonstrates a mapping tool that was created and documented within the Mobile Test department to monitor a drive's progression from start to finish in order to eliminate errors and omissions in data collection. Examples used for this paper are taken from the September 2005 Denver drive route. This mapping tool helps formulate more efficient drive routes, applies quality control in the field, and facilitates faster drive time analysis.

## Introduction

Telephia's Mobile Test program is currently the largest independent, syndicated wireless network benchmarking program available in North America. Twenty Dodge Sprinter vans collect over 1 million miles worth of network data annually for 350 markets. Three hundred of these markets are driven twice a year, and 55 gigabytes of data are shipped back to the Telephia office daily. Figure 1 illustrates current western region drive routes in grey and potential expansion markets in blue.

Mobile Test consists of six steps: data collection, post processing, data loading, quality checks, reporting, and analysis. Once a market has been driven, post processing, quality control checks, and reporting takes an average of 13 days per market to complete (Figure 2).

Telephia builds drive routes using census data, carrier input, and consumer research. Specific routes will often expand from year to year, but each client's annual report includes the same baseline route to measure trends. Route creation starts with selecting the Metropolitan Statistical Area (MSA) boundary for the market, then selecting 100% of the primary and secondary highways as defined by MapInfo Street Pro, and finally selecting all major roads that fall within selected block groups. Figure 3 is an example of the Portland, Oregon Drive Route.

Morrow, Francisco. 2006. Using GIS to Improve the Daily Drive Route Evaluation Process for Mobile Test Operations. Volume 8, Papers in Resource Analysis. 14 pp. Saint Mary's University of Minnesota Central Services Press. Winona, MN. Retrieved (date) from http://www.gis.smumn.edu/

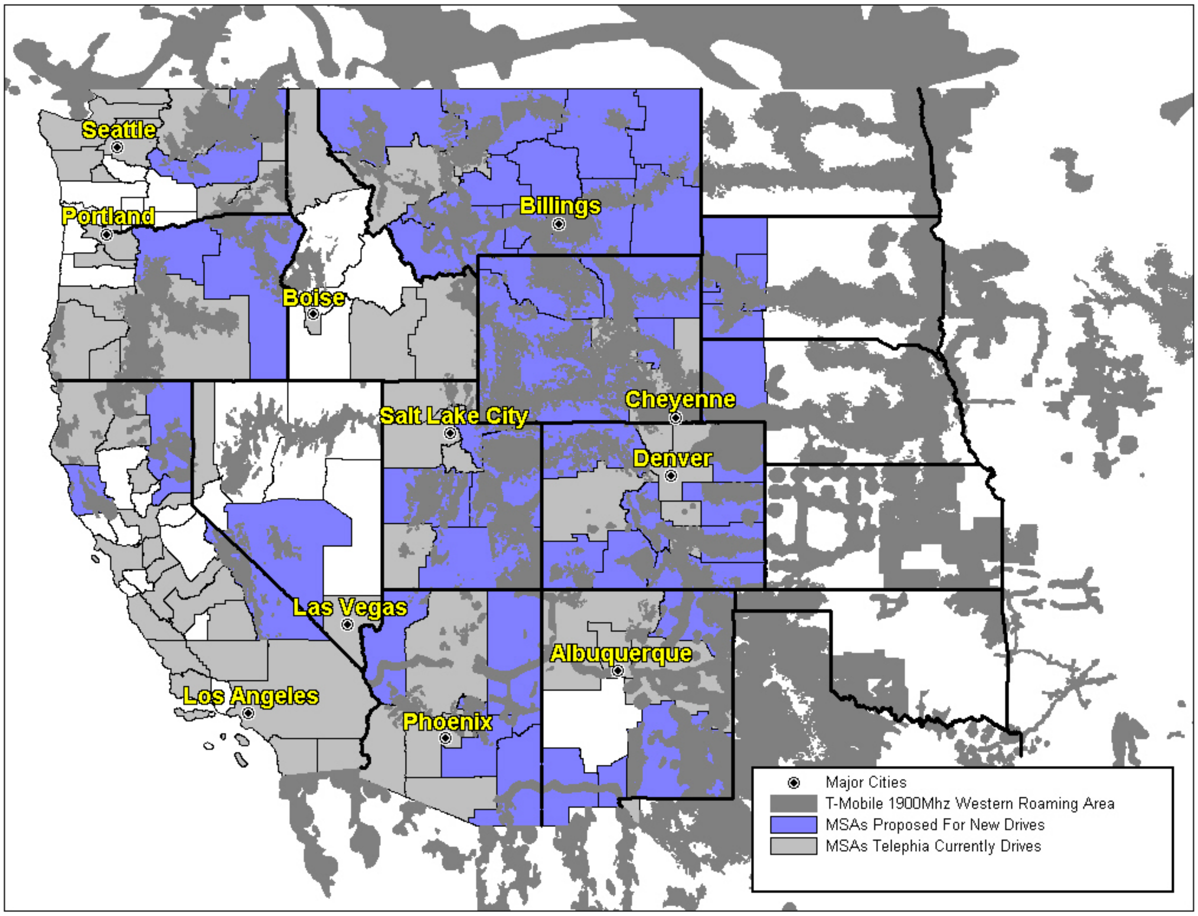



Figure 1. Western Region Markets Driven and Proposed in 2005 by Telephia Mobile Test Team.

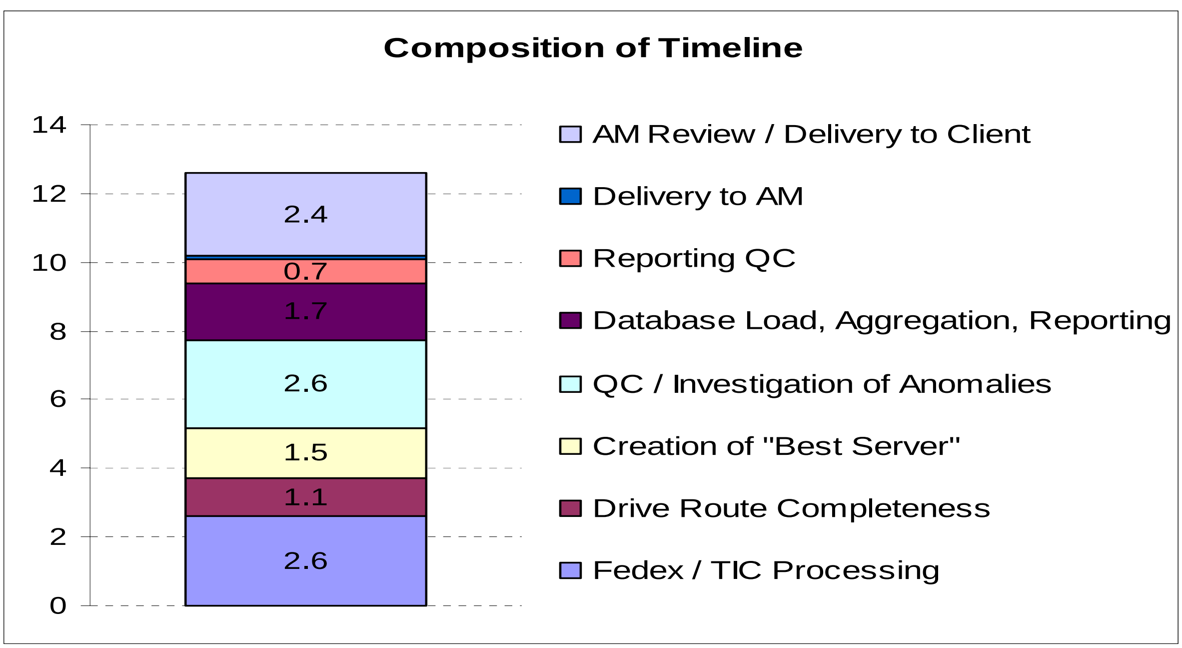



Figure 2. Average Days from Drive End to Report.

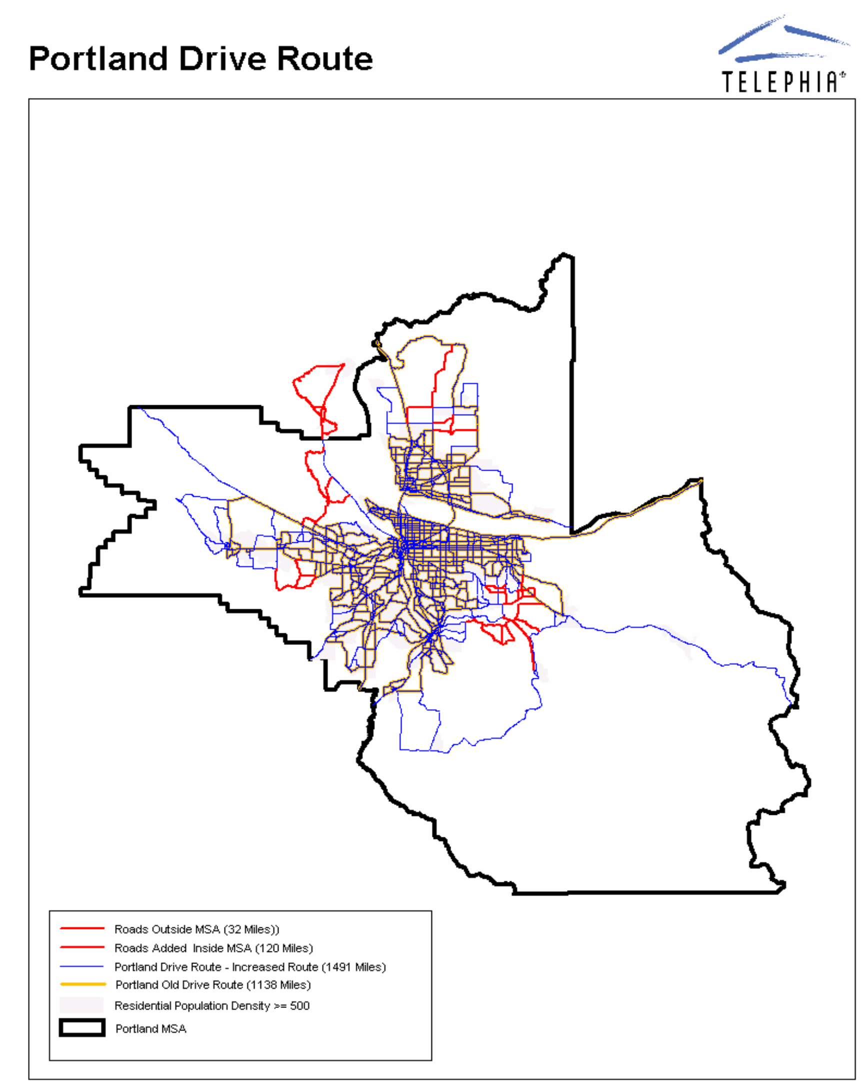



Figure 3. Portland, OR Drive Route.

A Standard Operating Procedure (SOP) is used to manage field collections. Each field technician has a copy of the SOP, receives updates, and follows pre-drive checklists to ensure consistent data collection quality. Upon drive route completion, field technicians cut log files, burn them to DVD, and ship them back to Telephia's Mobile Test operation center (the files are "cut" into manageable segments based on one hour of driving). Data is then loaded onto the network for step 2, Post Processing (Figure 4).

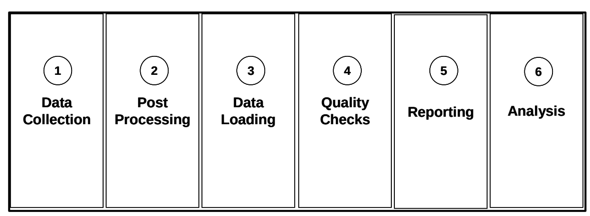



Figure 4. Mobile Test Process.

### *Improving the Daily Drive Route Processes*

Even though field technicians cut log files, burned them onto DVD and send daily FedEx packages, it was very difficult for the Telephia office team to know how much of a market had actually been driven until a

Drive Route Completion (DRC) map was created (Figure 5).

Creating the DRC map is the first step in Post Processing, but cannot be completed until all data for any given market is received by Telephia's mobile test operation center. Once received, all collected data is plotted and assigned one of two colors: red for un-driven, and green for driven. However, just because a route was driven, it does not necessarily mean the data collected was actually complete and accurate. In fact, it is often necessary to re-drive the route to obtain sufficient data.

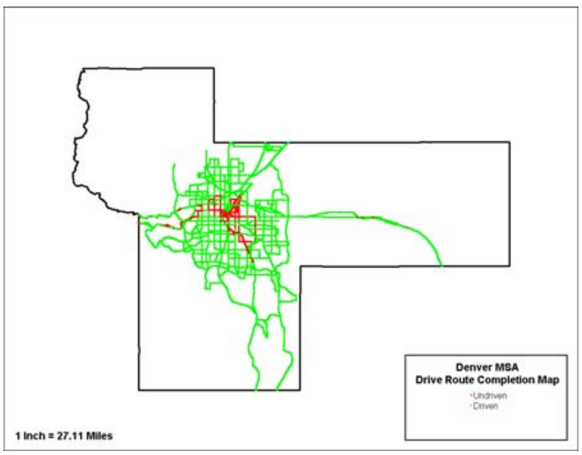



Figure 5. City of Denver, CO DRC Map.

Upon completion of the initial drive, drive teams often have to wait up to four days before receiving either confirmation of completion or instructions to re-drive portions of the route. Moreover, if a re-drive was requested, the only guide for the drive team to work from was a low quality red and green map. The time to wait for confirmation was costing Telephia thousands of dollars per day and the low quality preliminary map did little to add efficiency to the re-drive process.

### *Data*

The Denver and Chicago Drive Routes have been created in MapInfo using MapInfo's street, boundary, and demographic data sets. Denver network performance tests were conducted over a nine day period, while the Chicago network was conducted over 36 days.

Data collection in the field was performed using Dodge Sprinter vans equipped with Invex software created by Andrew Corporation. This software evaluates performance of digital service by placing simultaneous calls on each of the carriers' networks. Once the data have been recorded, two file types are created: SHT files, with radio frequency (RF) parameters (i.e. transmission strength to and from the cell phone), and mini SHT files. Mini SHT files include the number of successful calls and failures but have no RF parameters. All SHT files must be burned to CD and sent to the Telephia office via FedEx. All mini SHT files are transmitted to the office over the internet. This project uses and analyzes mini files.

## Methods

### *Generating Daily Market Statistics for Analysis*

To ensure the highest quality in data collection, market quality control (QC) and analysis was performed daily for each market. An overview of the entire process, starting from field collection to final report, can be observed in Figure 6. Daily QC including drive route analysis can be further broken down as seen in Figure 7.

SHT files and ILF files are terms used by two different programs. When the field team collects raw data, recorded files have an ".SHT" suffix. When SHT files get loaded into TIC (Figure 6), the office analysis program, the SHT files, once processed, convert to ILF files with an ".ILF" suffix. Same file, different suffix ending. For all practical descriptive purposes, SHT and ILF are interchangeable terms. To avoid confusion we will refer to these files as SHT files for the remainder of this paper.

Once all of the day's SHT files have been received from the field and loaded into the market drive server, two queries are performed. The first query checks to make sure that every market had been properly labeled with a market ID, and the second checked for proper drive date labeling. After all files are in good order, daily statistics are generated with a series of six queries. These daily statistics are very important both for the information they contain and for facilitating the analysis of the current status of the market's drive.

For each SHT file, the system ID,

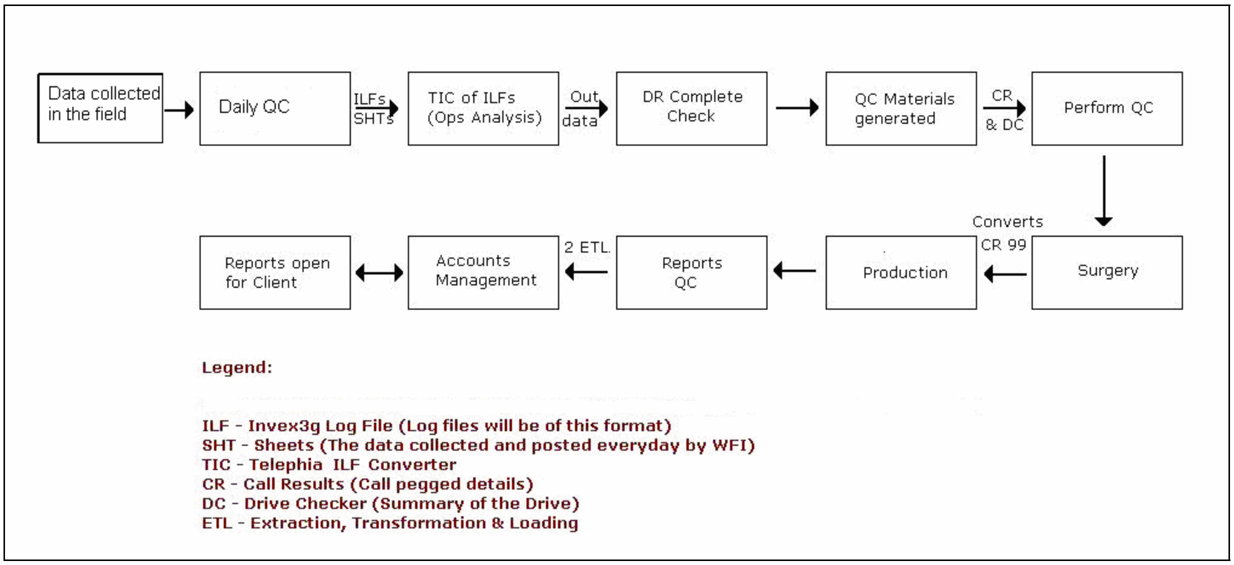



Figure 6. Mobile Test Process.

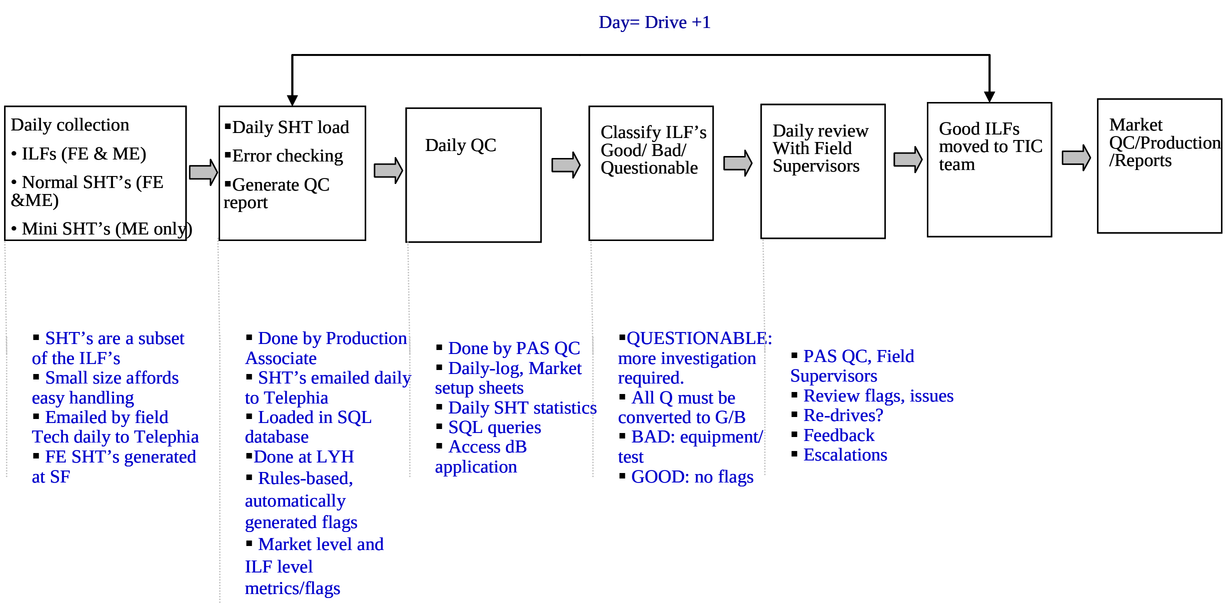



Figure 7. Daily QC Process.

technology, number of failures, average Mean Opinion Score (MOS), percentage of Null MOS, average handset Receive Signal Strength Indication (RSSI) and difference between handset and scanner RSSI are listed in the "Traditional view" tab of the statistics program. Figure 8 depicts a graphic of the "Traditional View tab" of the SHT stats for the Code Division Multiple Access (CDMA) carrier; Denver log. "Red flags" are automatically generated within the spreadsheet when the values fall outside of acceptable range (Table 1).

Red flags require immediate attention, while yellow flags require immediate attention if the frequency of MOS is greater than 30%. If additional information is required on an SHT-level in order to classify a file, the SHT-level tab is used. Figure 9 is a screenshot of a detailed SHT-level summary of the SHT statistics for each carrier of the Denver log. Three examples of the types of statistics are: the total number of call attempts made, the type of failure (Origination, Ab-End etc.), and frequency sub-band the phone was in.

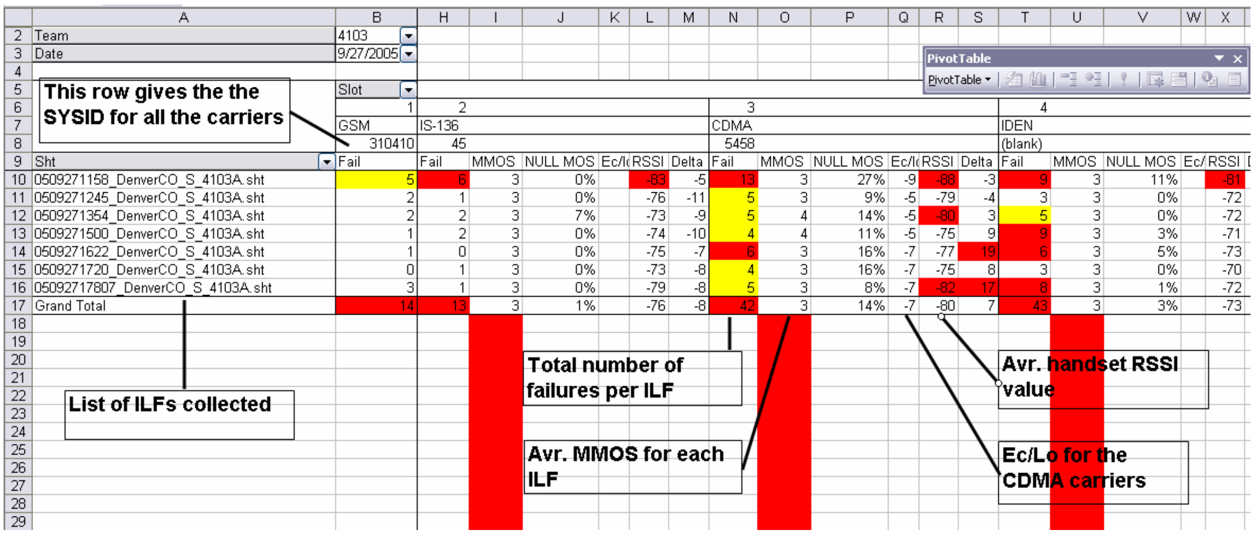



Figure 8. Denver - Traditional View tab for 9/27/05.

Table 1. Daily QC Flags highlighted in Daily Statistics.

| Flag Index | Flag | Color |
|---|---|---|
| Flag 1 | Number of failures per carrier is between 3 and 5 in an ILF | Yellow |
| Flag 2 | number of failures for a carrier is 5 or more | Red |
| Flag 3 | mobile MOS is between 3 and 3.2 | Yellow |
| Flag 4 | mobile MOS of less than 3 generates a red flag | Red |
| Flag 5 | % Null MOS is between 30% and 50% | Yellow |
| Flag 6 | % Null MOS is greater than 50% | Red |
| Flag 7 | Ec/Io is less than -15.00 (PILOT_STRENGTH is the ratio of received pilot energy, Ec, to total received energy or the total power spectral density, Io) | Red |
| Flag 8 | Handset RSSI is between -80 and -95 dBm (power ratio in terms of decibels ) | Yellow |
| Flag 9 | Handset RSSI is less than -95 dBm | Red |
| Flag 10 | Handset scanner difference is between -8 and -15 | Yellow |
| Flag 11 | Handset-scanner difference is below -15 dBm | Red |

| | Team | Shift | Date | Zip | Sht | Market | Std | Slot | % 1900 F | Total Attempts | % Origination Failure | % Setup failure | % No Service | % Ineffective Failure | % Ab-Ends | % Total Failure | Avg Coded Level | % between -4 and 2 | Avg MMOS | % MOS | Avg RSSI | Avg Sig Qual | Avg Ec/Io | Avg Delay Spread | Scanner-Handset delta |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3217 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271158_DenverCO_S_4103A.sht | DENVER, CO | GSM | 1 | 0 | 18 | 4 | 1 | 0 | 5 | 0 | 500% | -2.52 | 70% | 3.39 | 0% | -84.86 | 3.17 | | 8 | -5.31 |
| 3218 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271245_DenverCO_S_4103A.sht | DENVER, CO | GSM | 1 | 0 | 28 | 0 | 2 | 0 | 2 | 0 | 200% | 0.66 | 100% | 3.63 | 0% | -72.06 | 1.48 | | 7 | 2.17 |
| 3219 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271354_DenverCO_S_4103A.sht | DENVER, CO | GSM | 1 | 0 | 27 | 0 | 1 | 0 | 1 | 1 | 200% | 1.07 | 93% | 3.67 | 3% | -73.59 | 1.17 | | 4 | 2.21 |
| 3220 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271500_DenverCO_S_4103A.sht | DENVER, CO | GSM | 1 | 0 | 28 | 0 | 1 | 0 | 1 | 0 | 100% | 1.36 | 96% | 3.64 | 0% | -73.90 | 1.56 | | 10 | -9.12 |
| 3221 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271622_DenverCO_S_4103A.sht | DENVER, CO | GSM | 1 | 0 | 23 | 0 | 0 | 0 | 0 | 1 | 100% | 0.90 | 95% | 3.47 | 4% | -73.45 | 2.31 | | 40 | -5.76 |
| 3222 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271720_DenverCO_S_4103A.sht | DENVER, CO | GSM | 1 | 0 | 19 | 0 | 0 | 0 | 0 | 0 | 0% | 1.29 | 95% | 3.61 | 0% | -69.77 | 1.20 | | 7 | 1.59 |
| 3223 | 4103 | a | 9/27/2005 | 0927_4103. | 05092717807_DenverCO_S_4103A.sht | DENVER, CO | GSM | 1 | 0 | 28 | 0 | 0 | 0 | 0 | 3 | 300% | -1.83 | 95% | 3.49 | 5% | -78.77 | 2.73 | | 30 | -7.50 |
| 3224 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271158_DenverCO_S_4103A.sht | DENVER, CO | IS-136 | 2 | 0 | 19 | 5 | 0 | 0 | 5 | 1 | 600% | -2.03 | 100% | 3.32 | 0% | -83.37 | 0.56 | | 0 | -4.86 |
| 3225 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271245_DenverCO_S_4103A.sht | DENVER, CO | IS-136 | 2 | 0 | 28 | 0 | 0 | 0 | 0 | 1 | 100% | -2.25 | 97% | 3.15 | 0% | -76.40 | 0.40 | | 109 | -11.03 |
| 3226 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271354_DenverCO_S_4103A.sht | DENVER, CO | IS-136 | 2 | 0 | 27 | 0 | 0 | 0 | 0 | 2 | 200% | -2.07 | 93% | 3.14 | 7% | -73.36 | 0.51 | | 178 | -8.70 |
| 3227 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271500_DenverCO_S_4103A.sht | DENVER, CO | IS-136 | 2 | 0 | 29 | 2 | 0 | 0 | 2 | 0 | 200% | -2.04 | 100% | 3.13 | 0% | -74.07 | 0.23 | | 152 | -9.58 |
| 3228 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271622_DenverCO_S_4103A.sht | DENVER, CO | IS-136 | 2 | 0 | 23 | 0 | 0 | 0 | 0 | 0 | 0% | -2.00 | 100% | 3.34 | 0% | -74.83 | 0.40 | | 0 | -7.37 |
| 3229 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271720_DenverCO_S_4103A.sht | DENVER, CO | IS-136 | 2 | 0 | 19 | 0 | 0 | 0 | 0 | 1 | 100% | -2.31 | 100% | 3.30 | 0% | -72.52 | 0.38 | | 3 | -7.99 |
| 3230 | 4103 | a | 9/27/2005 | 0927_4103. | 05092717807_DenverCO_S_4103A.sht | DENVER, CO | IS-136 | 2 | 0 | 28 | 1 | 0 | 0 | 1 | 0 | 100% | -2.02 | 98% | 3.32 | 0% | -79.01 | 0.58 | | 2 | -7.85 |
| 3231 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271158_DenverCO_S_4103A.sht | DENVER, CO | CDMA | 3 | 0 | 22 | 2 | 0 | 4 | 6 | 7 | ### | -2.46 | 72% | 3.45 | 27% | -87.97 | 1.71 | -8.70 | 10 | -2.93 |
| 3232 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271245_DenverCO_S_4103A.sht | DENVER, CO | CDMA | 3 | 0 | 29 | 0 | 2 | 0 | 2 | 3 | 500% | -1.29 | 89% | 3.46 | 9% | -78.94 | 0.35 | -5.48 | 28 | -3.64 |
| 3233 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271354_DenverCO_S_4103A.sht | DENVER, CO | CDMA | 3 | 0 | 29 | 0 | 0 | 0 | 0 | 5 | 500% | -0.35 | 86% | 3.50 | 14% | -80.43 | 0.19 | -5.34 | 19 | 2.97 |
| 3234 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271500_DenverCO_S_4103A.sht | DENVER, CO | CDMA | 3 | 0 | 29 | 0 | 0 | 0 | 0 | 4 | 400% | -0.38 | 89% | 3.50 | 11% | -74.96 | 0.16 | -5.39 | 12 | 9.46 |
| 3235 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271622_DenverCO_S_4103A.sht | DENVER, CO | CDMA | 3 | 0 | 26 | 0 | 0 | 0 | 0 | 6 | 600% | -0.96 | 84% | 3.48 | 16% | -76.67 | 0.30 | -6.85 | 12 | 18.68 |
| 3236 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271720_DenverCO_S_4103A.sht | DENVER, CO | CDMA | 3 | 0 | 20 | 0 | 0 | 0 | 0 | 4 | 400% | -0.77 | 84% | 3.49 | 16% | -75.49 | 0.70 | -6.93 | 16 | 7.68 |
| 3237 | 4103 | a | 9/27/2005 | 0927_4103. | 05092717807_DenverCO_S_4103A.sht | DENVER, CO | CDMA | 3 | 0 | 29 | 1 | 0 | 0 | 1 | 4 | 500% | -3.03 | 86% | 3.45 | 8% | -82.35 | 0.41 | -7.50 | 15 | 17.23 |
| 3238 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271158_DenverCO_S_4103A.sht | DENVER, CO | IDEN | 4 | 0 | 19 | 0 | 5 | 3 | 8 | 1 | 900% | -0.47 | 88% | 3.41 | 11% | -81.48 | 22.64 | | 21 | -12.30 |
| 3239 | 4103 | a | 9/27/2005 | 0927_4103. | 0509271245_DenverCO_S_4103A.sht | DENVER, CO | IDEN | 4 | 0 | 28 | 0 | 3 | 0 | 3 | 0 | 300% | -0.49 | 100% | 3.32 | 0% | -72.17 | 28.39 | | 27 | -11.47 |

Figure 9. Denver - SHT tab for 9/27/05 (Yellow columns designate vital areas of observation; red are flags).

Once daily statistics are determined to be acceptable, a market classification analysis and progression map are conducted for each market.

This paper analyzes the Denver, Colorado market. Keep in mind, however, that this same process was taking place in 22 markets, each day—each market with its own drive team.

## Analysis

The initial goal is to determine whether a specific SHT file is "good" (complete and error free) or "bad" (incomplete and/or some errors). The second goal is to determine what steps must be taken to make "bad" SHT files "good." The ultimate goal is to have all files be "good" so that only "good" data is forwarded on for the final steps in the entire process toward generating a useful report for the Telephia Client.

In order to mark a file "bad," the codes in Table 2 are used to classify each SHT in the SHT statistics tab listed above.

"Good/bad" classification is performed daily with the following instructions and guidelines:

a. The daily QC flags that are used to trigger any investigations have been defined in Table 1 above. Each table provided in this section refers back to a flag that has been described in Table 1 using the Flag ID number.

b. The conditions listed in the tables in each section have to ALL be true/false in order to mark a file "Good/Bad."

c. Any investigation required prior to classifying an SHT as "good/bad" that takes more than a day to resolve will require that the SHT be classified as "Questionable" until a final resolution is reached. "Questionable" status is simply a transition state, not a final classification.

d. ALL "Questionable" SHTs must be further classified as "good" or "bad."

Table 2. QC Codes towards marking a file “BAD.”

| # | Description | QC Category |
|---|---|---|
| 1 | Field marked ‘BAD’ | FIELD |
| 2 | Test Files | TEST |
| 3 | Failures under Good RxLevel- GSM, CDMA and iDEN | FAILUREG<br>FAILUREC<br>FAILUREI |
| 4 | Poor handset RSSI not matching with scanner- GSM<br>Poor handset RSSI not matching with scanner- CDMA<br>Poor handset RSSI not matching with scanner- iDEN | HANDSETG<br>HANDSETC<br>HANDSETI |
| 5 | Large Handset-Scanner delta | SCANNER |
| 6 | PRL issue with CDMA handset | PRL |
| 7 | Did not collect all required handsets | MISSHANDSET |
| 8 | Low MMOS, 50% or more NULL MMOS | MMOS |
| 9 | Fixed-End issue | FE |
| 10 | Scanner showing values outside acceptable range- GSM<br>Scanner showing values outside acceptable range- CDMA | SCANNERG<br>SCANNERC |
| 11 | ILFs with failures that can trigger sensitive CQ’s | SENSITIVE |
| 12 | 0KB | 0 KB SHTs |
| 13 | Drive outside regular hours | DRIVETIME |
| 14 | Customer/AM request to remove ILFs | AMREQUEST |
| 15 | Field Operations re-drove a particular ILF | REDRIVE |

### *Breakdown of Codes*

For each of these “codes,” in Table 2 there are specific performance tests referred to as “flags.” The “codes” and related “flags” form a complex “if/then” evaluation and diagnostic key that evaluates each SHT file as “good” or “bad” and suggests the most likely problem. There are 15 codes and 12 flags but not all flags apply to all codes.

While Denver experienced several “bad” flags, Code 4 and its rules (Flags 3, 4, and 5) were some of the more common. Table 3 highlights two examples of the “code/flag” tests.

Table 3. Example of code 4 “Flags.”

| Flag | Condition | Status |
|---|---|---|
| 3,4,5 & 6 | If avg. RSSI for SHT < -85 | Good |
| 3,4,5 & 6 | If avg. RSSI for SHT > -85 | Bad |

### Results

Each day was summarized by Date, File Name, Status, and Notes. Of the 95 SHT files created for Denver, 64 were acceptable on the first run, 11 files converted to good, and 19 files required a re-drive (Table 4).

### Discussion

In most technology based service companies, the biggest challenge is not so much the creation of basic technology, but finding economically sustainable business models for adapting basic technology to meet the needs of willing clients. In order to do this, the technology has to provide useful, value adding information that can be gathered and delivered to clients in an efficient and profitable manner. For Telephia, the final Mobile Test product is a series of drive route maps that convert massive amounts of reception and

Table 4. Daily SHT – Good, Bad, Questionable Pivot Table.

| Count of File Name | Status | | | |
|---|---|---|---|---|
| Notes | Bad | Good | (Blank) | Grand Total |
| 0 KB | 6 | | | 6 |
| 0 KB - Valid Network issue across all carrier (changed from Bad to Good on 10/6) | | 1 | | 1 |
| 97% null MOS for Verizon Wireless | 1 | | | 1 |
| CDMA (Code-Division Multiple Access, a digital cellular technology) scanner issue Changed from Questionable to Good on 10/3 | | 10 | | 10 |
| Failure across all carriers | 1 | | | 1 |
| Field marked it Bad | 1 | | | 1 |
| Handset issue , marked Bad by the engineer | 1 | | | 1 |
| MMOS issue for 2 carriers | 1 | | | 1 |
| Null MOS for Alltel | 1 | | | 1 |
| Test/Bad files marked by field | 7 | | | 7 |
| Blank | | 64 | 1 | 65 |
| Grand Total | 19 | 75 | 1 | 95 |

transmission data to accurately confirm network coverage.

In early stages of the Mobile Test product development, Telephia technicians tended to assume that once a drive route was completed, the resulting map could automatically be considered "green" (complete and accurate). Unfortunately, this assumption rapidly led to a discrepancy between performance as predicted by Telephia and performance as experienced by the customer. It was crucial to develop a timely process for evaluating drive route maps as "green" (acceptable) or "red" (unacceptable), and at the same time determine the most likely source of error in the unacceptable maps. Only when all maps in the target geography are declared green can a report be sent to the client.

The new evaluation process is based on a "code/flag" system of complex "if/then" evaluation and diagnostic keys to evaluate data files as they are gathered. The files are then clearly identified on maps as "green routes" (driven and judged acceptable), "blue routes" (driven but not yet evaluated) and "red routes" (driven but unacceptable).

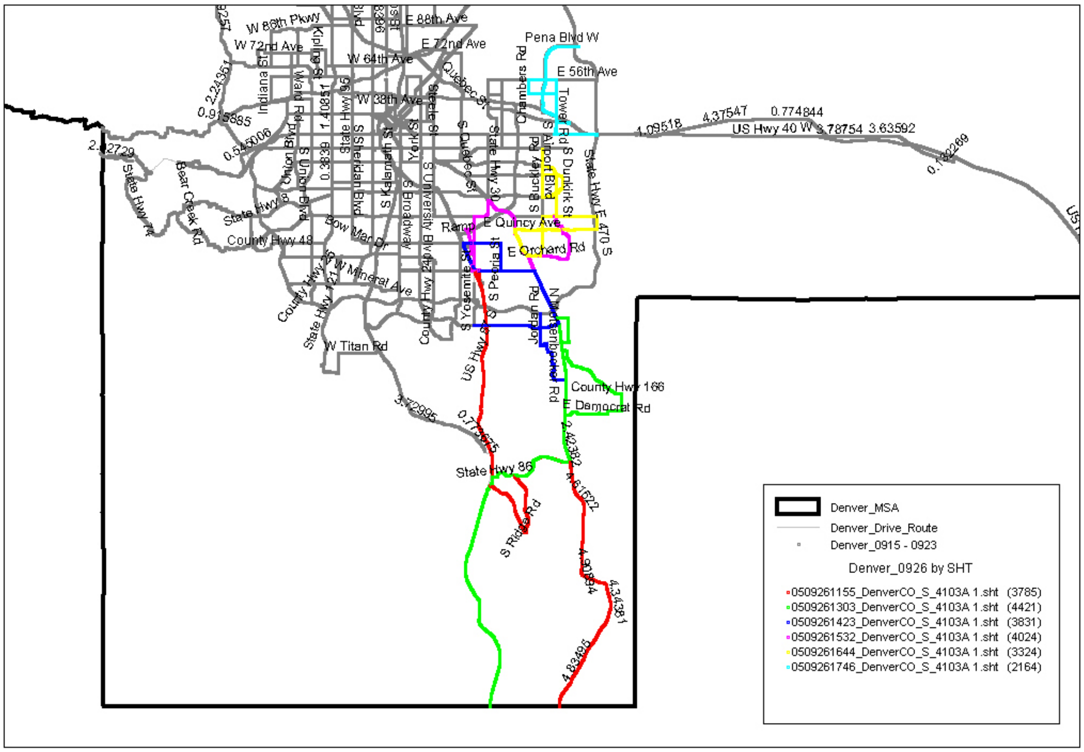
This process is outlined using the Denver SHT files as an example. The SHT files appended with a "good" or "bad" (flagged) status reading as seen in Table 4 have allowed for the integration of customized Drive to Date (DTD) and daily SHT maps. This integration has allowed Mobile Test to create daily "snapshots" of a market's progression from start to finish.

The process can be summarized as follows: All SHT files are first plotted in "blue" meaning driven but not yet evaluated. These files remain blue until evaluated by the code/flag system and are then assigned a "good," "bad," or "questionable" status. As SHT files are evaluated by the code/flag system, they are automatically changed to one of three colors: Green for good, red for bad, and orange for questionable (Figure 11). Files that remain "bad" are highlighted in a re-drive map, and sent back to the field for re-drive as previously shown in the last two maps in figure 12.

This improved process has provided all field supervisors a daily monitoring tool that can document and publish daily updates of the status of each market study. This has allowed for better managerial oversight of field crews, time spent on each market, and fewer re-drives.

Through this system both the data and the process for acquiring data are improved, the clients are assured that their respective coverage has been accurately reported, and Telephia can build its reputation for accurate analysis.

## Denver SHTs for 09-26-05




## Denver Driven To Date

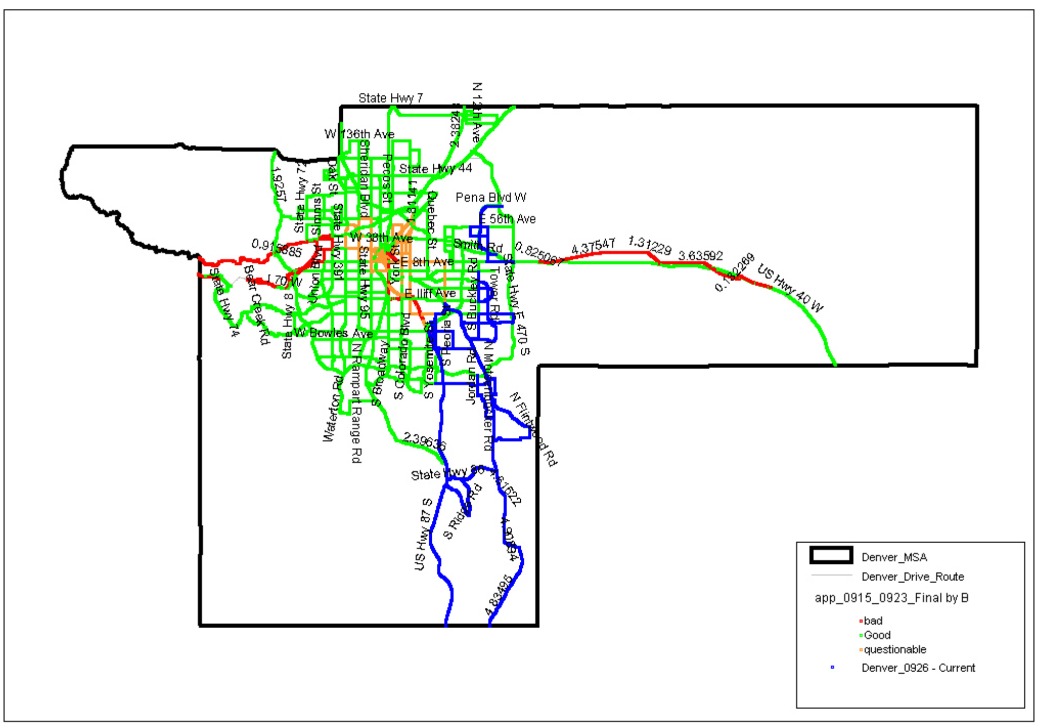



Figure 11. DTD – Progression Maps 9/26/05.

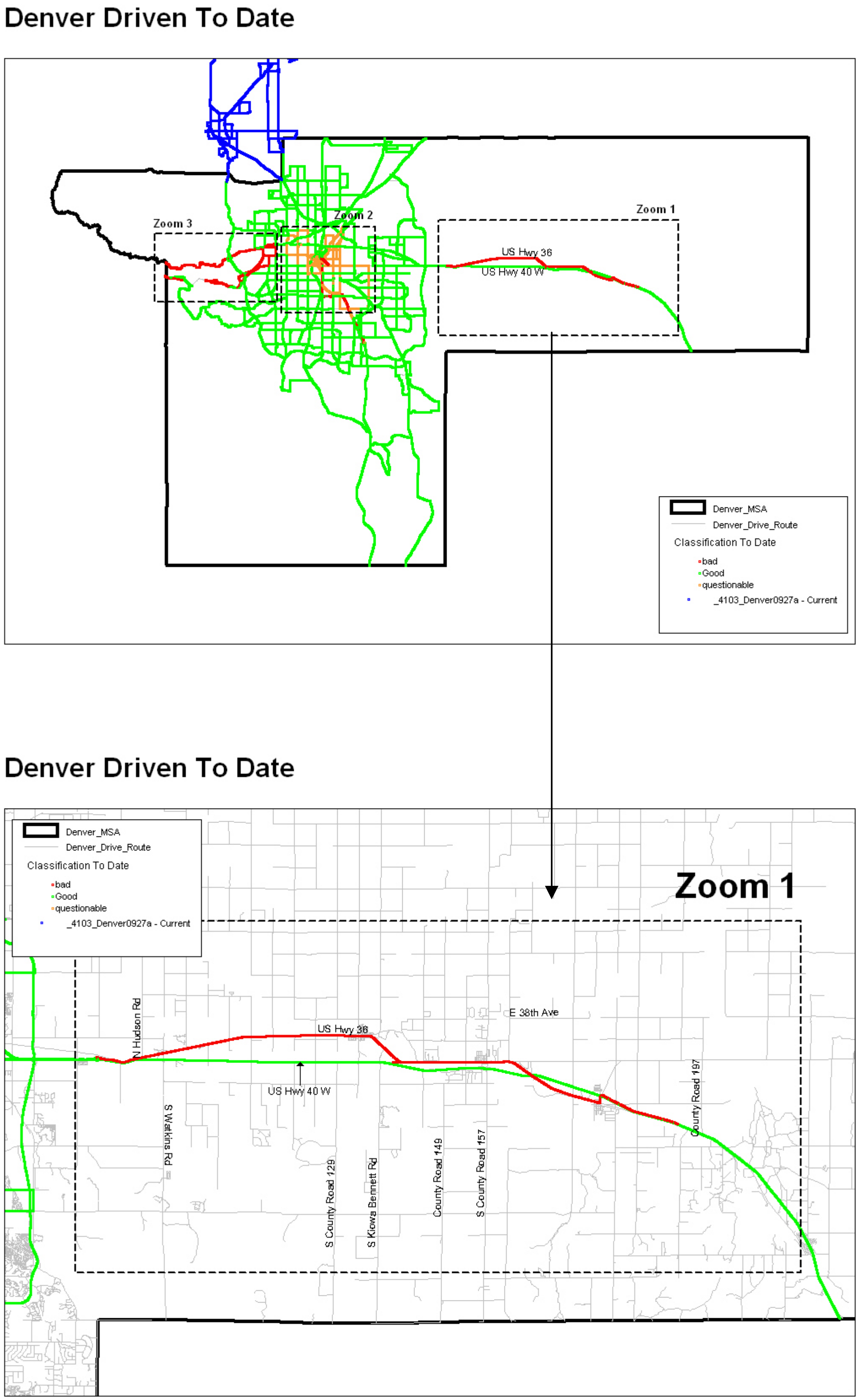



Figure 12. Denver Re-Drive Maps.

***What's next for Mobile Test?***

Mobile Test has reached two new milestones that are worth mentioning. First, field teams have gone techless. Telephia no longer has a two person team (one driver, one engineer) out in the field collecting data. The engineer previously rode along in a drive test van, evaluating equipment and troubleshooting when problems arose. In the techless system, field supervisors in Lynchburg, VA now remotely monitor and control the test equipment in the field, communicating via remote data links. They troubleshoot problems remotely, and work with the drivers when human intervention is required. Going techless has reduced expenses on the Mobile Test product by about $2.5 million dollars annually.

The second milestone has resulted in a cooperative project named Mobile View, in which Qualcomm and Telephia are jointly developing an "on device" metering chip that drastically changes the way mobile data is collected and measured. Mobile View is a client applied chipset device that directly measures a subscriber's network experience, and then sends results to a central server (Table 5).

This means Telephia is no longer restricted to collecting dropped calls on roads only. A chip now can be installed on any phone and track network connection quality at the subscriber's phone location (Figure 13).

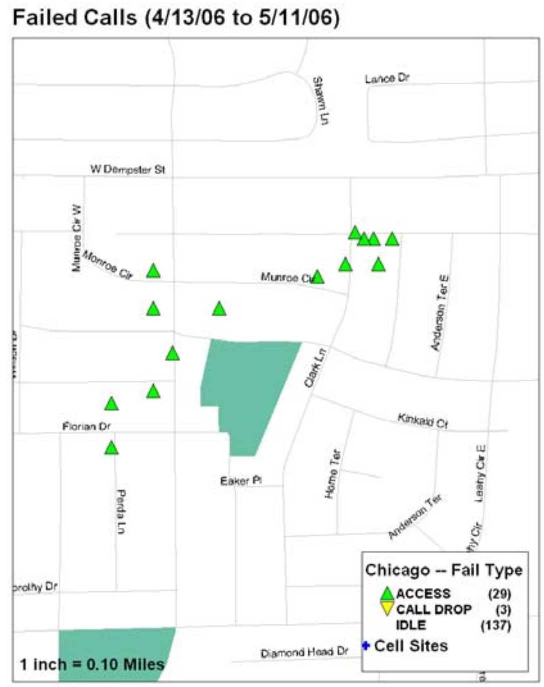



Figure 13. Mobile View, Chicago. Failed Calls (Because this is a zoomed view, the three dropped calls and six of the fourteen access failures are not visible).

Figure 14 and 15 are satellite views of the 14 access failures from the Mobile View of Figure 13. Satellite views are useful in providing suggestions about the sources of error - especially when there is some question as to whether the source of error is transmission, natural terrain or constructed buildings. Figure 14 highlights the superimposed transmission arcs (green) and failed calls represented in red, providing clues to solving these errors. Figure 15

Table 5. 14 Failed Calls.

| BSID | ASET_PN | Fail_Type | Time__CDT_ | GPS_Lat | GPS_Long | Avg_Tx | Avg_Rx | Avg_EcIo |
|---|---|---|---|---|---|---|---|---|
| 569 | 276 | ACCESS | 1145156451 | 42.03630 | -87.92600 | -49.8 | -89.9 | -5.8 |
| 569 | 276 | ACCESS | 1145242859 | 42.03630 | -87.92640 | -46.6 | -92.9 | -8.7 |
| 338 | 276 | ACCESS | 1145248247 | 42.03590 | -87.92630 | -47.3 | -92.3 | -7.5 |
| 569 | 276 | ACCESS | 1146198669 | 42.03300 | -87.93200 | -47.1 | -92.7 | -4.7 |
| 569 | 276 | ACCESS | 1146366067 | 42.03520 | -87.92970 | -46.7 | -92.6 | -7.7 |
| 569 | 276 | ACCESS | 1146367858 | 42.03630 | -87.92660 | -47.0 | -92.8 | -6.2 |
| 569 | 276 | ACCESS | 1146454262 | 42.03390 | -87.93110 | -47.8 | -92.0 | -6.6 |
| 338 | 276 | ACCESS | 1146452452 | 42.03640 | -87.92680 | -47.9 | -91.8 | -9.4 |
| 569 | 276 | ACCESS | 1146803471 | 42.03370 | -87.93200 | -47.1 | -92.6 | -7.0 |
| 338 | 282 | ACCESS | 1146886264 | 42.03580 | -87.93110 | -45.5 | -94.2 | -8.0 |
| 338 | 282 | ACCESS | 1146970851 | 42.03520 | -87.93110 | -46.4 | -93.2 | -5.9 |
| 338 | 282 | ACCESS | 1146972659 | 42.03450 | -87.93070 | -47.4 | -92.3 | -6.0 |
| 569 | 282 | ACCESS | 1147059053 | 42.03590 | -87.92700 | -45.7 | -94.0 | -8.3 |
| 569 | 282 | ACCESS | 1147059399 | 42.03570 | -87.92760 | -45.2 | -94.4 | -7.7 |

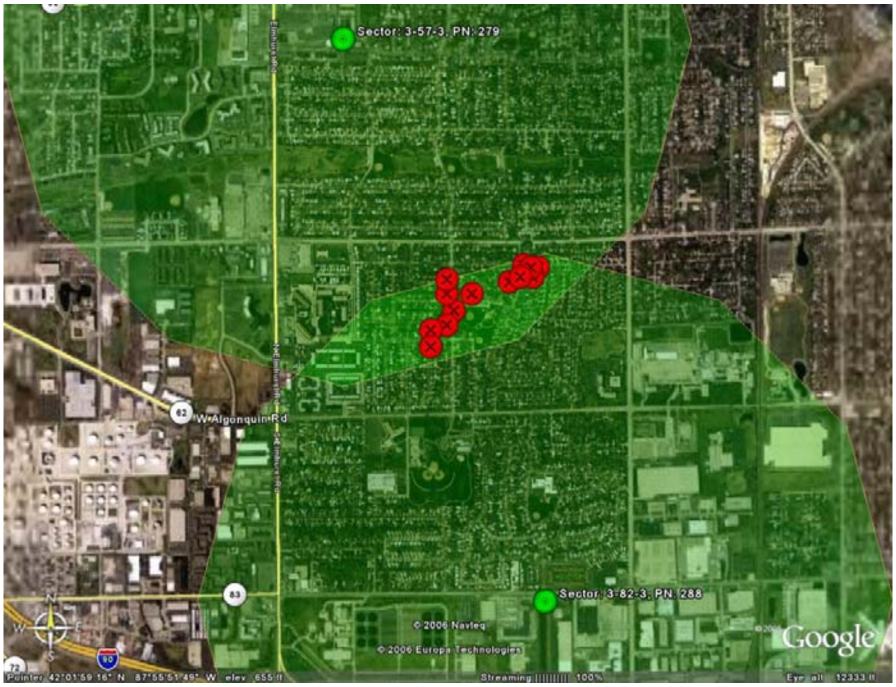



Figure 14. Satellite Image, Chicago.

confirms that there were no obvious problems in terrain or construction.

Traditional drive route collection methods would not have picked up the dropped calls because these residential roads would not have been driven (Figure 15), and no cell site location data would have been collected during the process. In this overlap case, a simple tower adjustment can correct the problem area.


Figure 15. Satellite Image, Chicago. Failed Calls.

Techless vans and monitoring chips are just two new advances within the mobile test arena. Is it possible that Mobile View might provide a basis for eliminating the need for vans? New GIS technologies and applications are between improving an existing process such as Mobile Test or to adopt a new technology such as Mobile View. Businesses sustain innovation with profits generated from providing services and often must simultaneously improve current technology as they investigate new. This paper has attempted to demonstrate this simultaneous challenge.

**Acknowledgements**

I would like to give a special thanks to John Ebert and Doc for their five plus years of guidance and patience to see this project through. Patrick Thorsell, thank you for correcting my paper, and encouraging me to finish this project. Kevin Ching, you are the coolest boss I have ever had! Dave Petersen, thank you for bringing me on for the Qualcomm project. Thank you Aunt Janine for helping me get my thoughts out on paper. Katie, you are the formatting queen! Thank you mom and dad for being so supportive and letting me put GIS studies on hold to chase fires in Southern California. Thank you also for five years of polite reminders that a GIS project awaits completion.  Here it is.

**References**

No sources were needed because the processes listed above were created internally by the author of this paper and the rest of the Telephia Mobile Test Team.