Test Report

For

Trial of 5G Base Station and User Equipment operating at 3.5GHz and 26/28GHz bands

Version 1

SmarTone

2019/20

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1. Introduction

With refer to the Communications Authority ("CA") promulgated its work plan for making available additional spectrum for public mobile services to meet the increasing aspirations of mobile service users towards 2020 and beyond. The work plan has made available the spectrum between 24.25 – 27.5 GHz ("26 GHz band"), 27.5 – 28.35 GHz ("28 GHz band") and 3.4 – 3.6 GHz ("3.5 GHz band") for the provision of fifth generation mobile ("5G") services.

Temporary permits were granted by CA to SmarTone Mobile Communications Limited ("SmarTone") in the 2nd half of 2019 for 5G NR network trials in the 3.5GHz and 26/28 GHz bands.

2. Test Scope

The scope of the test was concentrated on the radio propagation characteristics, penetration loss, indoor and outdoor coverage in typical Hong Kong environment. For the field trial, 3.5GHz and 28GHz cells were set up in Central and Shatin areas.

2.1. Test Equipment

2.1.1. 26/28GHz test equipment

Equipment	Technical Specifications	
28GHz Active Antenna	Frequency Band	28 GHz
	Bandwidth	4 x 100 MHz
	MIMO Configuration	512Tx/512Rx
Test User Equipment	Frequency Band	28 GHz
	MIMO Configuration	2Tx/2Rx

(A) (B)

Figure 1. (A) 28 GHz Active Antenna, (B) 28 GHz Test User Equipment

2.1.2. 3.5GHz test equipment

Equipment	Technical Specifications	
3.5GHz Active Antenna	Frequency Band	3.5 GHz
	Bandwidth	100 MHz
	MIMO Configuration	64T/64R
Test User Equipment	Frequency Band	3.5 GHz
	MIMO Configuration	4Tx/4Rx

(A) (B)

Figure 2. (A) 3.5 GHz Active Antenna, (B) 3.5 GHz Test User Equipment

2.2. Test locations

Location	Area	Test Scenario	Band	Antenna Configuration
1	Central	Outdoor	28 GHz	Bearing = 290^{o} Down-tilt = 25^{o}
2	Shatin	Indoor	28 GHz/3.5 GHz	Bearing = 10^{o} Down-tilt = 10^{o}

Figure 3. Test Location 1 for 5G 28GHz

Figure 4. 28GHz Active Antenna on site

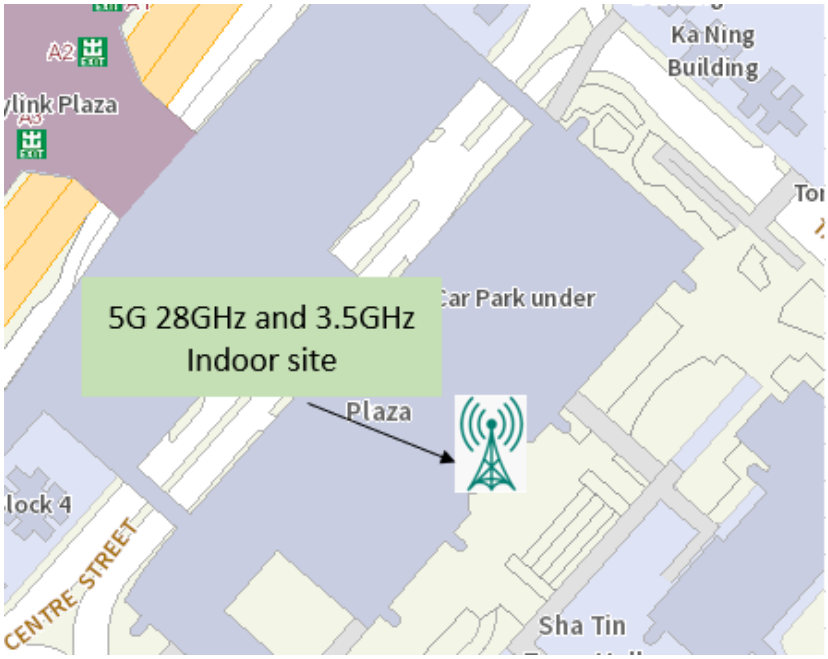

Figure 5. Test Location 2 for 5G 28GHz and 3.5GHz

2.3. Test configuration

5G network configuration was based on 3GPP Release 15 Option 3x. Co-located LTE cell was served as the anchor cell of 5G NR carrier.

Band	Operating Frequency	Bandwidth	EIRP
28GHz	27.75 - 28.15 GHz	4 x 100 MHz	50 dBm (Outdoor) 30 dBm (Indoor)
3.5GHz	3.53 - 3.6 GHz	1 x 70 MHz	30 dBm (Indoor)

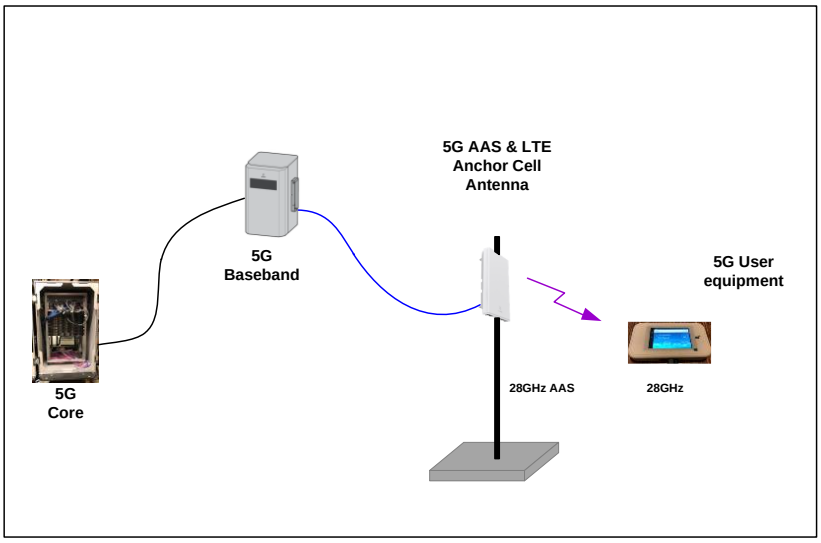

Figure 6. 5G test configuration for test location 1

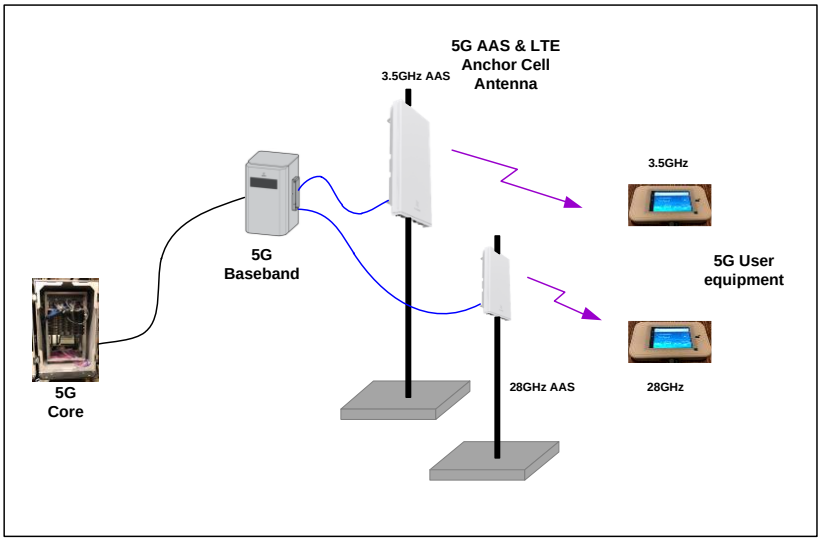

Figure 7. 5G test configuration for test location 2

3. Test Results

3.1. 28GHz Band

3.1.1. Outdoor Test Result

3.1.1.1. 28GHz outdoor coverage test at the test location 1

The signal strength was dropped significantly when the user equipment was moved to the non line-of-sight (NLOS) area. The signal strength was dropped from -88 dBm at test point 1 to -106 dBm at test point 2 which was blocked by a tent. No signal for 28GHz at test point 3 and 5 as there were a few tents between the measurement points and the 28GHz antenna.

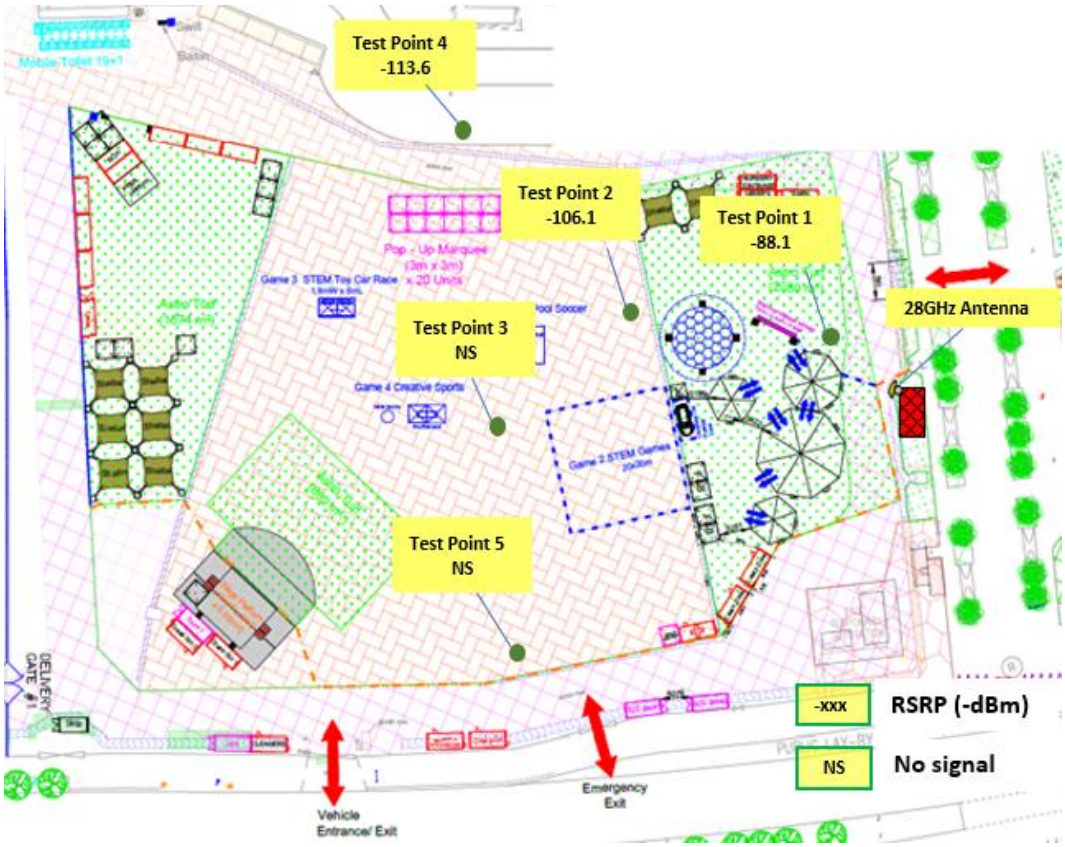

Figure 8. 28GHz coverage test result at test location 1

Figure 9. Test point 3 with NLOS to 28GHz antenna which is located behind the tents

3.1.1.2. 28GHz downlink throughput test at the different test points

The downlink throughput 1.5Gbps was achieved at test point 1 (near site and line-of-sight, LOS). When the test equipment was moved away from the test site (test points 4), the throughput was dropped significantly.

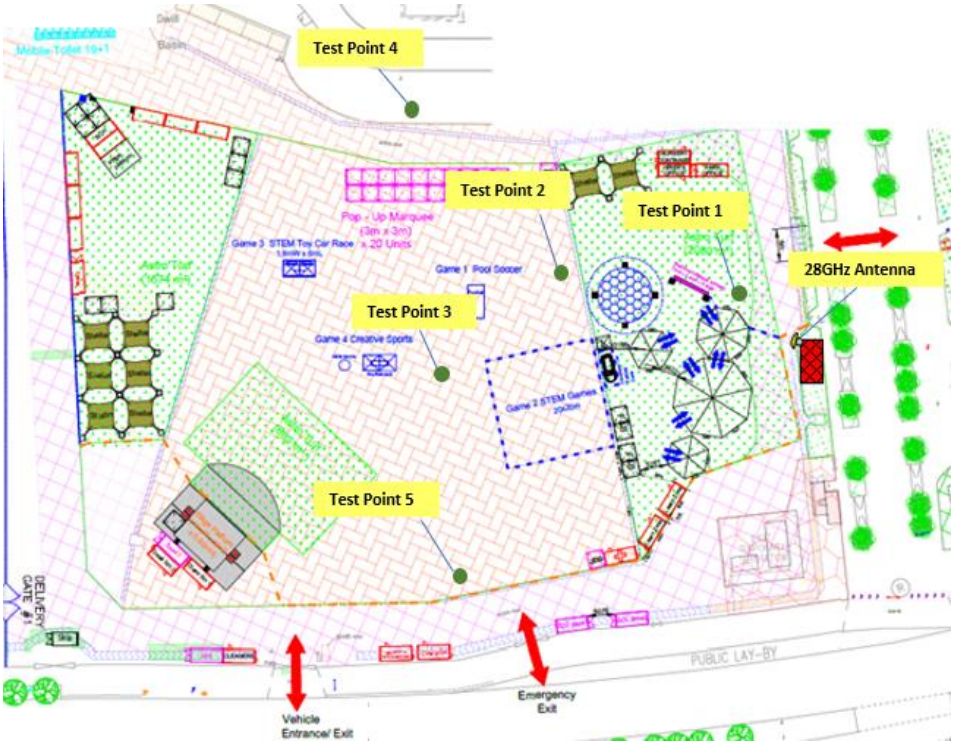

Figure 10. Test points at test location 1

Test Point	28GHz downlink throughput – Application Layer
1	1.5 Gbps
2	1.1 Gbps
3	--
4	0.2 Gbps
5	--

Figure 11. 28GHz downlink throughput test result at test location 1

3.1.2. Indoor Test Result

3.1.2.1. 28GHz indoor coverage test at the test location 2

The antenna was located at the 2/F with down-tilting. The signal strengths on 1/F with line-of-sight (LOS) were stronger than that on 2/F. The signal strength was dropped significantly when the user equipment was moved from test point 4 line-of-sight to the test point 6 non line-of-sight (NLOS) area at 1/F.

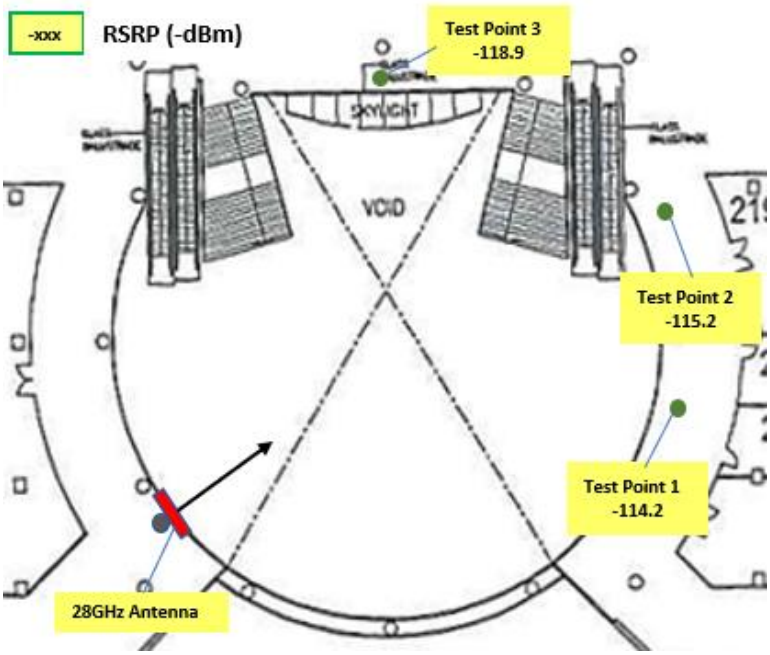

Figure 12. 28GHz indoor coverage test result at 2/F

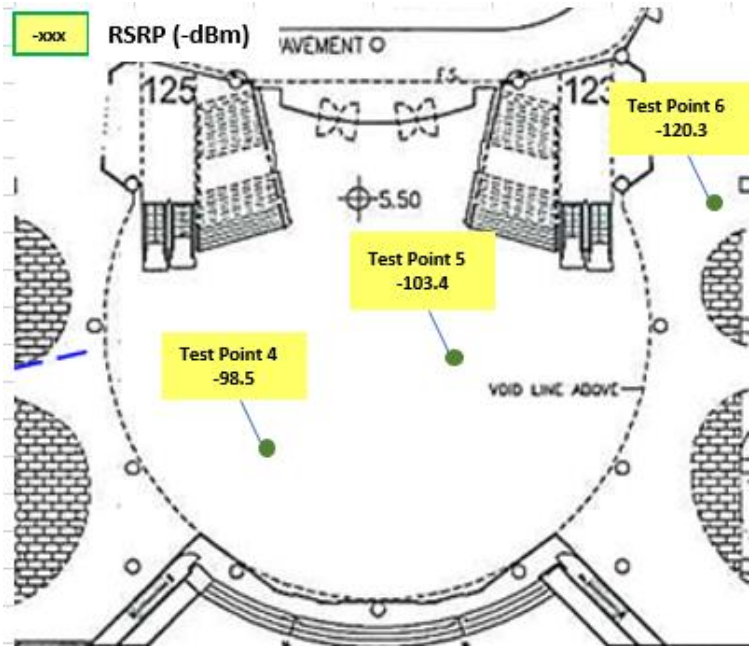

Figure 13. 28GHz indoor coverage test result at 1/F

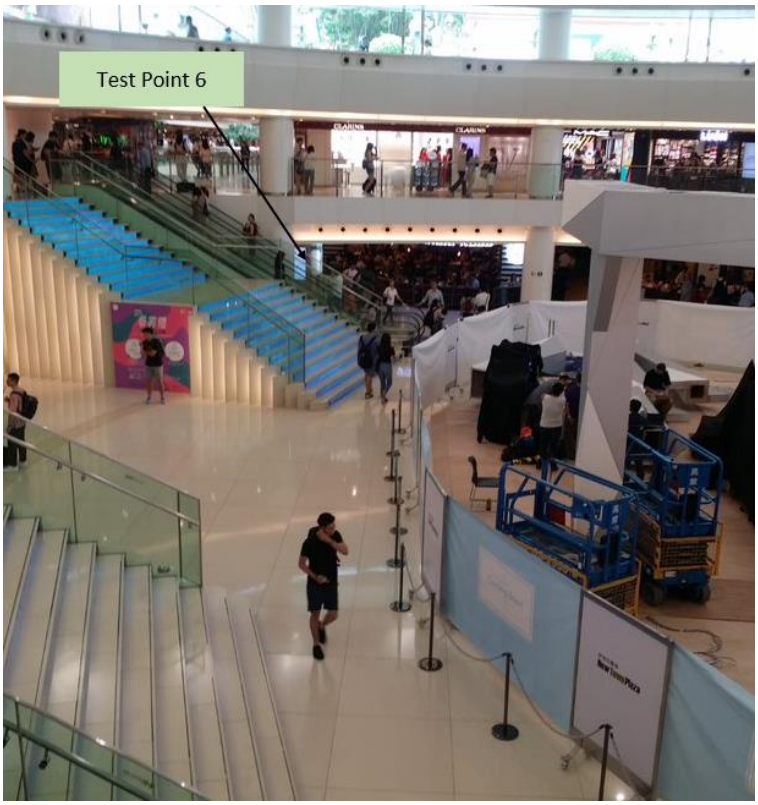

Figure 14. Test point 6 located at NLOS area

3.1.2.2. 28GHz indoor downlink throughput test at the test location 2

The downlink throughput around 1 Gbps was measured at the test point 4. The throughput was dropped to 0.2Gbps which was measured at the test point 6. Non line-of-sight and the body effect at the surrounding area caused the significantly drop in throughput at the test point 6. The downlink throughputs between 0.5Gbps and 0.7Gbps were measured at 2/F with similar signal strengths.

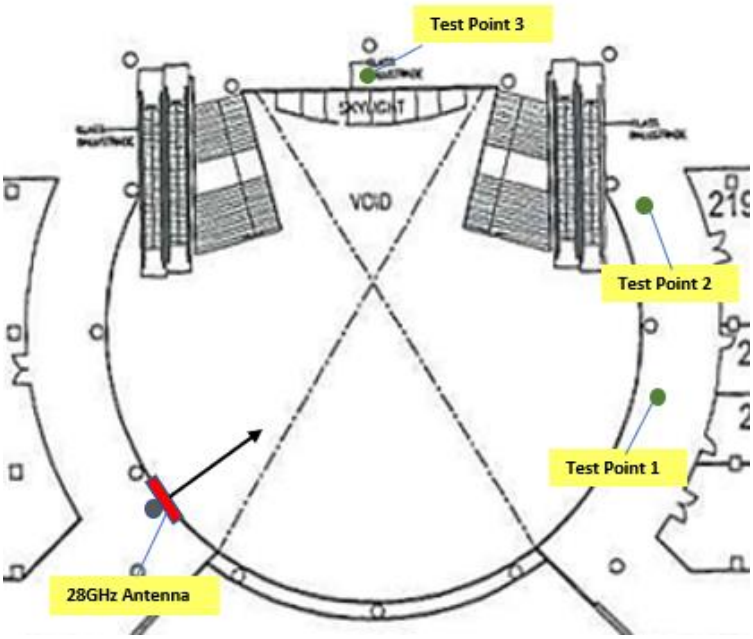

Figure 15. 28GHz test points for test location 2 at 2/F

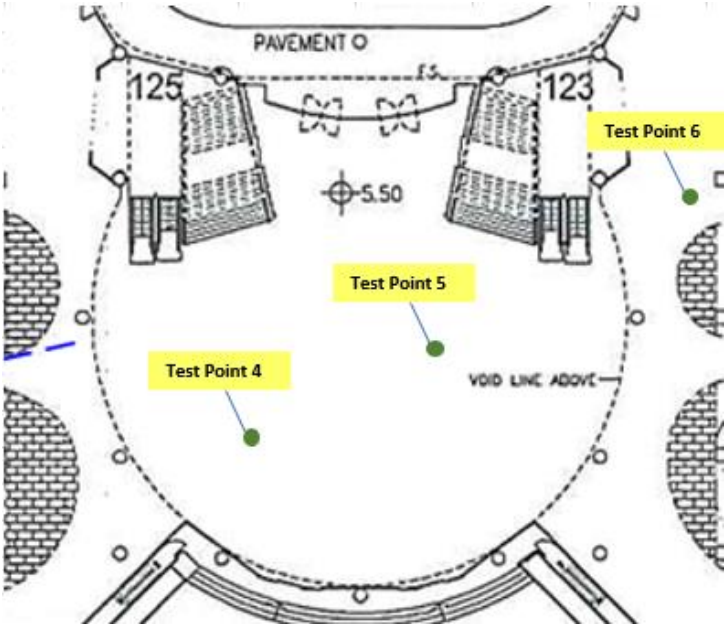

Figure 16. 28GHz test points for test location 2 at 1/F

28GHz Indoor test	
Test Point	**Downlink throughput – Application Layer**
1	0.6 Gbps
2	0.5 Gbps
3	0.7 Gbps
4	1.0 Gbps
5	0.9 Gbps
6	0.2 Gbps

Figure 17. 28GHz indoor downlink throughput test result at test location 2

3.2. 3.5GHz Band

3.2.1. Indoor Test Result

3.2.1.1. 3.5GHz indoor coverage test at test location 2

With the same transmitted EIRP equals to 28GHz (30 dBm), it was observed that the signal strengths of 3.5GHz is around 13 to 28 dB stronger than that of 28GHz cell.

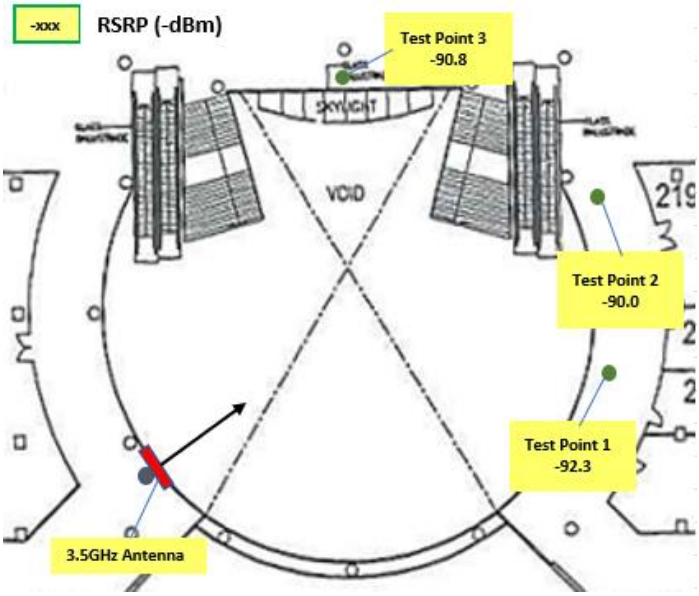

Figure 18. 3.5GHz indoor coverage test result at 2/F

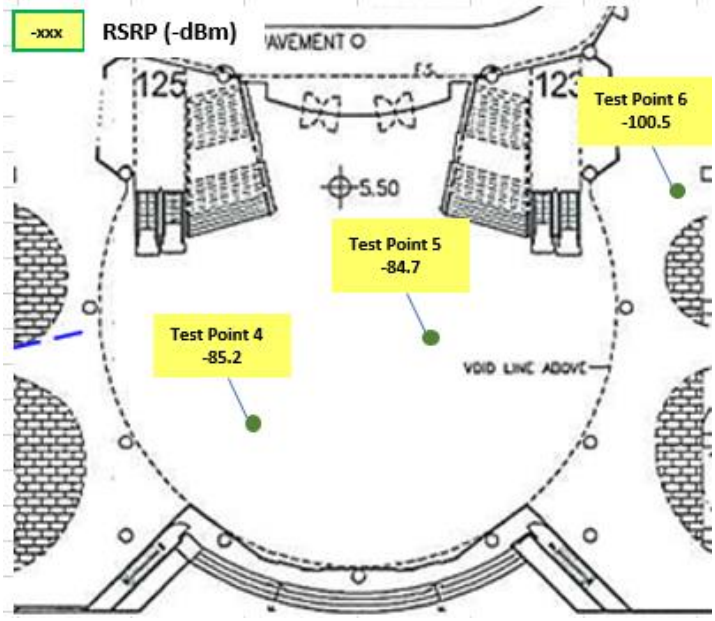

Figure 19. 3.5GHz indoor coverage test result at 1/F

3.2.1.2. 3.5GHz downlink throughput test

The downlink throughput 618Mbps was achieved at test point 4 (near site and LOS). The throughput 79Mbps was measured at the NLOS area at test point 6.

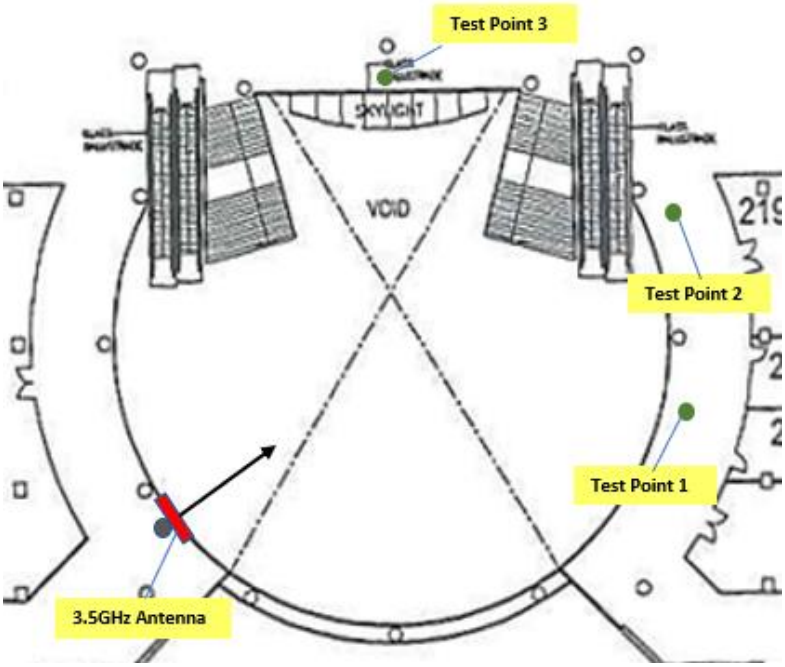

Figure 20. 3.5GHz test points for test location 2 at 2/F

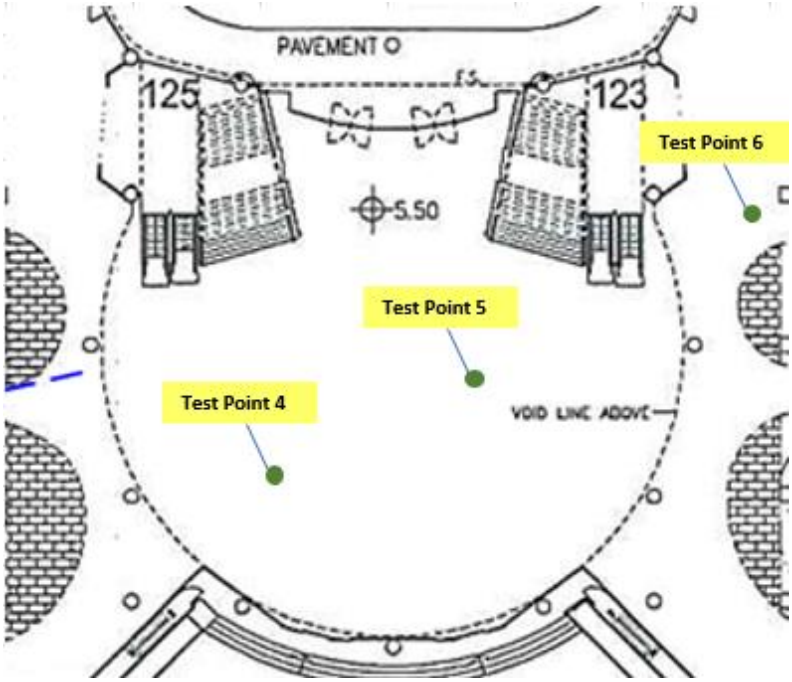

Figure 21. 3.5GHz test points for test location 2 at 1/F

3.5 GHz Throughput Test	
Test Point	**Downlink throughput – Application Layer**
1	265.5 Mbps
2	262.3 Mbps
3	266.7 Mbps
4	721.0 Mbps
5	532.9 Mbps
6	92.2 Mbps

Figure 22. 3.5GHz downlink throughput test result at test location 2

4. Conclusions

Further 5G NR trial tests were conducted at the indoor and outdoor environment to evaluate the 5G performance operating at 3.5GHz and 26/28GHz frequency bands.

For 28GHz band performance, a high download throughput (~1.5Gbps) can be achieved with 400M bandwidth configuration. The characteristics of the millimeter wave (mmWave) for indoor and outdoor sites such as high pathloss, high penetration loss, body loss and required line-of-sight propagation limits the 5G coverage at 26/28GHz band.

For 3.5GHz band performance, the download throughput 0.7Gbps was achieved with 70MHz carrier bandwidth in the good signal strength LOS indoor environments. Although the 3.5GHz carrier bandwidth is smaller than 28GHz band, it can provide a better coverage compared to 28GHz band.

According to the trial test results, the number of base stations has to be increased significantly to provide 5G continuous coverage for 26/28GHz mmWave band. Due to its propagation characteristics, it is more suitable to deploy 26/28GHz as hotspot or high traffic area at the early stage of deployment. Sub-6 3.5GHz or other lower frequency bands are better for providing 5G continuous and in-building coverage.