Rohde & Schwarz Webinar

LBS (LOCATION BASED SERVICE)

90 YEARS
OF ENSURING A SAFER AND
CONNECTED WORLD

Heewook Shin (5KRPS3)

ROHDE&SCHWARZ
Make ideas real

LBS (LOCATION BASED SERVICE)

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LBS 란?

LBS 란?

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- Public Safety Services
- Maps and Navigation Services
- Tracking Services
- Information Services
- Applications

3GPP TS37.571-X SPECIFICATION

Test Spec. (TS)	Title; User Equipment (UE) conformance specification for UE positioning
37.571-1	Part 1: Conformance test specification
37.571-2	Part 2: Protocol conformance
37.571-3	Part 3: Implementation Conformance Statement (ICS)
37.571-4	Part 4: Test suites
37.571-5	Part 5: Test scenarios and assistance data

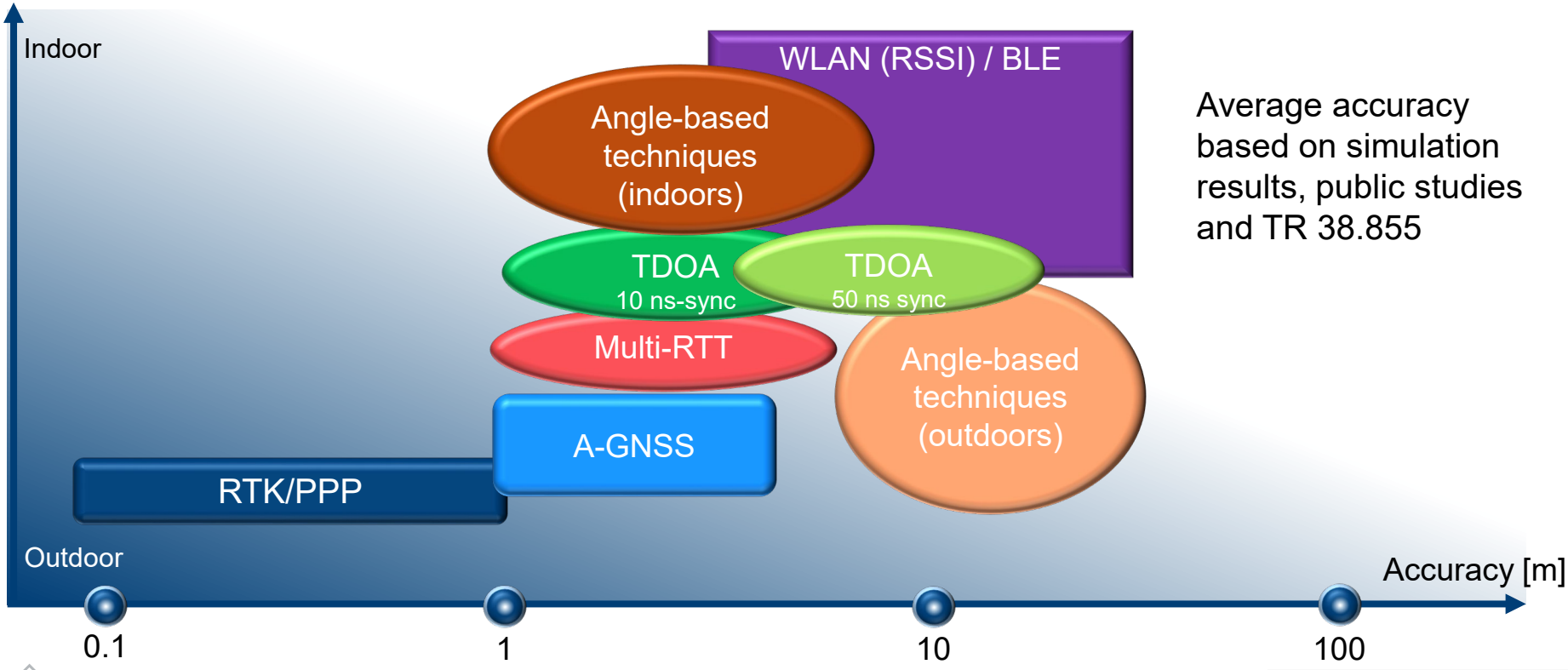
3GPP TS37.571-1 CHAPTER PREVIEW

RAT	No.	Descriptions	LBS Feature
E-UTRA	7	E-UTRA A-GNSS minimum performance requirements	A-GNSS
	8	E-UTRA ECID measurement requirements	ECID
	9	E-UTRA OTDOA measurement requirements	OTDOA
	10	E-UTRA OTDOA measurement requirements for CA	OTDOA
	11	E-UTRA and NR MBS measurement requirements	Indoor positioning (MBS)
	12	E-UTRA WLAN and BLE measurement requirements	Indoor positioning (WLAN, BLE)
NR (5G)	13	NR A-GNSS minimum performance requirements	A-GNSS
	14	NR RSTD measurement requirements	DL-TDOA
	15	UE Rx-Tx time difference measurement requirements	Multi-RTT
	16	NR PRS-RSRP measurement requirements	PRS-RSRP, DL-TDOA, DL-AoD
	17	NR PRS-RSRPP measurement requirements	PRS-RSRPP, DL-AoD

C-PLANE? U-PLANE?

- **C-Plane (Control Plane)**
  - Positioning information을 signaling channel 을 통해 전달하며, A-GNSS 의 Messaging protocol은 각 RAT 에 따라 정해집니다.
    - GSM (RRLP), WCDMA (RRC), LTE/5G (LPP/LPPe), CDMA (801.1) 등
- **U-Plane (Secure User Plane Location – SUPL)**
  - Positioning information을 TCP/IP 연결을 통해 전달하여, Bearer 에 독립적으로 동작할 수 있습니다.
  - SUPL은 RRLP, RRC, LPP, 801.1 을 모두 지원하고, 서로 다른 조합도 지원하게 됩니다.
    - 예; RRLP over LTE data

ACCURACY OF THE DIFFERENT POSITIONING TECHNOLOGIES



Average accuracy based on simulation results, public studies and TR 38.855

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SATELLITE BASED TECHNOLOGIES

TS37.571-1 CHAPTER PREVIEW

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GNSS (GLOBAL NAVIGATION SATELLITE SYSTEM)

- GNSS 는 잘 알려진 위성 측위 시스템인 GPS (Global Positioning System)를 포함하여, GLONAS, GALLILEO, BEIDOU 등을 모두 포함하는 위성 측위 시스템의 통칭
- 위성을 이용한 위치 측위는 시간 동기를 포함한 4개의 위성을 활용

A-GNSS (ASSISTED GNSS)

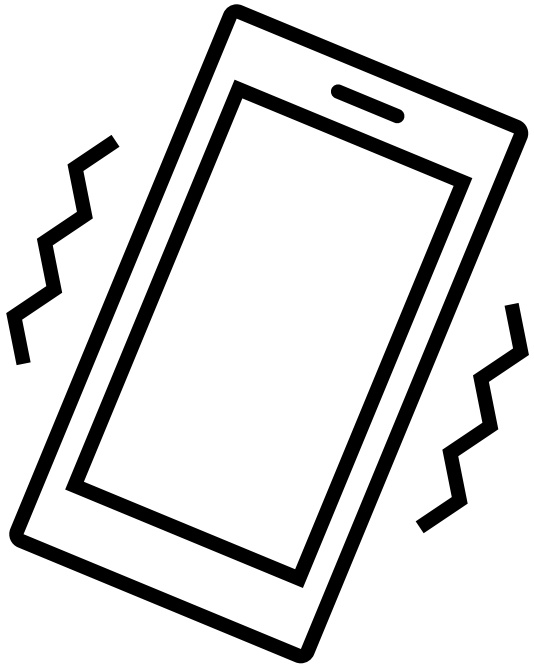
- The network assists the device GNSS receiver to improve the performance in several aspects:
  - Reduce GNSS start-up and acquisition times.
  - Increase GNSS sensitivity, reduce power consumption.
  - Gives the GNSS receiver a jump start!

Assistance Data
Reference Time
Reference Location
Ionospheric Models
Earth Orientation Parameters
GNSS-GNSS Time Offsets
Differential GNSS Corrections
Ephemeris and Clock Models
Real-Time Integrity
Data Bit Assistance
Acquisition Assistance
Almanac
UTC Models

- 운용 모드
  - Mobile Assisted
  - Mobile Based

주요 GNSS 수신기 측정 항목

- TTFF (Time to first fix)
- Reacquisition time
- Sensitivity
- Location Accuracy
- 기타 (Interference/Multipath/Atmospheric Modeling)



MINIMUM PERFORMANCE REQUIREMENT

- 3GPP TS37.571-1 : Chapter 7 (LTE) / 13 (NR)
- 주요 시험 항목

Chapter 7	Test case	Chapter 13	Test case
7.1	Sensitivity	13.2	Sensitivity
7.2	Nominal Accuracy	13.3	Nominal Accuracy
7.3	Dynamic Range	13.4	Dynamic Range
7.4	Multi-path scenario	13.5	Multi-path scenario
7.5 / 7.5A	Moving Scenario	13.6 / 13.7	Moving Scenario

13.2.1 SENSITIVITY COARSE TIME ASSISTANCE (NR)

- 목적; 휴대폰은 처음 켜거나 Cold-Start (GPS reset)에서 단말 (DUT)이 coarse time assistance만 제공할 때, 처음 위치를 추정하는 성능을 확인
- 주요 Test parameter (e.q. Sub-test 1. A-GPS)

Parameters	Unit	Value
Number of generated satellites	-	8
HDOP Range	-	1.1 to 1.6
Propagation conditions	-	AWGN
GPS Coarse time assistance error range	seconds	±2
GPS L1 C/A Signal for one satellite	dBm	-142
GPS L1 C/A Signal for remaining satellites	dBm	-147

13.2.1 SENSITIVITY COARSE TIME ASSISTANCE (NR)

- 목적; 휴대폰은 처음 켜거나 Cold-Start (GPS reset)에서 단말 (DUT)이 coarse time assistance만 제공할 때, 처음 위치를 추정하는 성능을 확인
- GNSS reference time (TS37.571-5 6.2.7.4.1 참조)

referenceTimeUnc		'117' (2.274 seconds) Absent for Sensitivity Fine Time Assistance test case. Present otherwise
gnss-ReferenceTimeForCells		Present for Sensitivity Fine Time Assistance test case. Absent otherwise

13.2.1 SENSITIVITY COARSE TIME ASSISTANCE (NR) – CON'T

► Test result (RS-CONTEST)

GNSS result table

It.	Scn.#	Scn. start offs.	ToD offs. (s)	Reported Time of Fix	Sim. Pos.	Rep. Pos.	Pos. Err. (m)	Max.2D Err. (m)	Rpt. Delay (s)	Result	Observation
1	1	00:00:00	00:00:00	2020-09-17 23:40:23.000	Lat: 35° 45' 0.163" N, Lon: 139° 41' 14.065" E, Alt: 300.06 [m]	Lat: 35° 45' 0.135" N, Lon: 139° 41' 14.047" E, Alt: 303.00	0.986	101.3 m	16.92	Inside	

Statistics for GNSS Test Scenario #1 (3GPP-2020 A-GPS Performance Test Scenario 1 for Subclause 7, Subtest 1: Tokyo, Japan)

Total number of measurements	39
Number of measurements 'outside'	0
Number of measurements 'inside'	39
Number of errors (reports without measurements)	0
Outside rate [%]	0.0
Error rate [%]	0.0

Description	Min	Median	Average	Max
2D position error [m]	0.39	2.29	2.27	5.53
Time to first fix [s]	16.92	16.92	16.92	16.92

> 기본 77회 반복 측정하여, TTFF 및 2D Position error 로 판정

NON-SATELLITE BASED TECHNOLOGIES

TS37.571-1 CHAPTER PREVIEW

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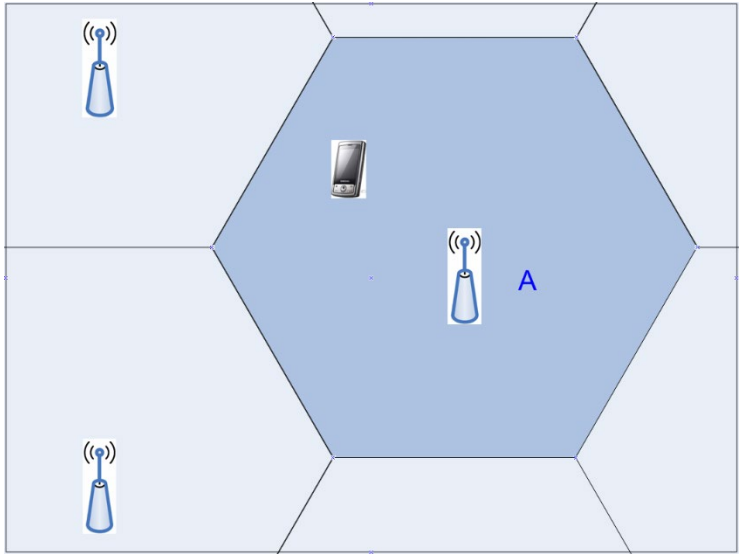
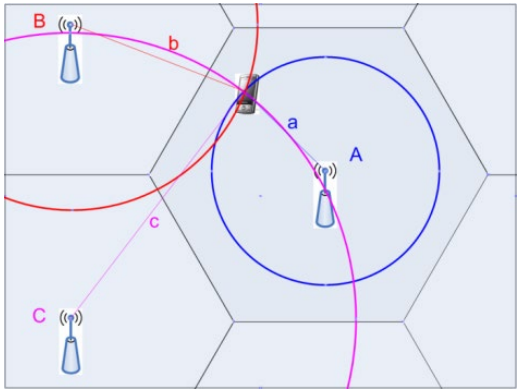
ECID (ENHANCED CELL ID)

- CID (Cell ID), COO (Cell of Origin)
- 휴대폰이 등록된 기지국은 고정된 위치로서 셀 반경하에 등록된 휴대폰이 있음을 추정

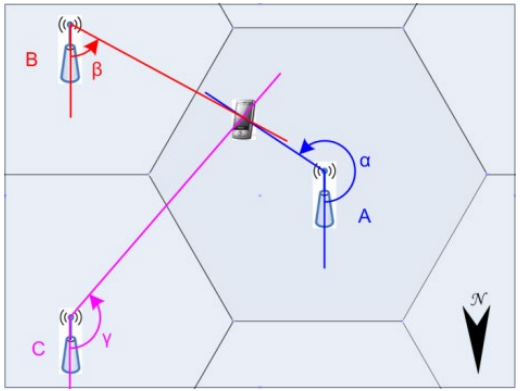


ECID (ENHANCED CELL ID) – CON'T

- ECID 는 RSRP / TOA / TADV (RTT) / AoA 등 여러가지 기지국에서 측정 가능한 파라미터를 이용하여, 2D Position 추정
- RSRP (Reference Signal Received Power), TOA (Time of Arrival) 는 단말에서 기지국까지의 거리 추정에 사용되며, RTT, AoA, AoD 방식 등에 활용



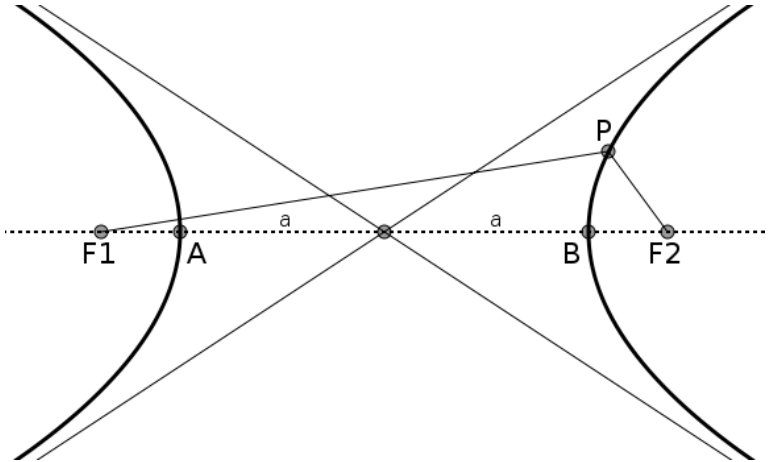
RTT (Round Trip Time, Timing Advance)



AoA (Angle of Arrival)

TDOA

- LTE ; OTDOA (Observed Time Difference Of Arrival), UTDOA (Uplink Time Difference of Arrival)
- NR ; TDOA (Time Difference Of Arrival)



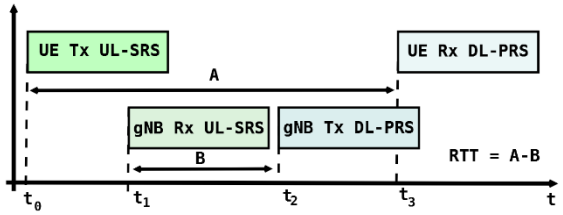
NON-SATELLITE BASED TEST CASES

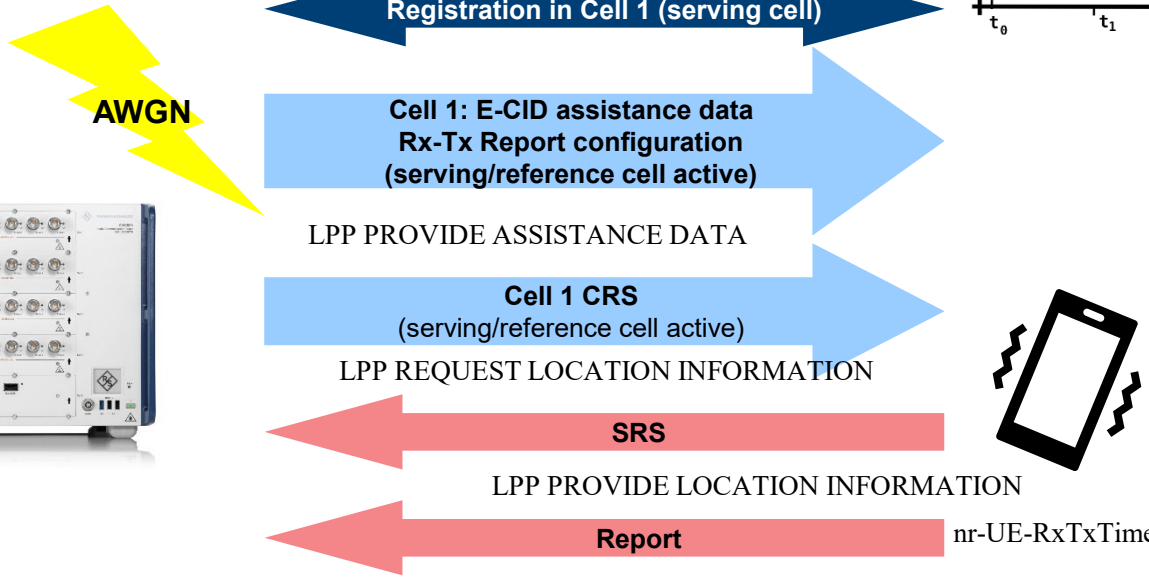
- 3GPP TS37.571-1 : Chapter 8, 9, 10 (LTE) / 14, 15, 16, 17 (NR)
- 주요 시험 항목

LTE	Test case	NR	Test case
8.1	UE Rx Tx Time difference	14.x	NR RSTD measurement
9.x	RSTD measurement	15.x	Rx-Tx Time difference
10.x	RSTD measurement for CA	16.x	PRS-RSRP measurement
		17.x	PRS-RSRPP measurement

15.2 UE RX-TX TIME DIFFERENCE MEASUREMENT

- 목적: Multi-RTT 를 이용하여 위치 측위 성능을 확인
- Test Procedure (15.2.1)

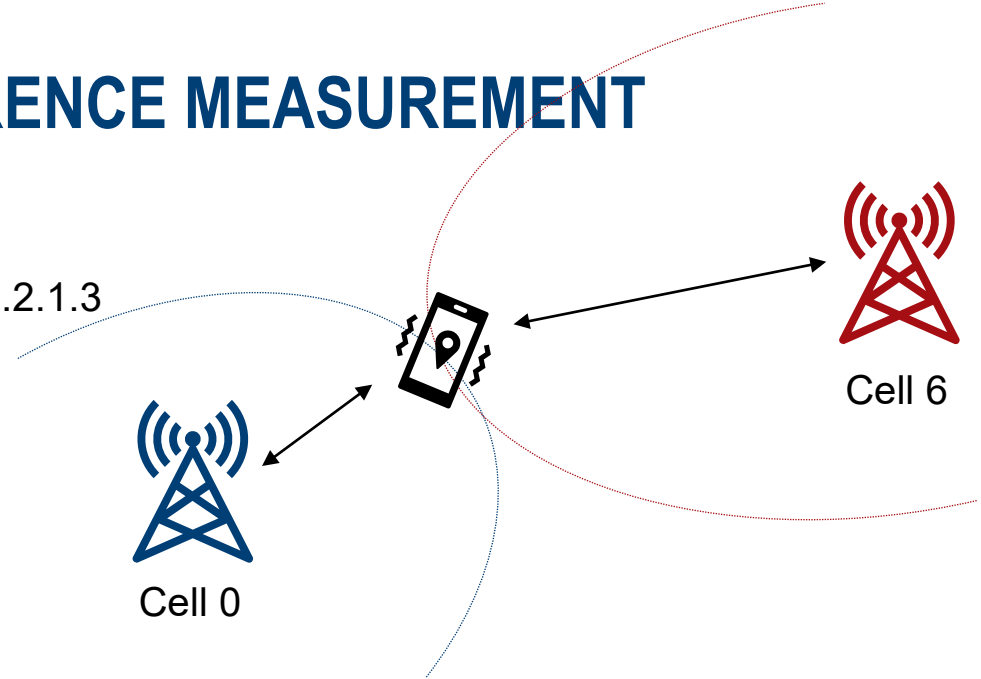




Measure Rx-Tx = received CRS – sent SRS

15.2 UE RX-TX TIME DIFFERENCE MEASUREMENT

- Test requirement (TS37.571-1 15.2.1.5)
  - Minimum conformance requirement; 15.2.1.3
  - Max. Delay < 11.3s
  - 77회 반복 측정 90% 이상 inside



- Test result (RS-CONTEST)

Report Mcrtt table

It.	Cell ID / Reported RxTx[Ts]	Rpt. Delay(sec)/ Max. Delay(sec) (s)	Result	Observation
77	Cell 0 / 232Cell 6 / 343	11.2/ 11.3	Inside	

Iteration Number : 77, Status : Inside

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OTHER LBS TECHNOLOGIES

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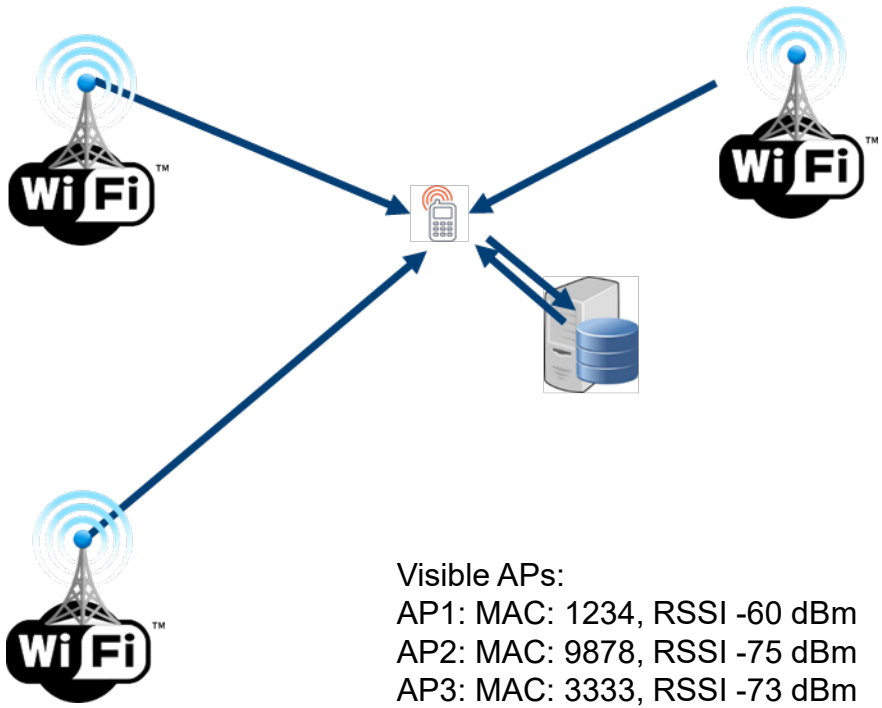
INDOOR POSITIONING

- A-GNSS 와 CID, TDOA 등으로는 음영지역, 실내 및 지하 등의 위치 서비스를 제공하기 어려움

- RAT independent (WLAN, Terrestrial Beacon system, Barometric)
  - WLAN/Bluetooth based positioning
  - Terrestrial Beacon Systems (Metropolitan Beacon Systems)
  - Barometric Pressure Sensor positioning

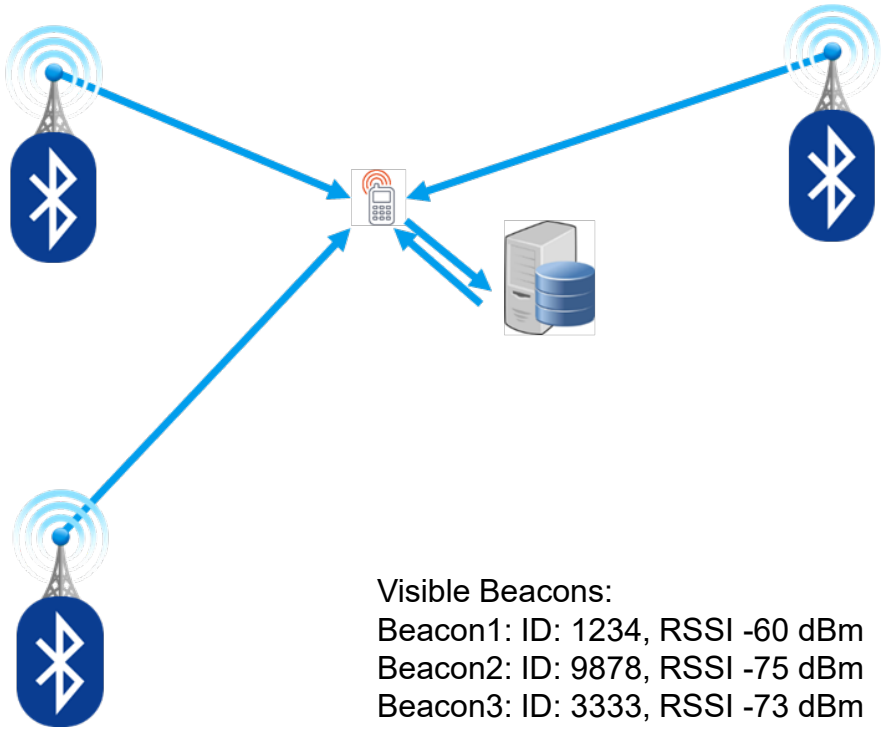
WLAN RSSI BASED MEASUREMENT



Visible APs:
AP1: MAC: 1234, RSSI -60 dBm
AP2: MAC: 9878, RSSI -75 dBm
AP3: MAC: 3333, RSSI -73 dBm

- UE 는 WLAN AP의 MAC address 를 확인
- UE 는 AP 별 RSSI (Received Signal Strength Indicator)를 Report
- 네트워크는 해당 정보를 기준으로 위치 파악

BLUETOOTH LE BEACONS

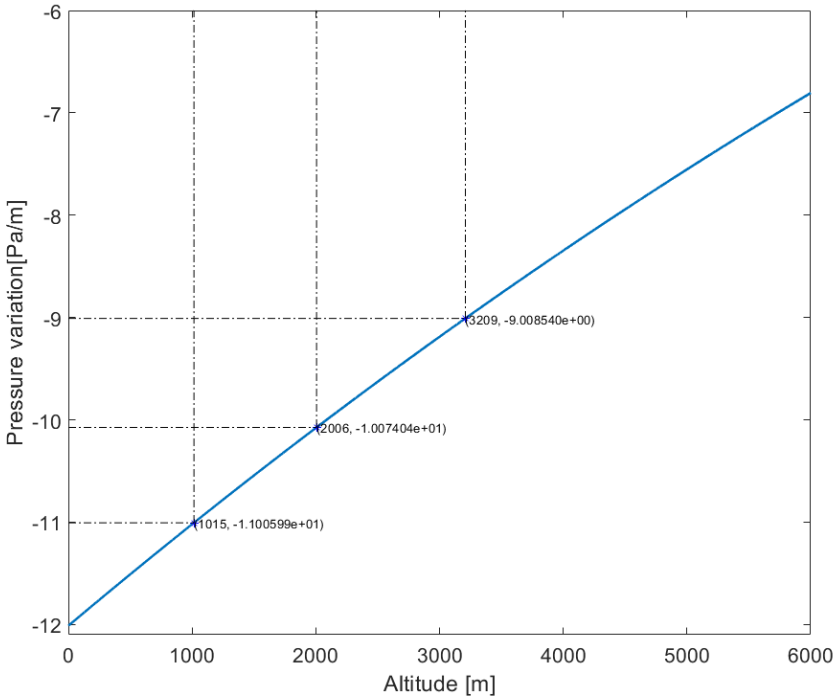


Visible Beacons:
Beacon1: ID: 1234, RSSI -60 dBm
Beacon2: ID: 9878, RSSI -75 dBm
Beacon3: ID: 3333, RSSI -73 dBm

- UE는 Bluetooth beacon ID 를 Report
- UE 는 각 Beacon 별 RSSI (Received Signal Strength Indicator)를 Report
- 네트워크는 해당 정보를 기준으로 위치 파악
- WLAN의 RSSI 와 동일 컨셉

Z-AXIS POSITIONING MEASUREMENT

- FCC regulations accuracy regulate floor level accuracy
- Typical height for a floor level can be approximated to 3m
- Pressure/m and Floor level varies with altitude
  - At sea level: 36 Pa (3 m x 12 Pa/m)
  - at 1000 meters: 33 Pa (3 m x 11 Pa/m)
  - At 2000 meters: 30.2 Pa (m 3 x 10.1 Pa/m)
  - At 3000 meters: 27.6 Pa (3 m x 9.2 Pa/m)



HYBRID METHODS

hybrid

noun [C]

US /ˈhaɪ·brɪd/

Add to word list

BIOLOGY

a plant or animal that has been produced from two different types of plant or animal

A hybrid is also anything that is a mixture of two or more things:

- *The architecture is a hybrid of classical and modern styles.*

A hybrid vehicle is one that is able to operate using either of two fuels:

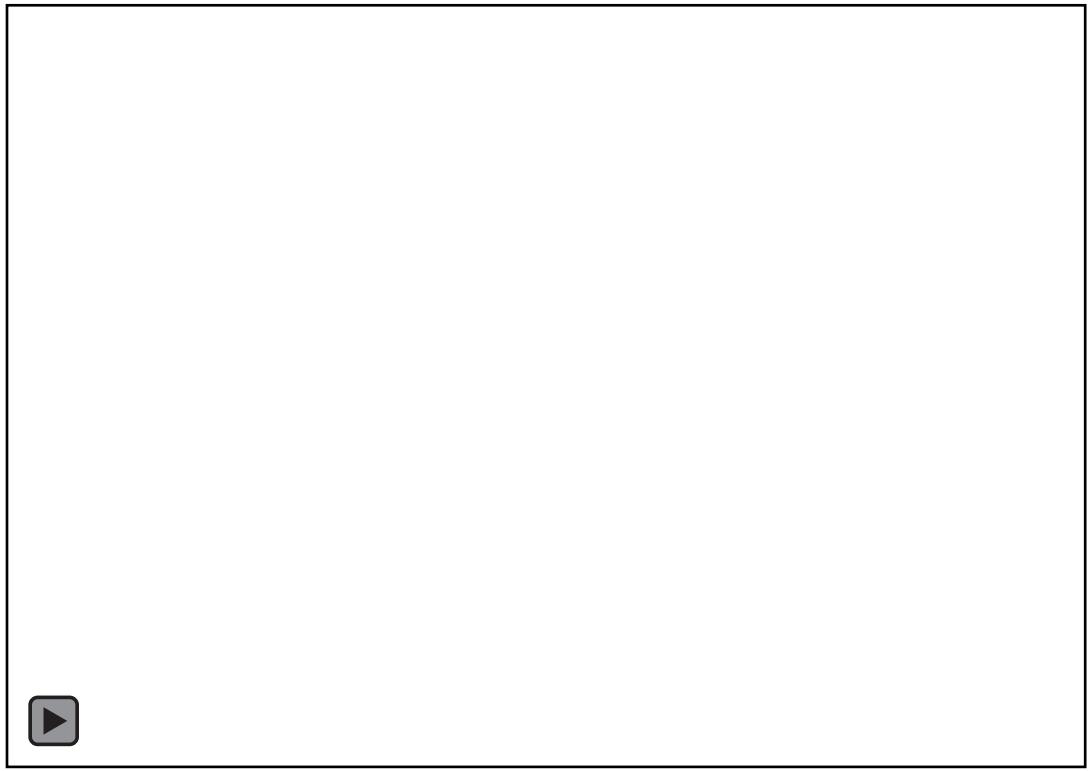
- *US automakers are wrestling with how much to invest in hybrid gas-electric cars.*

*reference; https://dictionary.cambridge.org/

HYBRID METHODS

- A-GPS + A-GAL
- A-GPS + A-GLONASS

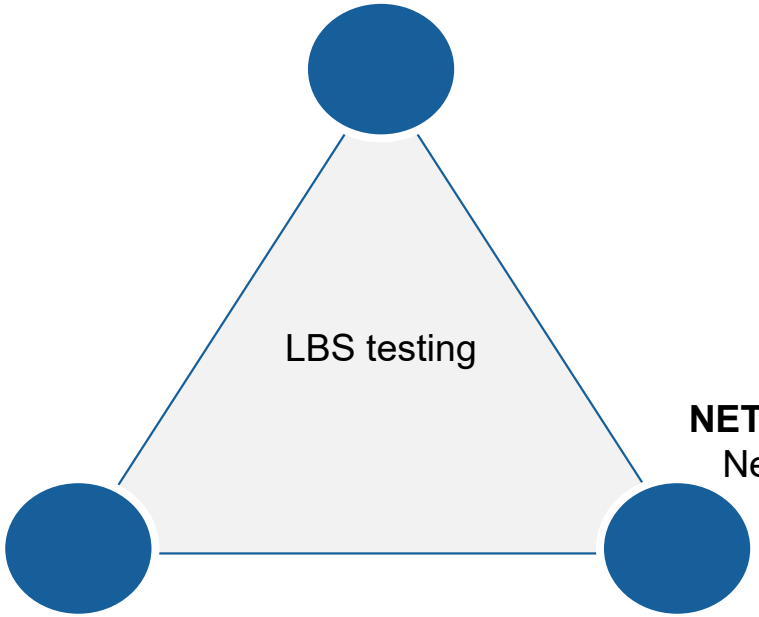
- A-GNSS + TDoA
- A-GNSS + WLAN



R&S TEST SOLUTION

NEED FOR TESTING

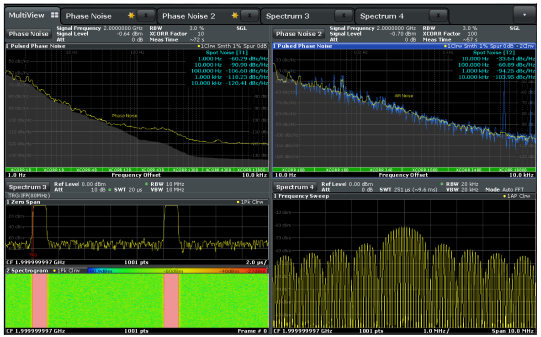
R&D TESTING
Early chipset development
Prototype development

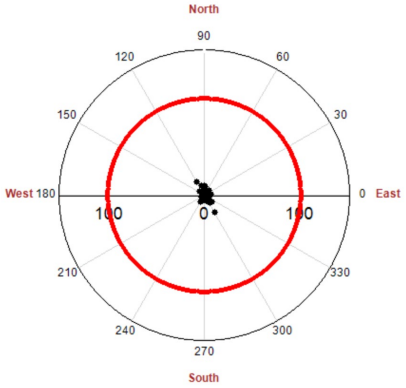


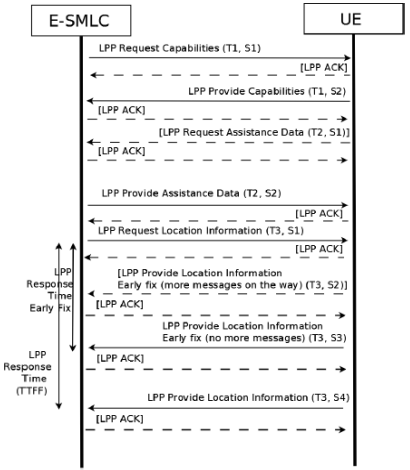
REGULATORY & CERTIFICATION
GCF
PTCRB
CTIA
FCC

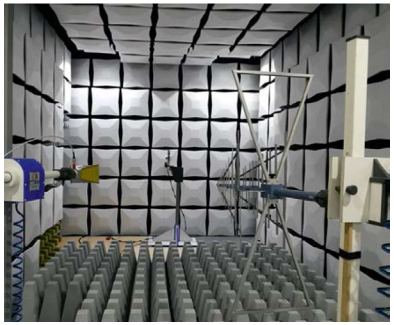
NETWORK OPERATOR TESTING
Network-specific configurations
Interoperability testing

AREAS FOR TESTING









RF TESTING

Receiver performance

Tracking performance

PERFORMANCE TESTING

Position accuracy

TTFF

Z-axis accuracy

PROTOCOL TESTING

LPP, LPPe, RRLP

E911 call flows

SUPL, LBS OTT Applications (AML, WEA..)

OVER THE AIR TESTING

Antenna performance, TIS

TEST SOLUTIONS FROM ROHDE & SCHWARZ

R&S®CMX500
5G radio communication tester
5G FR1 & FR2

R&S®CMW500
wideband radio communication tester
2G, 3G, 4G

R&S®SMBV100B
vector signal generator
GPS, GLONASS,
BDS, Galileo
Wi-Fi, Bluetooth®

TEST CHAMBERS

WPTC
wireless performance test chambers
OTA and antenna testing

R&S®ATS1800C
CATR based 5G NR mmWave test chamber
Best-in-class CATR
FR2 R&D, conformance, compliance

R&S®CMQ500
shielding cube
Best-in-class mmWave shielding box

R&S Barometric test system
Z-axis accuracy testing
UPB accuracy testing

LBS NR SYSTEM FOR FR1/FR2

- R15 no additional SW required
- Rel.16 stack extension
- LBS Server R16 extension
- Multi-Cell Rel.16 Support
- Supporting all 5G NR TCs

OTA 5G NR GNSS FR1 ON TOP OF 3RD PARTY OTA SOLUTION

OTA 5G NR FR1 GNSS upgrade on ETS OTA Solution

- Reuse all 3rd Party HW+SW
- Adding **CMX as OBT**
- Adding **SMBV100B**
- Adding **LBS Framework**
- Adding **LBS API** (Remote Control Software)

TS-LBS-NR

\+

LBS SYSTEMS API

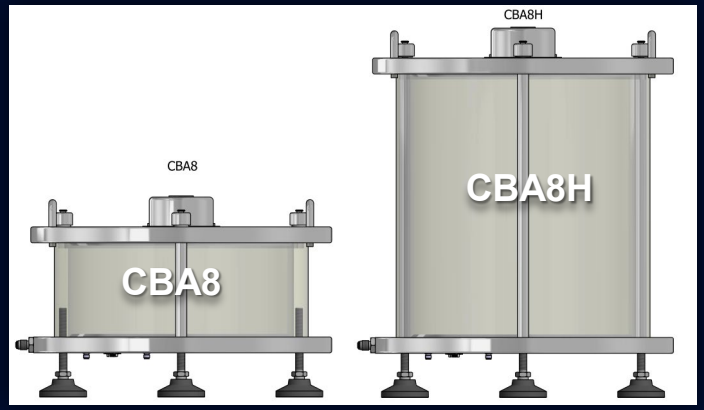
\+

3rd Party Chamber Solutions

LBS OTA API enables easy of integration with 3rd party suppliers

BAROMETRIC PERFORMANCE TESTS ON LBS

- Barometric performance testing for z-axis
- FCC mandates 3m accuracy
- ELS based Z-axis reporting
- can be placed in temperature chamber
- Chamber in 2 sizes



CBA8
Barometric Chamber

Air Data Test Set

NEW 5G NR F2L SOLUTION

- Support **all** US **NetOps**
- Supports **multi-frequency** (L1/E1, L2, L5/E5) GNSS replay
- Replay's **open source GNSS IQ data** formats
- **Synchronized with CMX500** for assisted GNSS scenario
- **One replay box** including recordings on SSD and RF GNSS output

Thank you!

Q&A