Test Report

For

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

Version 1

SmarTone

September 2019

Table of Contents

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 1st 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 Kwun Tong and Mong Kok areas.

2.1. Test Equipment

2.1.1. 26/28GHz test equipment

Equipment	Technical Specifications	
28GHz Active Antenna	Frequency Band	28 GHz
	Bandwidth	8 x 100 MHz
	MIMO Configuration	512Tx/512Rx
Test User Equipment	Frequency Band	28 GHz
	MIMO Configuration	1Tx/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	1Tx/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	Kwun Tong	Outdoor	28 GHz/3.5 GHz	Bearing = 245º Down-tilt = 16º
2	Kwun Tong	Indoor	28GHz	Bearing = 260º Down-tilt = 0º
3	Mong Kok	Outdoor and Indoor Penetration	3.5 GHz	Bearing = 205º Down-tilt = 26º

Figure 3. 5G 28GHz Test Location 1 and 2, 3.5GHz Test Location 1

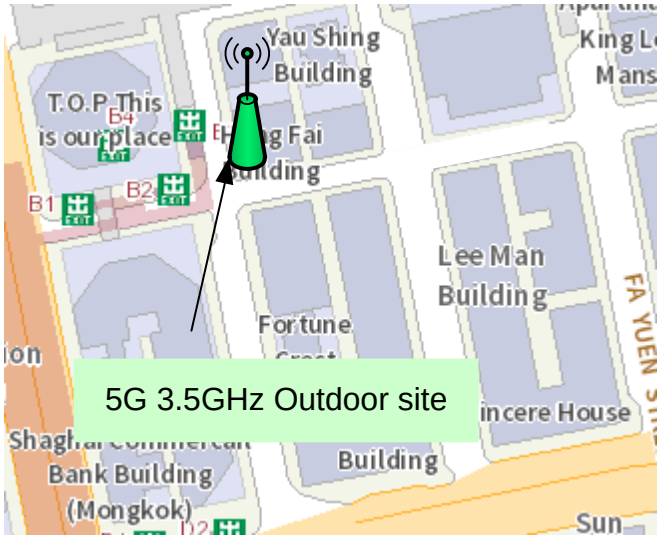


Figure 4. 5G 3.5GHz Test Location 3

(A) (B)

Figure 5. (A) 3.5GHz and (B) 28GHz Active Antenna on site

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	27.5 - 28.3 GHz	8 x 100 MHz	50 dBm (Outdoor) 30 dBm (Indoor)
3.5GHz	3.5 - 3.6 GHz	1 x 100 MHz	29 dBm (Location 1) 26 dBm (Location 3)

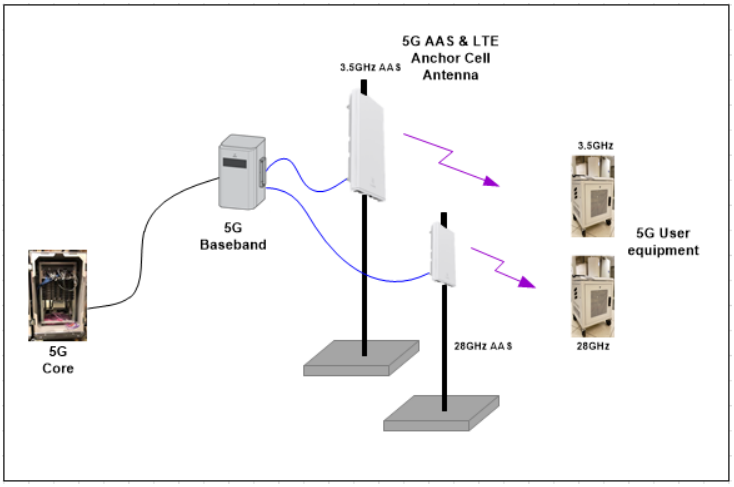


Figure 6. 5G test configuration

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.

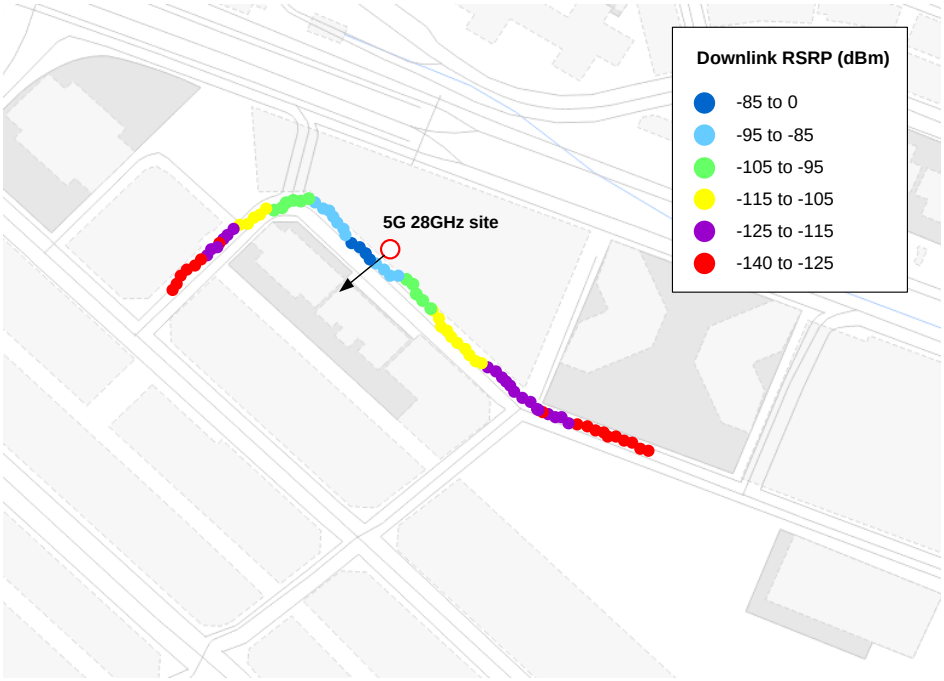
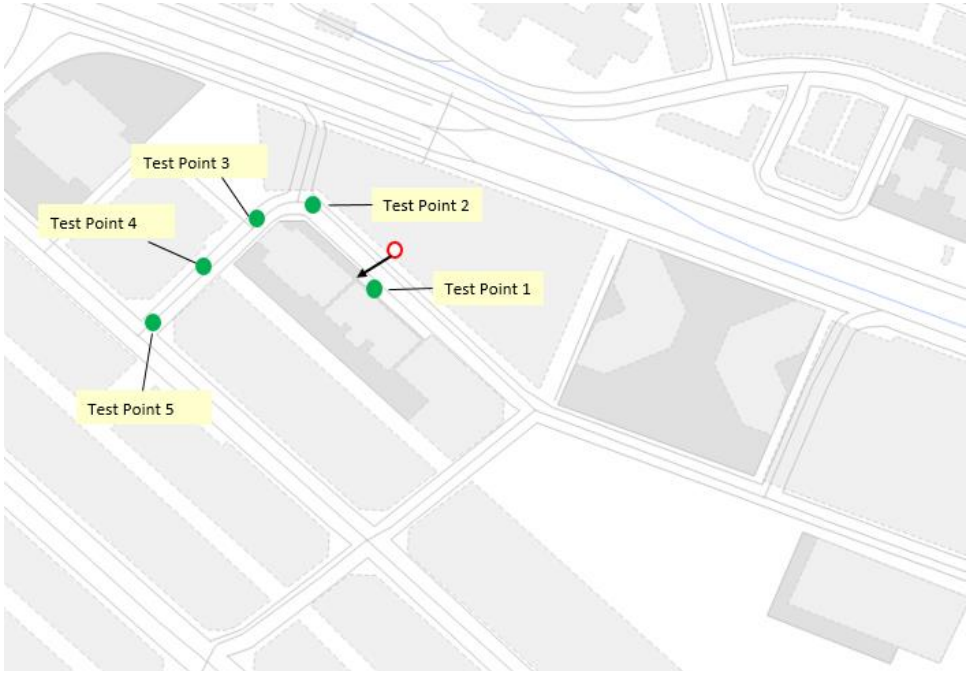


Figure 7. 28GHz coverage test result at test location 1

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

The downlink throughput 3.4Gbps 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 2 to 5), the throughput was dropped significantly.



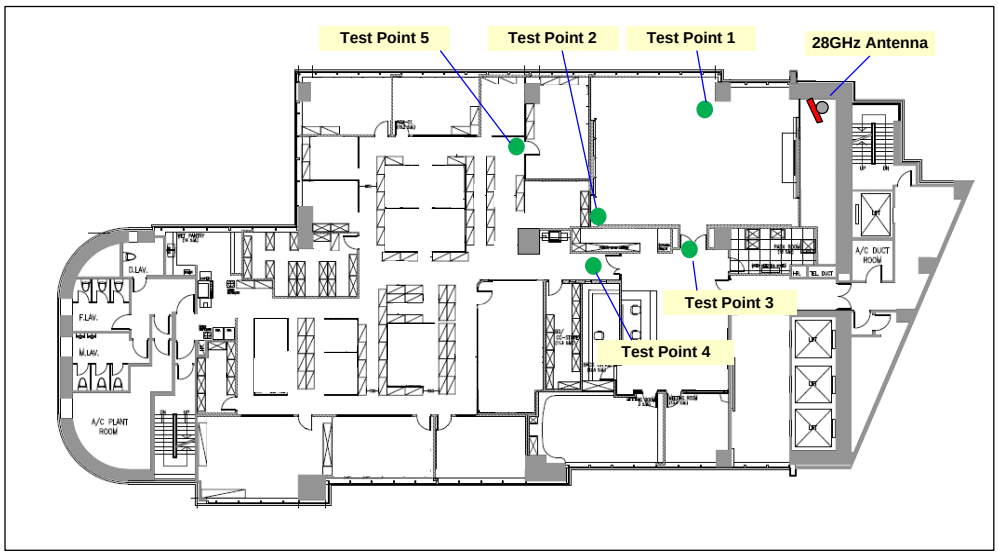
Test Point	28GHz downlink throughput – MAC Layer
1	3.4 Gbps
2	1.1 Gbps
3	0.4 Gbps
4	--
5	--

Figure 8. 28GHz downlink throughput test result at test location 1

3.1.2. Indoor Test Result

3.1.2.1. 28GHz indoor downlink throughput test at the test location 2

The downlink throughput >3 Gbps was measured at the test point 1 and 2. The throughput was dropped to 1.3Gbps which was measured outside the meeting room. When the user equipment was moved away from the antenna and blocked by several partition walls, it was out of the 28GHz coverage.



28GHz Indoor test	
Test Point	**Downlink throughput - MAC layers**
1	3.9 Gbps
2	3.1 Gbps
3	1.2 Gbps
4	--
5	--

Figure 9. 28GHz indoor downlink throughput test result at test location 2

3.2. 3.5GHz Band

3.2.1. Outdoor Test Result

3.2.1.1. 3.5GHz outdoor coverage test at test location 1

Although the transmitted EIRP was only 29 dBm, it was observed that 3.5GHz coverage was slightly larger than 28GHz cell with 50 dBm EIRP.

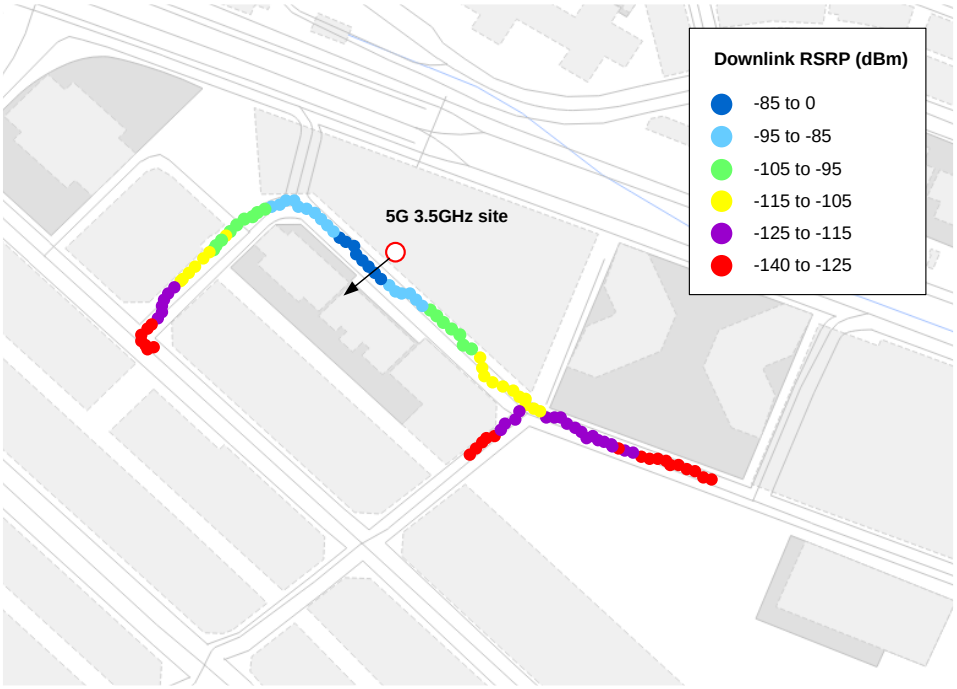
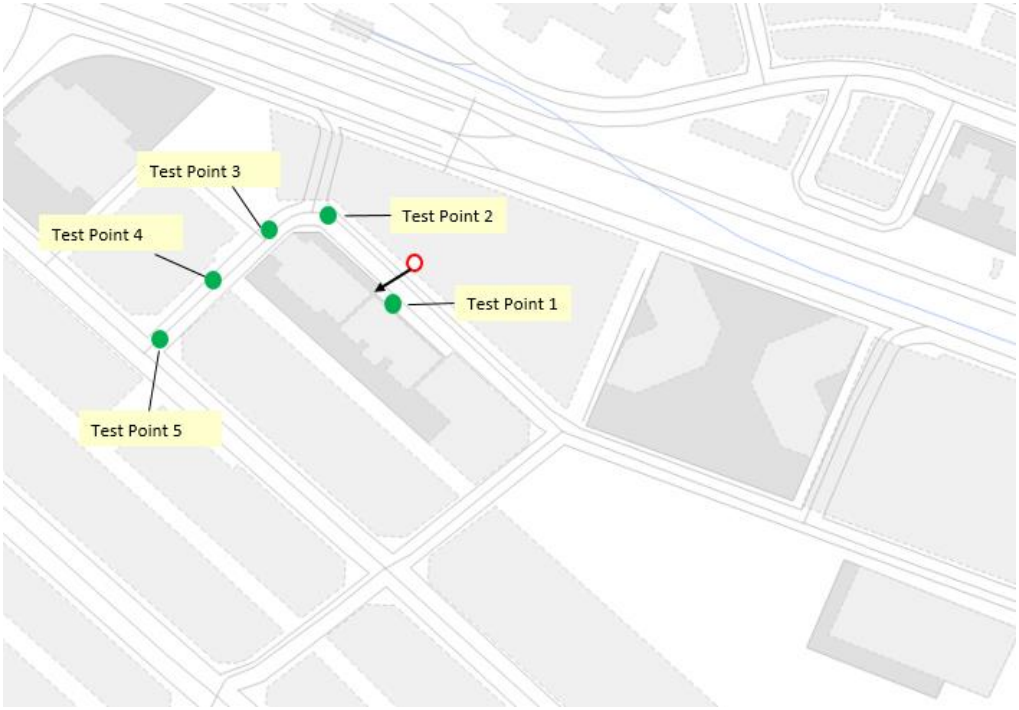


Figure 10. 3.5GHz coverage test result at test location 1

3.2.1.2. 3.5GHz downlink throughput test

The downlink throughput 1.5Gbps was achieved at test point 1 (near site and LOS). The throughput 0.3 to 0.6Gbps was measured at the NLOS areas (test point 4 and 5).



3.5 GHz Throughput Test	
Test Point	**Downlink throughput - Mac Layer**
1	1.5 Gbps
2	1.1 Gbps
3	1.0 Gbps
4	0.6 Gbps
5	0.3 Gbps

Figure 11. 3.5GHz downlink throughput test result at test location 1

3.2.1.3. 3.5GHz outdoor coverage test at test location 3

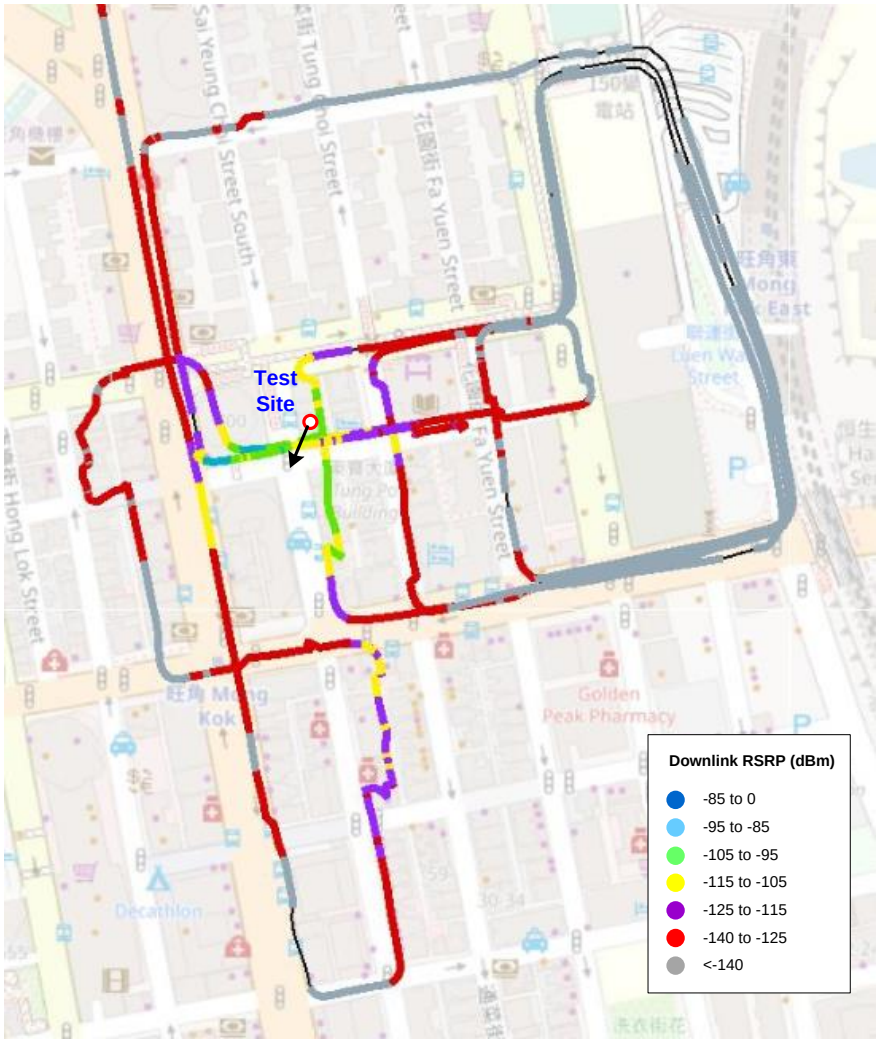


Figure 12. 3.5GHz coverage test result at test location 3 (RSRP)

3.2.1.4. 3.5GHz Indoor penetration test (Location 3)

A scanner was used to measure the indoor coverage by the 3.5GHz outdoor site. Although the transmitted EIRP was only 26dBm, the measurement results could be served as an initial reference.

Figure 13. 3.5GHz indoor penetration test

Downlink RSRP is measured using a scanner at the different floors of the shopping mall (basement to 3/F).

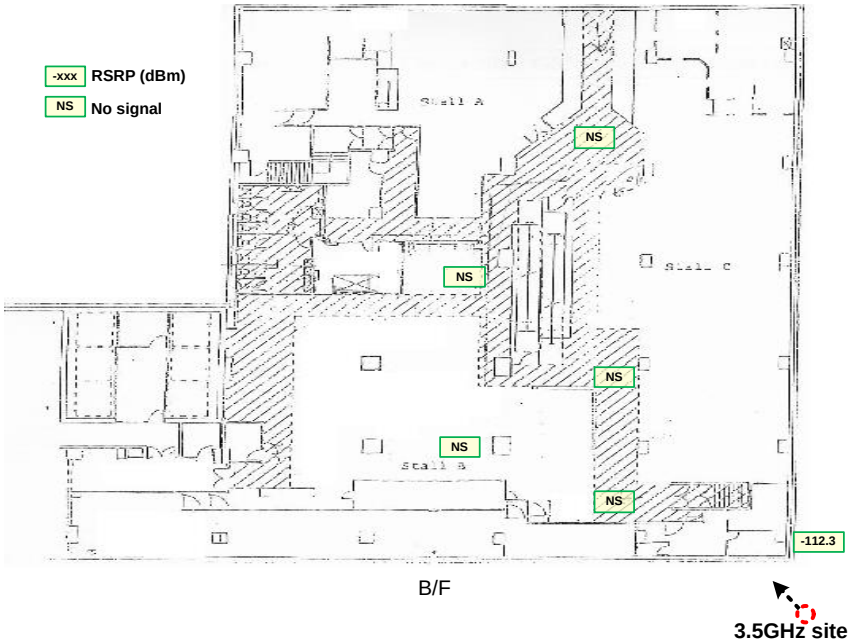


Figure 14. 3.5GHz indoor penetration test result - Basement

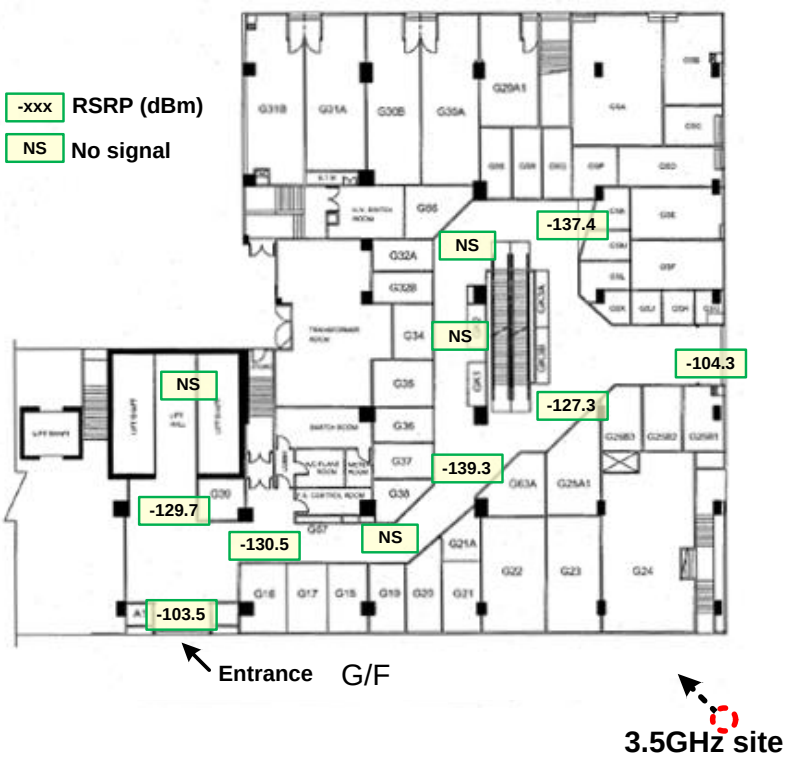


Figure 15. 3.5GHz indoor penetration test result – G/F

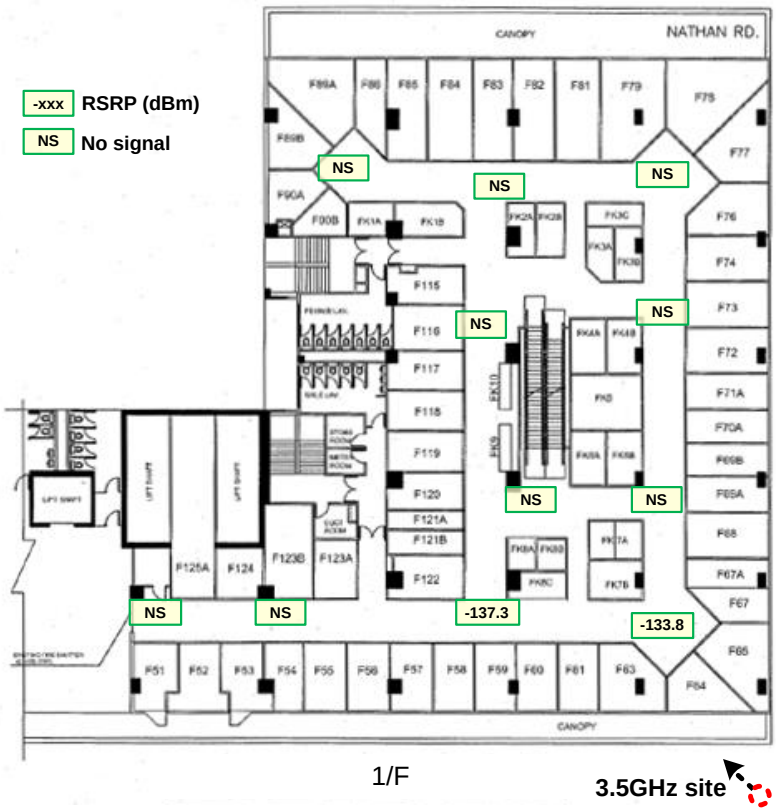


Figure 16. 3.5GHz indoor penetration test result – 1/F

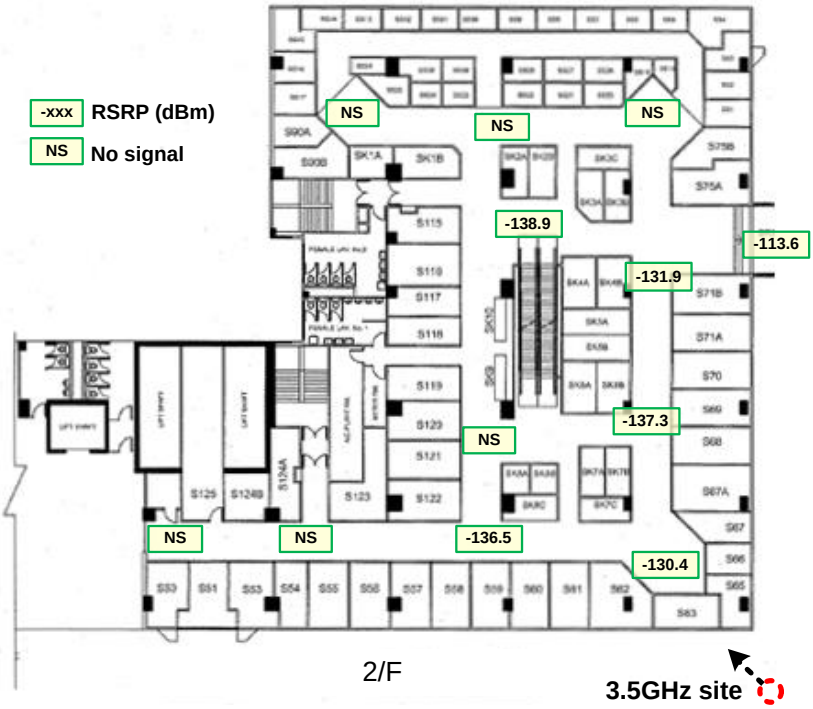


Figure 17. 3.5GHz indoor penetration test result – 2/F

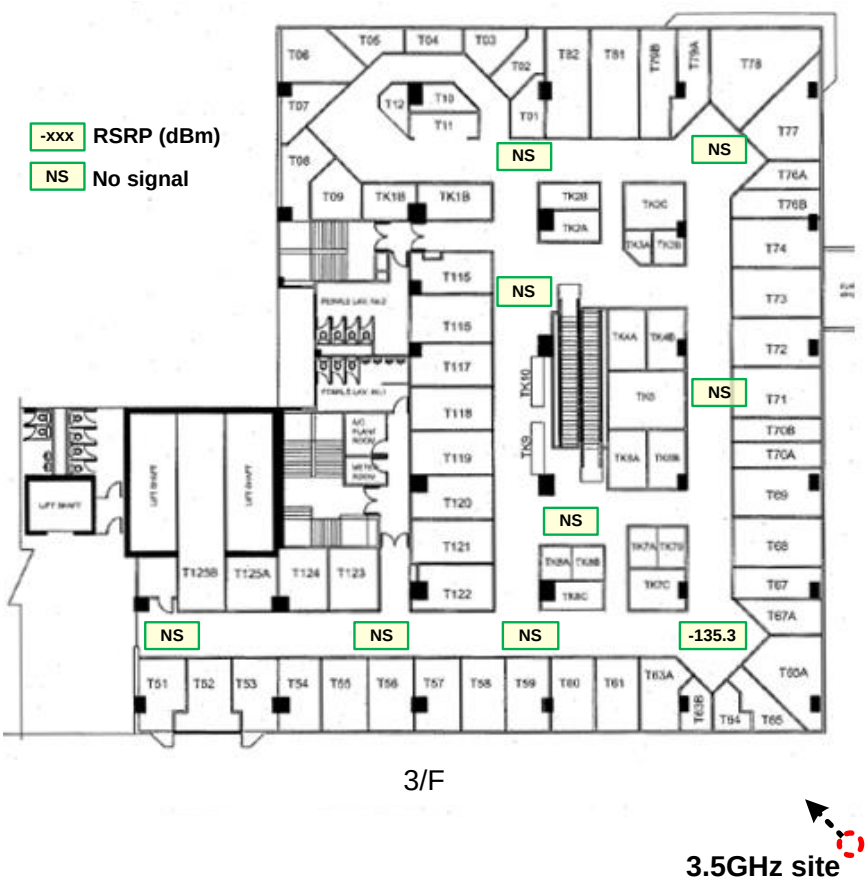


Figure 18. 3.5GHz indoor penetration test result – 3/F

Refer to the reference of -103dBm measured at the G/F entrance, 30dB or more path and penetration loss was observed which was contributed by different building materials of the exterior wall and interior layout such as the infrared reflective (IRR) glass, concrete, wood, etc.

4. Conclusions

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

For 28GHz band performance, a high download throughput (~4Gbps) was achieved with large bandwidth configuration in both indoor and outdoor environments. The test results were confirmed the comparatively smaller 5G coverage at 26/28GHz was observed due to the characteristics of the millimeter wave (mmWave) frequency band such as high pathloss, high penetration loss and required line-of-sight propagation.

For 3.5GHz band performance, the download throughput 1.5Gbps and 300Mbps was achieved with 100MHz carrier bandwidth in the good signal strength LOS and weak signal strength NLOS outdoor environments, respectively. Although the 3.5GHz carrier bandwidth is smaller than 28GHz band, the test results were shown the better coverage compared to 28GHz band.

Based on the trial test results, the 26/28GHz mmWave band is not suitable for providing 5G continuous coverage due to the limitation of mmWave propagation characteristics. Due to its propagation characteristics, the interference to surrounding neighbour cells will be reduced and it should be good for hotspot high traffic load deployment. Sub-6 3.5GHz or other lower frequency bands are required to provide 5G continuous and in-building coverage.