4G Unwired
RF Engineering Services

WirelessMetrix

Fixed Wireless LTE Measurements with Car-Mounted BEC Modem

and Wireless Metrix

LML & LMA Software

Draft November 2019

BEC TECHNOLOGIES

XtremeLTE
join the broadband evolution

Test Objective: Determine if Wireless Metrix drive test software could be used with a BEC modem mounted inside a vehicle to test and map LTE coverage for a Fixed Wireless LTE Network -

- Yes! 4G Unwired has successfully tested Wireless Metrix drive test software with a BEC modem which can quickly collect a large amount of empirical data. These results can be mapped to verify existing LTE RSRP coverage levels.

- Collected measurement data from a drive test provides a true indicator of actual LTE coverage and can be used to validate LTE coverage at both existing and potential subscriber locations.

- The collected data can also be used to update and validate Computer Propagation Models –

--> This document highlights a method to easily collect measurement data to validate coverage <--

Data Collection with a ‘Drive Test’

In-vehicle BEC fixed modem with LML on a laptop

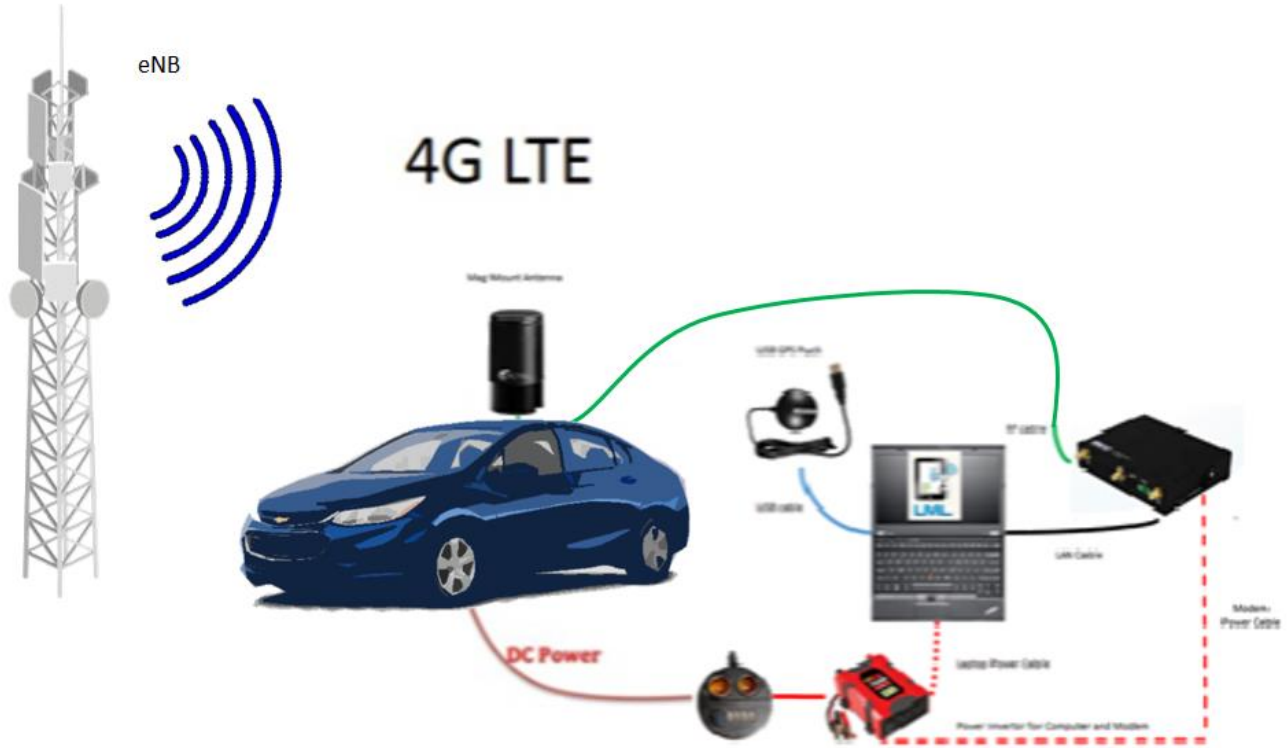


Diagram of Test Setup

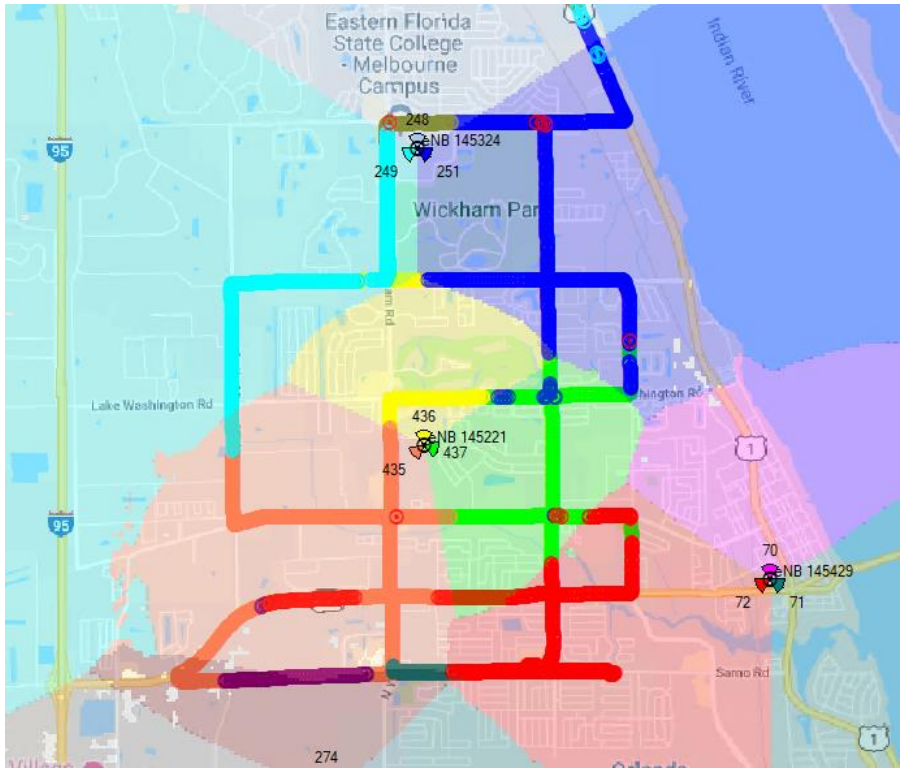
- A laptop running Link Master Logging Software is connected to a BEC modem via a LAN cable, to a GPS antenna with a USB cable, and powered through a power inverter.

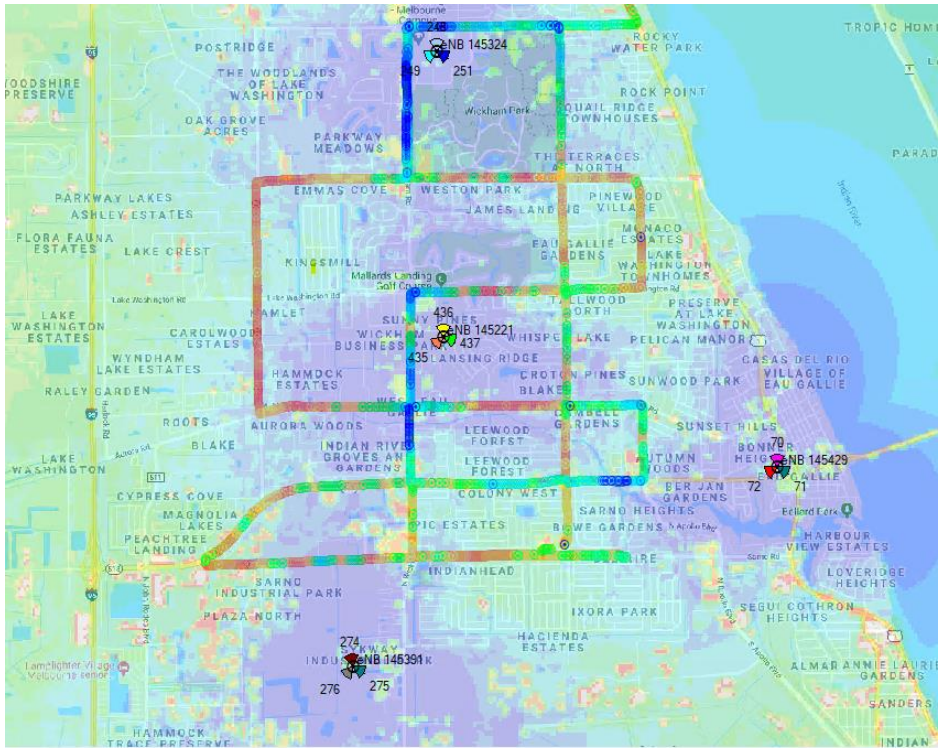
- The BEC modem is then connected to an omnidirectional magnetic-mount antenna positioned on the roof of the test vehicle.

- Another option would be to add a high-speed scanner that covers the target band to the laptop with a magnetic-mount antenna

Real World KPI Results with Link Master Analysis

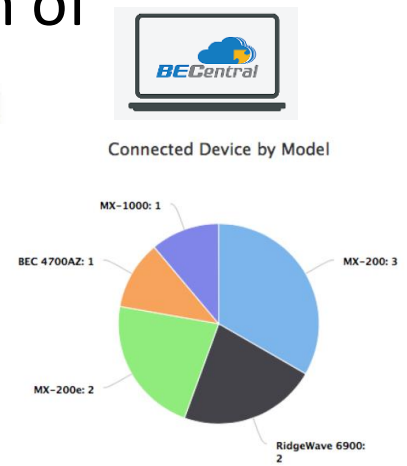
- Coverage Review
  - Note that we can compare which sector is strongest to help validate CPE configuration
  - Computer Propagation Prediction coverage levels can be compared with actual data as shown
  - Propagation model can be adjusted to better fit measurement data.

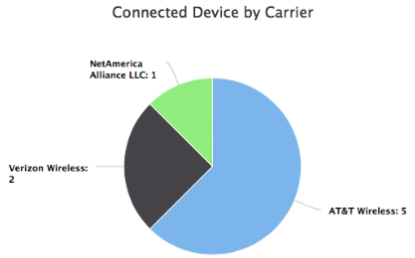




Existing Subscriber Measurements

- **BECentral** from BEC Technologies allows for the real-time collection of several KPIs*:
  - RSRP
  - SINR
  - RSSI
  - Serving PCI/Cell
  - Latitude and Longitude





*Note that the operator would need to confirm whether CPE is indoors, outdoors, gain of the CPE antenna, and height of the CPE antenna in order to validate any RF predictions.

--> This is a good way when the customers are existing

Drive Test Data Collection advantages:

- Collect measurements while driving through the coverage area -
- The SW collects a measurement every second -
- Use a mag-mount omnidirectional antenna connected to the test modem so that measurements are uniform in all directions -
- The test modem is connected to the laptop with a USB GPS antenna -
- Software on the laptop will collect LTE measurement data in real time and the measurements will be saved for further review and analysis -

Mobile Vs Static Testing:

More measurements = Better statistics:

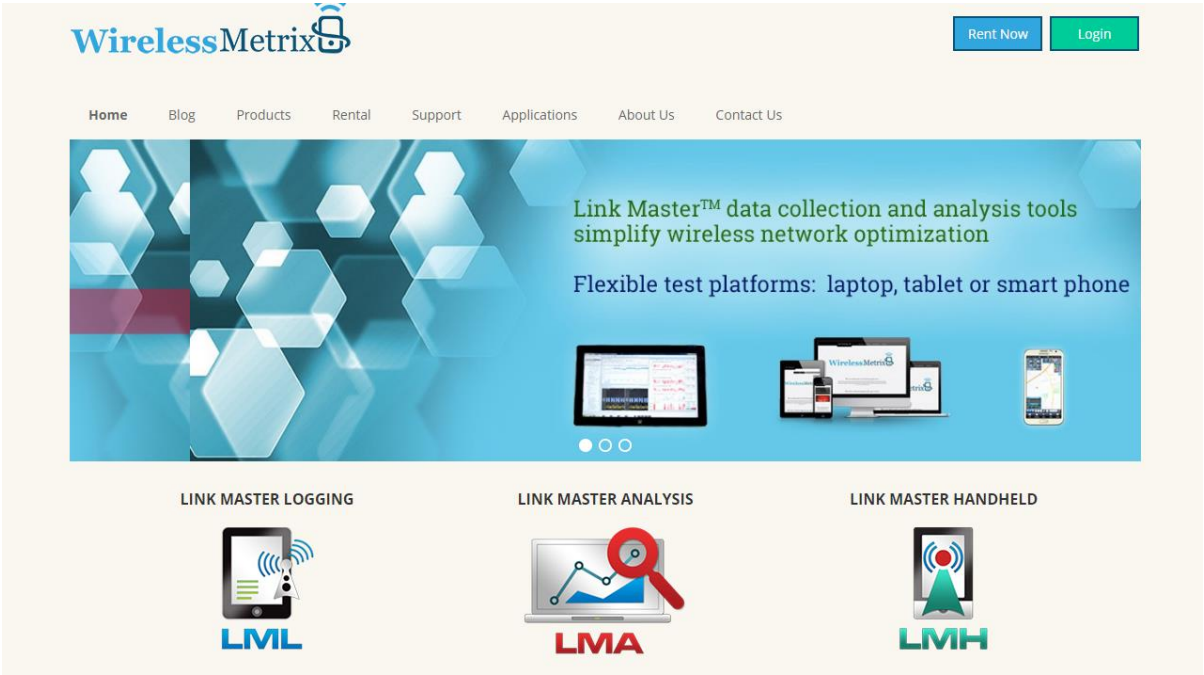
- **LML drive test SW can easily collect thousands of measurements in a single drive,** which then can be filtered by cell or target area -
  - Data can be easily imported into an RF planning tool for propagation model validation.
- **Receive Height Correction for Propagation Models:**
  - Propagation model formulas such as the HATA and Standard Propagation Models have corrections if the receive height is varied =

HATA Prediction Model		*f (MHz)*					
Relative Gain per Rx height		*750*	*850*	*1900*	*2100*	*2500*	*3650*
Receive Ht (m)	*1.5*	0.01	0.01	0.05	0.05	0.06	0.07
	3	*3.70*	*3.80*	*4.41*	*4.48*	*4.61*	*4.90*
	5	*8.63*	*8.84*	*10.22*	*10.39*	*10.69*	*11.34*

Drive Test Software – Wireless Metrix

(https://www.wireless-metrix.com/)

- Link Master Logging (LML): Software that runs on a laptop to interface with a CPE router/phone and logs the network KPIs.
- Link Master Analysis (LMA): Software used to post process the log files generated by LML.



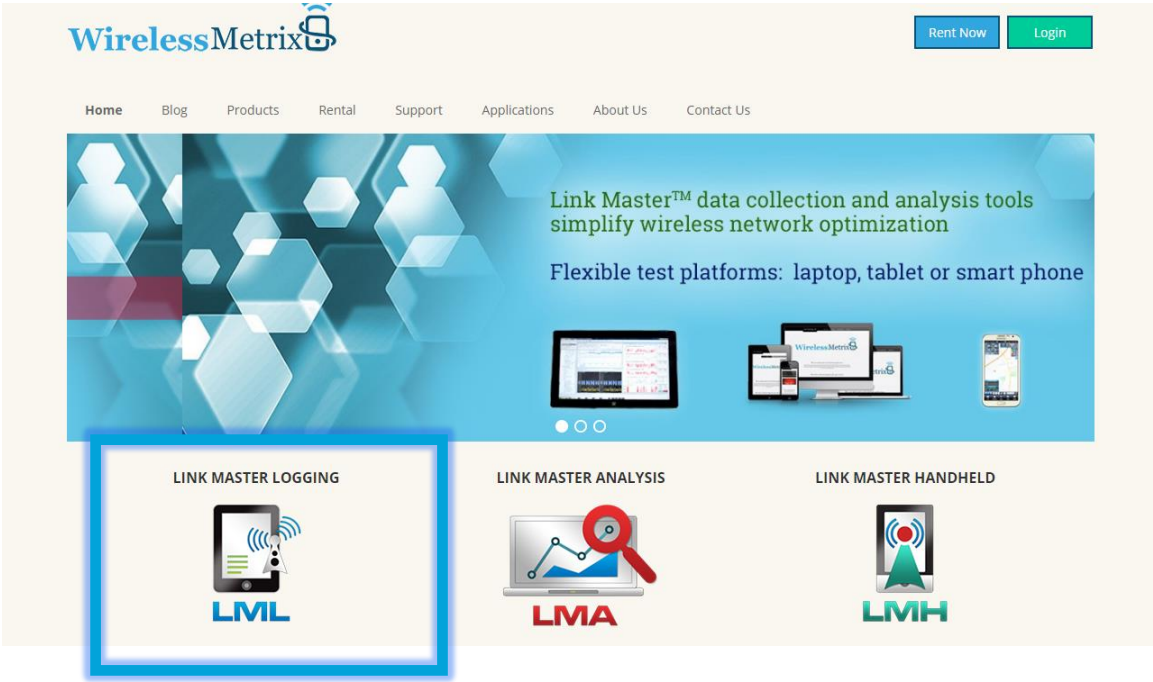
Test Devices

- Link Master Logging (LML) compatible devices:
  - Latest Android Smartphones
    - Such as Samsung Galaxy S7, S8, S9, S10, etc…
  - Certain fixed wireless Routers
    - This document confirms the BEC MX-200 A is compatible with LML. Other BEC routers (covering different bands) should also be compatible.

Wireless-Metrix Link Master Logging SW

- Download the latest version of LML from the Wireless Metrix website.
  https://www.wireless-metrix.com/
- Install on laptop to use for testing
- Click the ‘Rent Now’ to acquire a license for LML

$100/day for an up to date supported software. It does not get more affordable than this!



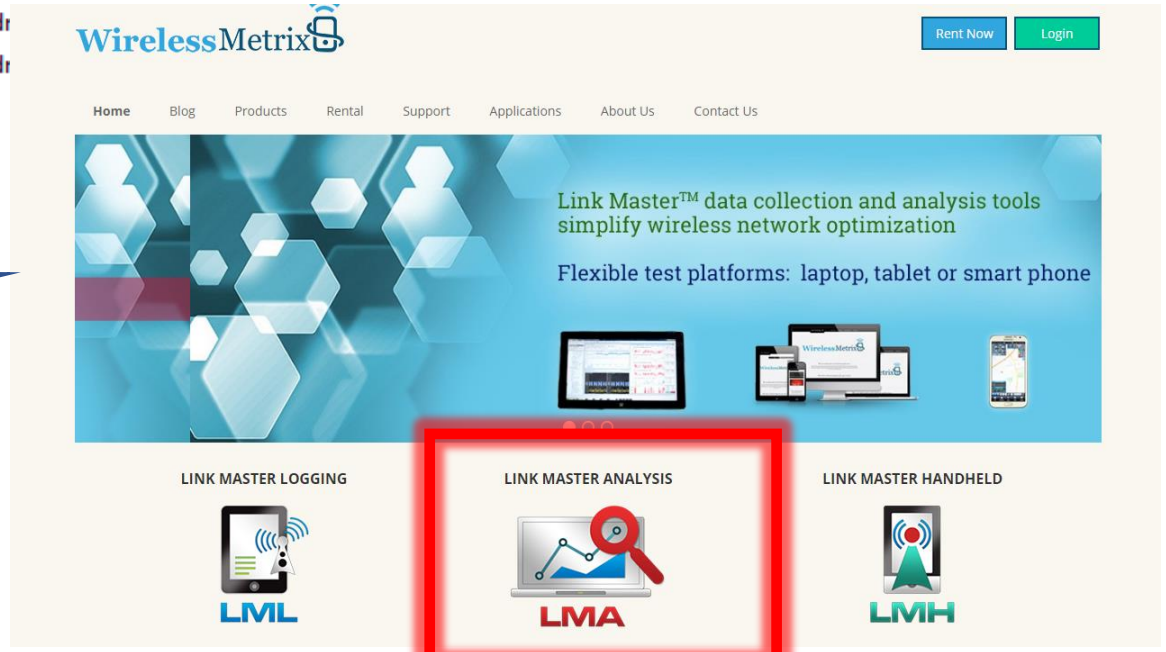
4G Unwired
RF Engineering Services

Link Master Logging Measurement Files

- In about **90 minutes nearly 5,000 data points** were collected.
- Once the drive test is complete the log files (.DML) can be imported and post processed in the Wireless Metrix Link Master Analysis Software.

_20191028_161555_CH01_VZW_BEC_DLUL_HTTP_50003970200_REDRIVE_2019t02h26B.dml	10/28/2019 4:19 PM	DML File	55,730 KB
_20191028_162313_CH01_VZW_BEC_DLUL_HTTP_50003970200_REDRIVE_2019t02h26B.dml	10/28/2019 4:35 PM	DML File	262,559 KB
_20191028_163552_CH01_VZW_BEC_DLUL_HTTP_50003970200_REDRIVE_2019t02h26B.dml	10/28/2019 5:09 PM	DML File	701,269 KB
_20191029_094256_CH01_VZW_BEC_DLUL_HTTP_50003970200_REDRIVE_2019t02h26B.dml	10/29/2019 9:45 AM	DML File	45,866 KB
_20191029_095016_CH01_VZW_BEC_DLUL_HTTP_50003970200_REDRIVE_2019t02h26B.dr			
_20191029_100528_CH01_VZW_BEC_DLUL_HTTP_50003970200_REDRIVE_2019t02h26B.dr			

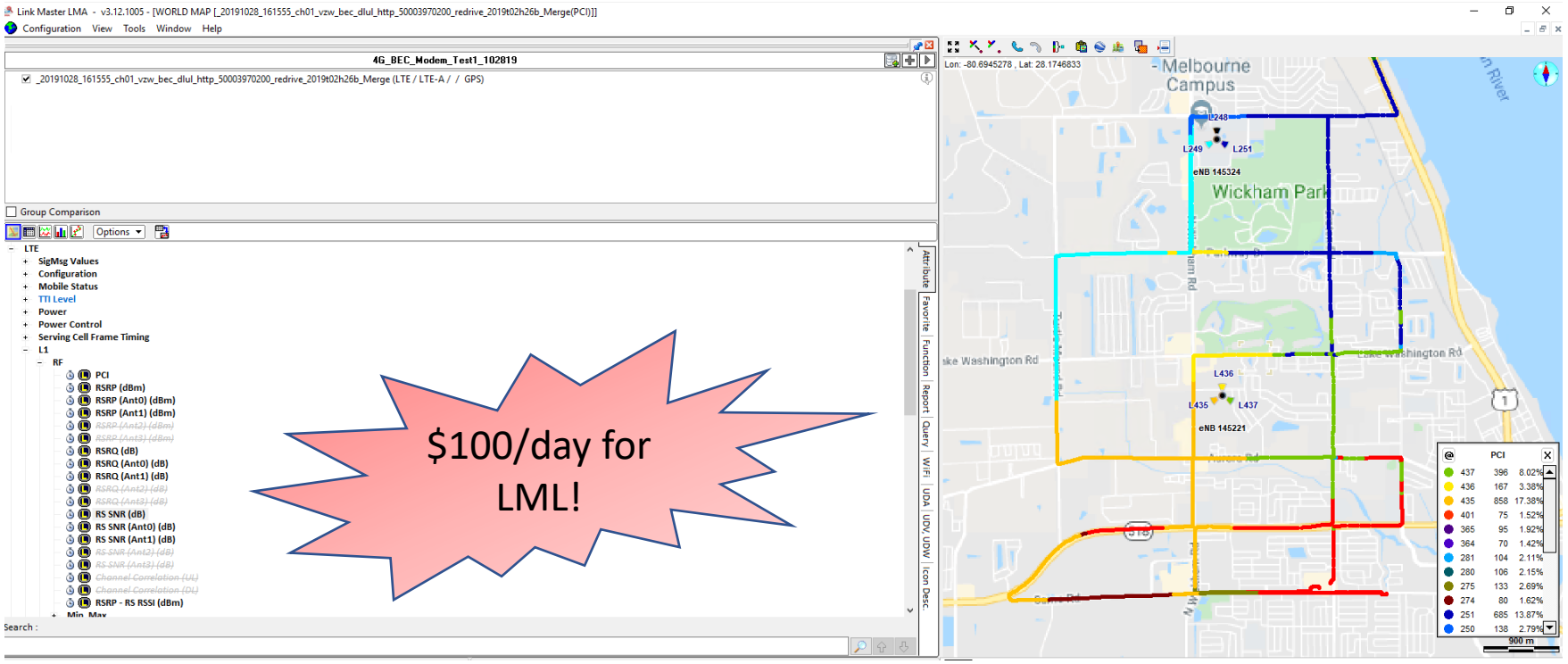
$100/day for LMA!



4G Unwired
RF Engineering Services

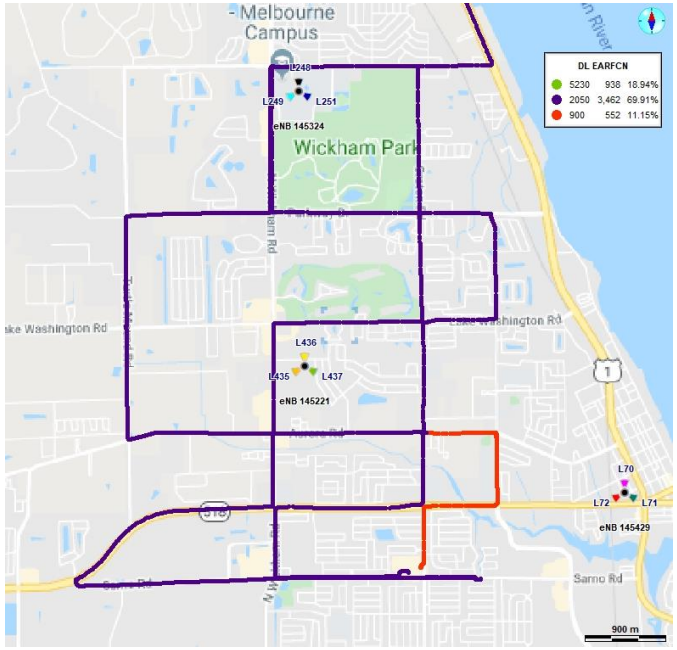
Link Master Analysis Software

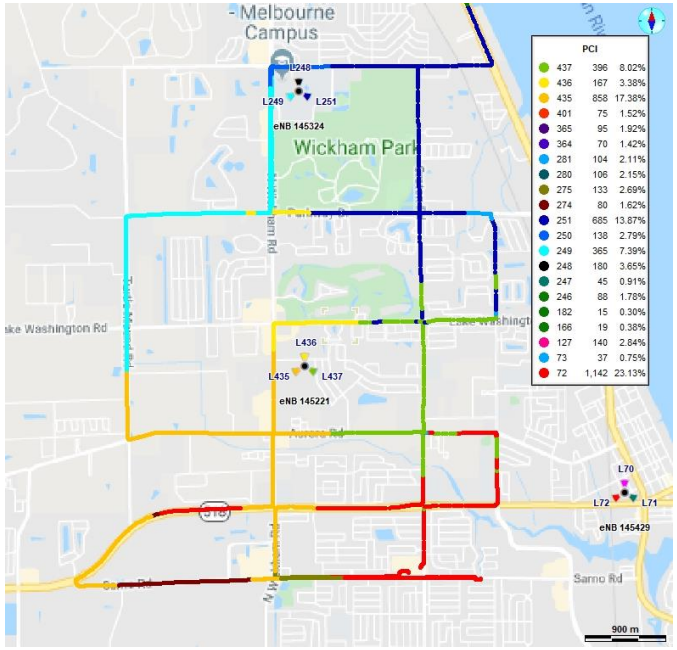
- Link Master Analysis Software is a full featured Post Processing Platform for the LML drive test files.
- To have 4G Unwired post-process the collected log files contact us at 321-726-4183
- Upload the drive data to an FTP folder or Dropbox folder with your site information



Link Master Analysis Files

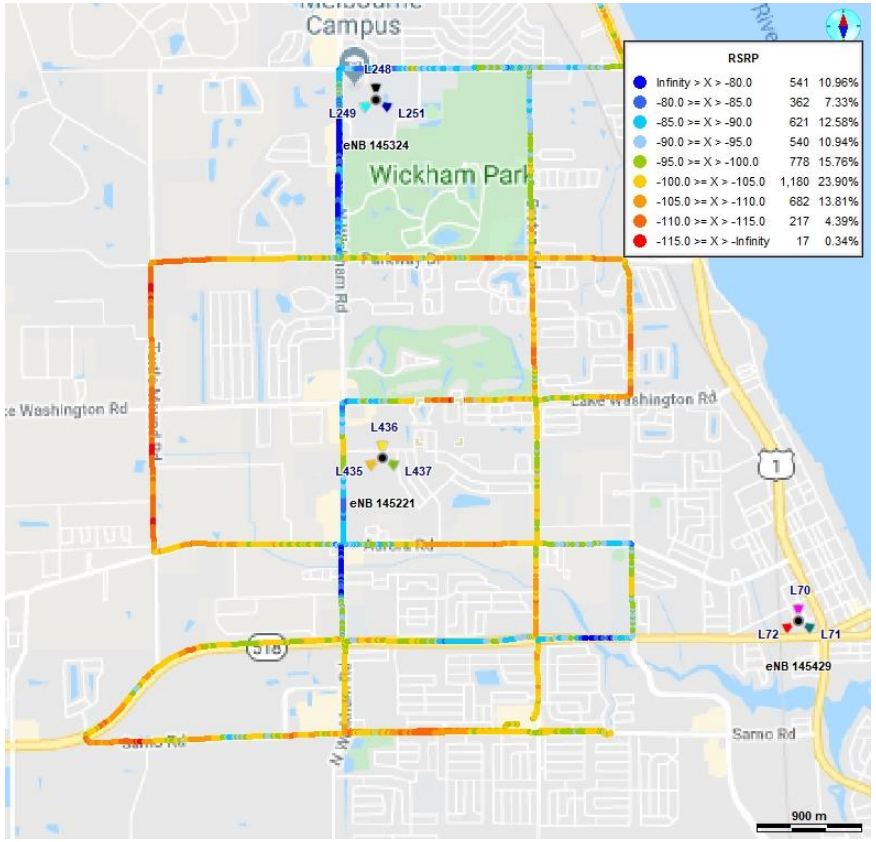
- LTE KPIs such as Downlink Enhanced Absolute RF Channel Number (EARFCN) and Physical Cell ID (PCI) will indicate the RF carrier and the serving cell of the modem measurements.
  - Note most of the drive took measurements on DL EARFCN channel 2050 which is an AWS band though some of the drive was on DL EARFCN 900 which is in the PCS spectrum.
  - The LTE networks site information can be imported into LMA and the antenna symbol can be color coded to the PCI measurements.

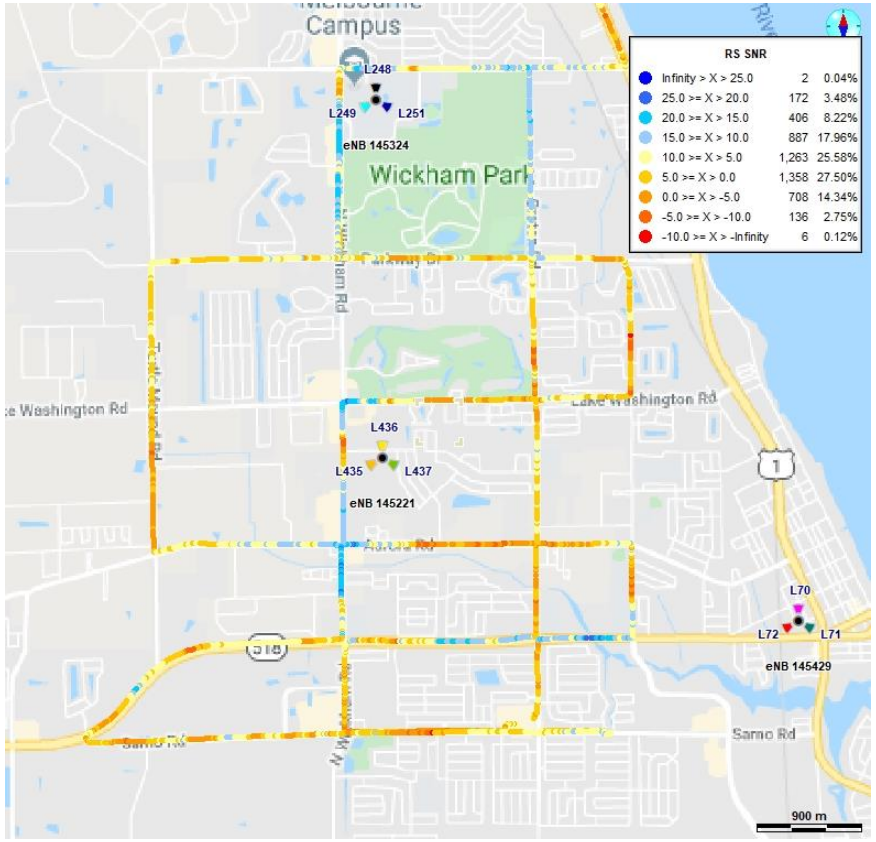




Link Master Analysis Files

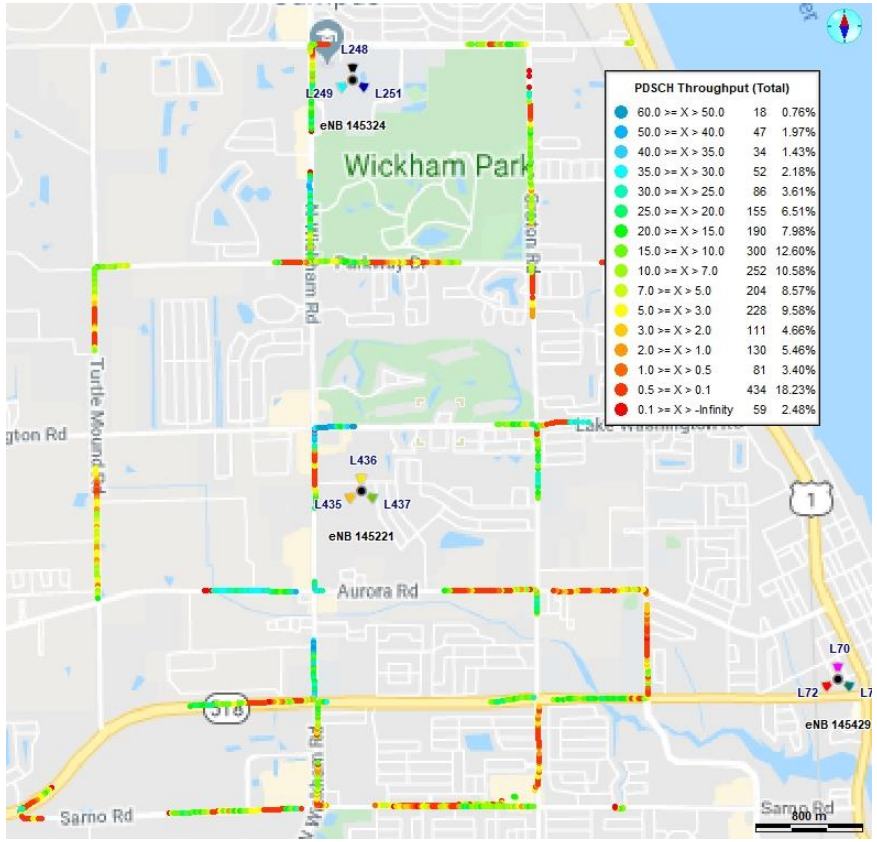
- LTE Layer 1 RF KPIs such as Reference Signal Receive Power (RSRP) and Reference Signal Receive Quality (RSRQ) and RS SNR can be easily plotted and reviewed. These KPIs indicate the coverage and quality of the serving LTE signals. This particular drive showed the best coverage and quality colored in blue.

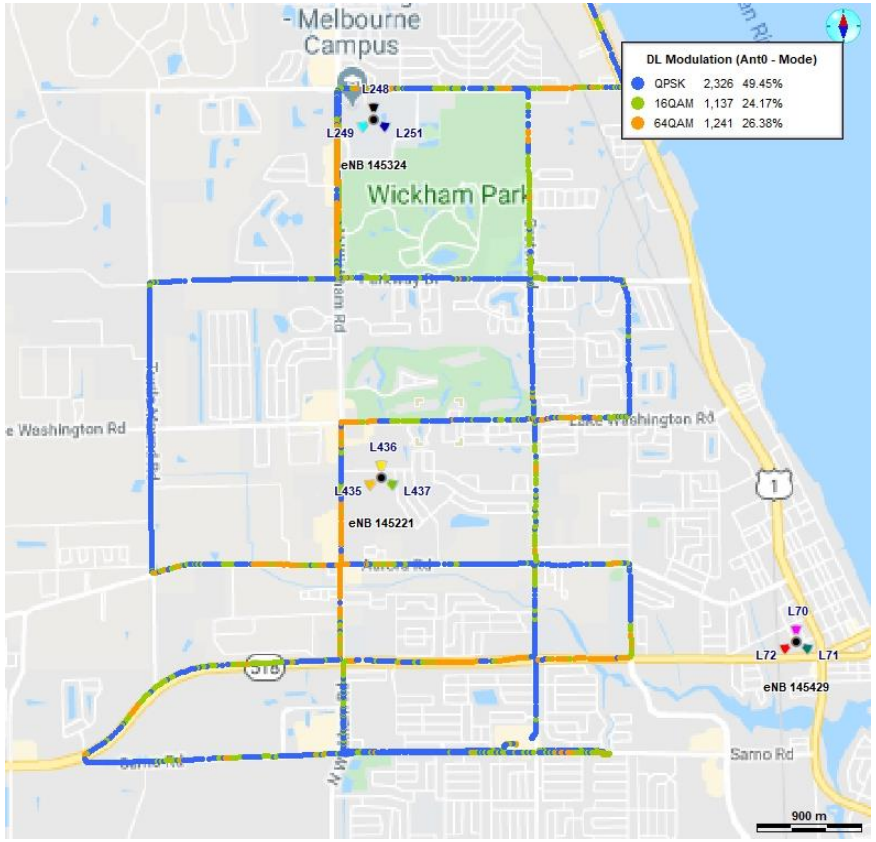




Link Master Analysis Files

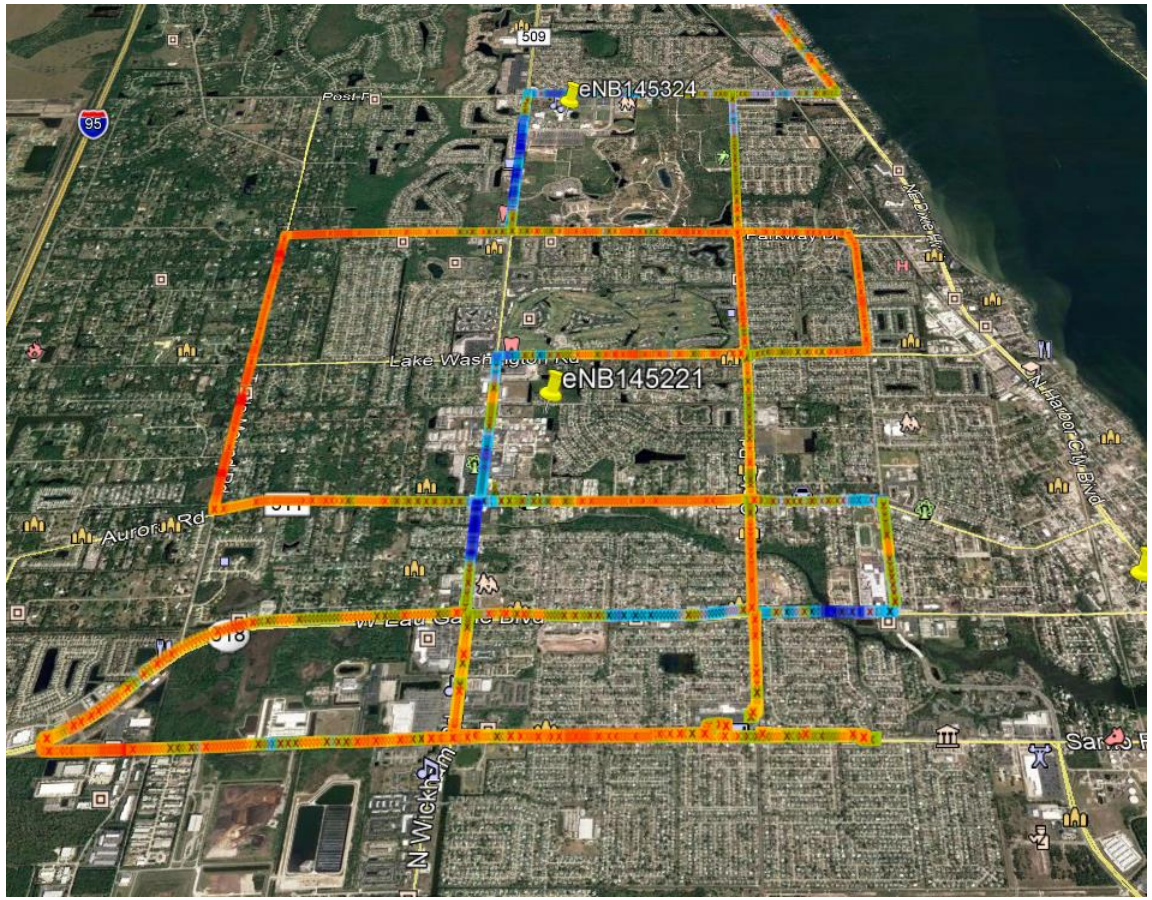
- If an active data session is setup in LML then the throughput and associated KPIs can be examined.
- In this particular drive we had an HTTPS Download Data Transfer programmed to repeat during the course of the drive.





Link Master Analysis Files

- LMA can easily export measurement data out to a Google Earth KML or an Excel file for further evaluation.

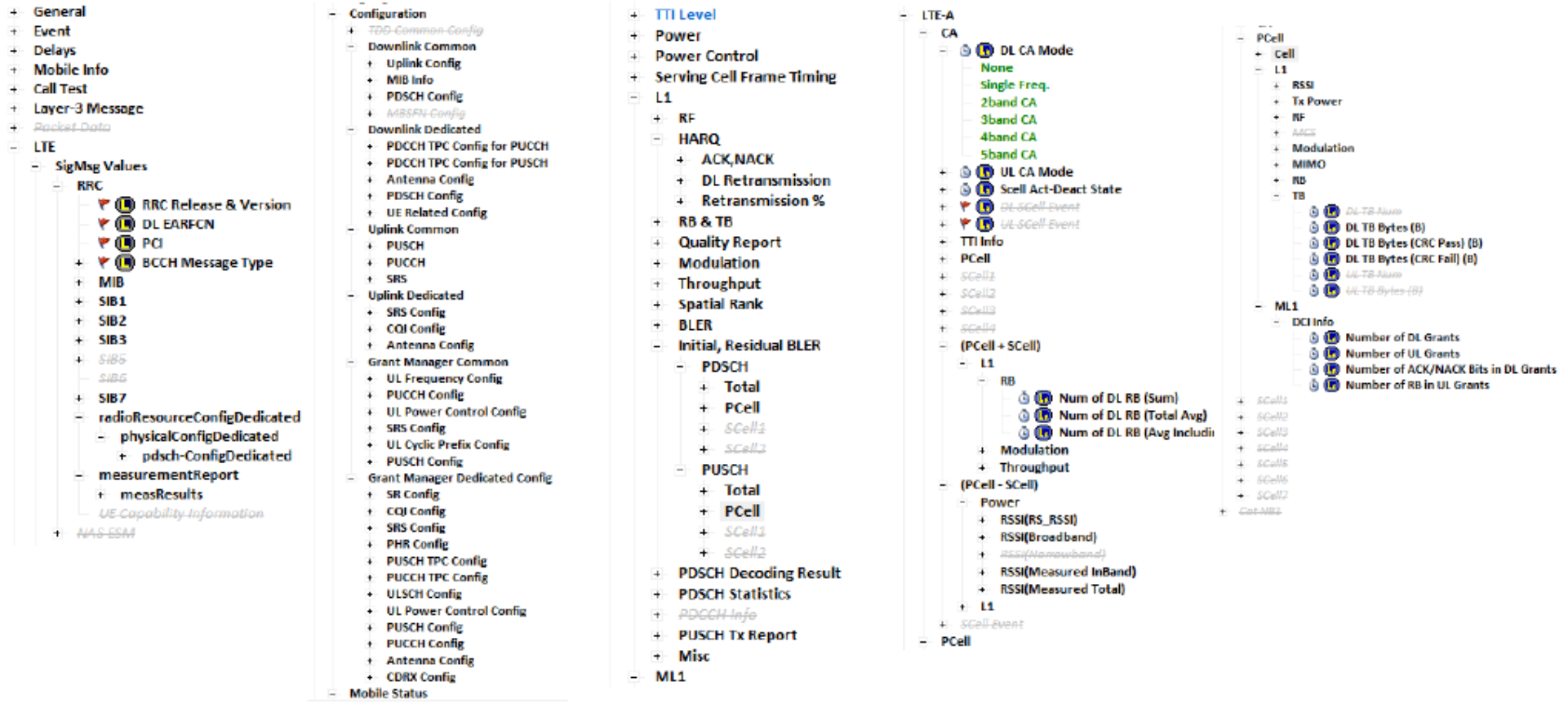


IDX	Lon	Lat	Time	[LTE] [L1] [Misc] DL EARFCN	[LTE] [L1] [RF] PCI	[LTE] [L1] [RF] RSRP (dBm)	[LTE] [L1] [RF] RSRQ (dB)	[LTE] [L1] [RF] RS SNR (dB)
1	-80.6485783	28.1215400	00:16:06.000	2,050	72	-96.39	-12.48	11.82
2	-80.6485783	28.1215400	00:16:07.000	2,050	72	-96.12	-12.78	12.20
3	-80.6485783	28.1215400	00:16:08.000	2,050	72	-96.40	-12.06	11.60
4	-80.6485783	28.1215400	00:16:09.000	2,050	72	-97.04	-12.65	11.03
5	-80.6485783	28.1215400	00:16:10.000	2,050	72	-96.17	-12.55	13.91
6	-80.6485783	28.1215400	00:16:11.000	2,050	72	-96.76	-12.49	13.35
7	-80.6485783	28.1215400	00:16:12.000	2,050	72	-97.04	-13.04	12.93
8	-80.6485783	28.1215400	00:16:13.000	2,050	72	-96.23	-12.92	12.33
9	-80.6485783	28.1215400	00:16:14.000	2,050	72	-96.42	-12.26	11.76
10	-80.6485783	28.1215400	00:16:15.000	2,050	72	-96.50	-12.14	11.90
11	-80.6485783	28.1215400	00:16:16.000	2,050	72	-96.88	-11.81	11.33
12	-80.6485783	28.1215400	00:16:17.000	2,050	72	-97.73	-13.23	10.03
13	-80.6485783	28.1215400	00:16:18.000	2,050	72	-96.91	-12.32	11.55
14	-80.6485783	28.1215400	00:16:19.000	2,050	72	-96.29	-12.54	12.37
15	-80.6485783	28.1215400	00:16:20.000	2,050	72	-96.04	-12.63	13.43
16	-80.6485783	28.1215400	00:16:21.000	2,050	72	-95.71	-12.61	13.28
17	-80.6485783	28.1215400	00:16:22.000	2,050	72	-95.99	-12.69	12.72
18	-80.6485783	28.1215400	00:16:23.000	2,050	72	-96.53	-12.67	11.82
19	-80.6485783	28.1215400	00:16:24.000	2,050	72	-97.27	-12.31	11.51
20	-80.6485783	28.1215400	00:16:25.000	2,050	72	-97.05	-12.77	12.10
21	-80.6485783	28.1215400	00:16:26.000	2,050	72	-96.92	-12.72	11.35
22	-80.6485783	28.1215400	00:16:27.000	2,050	72	-94.92	-12.56	14.30
23	-80.6485783	28.1215367	00:16:28.000	2,050	72	-100.4	-12.95	9.00
24	-80.6485767	28.1215300	00:16:29.000	2,050	72	-102.4	-13.15	7.64
25	-80.6485783	28.1215217	00:16:30.000	2,050	72	-103.0	-12.97	7.46
26	-80.6485767	28.1215100	00:16:31.000	2,050	72	-101.5	-12.74	7.55
27	-80.6485800	28.1215000	00:16:32.000	2,050	72	-104.9	-13.56	5.58
28	-80.6485817	28.1214933	00:16:33.000	2,050	72	-103.1	-13.49	6.80
29	-80.6485817	28.1214900	00:16:34.000	2,050	72	-104.4	-13.69	6.24
30	-80.6485900	28.1214900	00:16:35.000	2,050	72	-102.2	-12.84	8.01
31	-80.6486033	28.1214917	00:16:36.000	2,050	72	-102.0	-12.69	8.48
32	-80.6486300	28.1214883	00:16:37.000	2,050	72	-96.40	-12.35	12.47
			RecordCount:	cnt=4952	cnt=4938	cnt=4	cnt=4	cnt=493
				900 = 552	72 = 1142	Min =	Min = -	Min = -1
				2050 = 3462	73 = 37	Max =	Max =	Max = 2
				5230 = 938	127 = 140	Avg =	Avg =	Avg = 6.

4G Unwired
RF Engineering Services

Link Master Analysis KPIs

- **There are many KPIs available for review in Link Master Analysis, including many for Carrier Aggregation.**

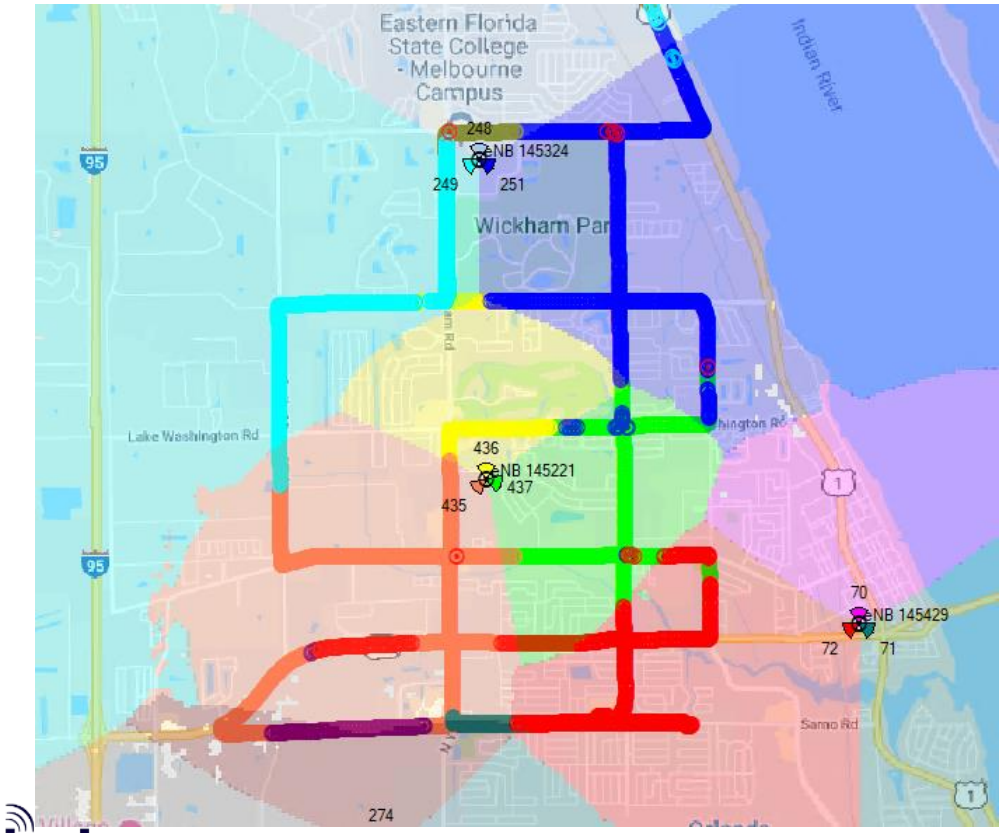


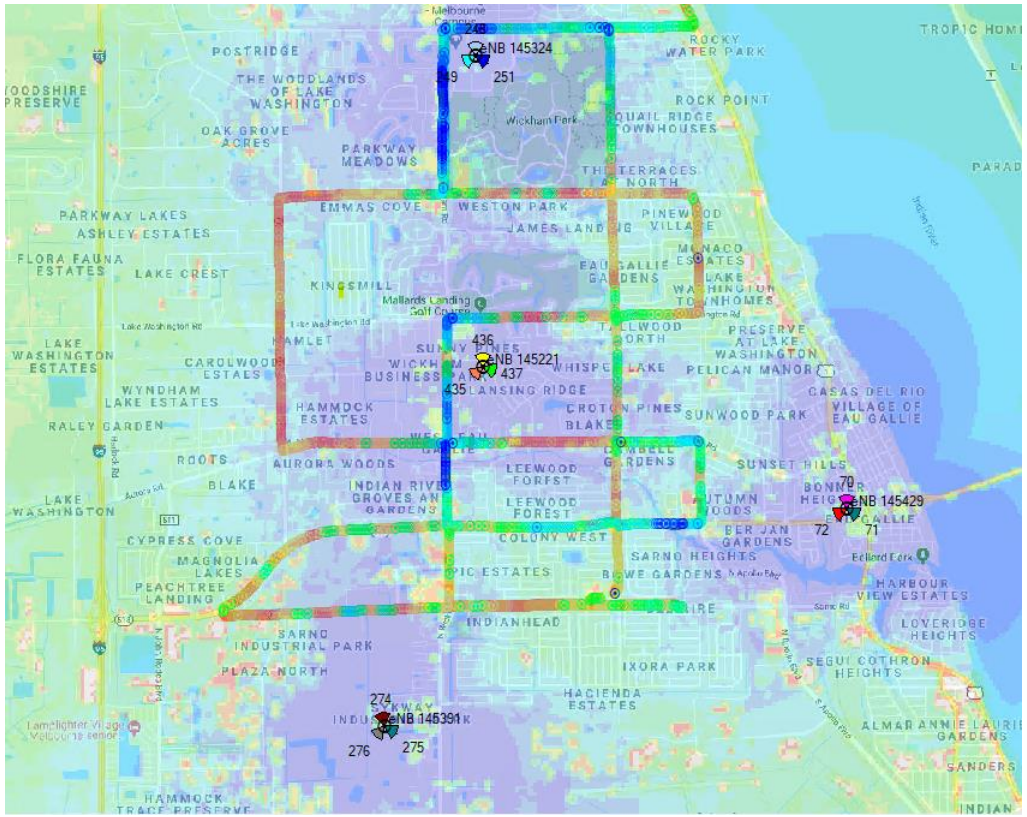
Link Master Analysis KPIs

- Coverage Review
  - Now that we have measurement data collected by the test device, we can compare that to the network coverage predictions.
  - Note that we can make adjustments to the measurements based upon:
    - The coverage predictions needed to make assumptions on Outdoor CPE antenna gain.
    - The coverage predictions also assumed the receiver height of the CPE antennas.
    - Measurements are taken with an omni-directional antenna with a known gain on top of the test vehicle.
    - Normalize the measurement data to compensate for the difference in antenna gains and receiver heights.

Link Master Analysis KPIs

- Coverage Review
  - Note that we can compare which sector is strongest to help validate configuration
  - Prediction coverage levels can be compared with the measurements
  - Propagation model can be adjusted to better fit measurement data.





Thank You

4G Unwired, Inc.

203 Nieman Ave

Melbourne, FL 32901

Scott Robinson

President

Office: 321.726-4183

email: Scott.Robinson@4GUwired.com

www.4GUnwired.com