

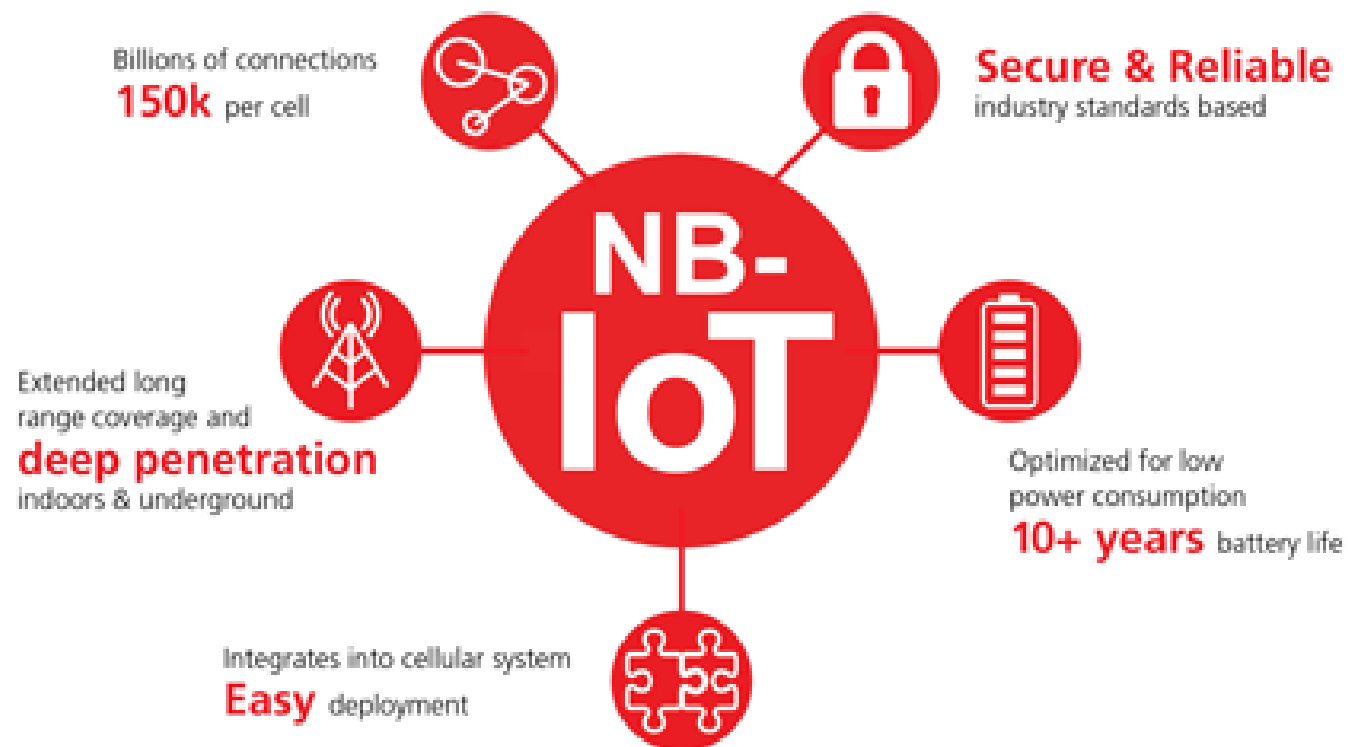
NB-IoT Coverage Study For Smart Metering In Singapore

LIM Wee Beng, PUB

MAKE
EVERY
DROP
COUNT

The Case for NB-IoT Water Meters

- NB-IoT is an emerging communications service offered by the 3 main MNOs in Singapore (Singtel, M1, Starhub).
- NB-IoT offers ease of deployment and maintenance (no need to set up separate comms infra)
- Uses licensed-band(s) and is at less risk of being re-designated for other uses, with low risk of interference
- NB-IoT only supports low data rate communications but in return offers superior power efficiency and potentially lower costs.
- NB-IoT is touted to enable a wide range of potential IoT use cases such as environmental monitoring and smart utility metering. It is also an open standard and reduces the risk of users being locked in to a particular vendor/ technology.



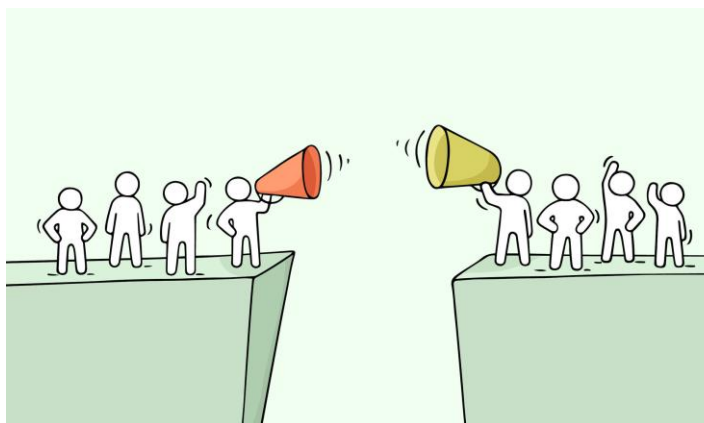
Challenges For NB-IoT In Water Metering

- NB-IoT for water metering is still nascent, and there are currently **no known** meter suppliers that can commit to PUB's requirements of **15 years lifespan for commercial water meters** based on minimum hourly readings with minimum daily transmissions.
- Key challenges identified from overseas study trips and engagements with the industry:
 - Meter's battery lifespan is significantly affected by network coverage and configurations which can vary across MNOs e.g. repetition configurations, coverage enhancement modes, eDRX, PSM, release assistance indication.

➤ Unfamiliarity of some meter suppliers on the complexity and design considerations involving mobile networks and emerging mobile technologies, including the use of other standards and protocols in the upper stack e.g. DTLS, LWM2M, CoAP

➤ Unfamiliarity of MNOs on metering environments, requirements and operations, which could require greater optimization of the mobile networks.

A gap needs to be bridged



Services of an independent professional third party engaged

Approach: Identify Key Physical Environments For Coverage Tests

DENSE URBAN

URBAN



CBD

- Urban canyon. Challenging for RF, due to severe reflection and attenuation (why GPS always has issues here!)
- Water meters typically at ground level in concrete chambers, below concrete slabs, and some in basements



HDB ESTATES/ CONDOS

- Less dense than CBD, but still high-rise, built-up areas
- Water meters in service ducts, within stairwells, and in concrete chambers. Need to provide coverage from ground to top levels

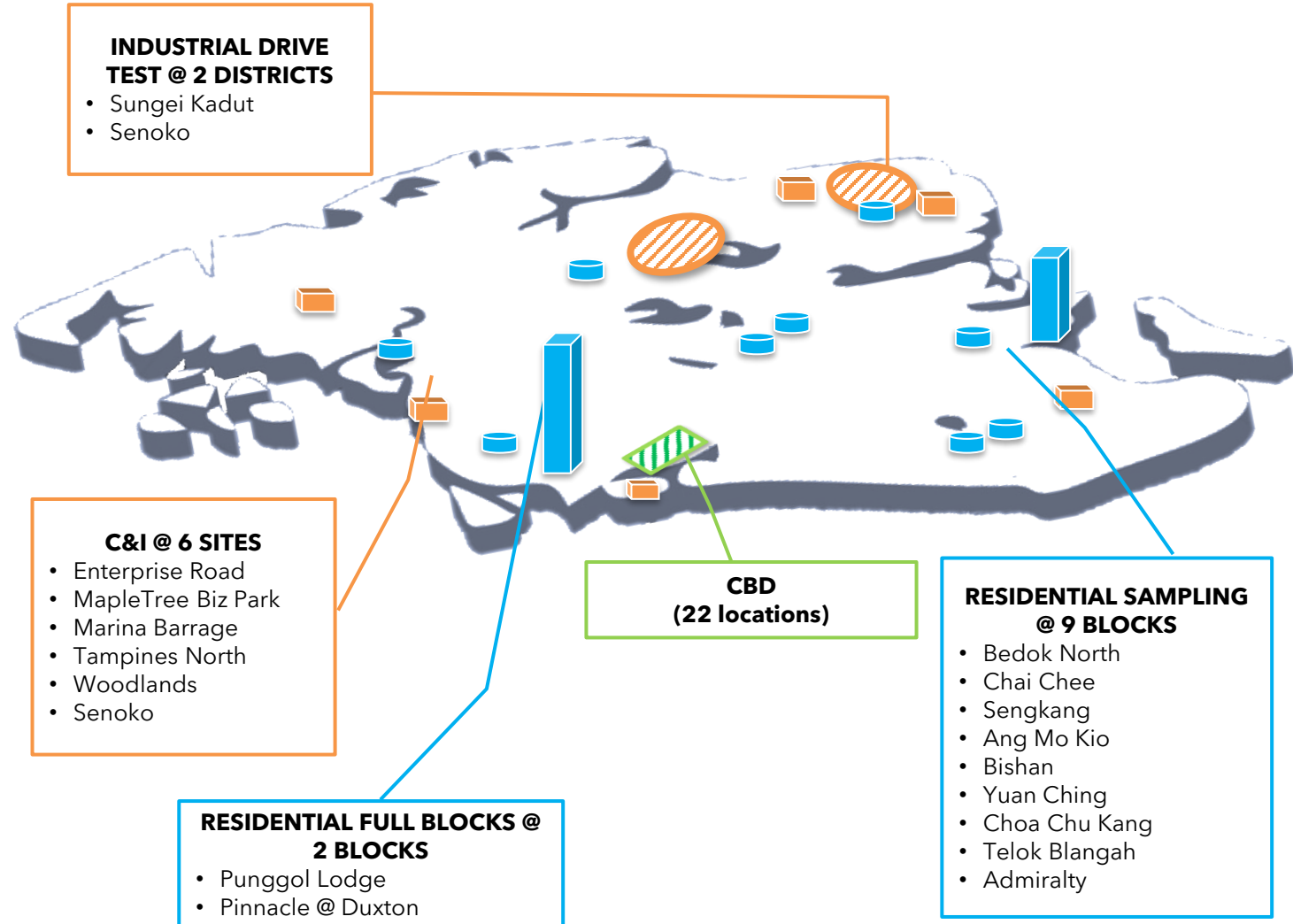


INDUSTRIAL AREAS

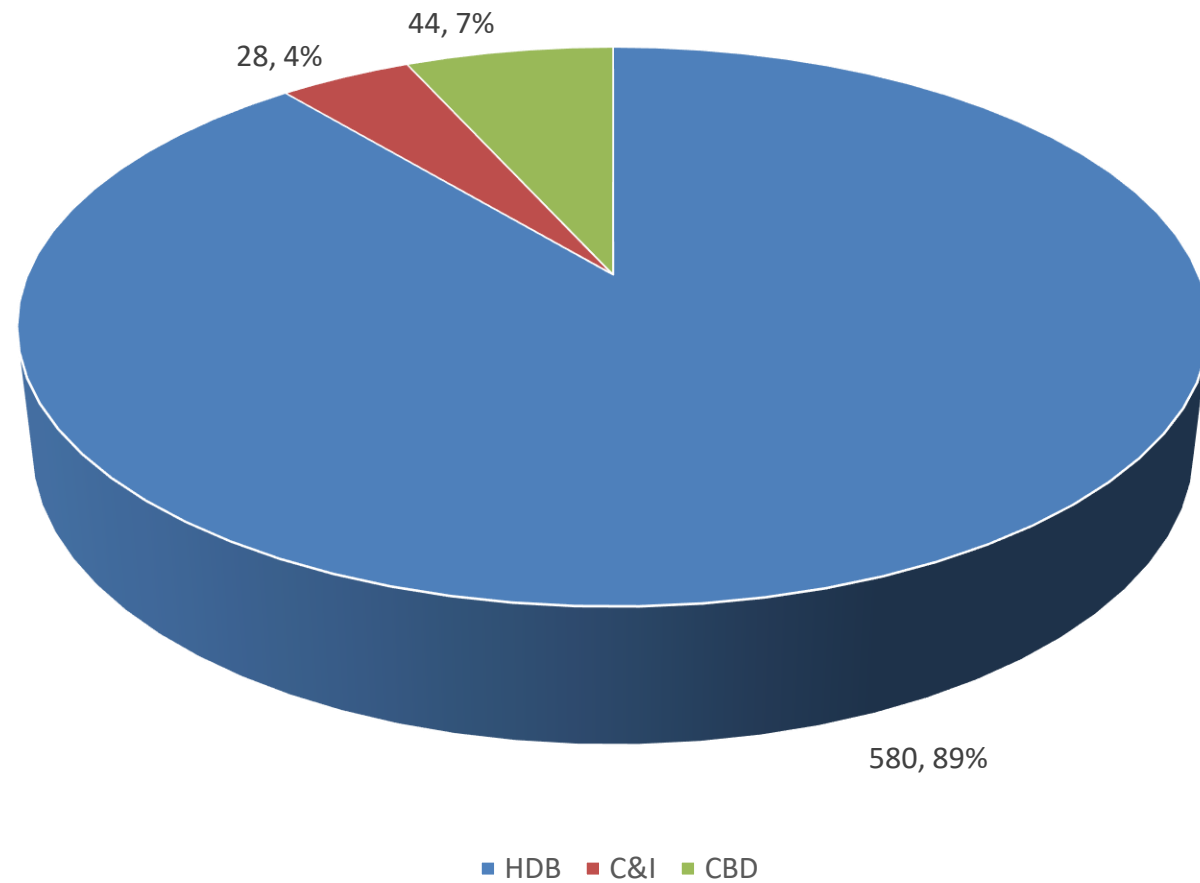
- Low-lying, built-up areas
- May lack sufficiently high ground for base station to provide wide area coverage
- Water meters typically at ground level in concrete chambers, below concrete ground

Scope Of The Study

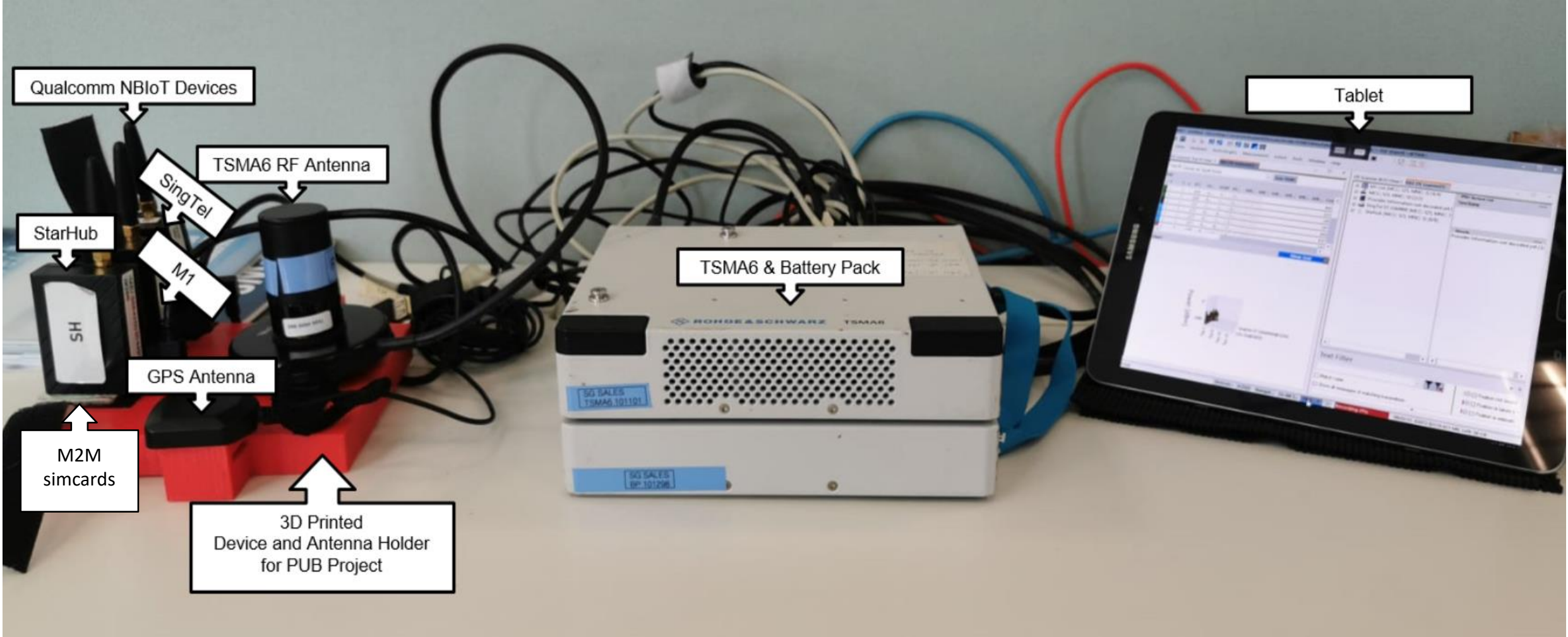
- Independent measurements for 3 local MNOs - Singtel, M1 & Starhub
- Performance of NB-IoT signals across Singapore at water meter locations
- Capture key NB-IoT parameters
- Different measurement scenarios
- Static measurements & Drive test



652 Data Points Measured (Number of Meter Points)

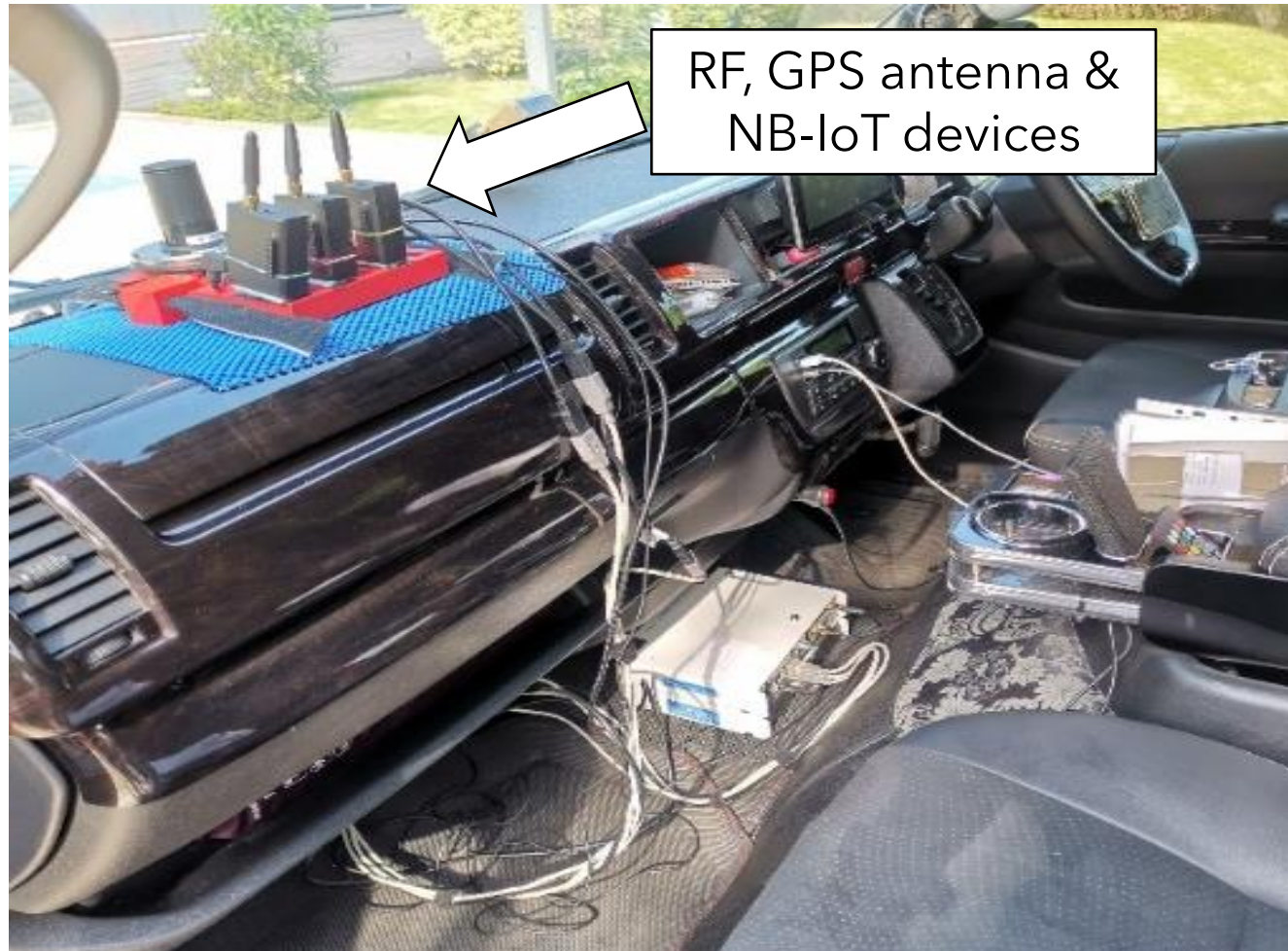


Measuring Equipment



Same equipment for both static and drive test. Setup supports: 6-7 Samples/sec

Measuring Equipment Mounted For Drive Test



- Same equipment are used as for static measurements
- Settings & configurations are similar
- Continuous measurements for drive test, sampling rate: 6-7 Samples/sec
- Additional GPS antenna is used to track the route automatically
- Speed of Vehicle <60km/h
- No measurement 30 mins before & after rain

Technical Parameters Measured

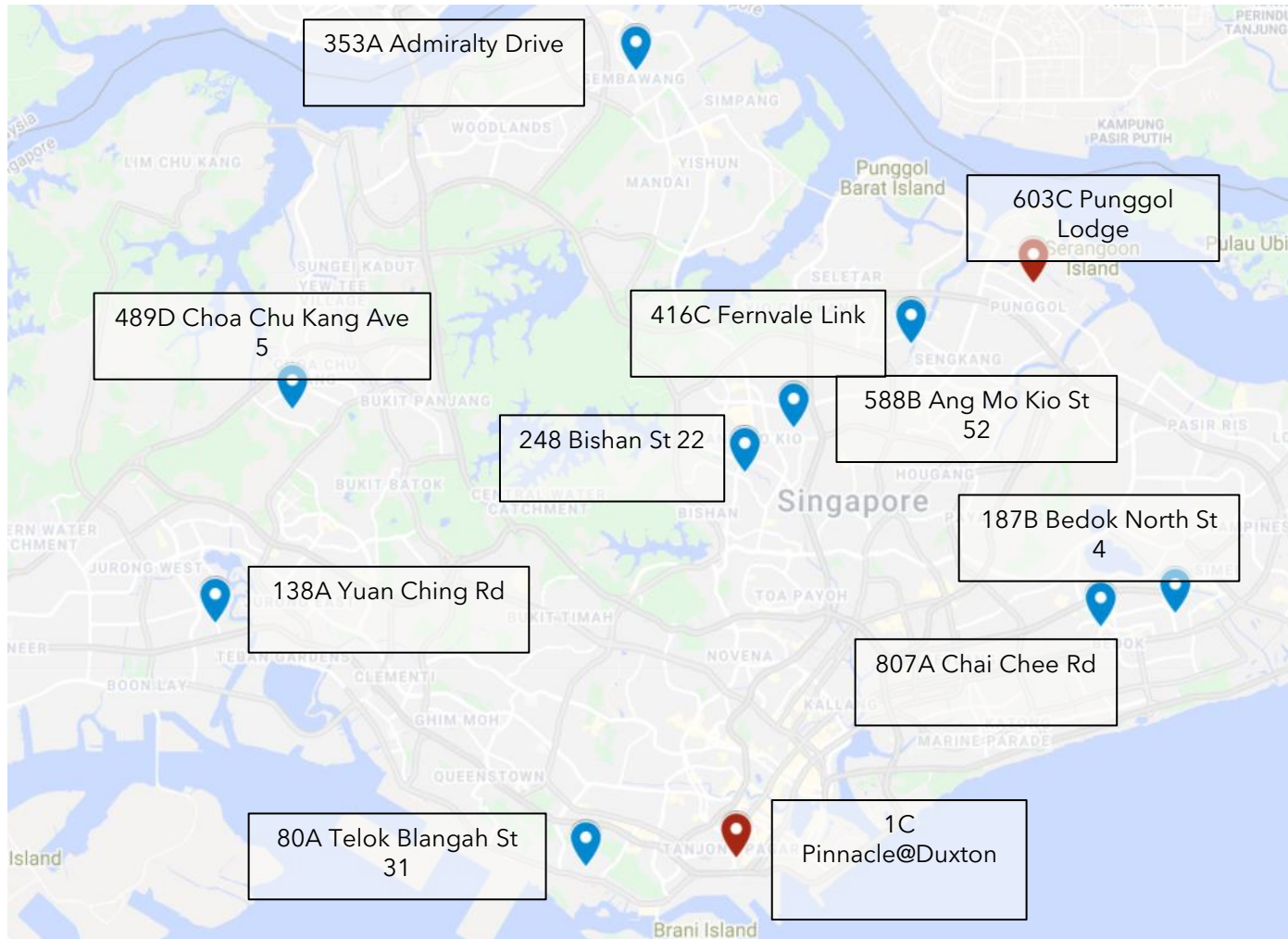
- RSRP and CE Mode are studied in detailed here
- IMDA QoS guideline criterion is based on RSRP ($> -109\text{dBm}$)
- CE mode directly affects battery life due to re-transmissions

Technical Parameters measured at every measurement site	Summary of parameters
Frequency Band	Measured value
Frequency Bandwidth	Measured value
Measurement of neighbour cell signal	The next strongest neighbour cell's average RSRP
Coverage Extension (CE) Mode	Average value over measurement period of 1 minute
RSSI	Average values over measurement period of 1 minute
RSRP	Average values over measurement period of 1 minute
SNR / SINR	Average values over measurement period of 1 minute
RSRQ / Surrounding noise measurement	Average values over measurement period of 1 minute
Attenuation measurement and comparison	Difference in values of average RSRP of the 2 measured points at each measurement site

Residential Measurements

MAKE
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DROP
COUNT

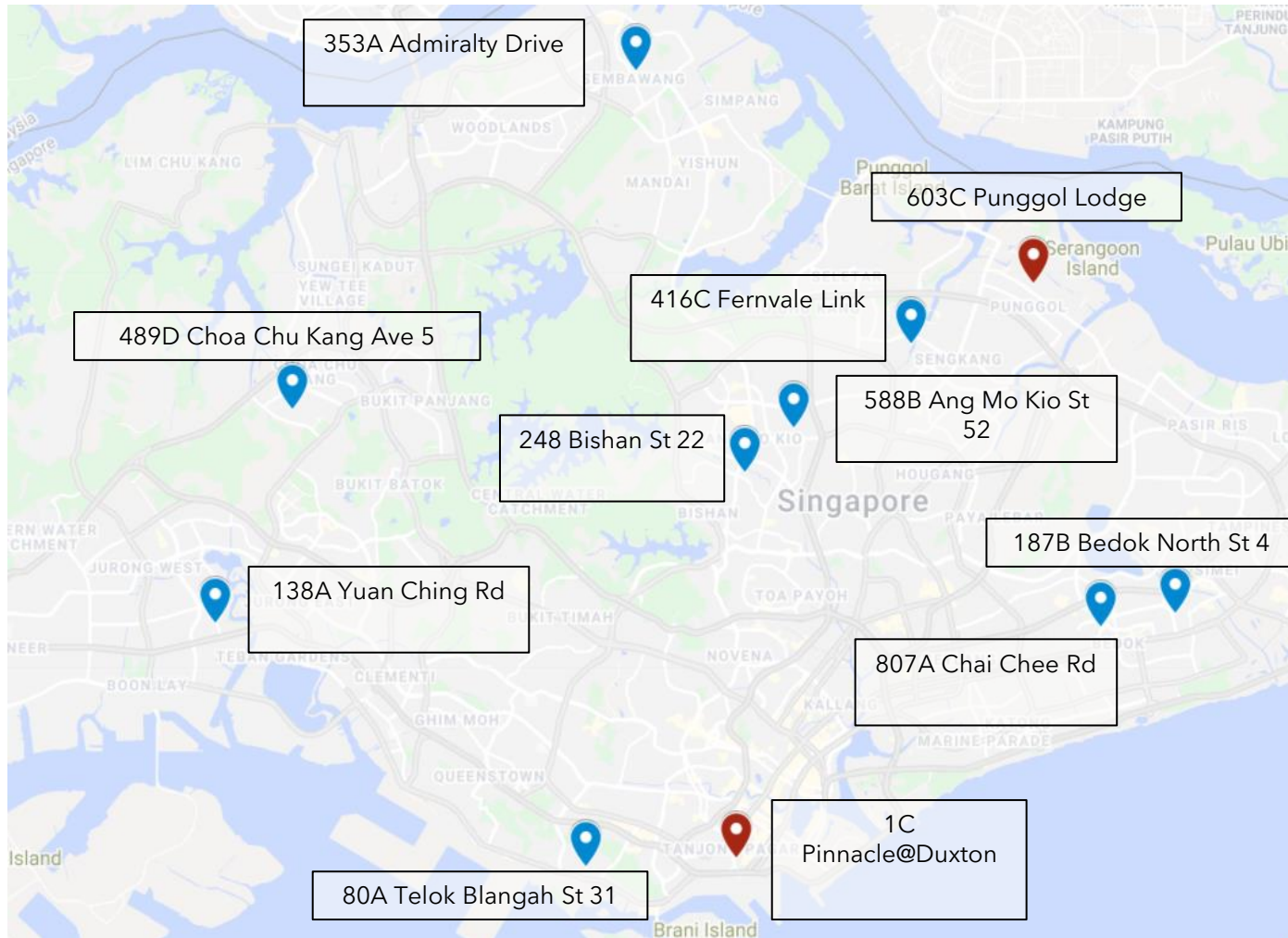
Residential Measurements



- 📍 Samples from 9 HDB blocks, For each block;
 - 3 meter, low levels
 - 3 meter, mid levels
 - 3 meter, top levels
 - Large meter
 - Total ~160 measurements

- 📍 Full meas. for 2 HDB blocks,
 - All meters are measured at every level
 - Large meter
 - Total ~420 measurements

Residential Measurements



No major concerns for all 11 HDB locations, with regards to:

- RSRP performance
- CE Mode performance

General observations

- Higher attenuation at lower levels observed.
- Comparing coverage results from Pinnacle. Coverage at higher levels is lower. This could be due to antenna down tilt angle.
- Some MNOs' CE mode settings can be optimized further.

Residential Measurements - Key Learning points

416C Fernvale Link



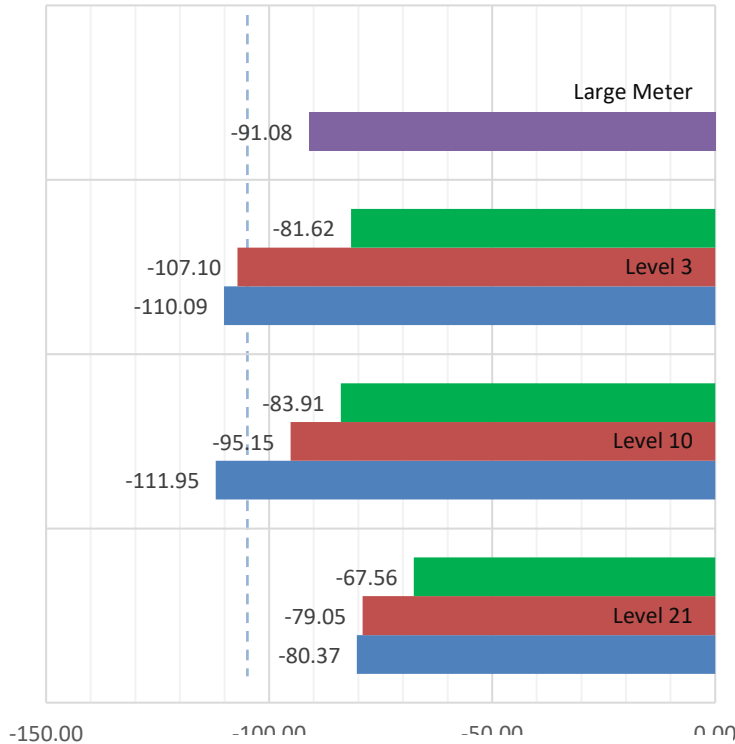
Measurements taken;

- 3 meter at level 3
- 3 meter at level 10
- 3 meter at level 21
- Large meter
- Total 20 measurements
- Each measurements is 60sec

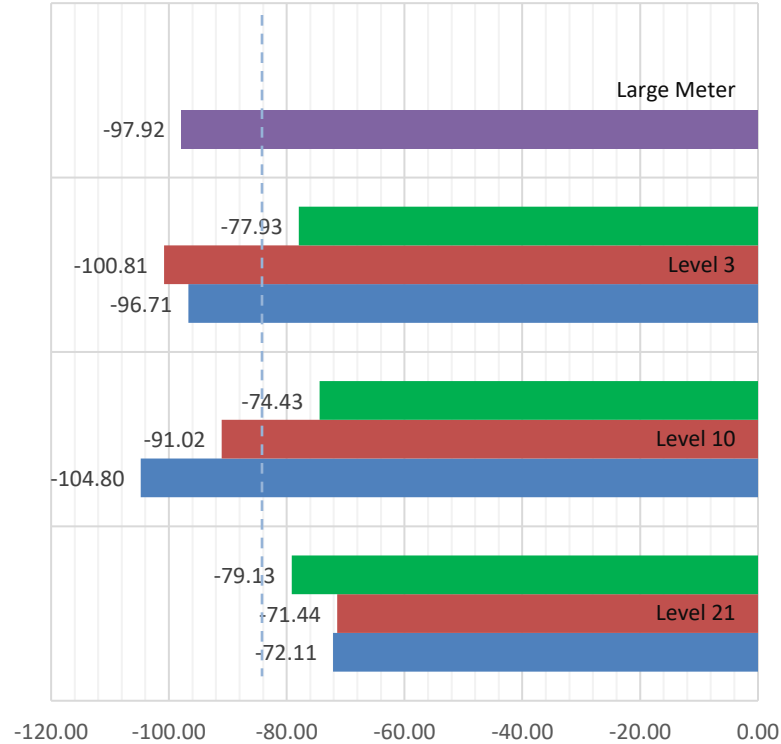
Residential Measurements – Key Learning Points

416C Fernvale Link

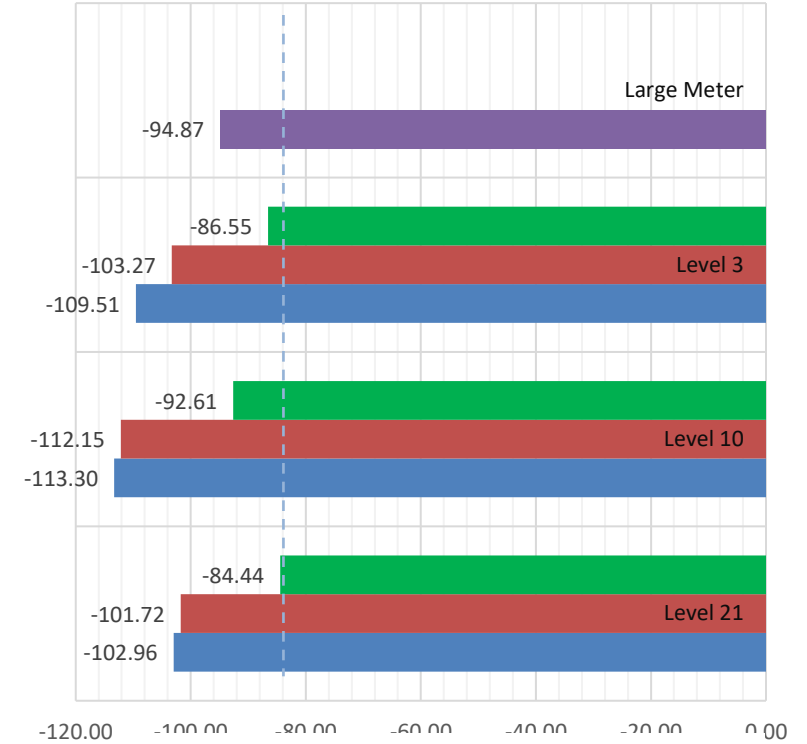
Singtel RSRP



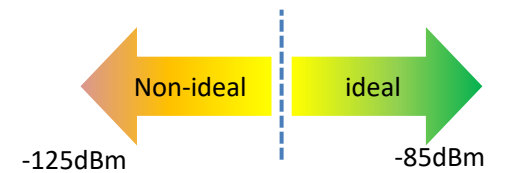
M1 RSRP



Starhub RSRP

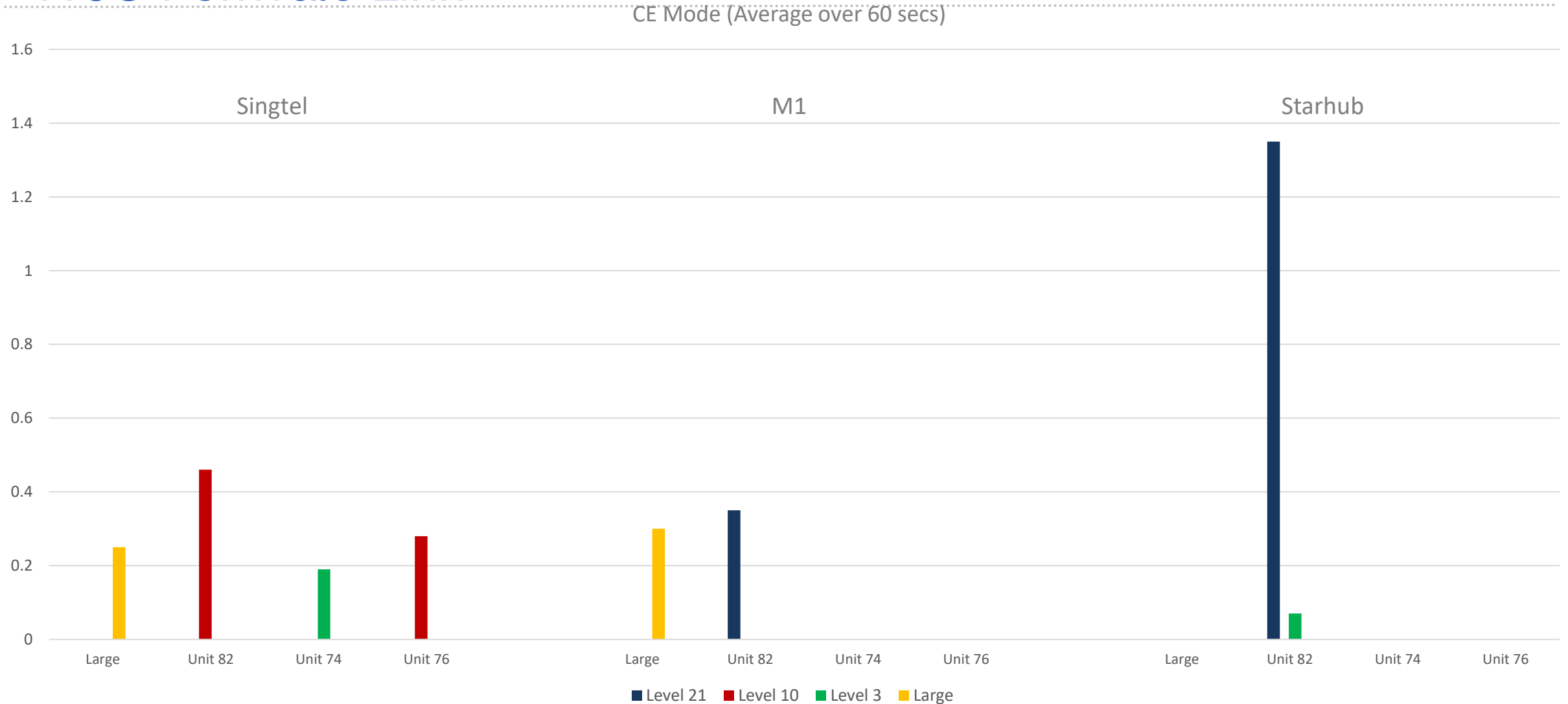


■ Unit 76 ■ Unit 74 ■ Unit 82
 - - - - Ref. Line. -109dBm



Residential Measurements – Key Learning Points

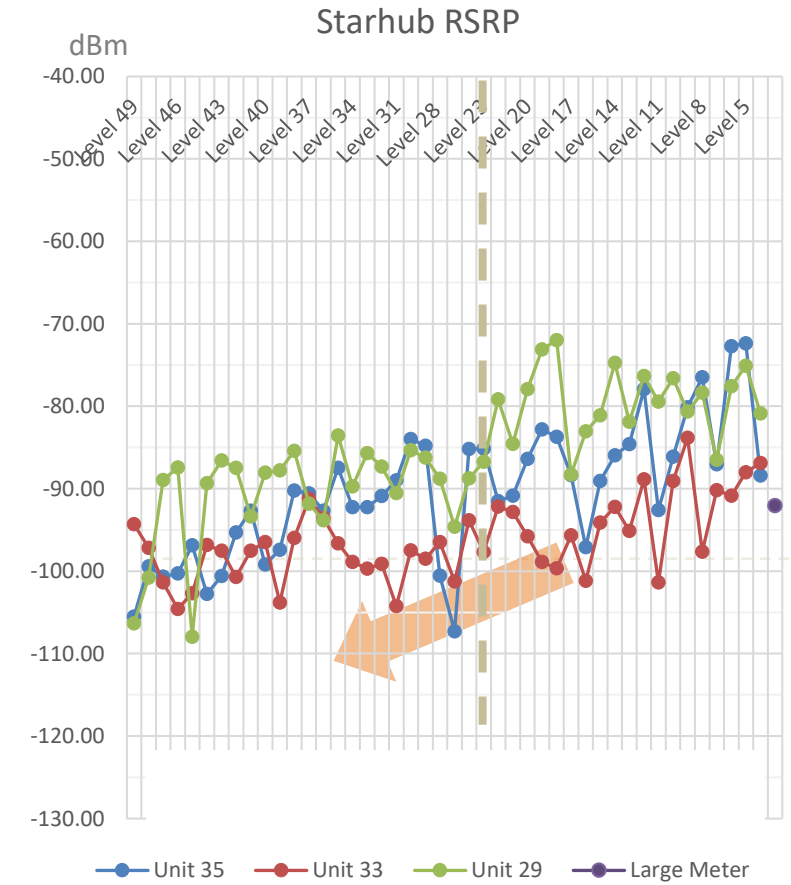
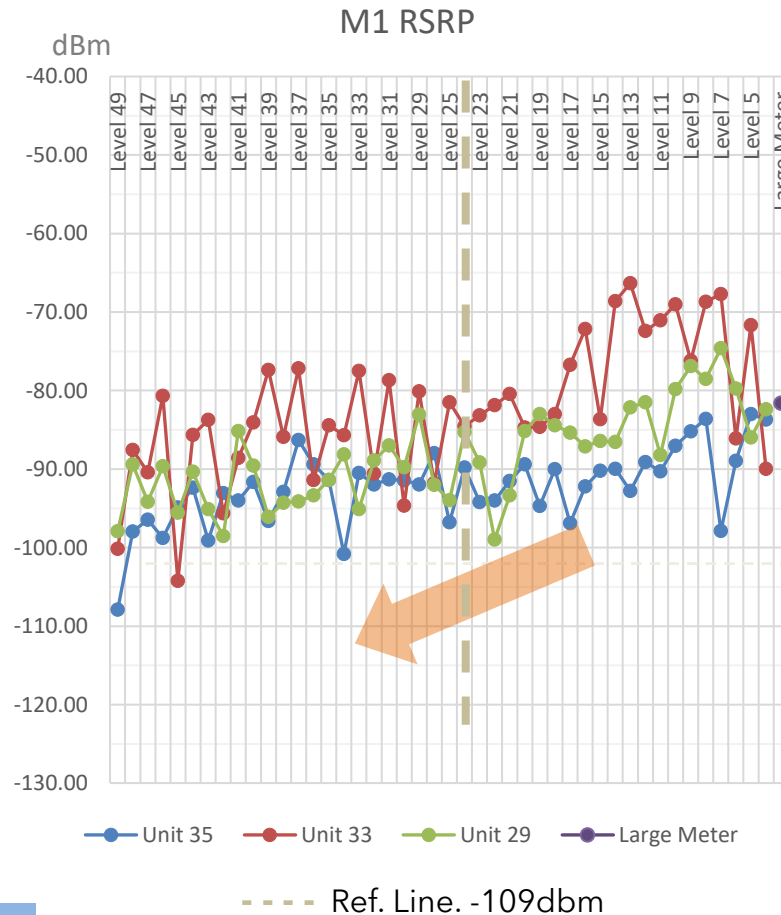
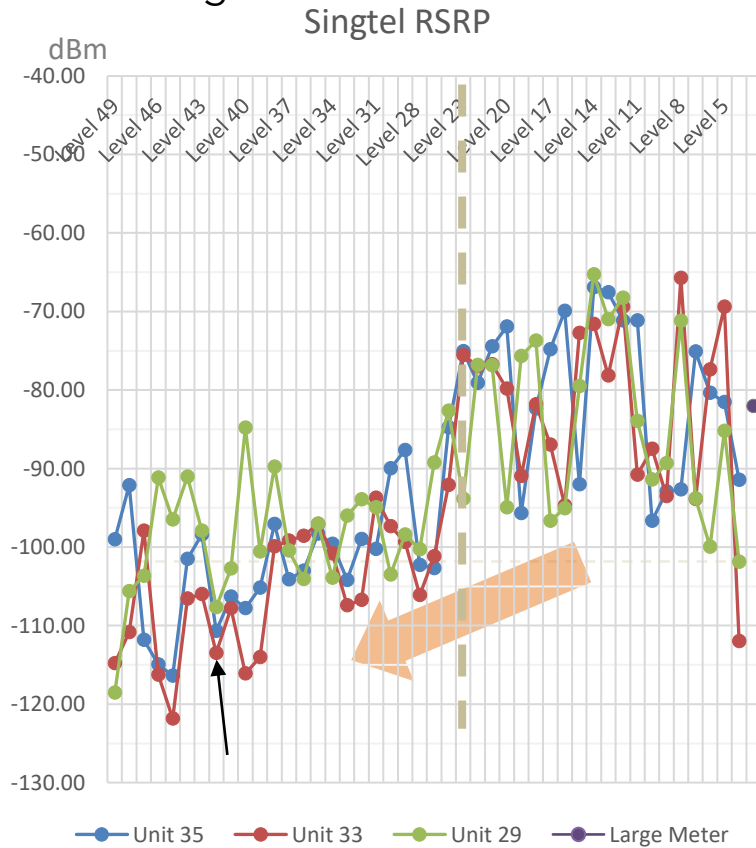
416C Fernvale Link



Residential Measurements – Key Learning Points

1C Pinnacle@Duxton

- Best coverage around levels 6 - 25.
- A general decline trend as level increases above 25



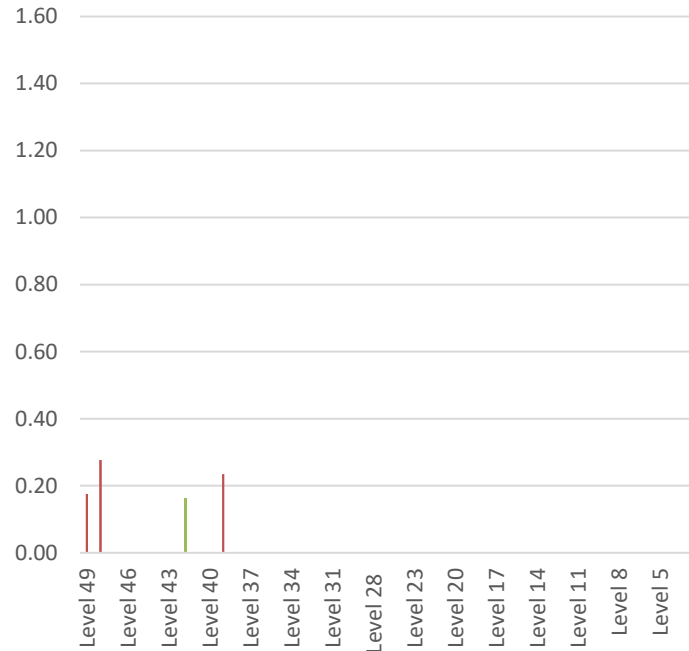
- Device is able to log onto base station at such RSRP values, despite being less than ideal based on IMDA's guidelines. This gives PUB an indication of the buffer RSRP values to cater in meter specs for minimal receiver sensitivity.

Residential Measurements – Key Learning Points

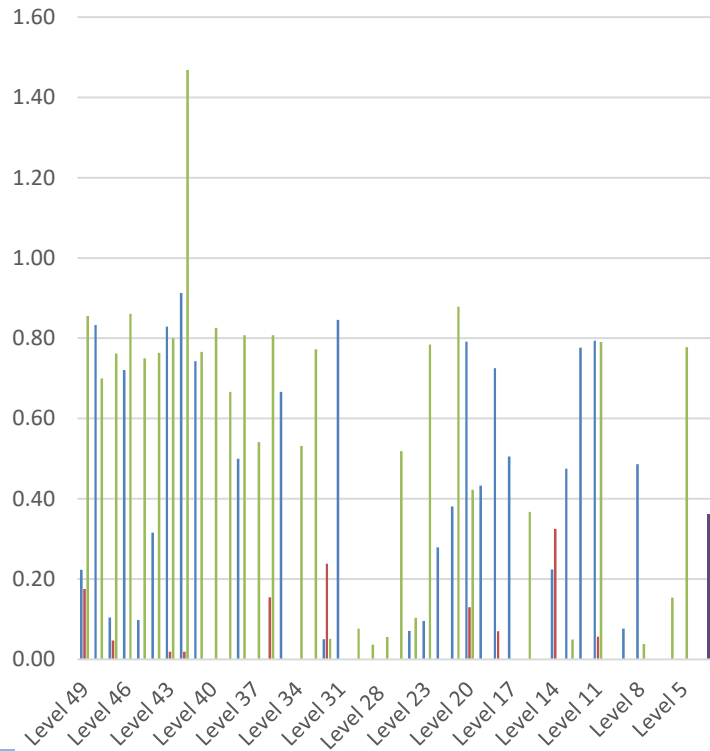
1C Pinnacle@Duxton

- CE mode values are average over 60 seconds

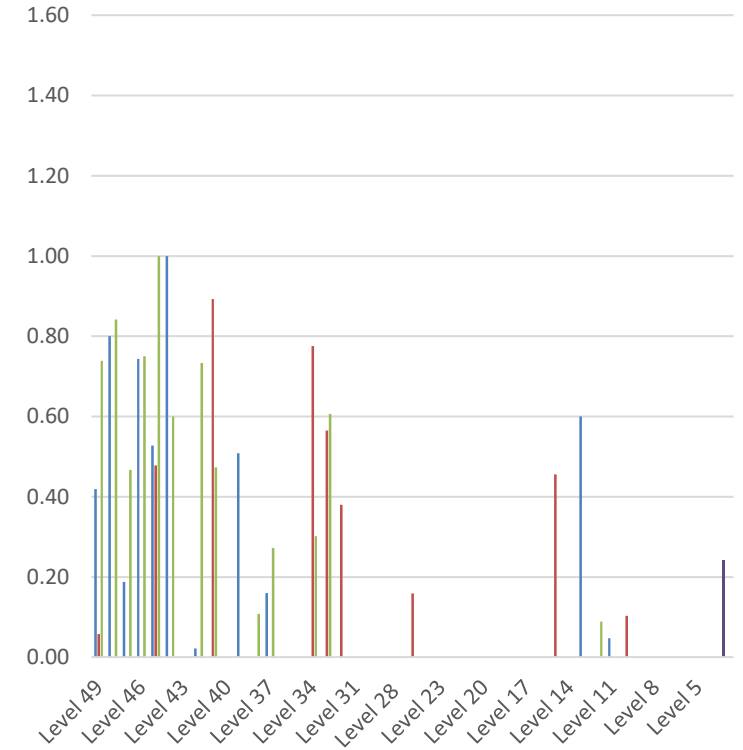
Singtel CE Mode



M1 CE Mode



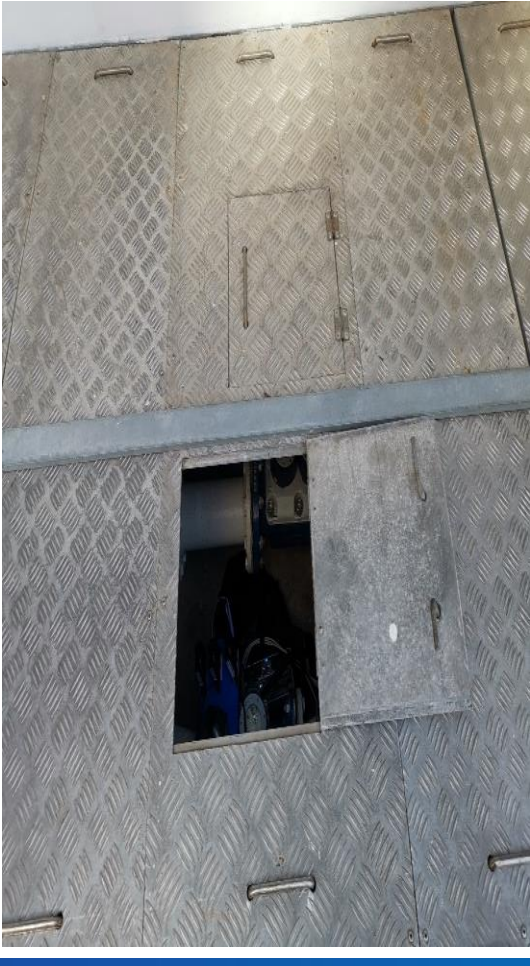
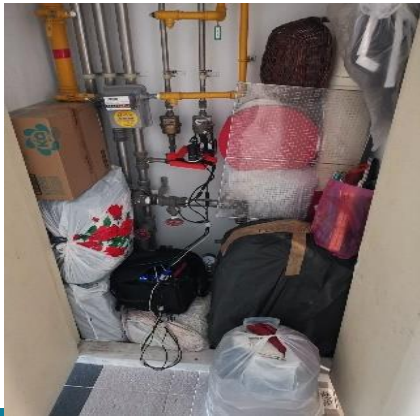
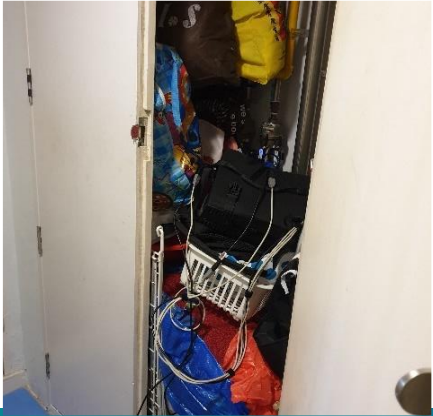
Starhub CE Mode



As CE mode values are not directly related to network parameters such as RSRP, there is opportunity for PUB to specify a maximum % of meters having CE 1 or CE 2 as part of MNOs' SLA.

- Unit 35
- Unit 33
- Unit 29
- Large Meter

Residential Measurements - Photos



CBD
Measurements

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CBD Measurements - Highlights



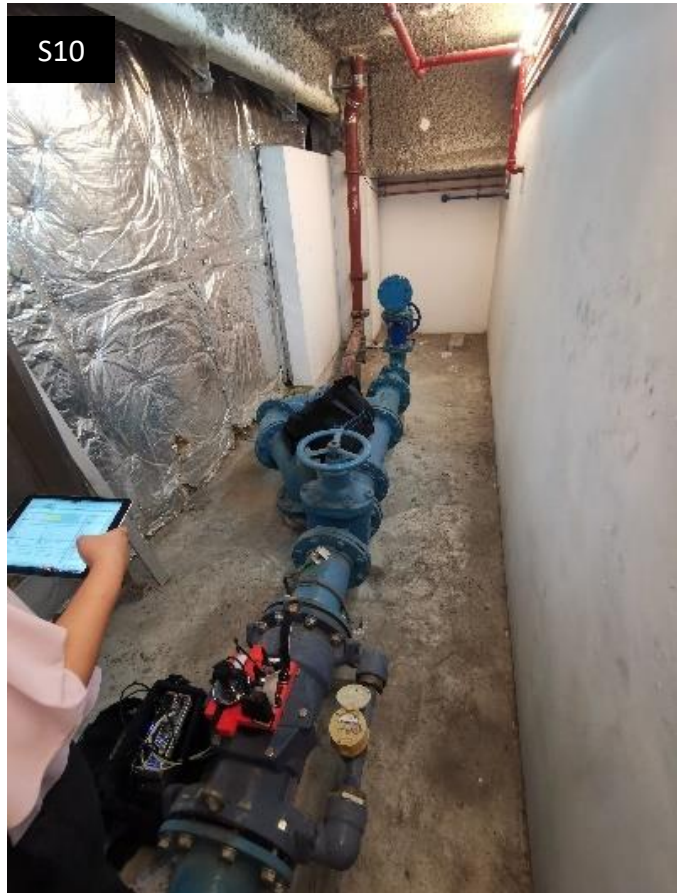
No major concerns for all 22 CBD locations, with regards to;

- RSRP performance
- CE Mode performance

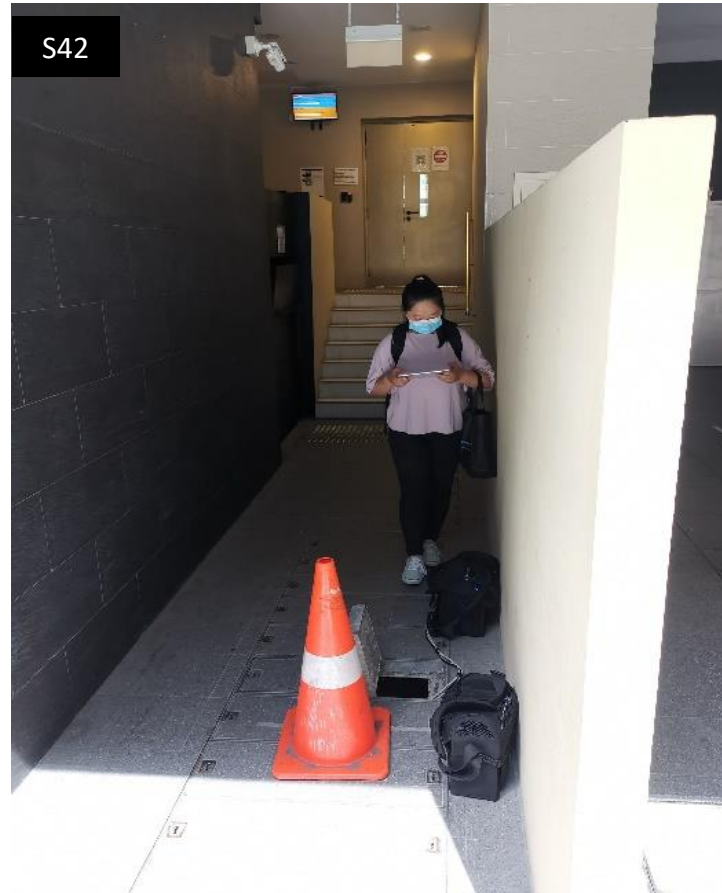
General observations

- Certain meter locations & surroundings has a direct impact on RSRP performance.
- Some MNOs' CE mode settings can be optimized further.

CBD Measurements - Key Learning Points



Meter in enclosed metering room

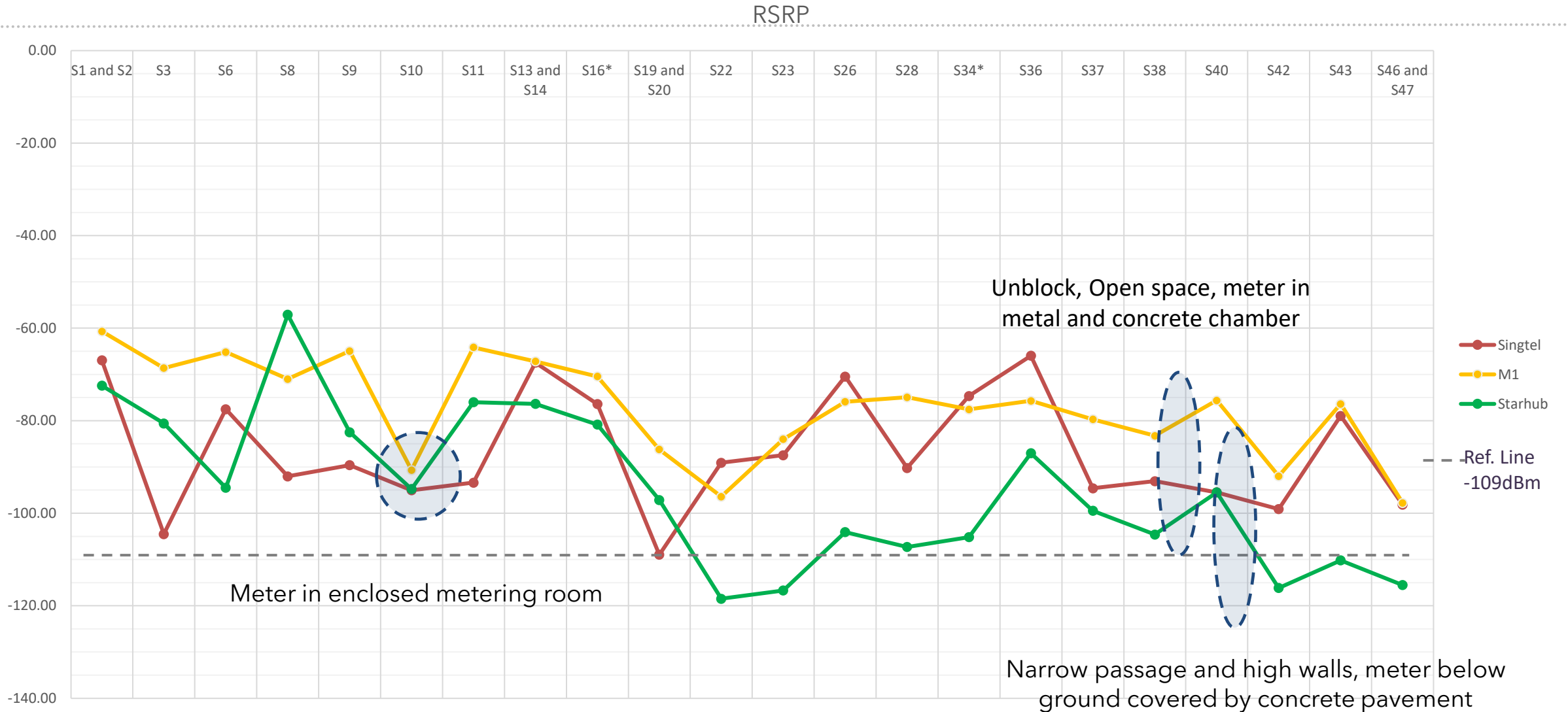


Narrow passage and high walls, meter below ground covered by concrete pavement



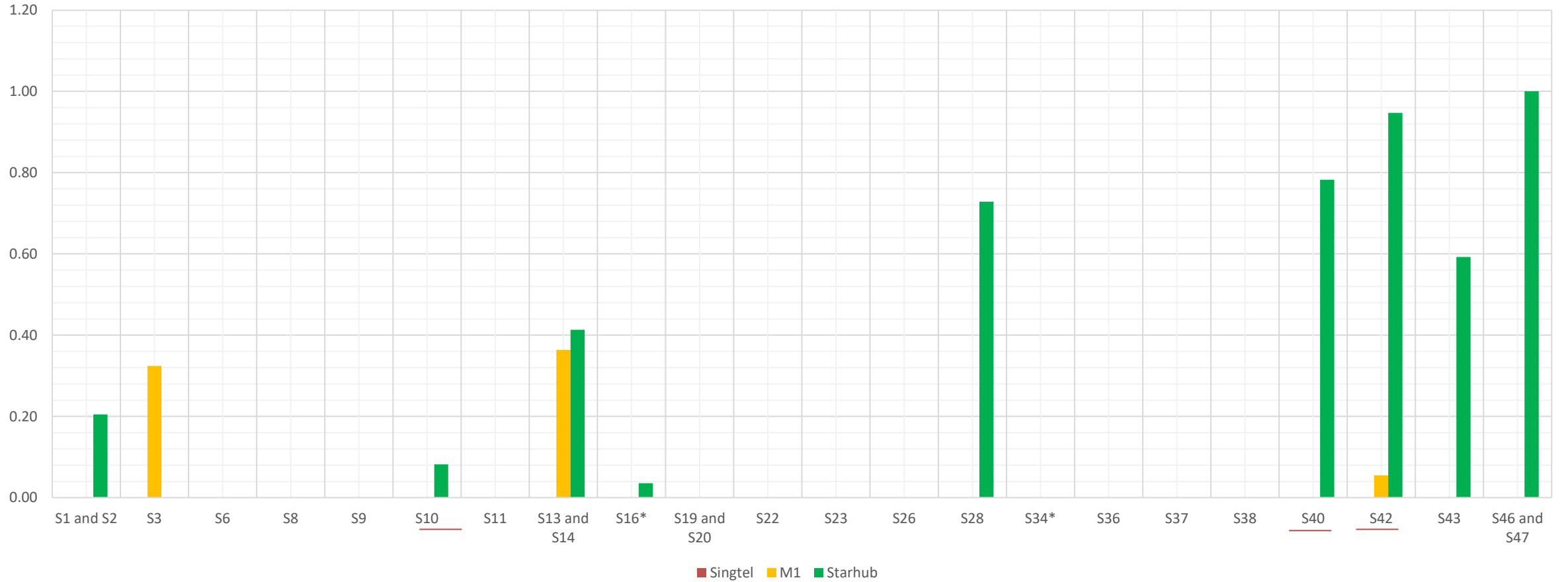
Unblock, Open space, meter in metal and concrete chamber

CBD Measurements – Key Learning Points



CBD Measurements – key learning points

Coverage Mode



Each MNO has different CE Mode settings

Drive Tests at
Industrial Areas

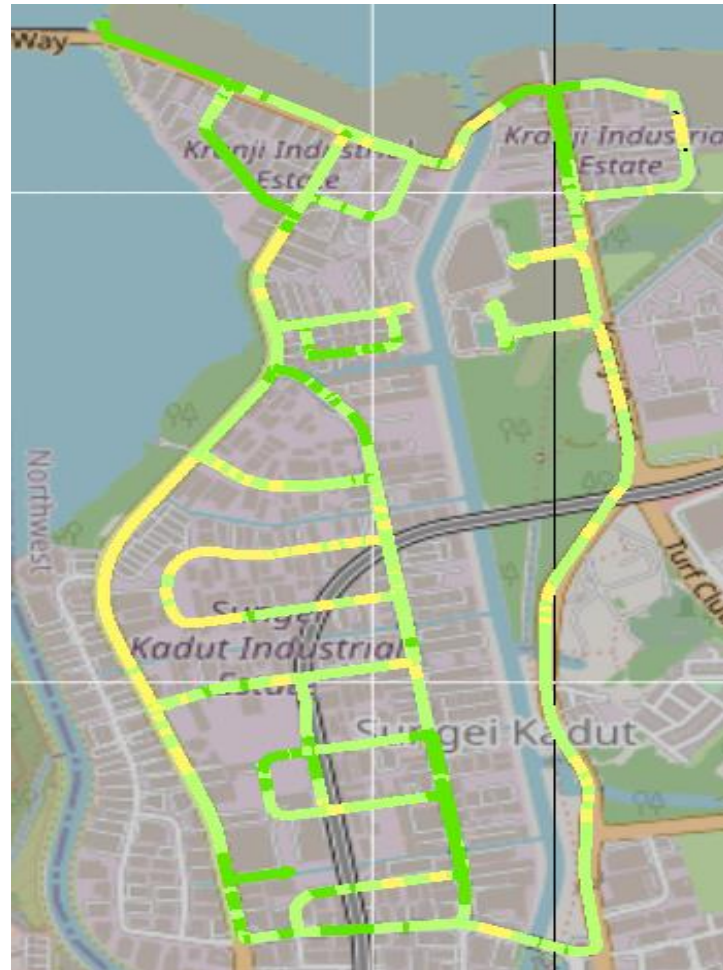
MAKE
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Drive Test Measurements – Key Learning Points

Sungei Kadut



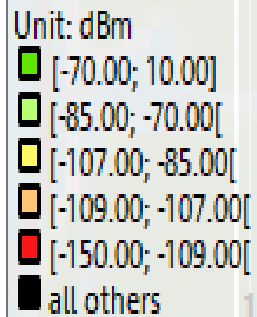
Singtel RSRP Coverage



M1 RSRP Coverage

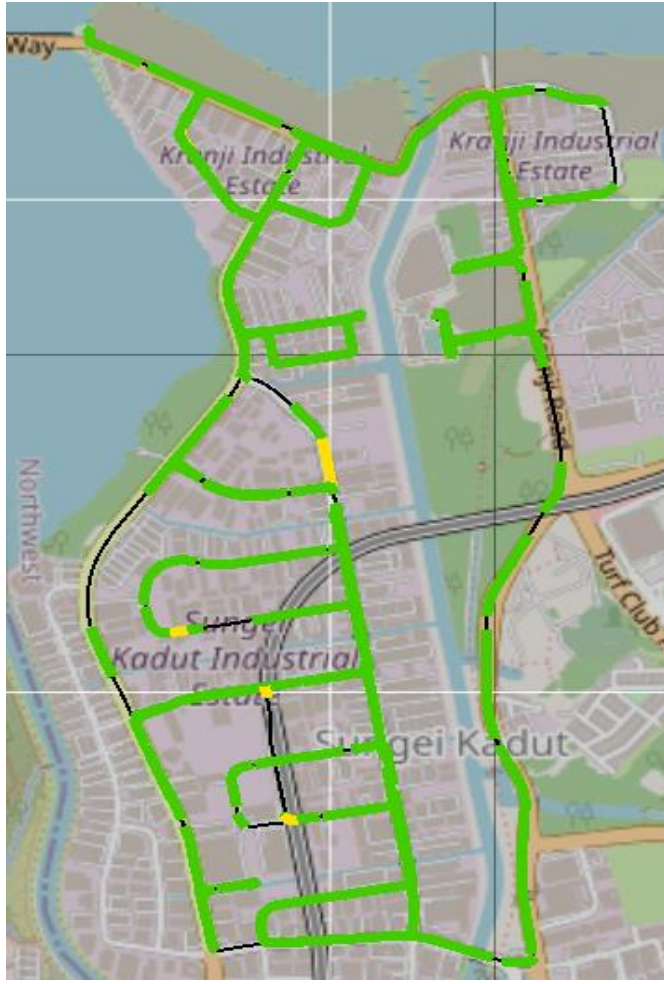


Starhub RSRP Coverage



Drive Test Measurements – Key Learning Points

Sungei Kadut



Singtel CE Mode



M1 CE Mode



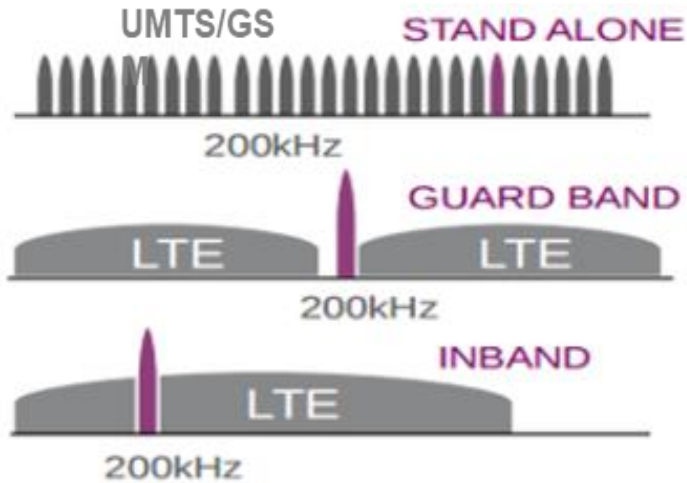
Starhub CE Mode



Summary Of Measurement Results

- NB-IoT services are generally well deployed for all locations measured, though some localized optimization may be required.
- From results, we observed mid levels between 6 to 25 stories appears to have most ideal coverage performance.
- Surroundings such as trees, adj. buildings, etc contributes to attenuation of coverage performance at lower levels.
- At very high levels (as seen from Pinnacle@Duxton), a dip in coverage performance. Likely due to down tilt of base stations antenna from nearby buildings. But deployment is possible based on the measurements.
- Materials of enclosure (Wooden / Metal door) don't seem to have significant impact to signal attenuation.
- Items stowed near water meter does not appear to affect measurement results much.
- Based on the study, NB-IoT signals can reach water meter positions in a variety of scenarios such as high rise housing, commercial buildings in Singapore which is representative of most meter positions
- RFP for NB-IoT water meters is underway. Meter vendors can bring overseas experience to Singapore.

Info About NB-IoT Networks In Singapore



All NB-IoT water meters need to work on frequency band 8 and 3, using INBAND mode

MNO	EARFCN	Frequency Band
Singtel	1209 3716	3 8
M1	3584	8
Starhub	3477	8

NOTE: All 3 MNOs currently deploy their NB-IoT signals using INBAND Mode.

Thank You

MAKE
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