II. CAVALIER SPECIFIC A-BLOCK DEPLOYMENT CONCERNS

16. Cavalier must deal with E-Block adjacent channel high-power operators, which can have deployment implications. Using the device performance test results, in tandem with Cavalier's markets, a deployment analysis has been created in order to quantify the undue hardships caused by potential interference to A-Block providers (specifically Cavalier), and to demonstrate the nature of this competitive disadvantage.

17. The Hata Suburban Pathloss model was applied to develop a nominal cell radius for a typical A-Block LTE eNodeB. Using the device sensitivity of the A-Block devices from Table 2, and adding a margin of 1 dB to simulate the worst-case scenario, Figure 3 was established to baseline a typical eNodeB cell radius for 64QAM. The heights of the LTE transmitter were varied from 100 ft. to 200 ft. AGL, and a nominal value of 140 ft. AGL was used in the subsequent calculations. The Cavalier LTE design baseline eNodeB antenna (CSS X7C-665-4) vertical antenna pattern was applied to accurately quantify losses due to antenna pattern. Table 3 below lists the calculated cell radius and cell edge signal strength for 64QAM modulation.

LTE Modulation Scheme	Cell Edge Signal Strength (dBm)	LTE Cell Radius (mi)
64QAM	-75	3

Table 3 - Cavalier LTE Site Coverage Radius for 64QAM

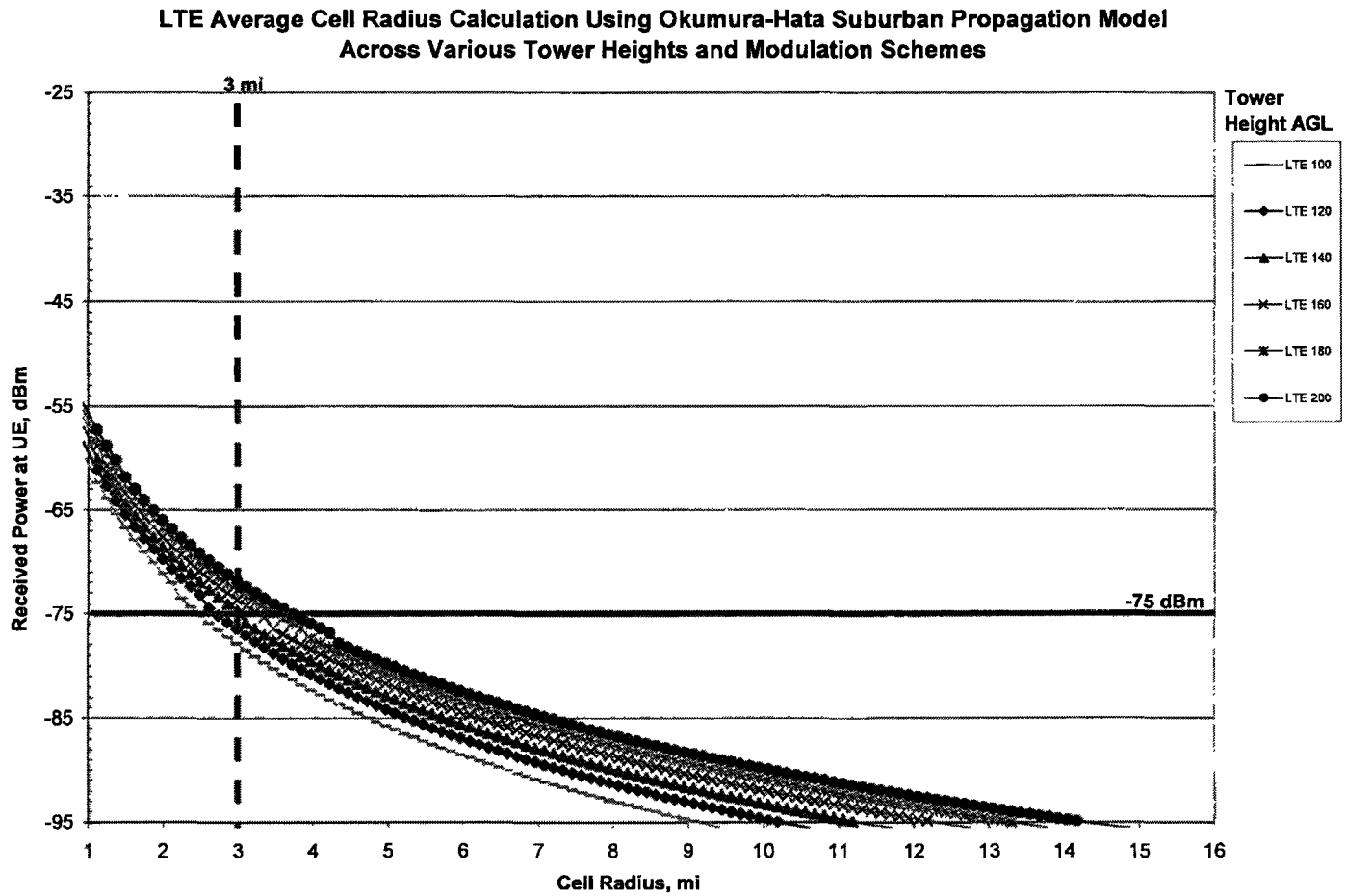

Figure 3 – LTE Cell Radius Calculation Using Okumura-Hata Suburban Pathloss Model

18. Similarly, the Hata Suburban Pathloss model was also applied to develop a nominal cell radius for a typical E-Block high-power mobile broadcast base station. Leveraging prior knowledge from our involvement in previous high-power mobile broadcast technology deployments, including Aloha and MediaFLO, it has been determined that, in order to provide a high-quality (i.e. picture quality as well as constant streaming with no freeze frames), multi-channel programming (i.e. sufficient channels to allow for a marketable service offering), a signal strength of -67 dBm or greater is required for optimized E Block deployments. Therefore, this signal strength level was applied to calculate a typical E-Block high-power mobile broadcast cell radius, as shown in Figure 4 below. The heights of the E-Block transmitter were varied from 200 ft. to 1000 ft. AGL, and a nominal value of 500 ft. AGL was used in the subsequent calculations. A Dielectric 7P-C1-7-L vertical antenna pattern was applied to accurately quantify losses due to antenna pattern. The nominal calculated cell radius for the E-Block transmitter is 7.58 miles with a subsequent cell area per site for a typical E-Block transmitter of 180.5 square miles.

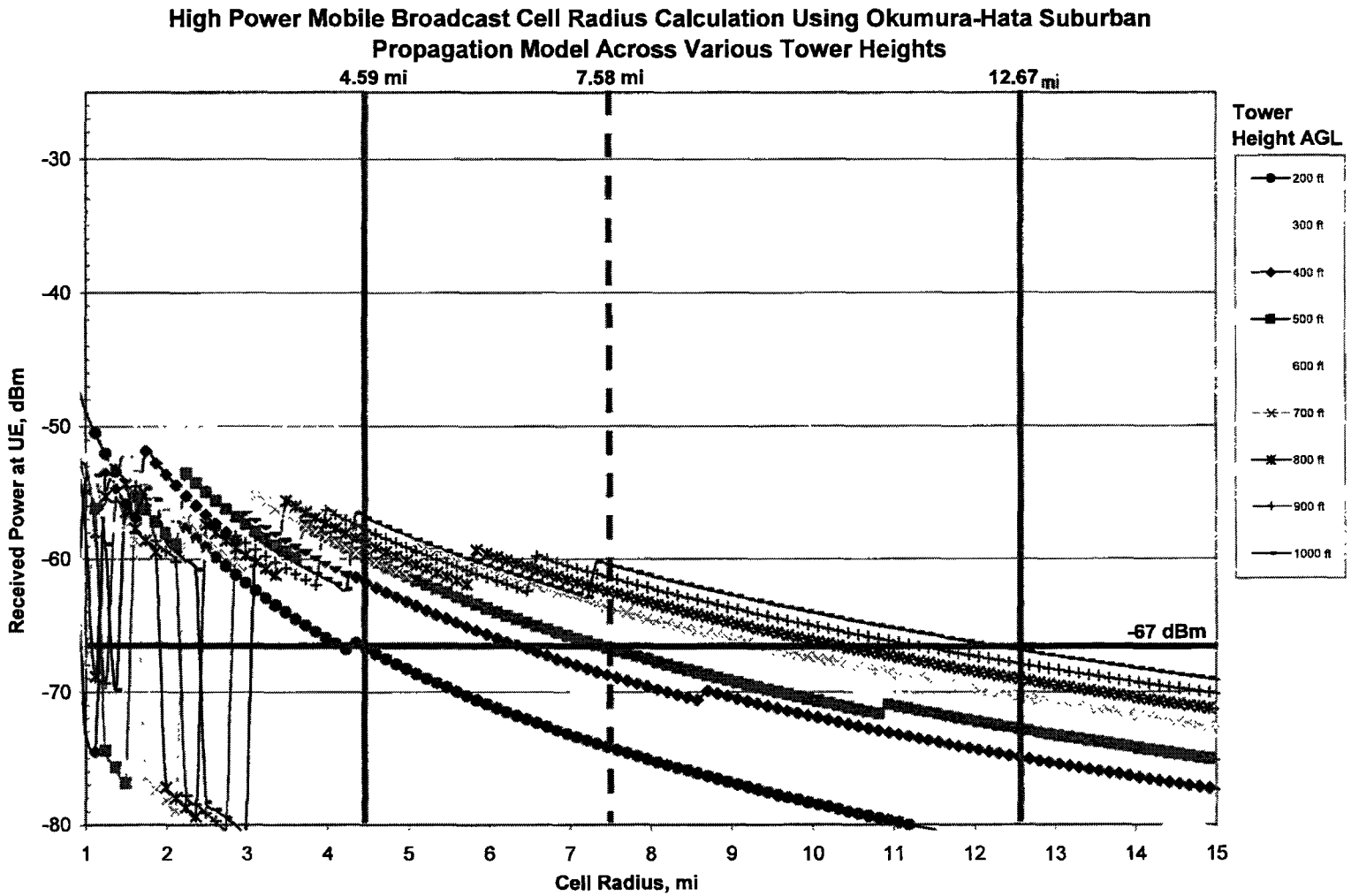

Figure 4 - High Power Mobile Broadcast Cell Radius Calculation Using Okumura Hata Suburban Pathloss Model

19. Cavalier has 22 A-Block licenses as shown in Table 4 covering a total geographic area of 216,036 square miles. For purposes of this analysis it was assumed that Cavalier would develop a wireless service offering based on LTE technology. As shown above, LTE technology has several levels of service offering; however, for these purposes the Cavalier design was assumed to be based upon a competitive, high-quality, high-throughput service offering. Nevertheless, iterations across all service levels were applied. Per FCC Rules[12], any land that is dedicated as a national forest or national park does not have to be counted as part of the BEA geographic coverage area requirement. Therefore, this Forest and Park land area is subtracted from the total geographic area coverage requirement. Further, the FCC Rules[13] state that the A-Block 10-year build-out requirement is 70% of the geographic area. Typically, a carrier would design and build to exceed the FCC limits; however, this 70% figure was used for the purposes of our analysis. The resultant geographic coverage area for the Cavalier A-Block markets therefore spans 131,091 square miles. These values and calculations are reflected in Table 5.

[12] FCC Part 27.14(g).

[13] Id.

BEA	Name	BEA Area (sq. mi)
5	Albany-Schenectady-Troy, NY	8,698
6	Syracuse, NY-PA	18,150
8	Buffalo-Niagara Falls, NY-PA	7,080
9	State College, PA	8,765
11	Harrisburg-Lebanon-Carlisle, PA	3,848
16	Staunton, VA-WV	6,554
18	Greensboro-Winston-Salem-High Point, NC-VA	9,808
22	Fayetteville, NC	3,210
23	Charlotte-Gastonia-Rock Hill, NC-SC	8,447
24	Columbia, SC	7,400
27	Augusta-Aiken, GA-SC	6,737
35	Tallahassee, FL-GA	11,360
37	Albany, GA	7,460
41	Greenville-Spartanburg-Anderson, SC-NC	6,802
47	Lexington, KY-TN-VA-WV	23,030
56	Toledo, OH	7,887
70	Louisville, KY-IN	7,831
87	Beaumont-Port Arthur, TX	5,117
132	Corpus Christi, TX	11,850
133	McAllen-Edinburg-Mission, TX	4,411
147	Spokane, WA-ID	35,110
172	Honolulu, HI	6,480
	Totals	**216,035**

Table 4- List of Cavalier Lower 700 MHz A-Block Market

Total Cavalier BEA Area (sq mi)	Total Cavalier BEA Area covered by National Parks and Forests (sq mi)	Remaining BEA Area (sq mi)	70 % Build-out Requirement (sq mi)
216,035	28,762	187,273	131,091

Table 5 - Cavalier A-Block License Coverage Requirement

20. The nominal LTE cell radii of Table 3 (3 miles) was then applied to the prospective Cavalier market geographic areas and the number of LTE eNodeBs was calculated to ensure 70% geographic area coverage for 64QAM coverage. The results of this calculation are shown in Table 6.

Service Levels	# Sites to meet service Level
64QAM 70% area Build-out:	4,637

Table 6 - Cavalier eNodeB Site Count by Service Offering

21. Likewise, the nominal cell area for an E-Block transmitter was applied to all of the Cavalier markets, to reflect a 70% geographic build-out in each market. The number of E-Block sites (726) required to ensure high-quality, multi-channel service, throughout all of the Cavalier markets was calculated and is shown in Table 7.

Typical High-Power Mobile Broadcast Cell Radius (mi)	High-Power Mobile Broadcast Cell Coverage (sq. mi)	# of Sites Required for 70% Build-out
7.58	180.5	726

Table 7 - Projected E-Block Site Count in Cavalier Markets

22. From Table 7, it can be seen that a mature E-Block development throughout all of the Cavalier markets consists of 726 sites. For a mature E-Block operator, this equates to an average of 33 sites per market for the 22 Cavalier A-Block markets. This calculated average number of sites required to meet a 70% geographic coverage requirement is in line with the initial MediaFLO build-out which included 60 sites in Chicago, Il, 39 sites in Los Angeles, CA, and 40 sites in the greater New York area (includes the MediaFLO New York, NY, Northeast, NJ and Long Island, NY sites). It should be noted that this MediaFLO deployment was halted by early 2011, prior to the AT&T acquisition of the D- Block from Qualcomm and therefore, the final quantity of required sites was a milestone which was never achieved by MediaFLO.

23. As is quantified above in Figure 2, and after applying a 1 dB worst-case scenario margin, a UE operating on the A-Block will be affected when receiving an E-Block signal greater than or equal to -47 dBm. Applying the Okamura-Hata Suburban Pathloss model, as used above, one can see that an interference radius of approximately 0.87 mi. (4600 ft.) would result for each E-Block site. In order to overcome this interference, a desired LTE signal strength at the UE antenna port of -75 dBm or greater must be received. A diagram depicting the interference area in comparison with the LTE coverage area needed to overcome interference (assuming the sites are collocated) is shown below in Figure 5.

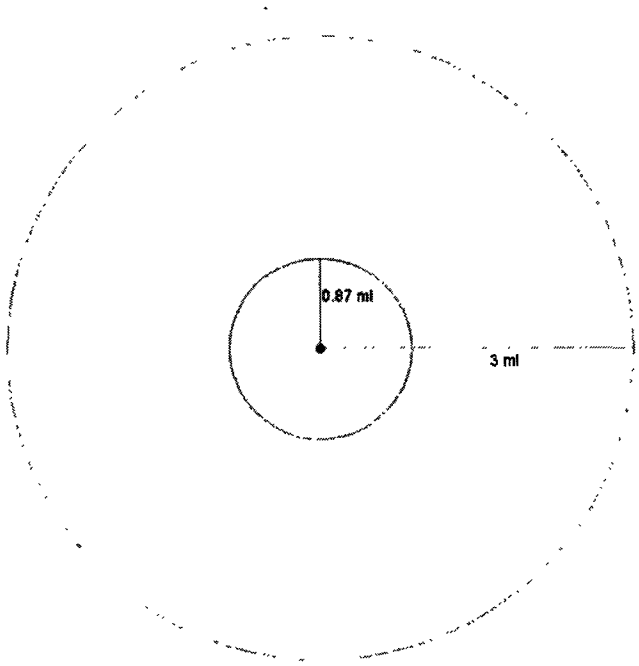

Figure 5 - Interference Radius in Comparison to Nominal LTE 64QAM Coverage Radius

24. As can be seen from Figure 5, collocation could be expected to mitigate the interference potential. However, theoretically, an A Block site can be placed within 2.13 mi. of the E-Block tower and still provide signal levels at the UE necessary to overcome the harmful interference. This is shown in Figure 6. This 2.13 mile distance can be extrapolated into a ring around the E-Block tower, within which a site can be placed to mitigate the harmful interference. Figure 7 depicts this 2.13 mi. "mitigation radius", in comparison with the 3 mi. nominal LTE 64QAM coverage radius and 0.87 mi. interference radius.

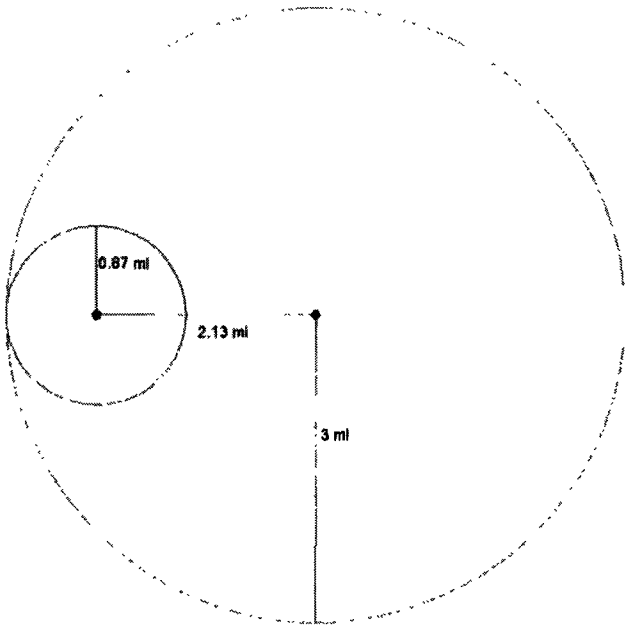

Figure 6 – Maximum Possible Distance of an LTE eNodeB to Mitigate E-Block Interference

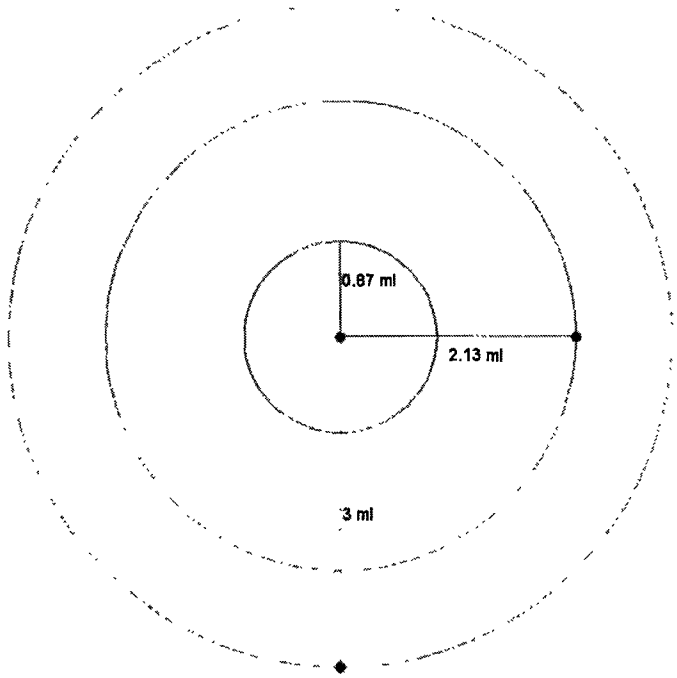

Figure 7 – Depiction of "Mitigation Radius" in Comparison to Interference Radius and LTE 64QAM Coverage Radius

25. If the nominal LTE 64QAM coverage radius of 3 mi. is assumed, an LTE coverage area of 28.27 sq. mi. results. Similarly, the area where an A Block site must be placed to mitigate the harmful interference caused by the E-Block is 14.25 sq. miles. This "mitigation area" is approximately 50% of a nominal LTE 64QAM coverage area. A fully mature A-Block LTE network design would consist of a grid pattern of sites throughout the service area. Therefore, for a fully mature E-Block and LTE design, the probability of any particular LTE site within the grid to be located within a "mitigation area" is approximately 50%. Conversely, the probability of an A-Block operator needing an extra site to mitigate the harmful interference caused by the E-Block is 50%. **Thus, in order to mitigate the interference into devices operating near E-Block sites on the A-Block which would not fall into this mitigation area, Cavalier would need to collocate on 50% of the 726 E-Block transmitters (totaling 363 sites) to overcome the E-Block interference and ensure a competitive quality of service for its consumers.** If a 1:2 collocation is applied, then Cavalier would be required to deploy an additional **363** sites just to overcome the unanticipated additional E Block interference.

26. If the FCC were to limit the powers of the E-Block transmitters to the same power levels of the A, B and C Block licensees, the impact to the A-Block licensees would be no different than expected when operating in adjacent spectrum with adjacent "like services", that is the A-Block licensees would only be concerned about specific co-location sites and managing inter-carrier interference at these sites

in a similar fashion to what wireless carriers do currently at these facilities. Therefore, No overbuild to mitigate inference from the adjacent E-Block deployment would be expected.

27. By FCC rule[14], the high-power operators in E-Block are required to provide 90-day notifications on their site build. Although informative and necessary, this notification results in reactionary burdens to any A Block holder. There is no way for any A Block holder to anticipate when and where these E-Block sites will eventually be placed . As both A and E Block operators face build-out deadlines, it is highly likely that the notifications will arrive toward the end of the Cavalier design and build program schedule. Assessing the impact and executing network changes through collocation and/or redesign of existing sites adds to the burden. At time of license acquisition through auction, and until recent device testing and analysis[15] showed the interference conditions and performance impact of the E-Block operations, these notifications were simply informative to adjacent channel licensees. The only possible recourse for the A-Block operators would be if the E-Block site design is determined not to meet FCC PFD limits. Even so, this recourse will not be applicable in most situations because even with a high gain antenna system, E-Block operators can meet the PFD limits at heights as low as 240 feet AGL. Therefore, this potential recourse will not be meaningful to A-Block operator as the PFD limits do not afford the necessary protection for A-Block licensees.

[14] FCC Part 27.50(c)(6), (8)

[15] As noted throughout the FCC NPRM 12-69 proceedings, these devices have only recently come to market and have not been heretofore available for any such testing

III. LABORATORY TEST FACILITY AND TEST EQUIPMENT

28. The Test Laboratory is a shielded facility located within the United States Cellular Corporation (USCC) building in Chicago, Illinois.

A. Test Lab and Equipment Overview

29. The Test Laboratory is a shielded facility located within the United States Cellular Corporation (USCC) building in Chicago, Illinois. The lab facility was built and testing equipment was purchased within the last year. Figure 8 shows the lab facility used for testing.

Figure 8 - Picture of USCC Shielded Test Facility

30. In order to ensure that all of the equipment being used was calibrated correctly and performed at/better than standards, the equipment calibration was verified and tested prior to conducting tests. All cables, connectors and adapters were tested to identify the losses present within the tests. The exact losses of all of these components were noted and factored into the test plan as offsets for the signal generator, so that the test devices were working with "true" power and any extraneous calculations were eliminated. Figure 9 depicts each major component used, with a description of each component used for the testing below.

- SFE-100 Signal Generator – used to generate the E-Block MediaFLO signal.
- Spectrum Analyzer – used to view, measure, and record the input and output signals.
- CMW-500 LTE Signal Emulator – used to generate the LTE eNodeB signal and control the UE transmission parameters.
- Channel 56 E-Block OOBE Filter – used to reduce the signal generator's noise into the device receive band.

- Isolators - used to minimize the reflections off the filter.
- UE Receive Filter – reduces the amplitude of the device transmission and interfering signal into the Spectrum Analyzer, allowing for a larger dynamic range.
- Power Splitter – needed to combine all test equipment together.
- For safety purposes a "20 dB pad" was used on the output of the CMW500 BTS Emulator to avoid any overload.
- Variable Attenuator – needed to control E-Block transmitter low power output levels
- DC Power Supply – provided power to the devices.

31. A visual inspection of equipment used was completed to ensure that there were no visible faults, marks, bends, or breaks in each cable, connector, and adapter.

32. The filters/isolators were tested to verify they met design specifications. The filters/isolator response was confirmed by sweeping across the desired frequencies.

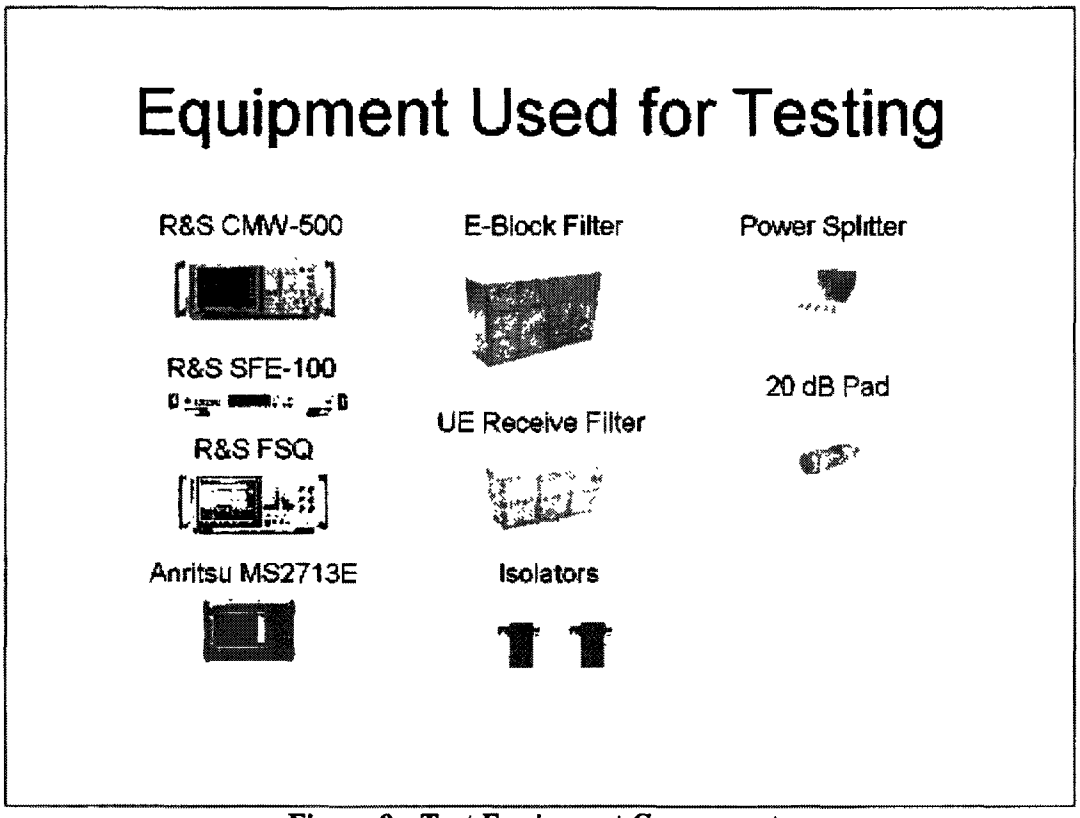

Figure 9 - Test Equipment Components

B. DEVSENS Test Configuration

33. A device sensitivity test was conducted on all Band 12 devices on A-Block (5 MHz), to establish a baseline for each Device Under Test (DUT). In order to baseline the UE and to mitigate any variations due to self-desensitivity, the sensitivity of the device was tested, both when the UE was not transmitting and when the UE was transmitting at Full Power (+23 dBm). The difference can affect the baseline performance of the UE during the Reverse PA IM tests, as the devices were transmitting during these tests. Additionally, multiple modulation and coding schemes were tested in order to measure any increase in sensitivity required for these cases, as compared to the base QPSK modulation scheme.

34. The CMW-500 LTE Emulator was connected with test cables to a power splitter/combiner. From the power splitter, two additional cables connected the DUT and the spectrum analyzer. The spectrum analyzer was used to validate the Uplink (UL) and Downlink (DL) signals.

35. Once all equipment was properly connected, the LTE emulator signal was decreased down to a level where the UE receiver would decode a minimum of 5% Block Error Rate (BLER). A Rhode & Schwarz (R&S) BLER program was used to establish the measurement for each of the DUTs. The BLER program sends UL and DL data on a continuous basis.

36. Measurements were taken using multiple modulation schemes which included QPSK, 16 QAM, and 64 QAM. For each test, measurements were repeated several times to ensure values were consistent among the tests.

37. Figure 10 reflects the test equipment used for the device sensitivity (DEVSENS) tests. For the DEVSENS test configuration for Band 12 devices, the following equipment was used:

- R&S FSQ Spectrum Analyzer – allowed the input and output signals to be viewed, measured, and recorded.
- CMW-500 LTE eNodeB Generator – generated the LTE eNodeB signal, and controlled the UE transmission parameters.
- Band 12 Devices – Band 12 front-end devices used for testing.
- UE Receive Filter – used to reduce the amplitude of the device transmission and interfering signal into the Spectrum Analyzer, allowing for a larger dynamic range.
- Power Splitter – combined LTE eNodeB signals with input from the Band 12 UE devices.
- DC Power Supply – provided power to the devices.

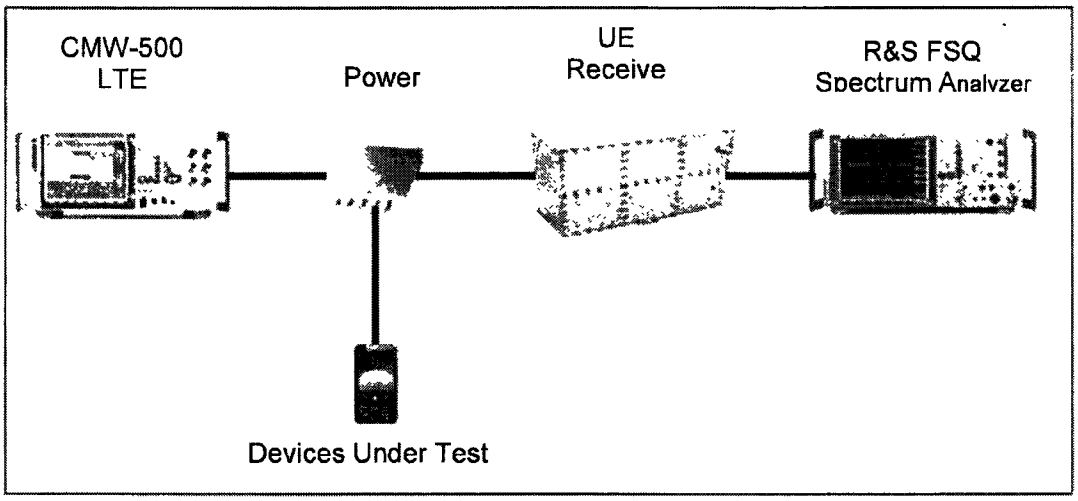

Figure 10 - DEVSENS Test Equipment Configuration

C. Channel 56 E-Block Blocking and Reverse PA IM Test Configuration

38. A Channel 56 E-Block Blocking and Reverse PA IM test was conducted for on all Band 12 devices to establish levels of "potential" interference when injected with an E-Block signal. A 5 MHz E-Block signal centered at 725 MHz was used to simulate a wideband, high-power broadcast transmission. The E-Block signal was combined with LTE signals as the desired source (A-Block Only) and input to the DUT. As the DUT received the desired LTE signal, the interfering signal was increased until the device BLER reached a level at or over 5%.

39. The Channel 56 E-Block blocking and Reverse PA IM test configuration is shown in Figure 11 below. For the Channel 56 E-Block Blocking and Reverse PA IM test configuration for Band 12 devices, the following equipment was used:

- SFE-100 MediaFLO Signal Generator – generated a Ch. 56 E-Block signal.
- R&S FSQ Spectrum Analyzer – allowed the input and output signals to be viewed, measured, and recorded.
- CMW-500 LTE eNodeB Generator – generated the LTE eNodeB signal, and controlled the UE transmission parameters.
- Band 12 Devices – Band 12 front-end devices used for testing.
- E-Block Filter – used to reduce the signal generator's noise into the devices' receive band.
- UE Receive Filter – used to reduce the amplitude of the device transmission and interfering signal into the Spectrum Analyzer, allowing for a larger dynamic range.
- Power Splitter – combined Channel 56 E-Block signal and LTE eNodeB

signals to input to the Band 12 UE device.

- Isolators – reduced reflections from sharp filters.
- For safety purposes a "20 dB pad" was used on the output of the CMW500 BTS Emulator to avoid any overload.
- Variable Attenuator – needed to control E-Block transmitter low power output levels.
- DC Power Supply – provided power to the devices.

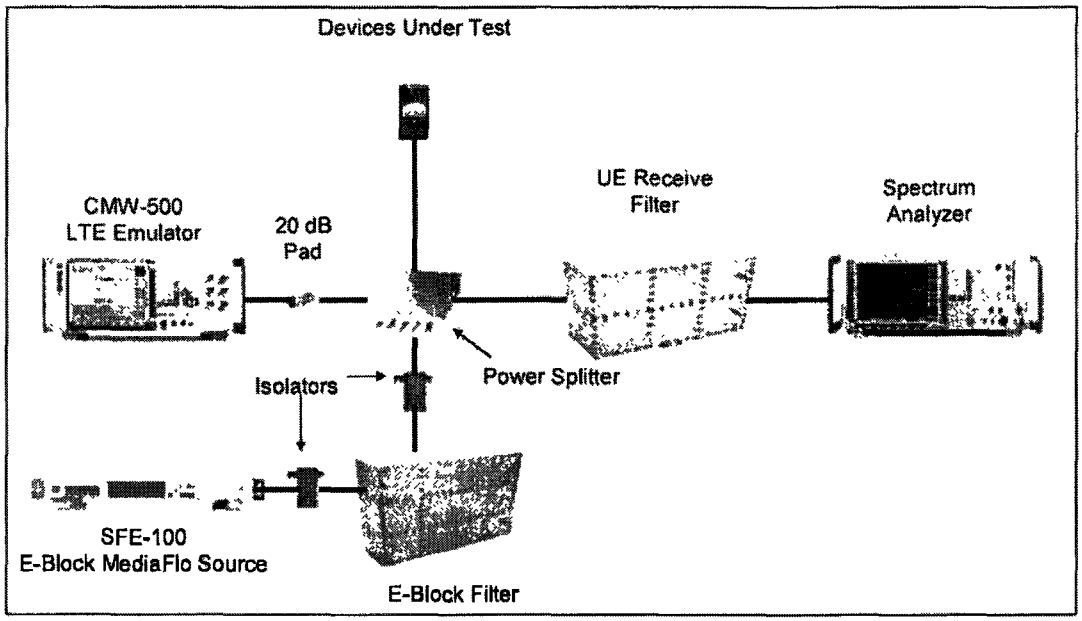

Figure 11 - Channel 56 E-Block Blocking and Reverse PA IM Test Configuration

40. The CMW-500 LTE Emulator was connected with test cables to a power splitter. From the power splitter, three additional cables connected the DUT, Channel 56 E-Block interfering source (SFE-100) and the spectrum analyzer. The spectrum analyzer was used to validate the Uplink (UL) and Downlink (DL) signals.

41. The signal generators were properly tuned in order to display the results. The connector/cable losses from the LTE Emulator to the UE RF Port were measured, including the UE adapter cable loss (typically 0.4 dB at 700 MHz).

42. For the 5 MHz channel bandwidth tests, the UE's were set to full-power transmission on all 25 RBs. The R&S BLER program was used to verify that the device provided the same measured results as when testing DEVSENS. The 10 MHz carrier was centered at 710 / 730 MHz, while the 5 MHz A-Block carrier was centered on 701.5 / 731.5 MHz.

43. The Channel 56 E-Block signal generator was setup to transmit a 5 MHz signal centered at 725 MHz to emulate a MediaFLO DTV high-power broadcast

signal on the Channel 56 E-Block. The power of the Channel 56 E-Block signal generator was varied to obtain the interfering levels on all of the Band 12 devices for different raised noise floor levels and multiple modulation schemes (QPSK, 16 QAM and 64 QAM).

44. Once completed, the Channel 56 E-Block tests were repeated with the UEs set to minimum power transmission on the Uplink. Again, the power of the Channel 56 E-Block signal generator was varied to obtain the interfering levels on all of the Band 12 devices for different raised noise floor levels and multiple modulation schemes (QPSK, 16 QAM and 64 QAM). Measurements were taken and documented in a separate table for later comparison to determine the level of IM contribution to the E-Block blocking interference.