Location Based Services in LTE

An Overview to Technology and Test Solution

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Where am I?

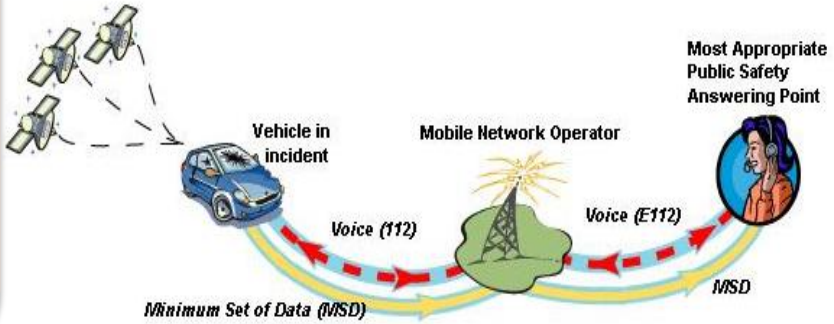
Contents

- Introduction to Location Based Services
- Satellite based positioning
- Network based positioning
- LBS – What to test?

Positioning Technologies – Why??

Public safety services

- e.g. Wireless E911 location accuracy requirements, FCC
- Carriers must provide location, confidence and uncertainty data for all emergency calls
- terminal based positioning
  - 67% of all calls must be within 50m
  - 95% of all calls must be within 150m
- network based positioning
  - 67% of all calls must be within 100m
  - 95% of all calls must be within 300m
- e.g. Europe eCall support
- e.g India 112 Call Support



Maps and Navigation Services

- e.g. routing to an address, to next ATM

Tracking Services

- e.g. finding friends / family, vehicle tracking

Information Services

- e.g. City Guides, Mobile yellow pages
- Future trend: augmented reality

Applications

- e.g. social networking, localized advertising

Testing of these Positioning Technologies – Why??

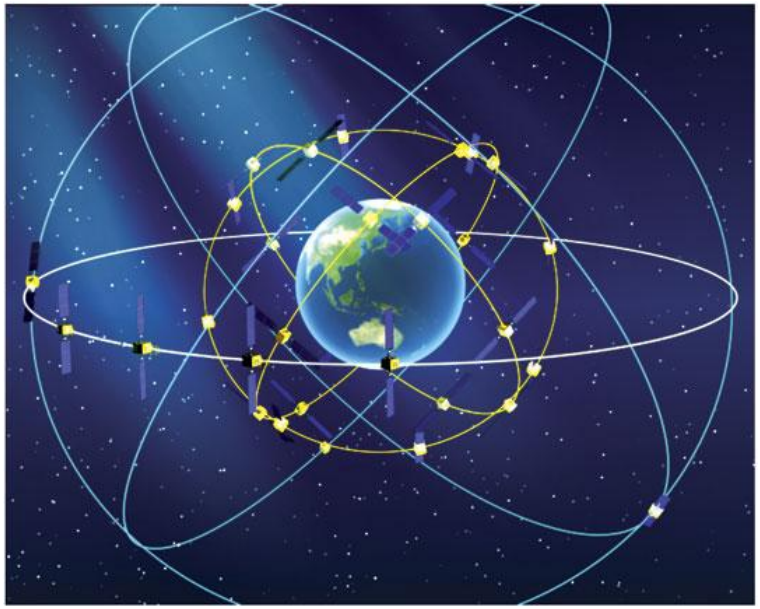
A test solution must address the LBS 'use cases'

Test Requirements:

- FCC E911 mandate
- 3GPP / GCF / PTCRB / OMA
- Network Operator Acceptance
- OTA Performance Testing (CTIA)
- R&D LBS Testing

Positioning Technologies

- **Satellite based methods**
  - GNSS = Global Navigation Satellite System
  - GPS, GLONASS, COMPASS/BEIDOU, GALILEO, IRNSS
- **Mobile radio based methods**
  - OTDOA
  - eCID
- **Hybrid methods**
  - Combination of:
    - Multiple satellite based methods
    - Satellites and Mobile radio positioning



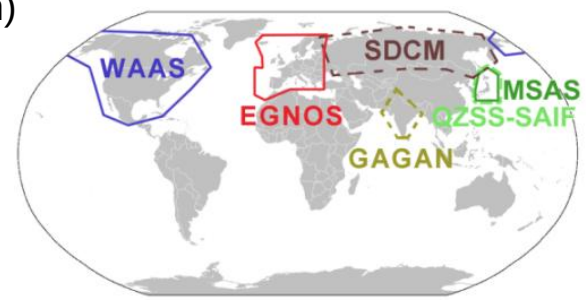
Satellite Based Positioning - GNSS constellations

- **GPS – Global Positioning System (USA, full operation since 1995)**
  - Modernized GPS (2014+) – L2C, L5 (Safety of Life), new military (M) signal & other performance enhancements
- **GLONASS (Russia, full operation since October 2011)**
- **BDS – Beidou-2 / Compass (China, under development, operational since Dec 2011, completion in 2020)**
- **Galileo (Europe, under development, target full operation 2019)**
- **IRNSS (India, Compeleted in April 2016, full Operation 2016)**

- **SBAS – Satellite based augmentation systems**

(Geostationary (regional) satellites providing additional information (e.g. error corrections) to enhance the performance of GNSS)

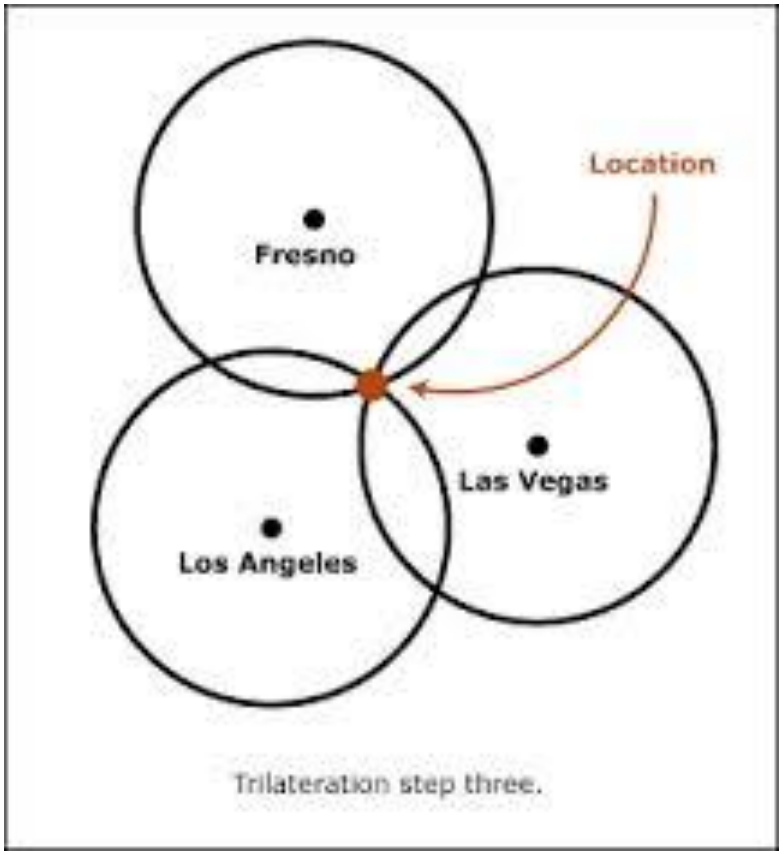
- WAAS – Wide Area Augmentation System (USA)
- EGNOS – European Geostationary Navigation Overlay Service (Europe)
- MSAS – Multi-Functional Satellite Augmentation System (Japan)
- QZSS – Quasi-Zenith Satellite System (Japan)
- GAGAN – GPS Aided Geo Augmented Navigation (India)

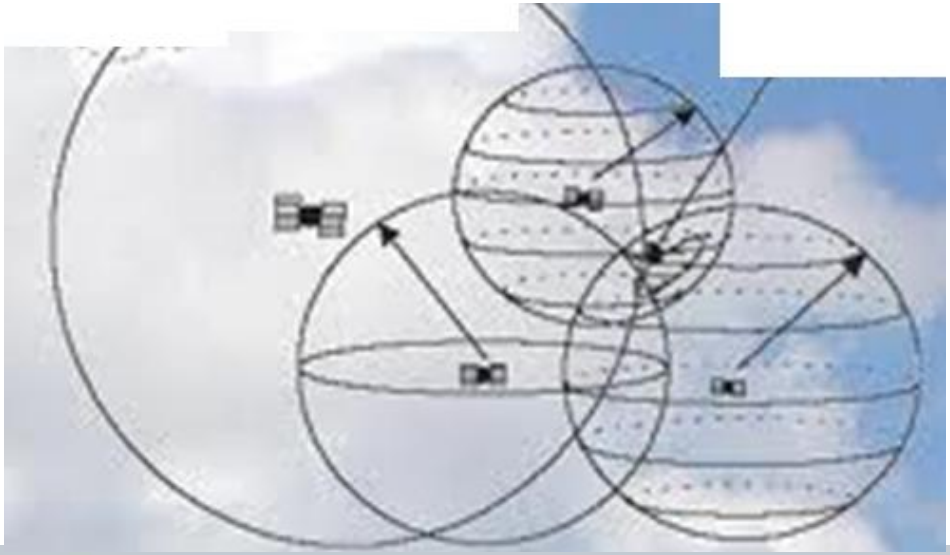


Satellite Based Positioning – How does it work?

- **Based on the simple idea of trilateration:**
  - Find **coordinates** of at least three objects
  - Find the **distance** to each of these objects
  - Intersecting point of 3 circles is your 2D position

- **And apply this to satellites and a receiver:**
  - Find coordinates of at least FOUR satellites
  - Find the distance to each of these satellites
  - Intersecting point of the 4spheres is your 3D position





While is makes sense that three sats would be enough (since you can rule out being in the middle of the planet or up in the sky), 4 are still needed to overcome the problem of inaccurate quartz clocks in gnss receivers

Assisted A-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!

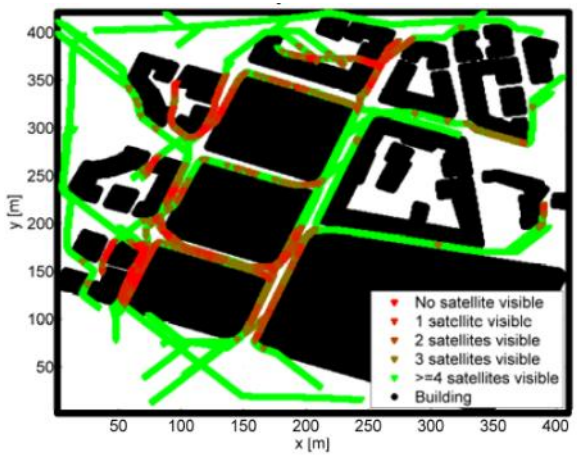
Assistance Data
Reference Time
Reference Location
Ionospheric Models
Earth Orientation Parameters
GNSS-GNSS Time Offsets
Differential GNSS Corrections
Ephemeris and Clock Models
Real-Time Integrity
Data Bit Assistance
Acquisition Assistance
Almanac
UTC Models

- **Two modes**
  - **Mobile assisted mode**
    - Device (= User Equipment, UE) transmits GNSS measurement results to network server, where position calculation takes place.
  - **Mobile based mode**
    - UE performs GNSS measurements and position calculation
    - Using Data to assist in GNSS measurements and position calculations, e.g. reference time, visible satellite list, reference position, satellite ephemeris, etc.

Why sometimes even A-GNSS is not enough…

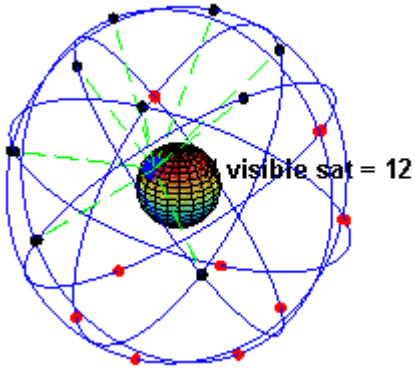
Critical scenario

Very critical scenario



GPS Satellites visibility (Urban)

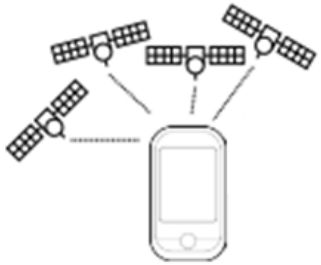
- **Global navigation satellite systems (GNSSs)**
  - are designed for continuous reception, outdoor
  - have restricted performance in certain environments
    - GNSS is low power and relatively high frequency (easily blocked)



- **Often less than four satellites visible: critical situation for GNSS positioning**
  → alternatives required (Mobile radio positioning)

Reference [DLR]

GNSS vs. Mobile radio positioning methods



GNSS	Mobile radio systems
Low bandwidth (1-2 MHz)	High bandwidth (up to 20 MHz in LTE)
Very weak received signals	Comparatively strong received signals
Similar received power levels from all satellites	One strong signal from the serving BS, strong interference situation
Long synchronization sequences	Short synchronization sequences
Signal a-priori known due to low data rates	Complete signal not a-priori known to support high data rates, only certain pilots
Very accurate synchronization of the satellites by atomic clocks	Synchronization of the BSs not a-priori guaranteed
Line of sight (LOS) access as normal case → not suitable for urban / indoor areas	Non line of sight (NLOS) access as normal case → suitable for urban / indoor areas
3-dimensional positioning	2-dimensional positioning

Reference [DLR]

LTE supports the following positioning techniques:

- **AGNSS based positioning using different GNSS constellations (or even combinations)**

Sub-Test Case Number	Supported GNSS
1	UE supporting A-GLONASS only
2	UE supporting A-Galileo only
3	UE supporting A-GPS and Modernized GPS only
4	UE supporting A-GPS and A-GLONASS only

  - A-GNSS (using GPS, GLONASS, GALILEO, BEIDOU-2, IRNSS)

- **Mobile radio based positioning methods**
  - OTDOA, UTDOA, eCID etc.

- **Hybrid methods**
  - Intelligent switching/combining of different methods for more reliability towards different scenarios

LTE supported positioning methods

- **Satellite positioning method:** **A-GNSS**
- **Network positioning methods:** **OTDOA, eCID, UTDOA**

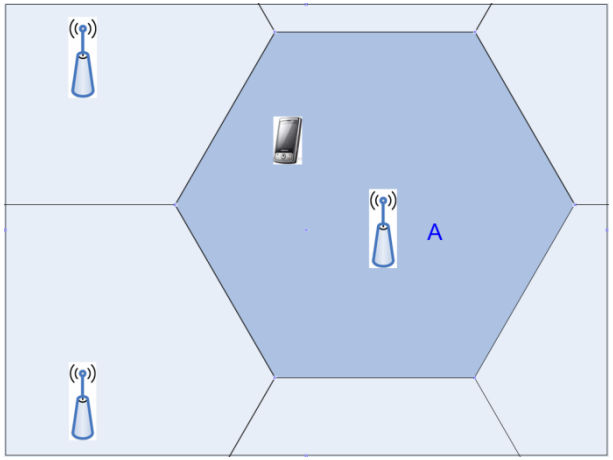
Method	UE-based	UE-assisted	eNB-assisted	3GPP Release
A-GNSS	Yes Measurement: UE Estimation: UE	Yes Measurement: UE Estimation: LS	No	Rel-9
Downlink (OTDOA)	No	Yes Measurement: UE Estimation: LS	No	Rel-9
Enhanced Cell ID (eCID)	No	Yes Measurement: UE Estimation: LS	Yes Measurement: eNB Estimation: LS	Rel-9
Uplink (UTDOA)	No	No	Yes Measurement: eNB Estimation: LS	Rel-11

- **Measurements are performed by UE or eNB**
- **Position estimations are performed by UE or LS (Location Server)**

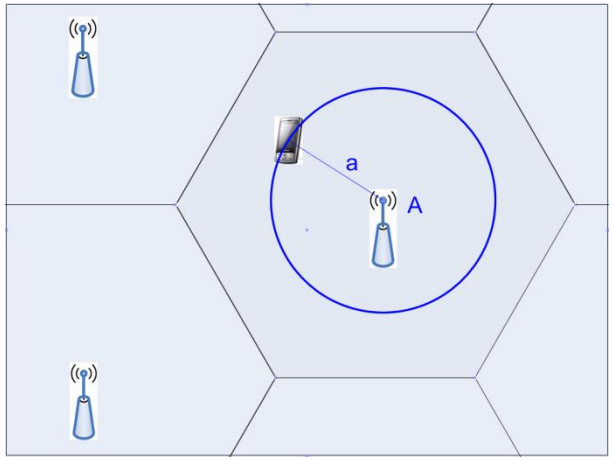
Reference: 3GPP TS 36.305

Methods‘ overview

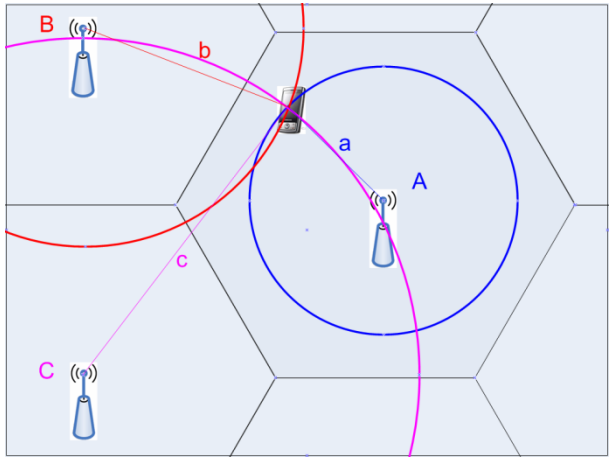
CID



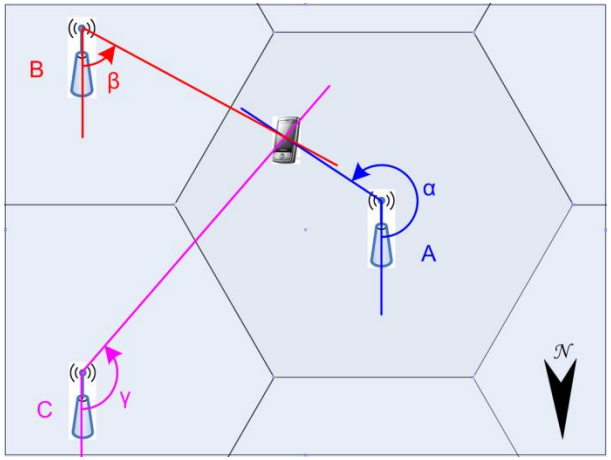
E-CID (RSRP/TOA/TADV)



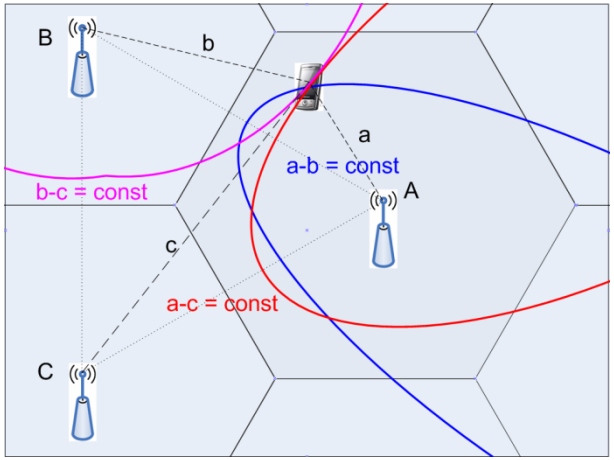
E-CID (RSRP/TOA/TADV) [Trilateration]



E-CID (AOA) [Triangulation]

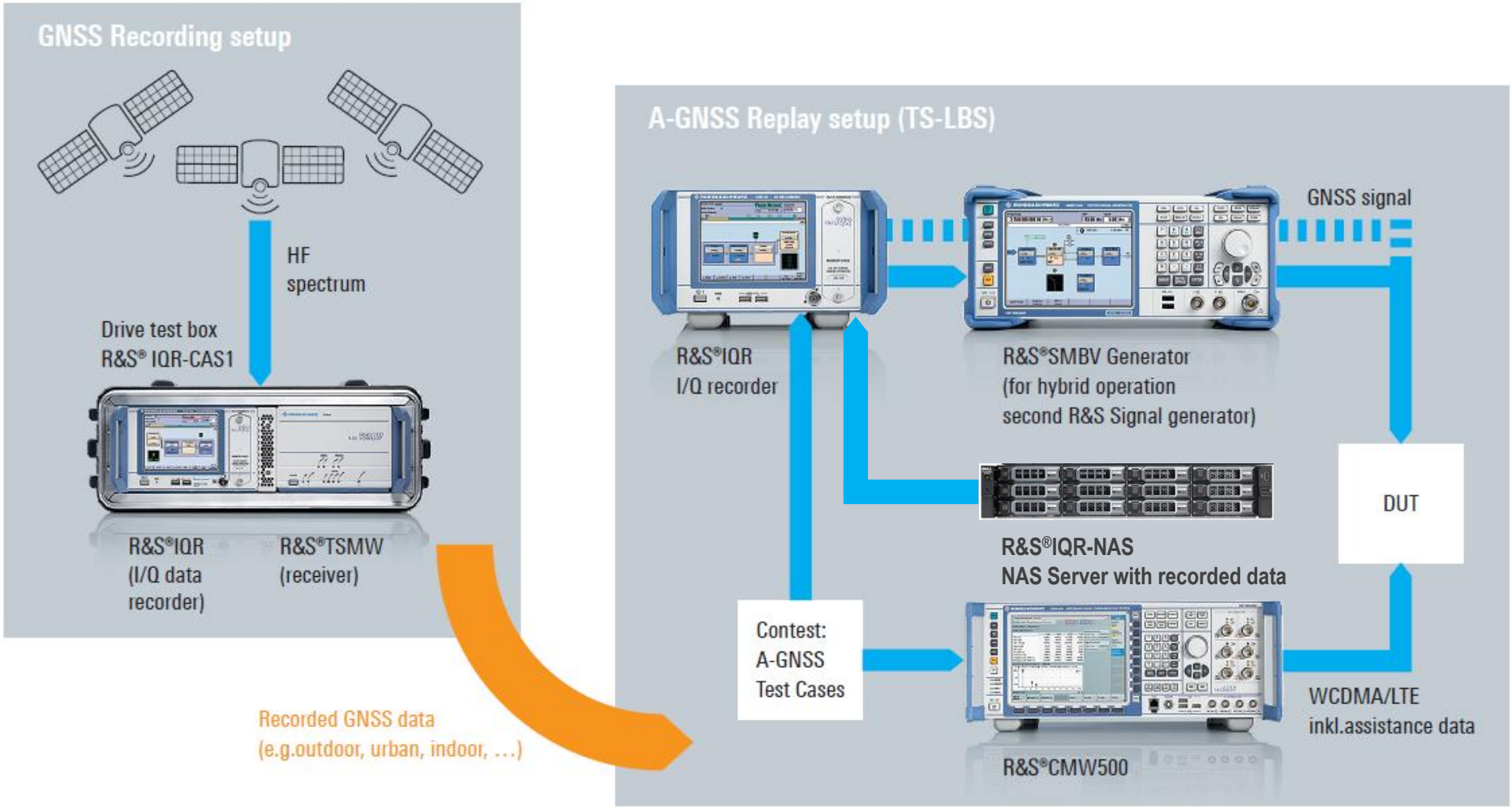


Downlink / Uplink (O/U-TDOA) [Multilateration]



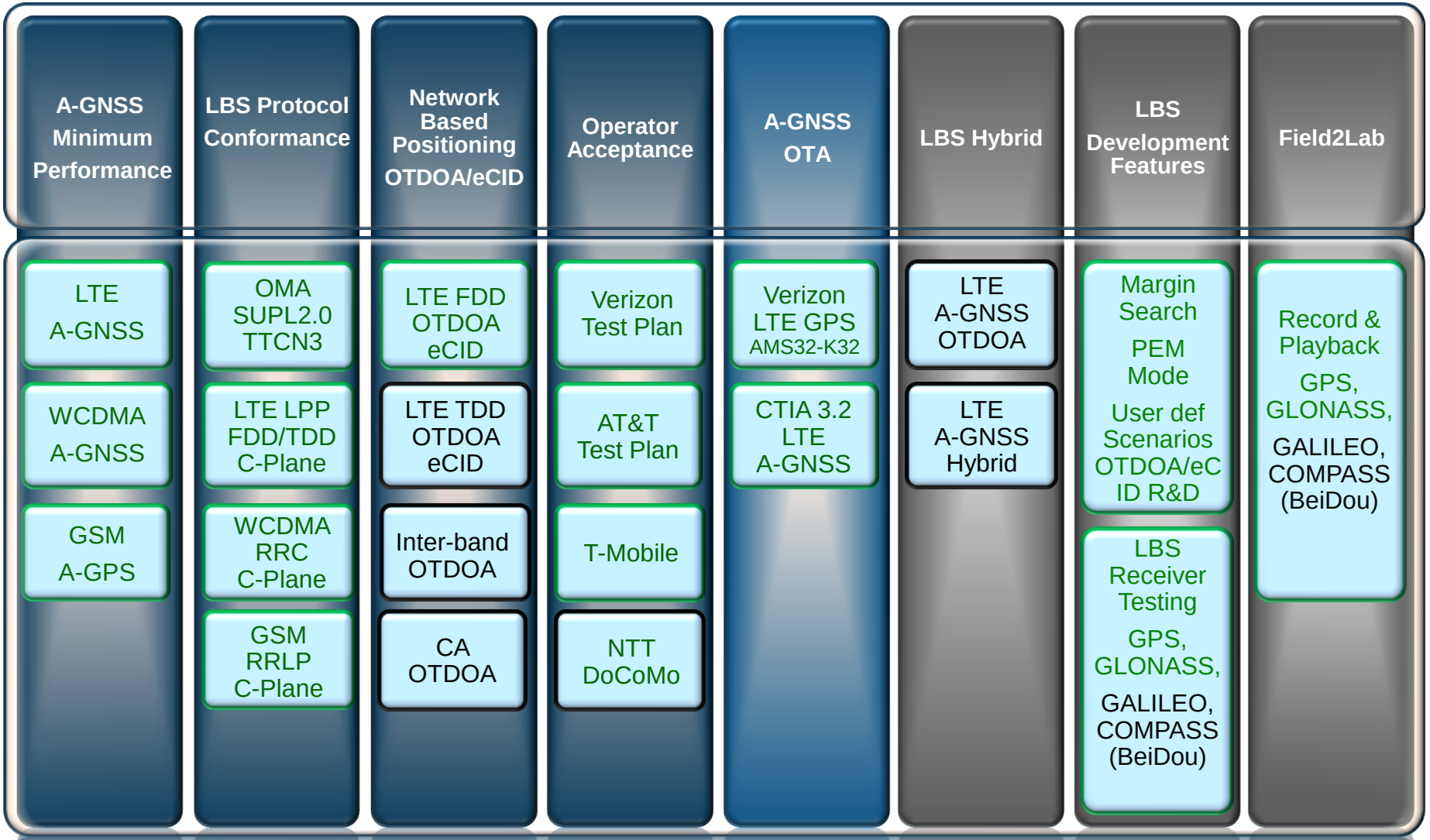
LBS – Field to Lab (F2L)

A-GNSS Record Replay solution



LBS – What to test?

LBS general overview



TS-LBS A-GNSS set up

Capabilities (2G/3G/LTE) Min Perf

- **RF minimum performance**
  - 2G: TS51.010-1 sections 70.11.x, 70.16.x
  - 3G: TS37.571-1 section 5/6
  - LTE: TS37.571-1 section 7
  - SUPL
- **Network operator specific test cases**
- **GPS, GLONASSS, GALILEO & COMPASS**

Capabilities (2G/3G/LTE) protocol

- **A-GNSS protocol conformance**
  - 2G: TS51.010-1
  - 3G: TS34.123 / TS37.571-2
  - LTE: TS37.571-2
  - SUPL
  - **Network operator specific test cases**
- **GPS, GLONASSS, GALILEO & COMPASS**

Benefits

- **Small form factor**
- **CONTEST for execution:**
  - Automation
  - Reporting, Database,…
  - Upgradeable to OTDOA/ECID

Hardware Setup

- **Dedicated, small system:**
  - CMW500
  - SMBV100A
  - Control PC
  - CONTEST Software + Test Cases

TS-LBS Advanced OTDOA/eCID Setup

Capabilities (LTE)

- **LTE cellular network positioning**
- **TS37.571-1**
  - FDD sections 8.1.1, 9.1.1 and 9.1.3
  - TDD sections 8.1.2, 9.1.2 and 9.1.4
- **Network operator specific test cases**

Benefits

- **Small form factor**
- **Same HW like TS-RRM advanced**
- **Upgradable to A-GNSS/Hybrid**
- **CONTEST for execution:**
- **Automation**
- **Reporting, Database,…**

Required Hardware:

- **2x CMW500**
- **1x TS-CONN or CMW-Z28**

Thank you
for your attention!