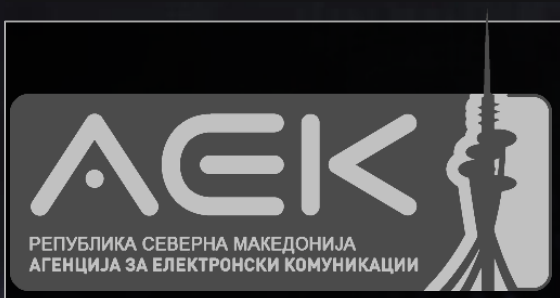
Data driven coverage calculation



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Outdoor coverage

Approaches in data driven outdoor coverage mapping

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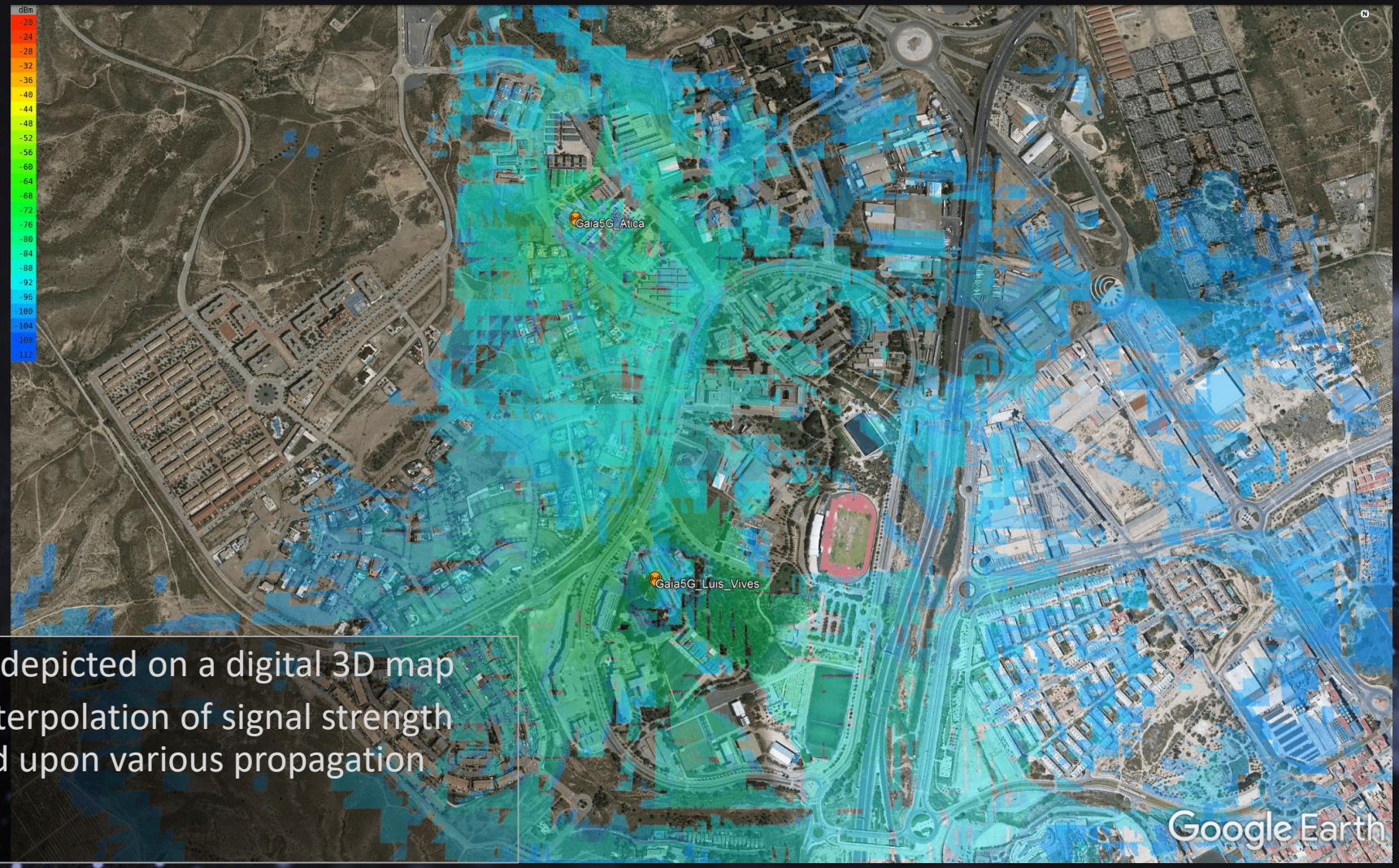
Coverage vs Measurement visualization a cognitive challenge



- Predicted coverage depicted on a digital 3D map
  - A predictive interpolation of signal strength variation based upon various propagation models

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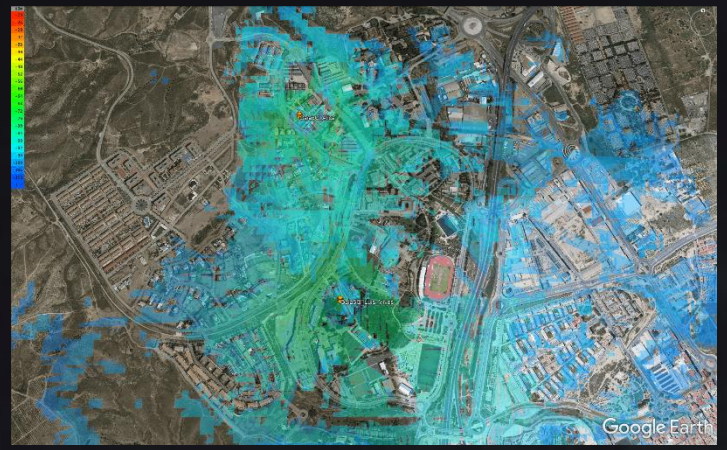
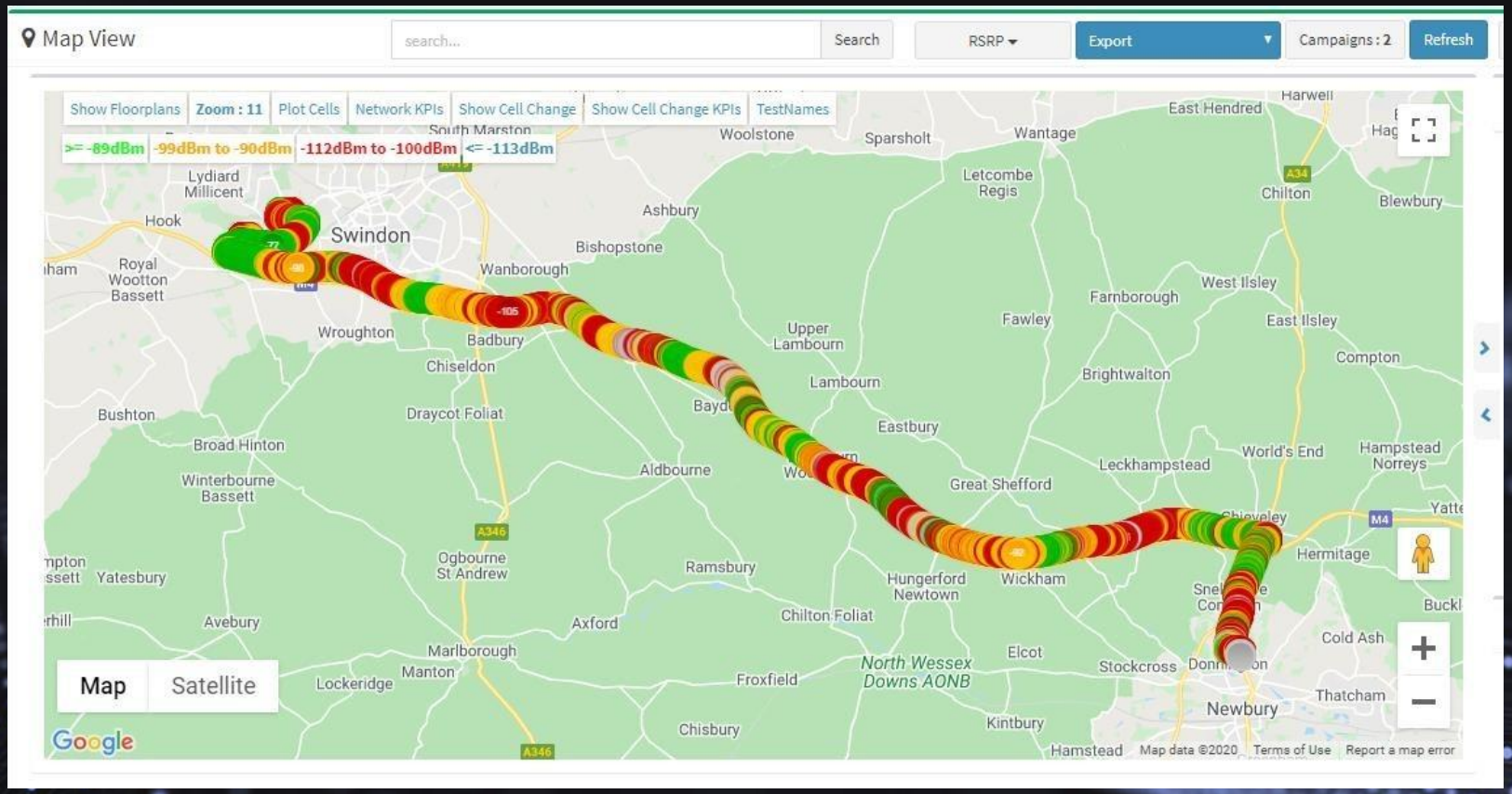
Coverage vs Measurement visualization a cognitive challenge





- Drive test map
  - No interpolation
  - Dotted visualization
  - Hard to correlate with the coverage map

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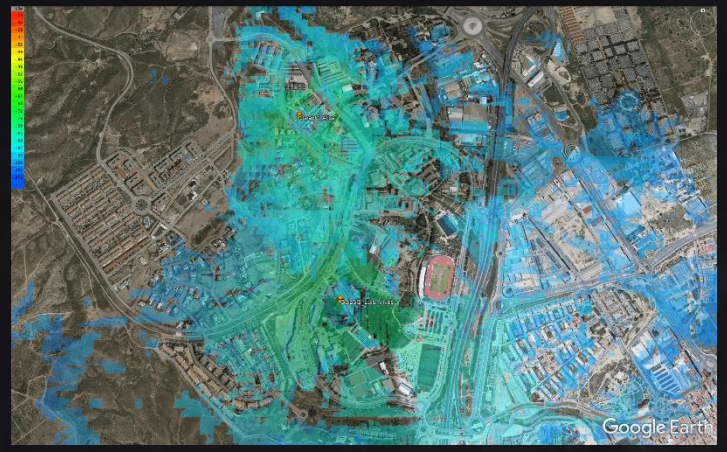
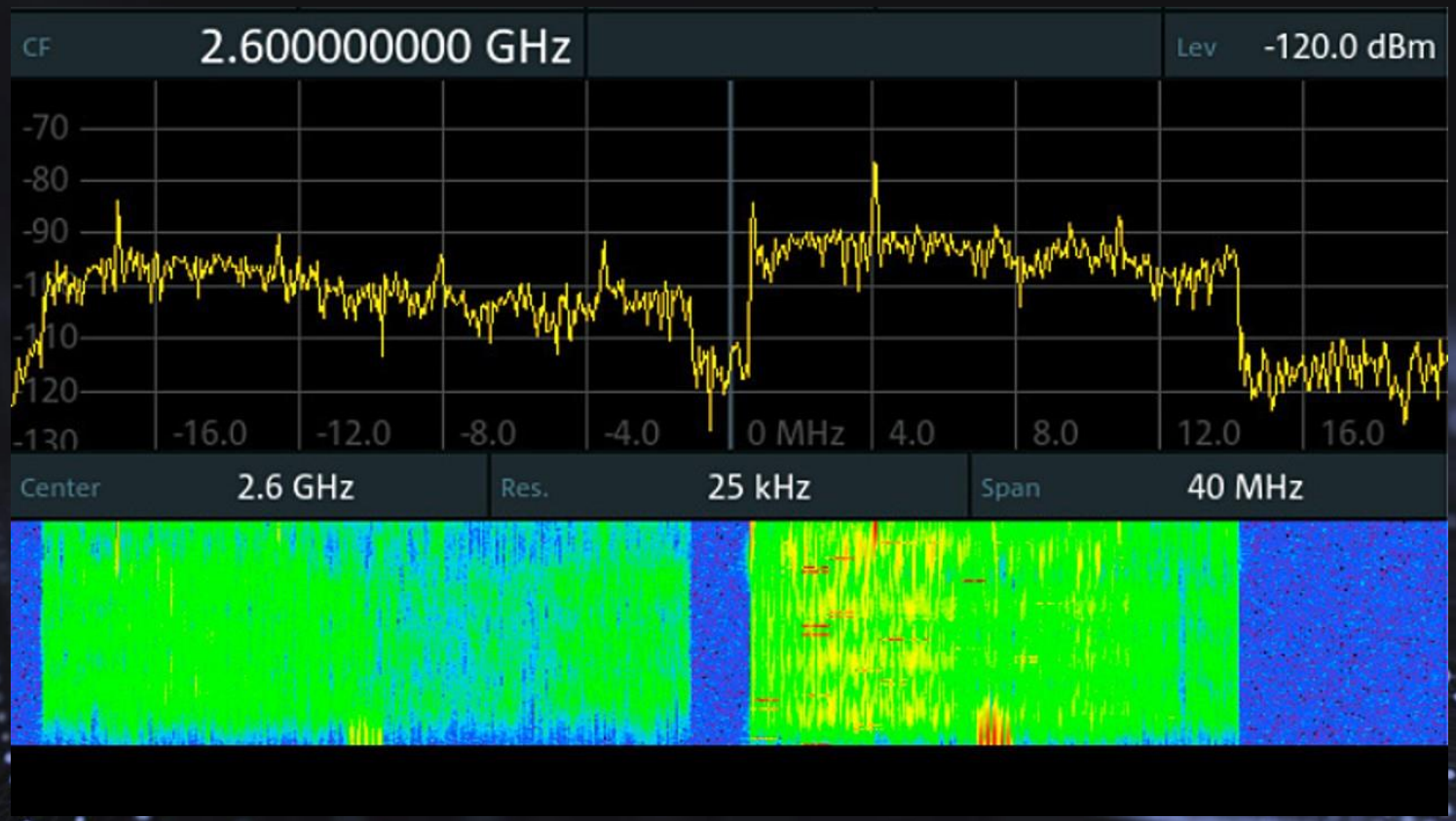
Coverage vs Measurement visualization a cognitive challenge





- Fix measurements and
  - Mostly represent RSSI in frequency and time domain
  - Even harder to corelate with actual RF coverage

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Other considerations for depicting measurements in interpolated manner

- Frequency usage
  - Mapping the uplink
  - Evaluate areas of high and low dense usage, identify overloads
  - Identify and localize interference or illegal spectrum usage
- Decision basis for frequency assignment and reallocation
- Comparison of spectrum for different periods
- Decision basis for modern dynamic spectrum assignments concepts (DSA/LSA)
- Evaluation of radiation hazards

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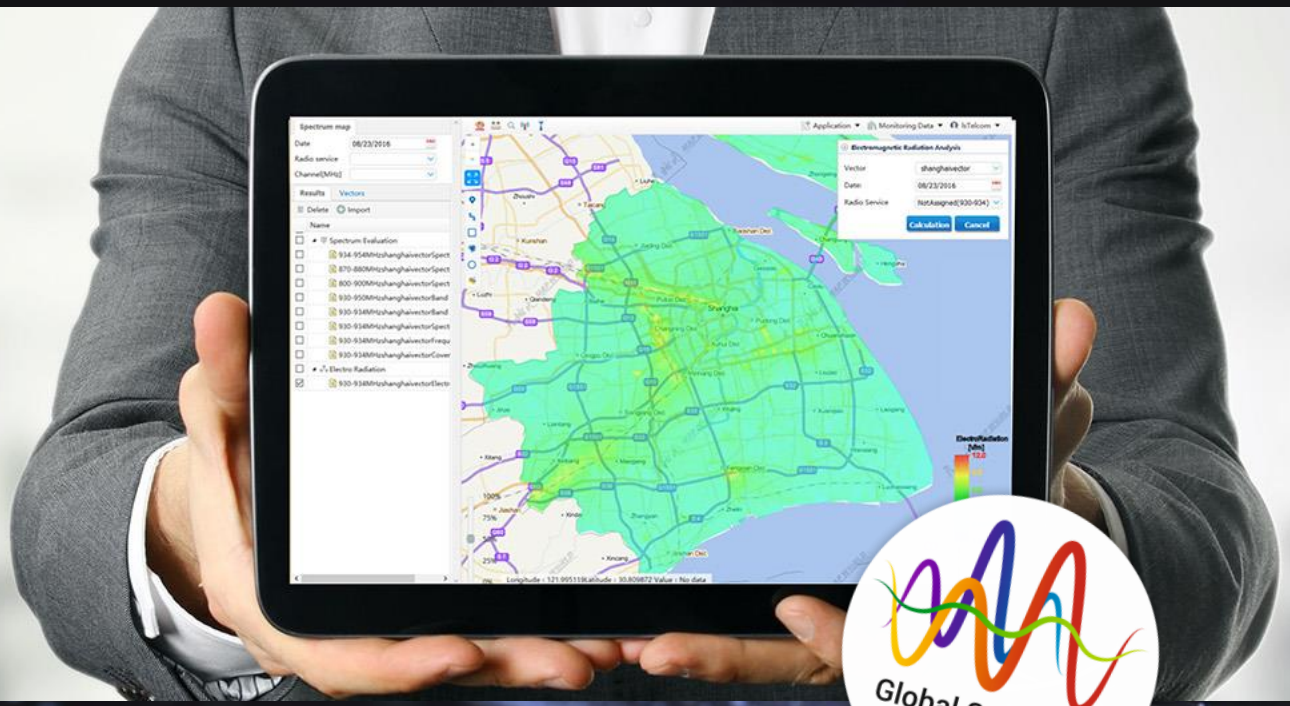
Possible solutions – drive tests

LS telcom
Smart Spectrum Solutions



Global Spectrum Experience

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Data gathering & processing

RF Data Collection

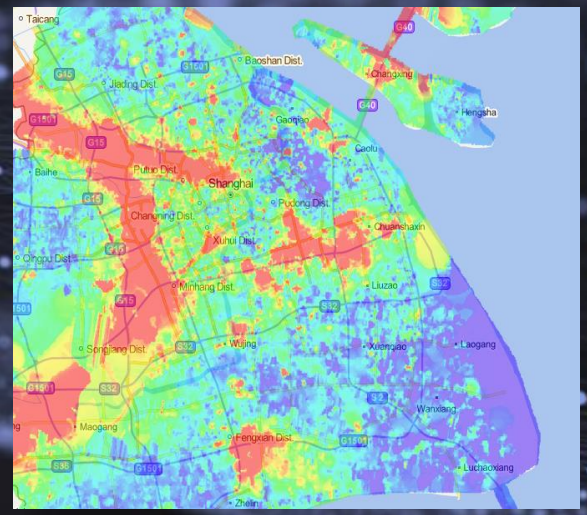
- Fixed stations
- Vehicle/UAV measurements
- Grid monitoring nodes
- Other RF Sensors

Data Mining/Fusion

- Data processing
- Fusion on frequency
- Fusion on time
- Fusion on location

Data Rendering/ Visualisation

- Display on various maps
- Dynamic display
- Comparison on time and frequency domain



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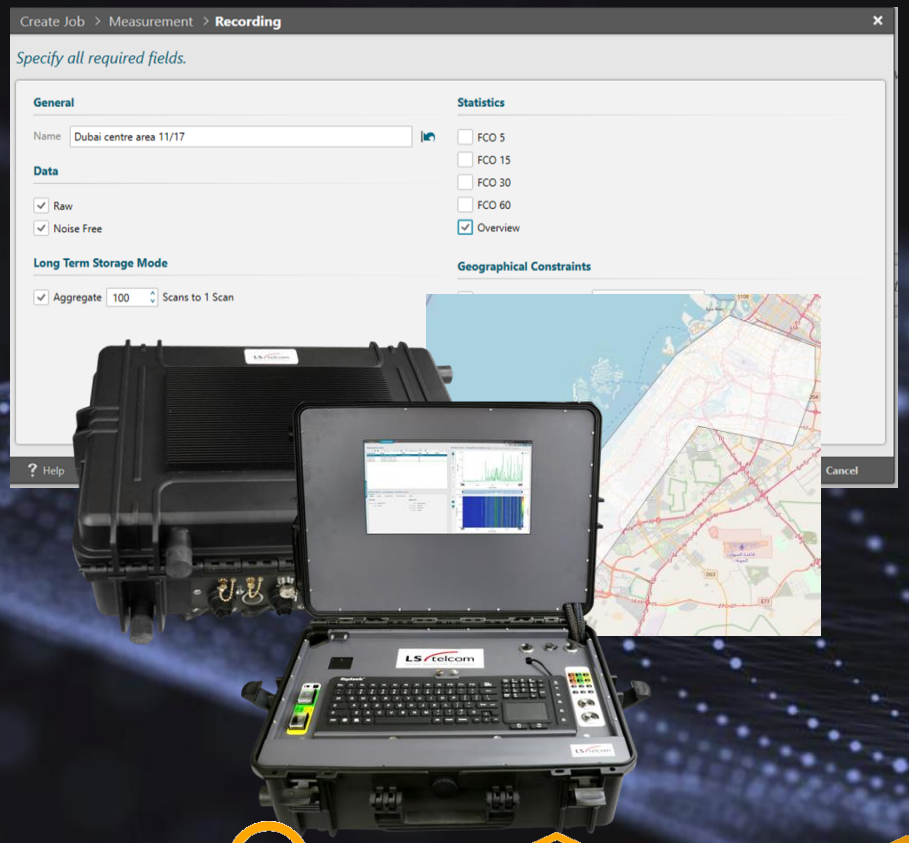
Data gathering & processing

- Measurement unit LS OBSERVER PPU
  - Large integrated storage and auto recording
  - Easy to integrate in a standard vehicle with a small magnetic antenna on the roof
  - Can be powered by vehicle outlet and includes 3h swappable battery
- Pre-definition of recording job by monitoring expert in LS OBSERVER CMS software
  - Job is automatically executed at the defined time with the defined parameters inside the defined area
  - No interaction with unit needed during drive
- Auto upload to server after drive is done



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Operational setup

Client network

Operator position 1 (CMS)
- Remote pre-config of measurement parameters and recording area
- Deep analysis of measurement results (power vs. frequency vs. time domain)
- Optional remote access during driving (VPN required)

Operator position 2 (SpectrumMap)
- Web-based analysis of various maps produced from a specific or merged from multiple drives
- Analysis of individual services and bands
- Historic analysis
- Maps with Tx data from SPECTRA_DB

Vehicles parking garage
- Auto upload of measurement results via WiFi or 5G connected to client network
- Battery charging
- Remote connection to operator position 1

Driving area
- Recording automatically starts with pre-conf parameters when vehicle is within defined vector

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Data gathering & processing circle

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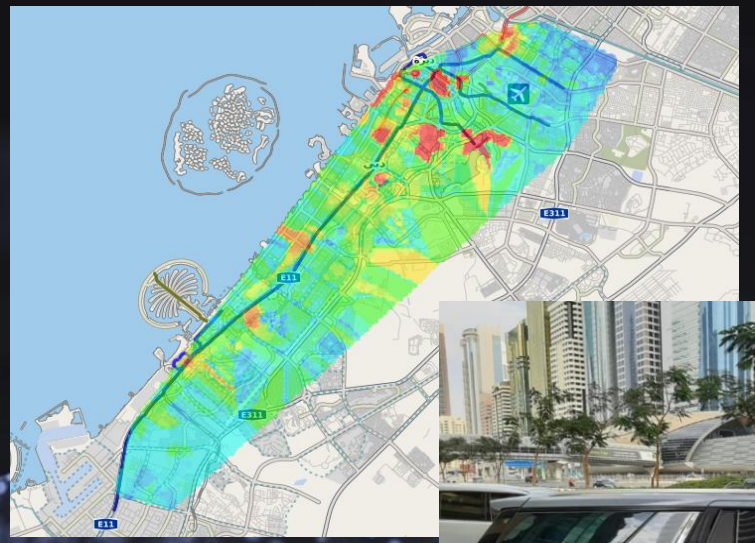
Practical implementation

- Analysis result for one day drive test
- 80 MHz - 6GHz
- Equipment: Standard vehicle with LS OBSERVER PPU + Antenna
- 268 GB of recorded data from 6:30 h drive test
- Automated recording, back-up and data processing



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Future considerations

- Quality of results Resuls relies on:
  - High data density
  - Deterministic repeating routes
- Public transport based monitoring
  - Busses
  - Taxis
  - Tram
  - Garbage trucks
  - Etc.
- Future of urban monitoring

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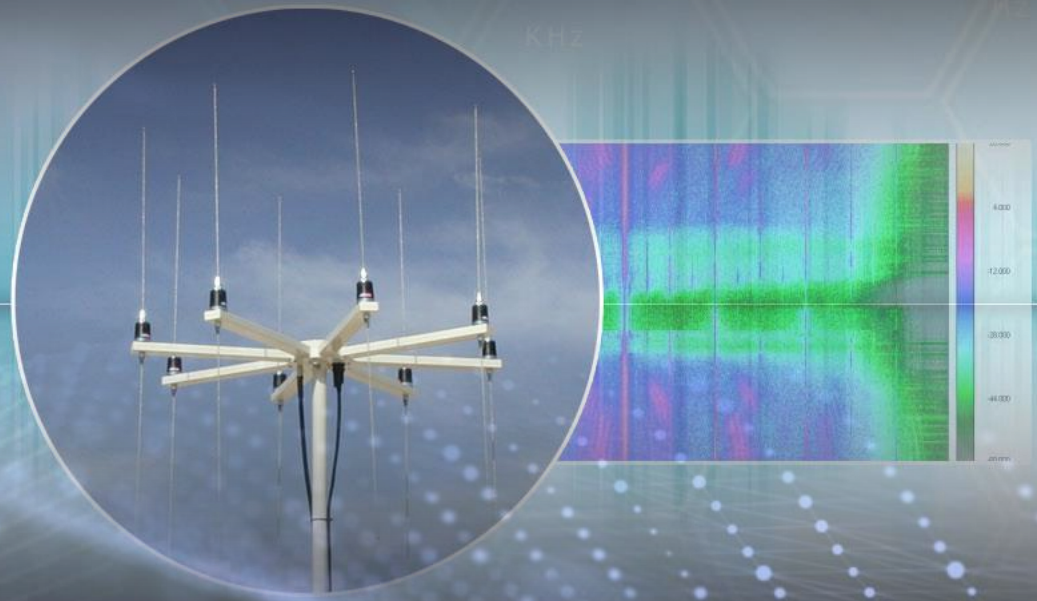
Depicting coverage from fixed monitoring sensor network, challenges.

- Still in experimental phase
- Sensor density equals data density
- Connectivity can be an issue
- Result quality dependant on RF sensor network design and coverage
- Edge computing increases power consumption



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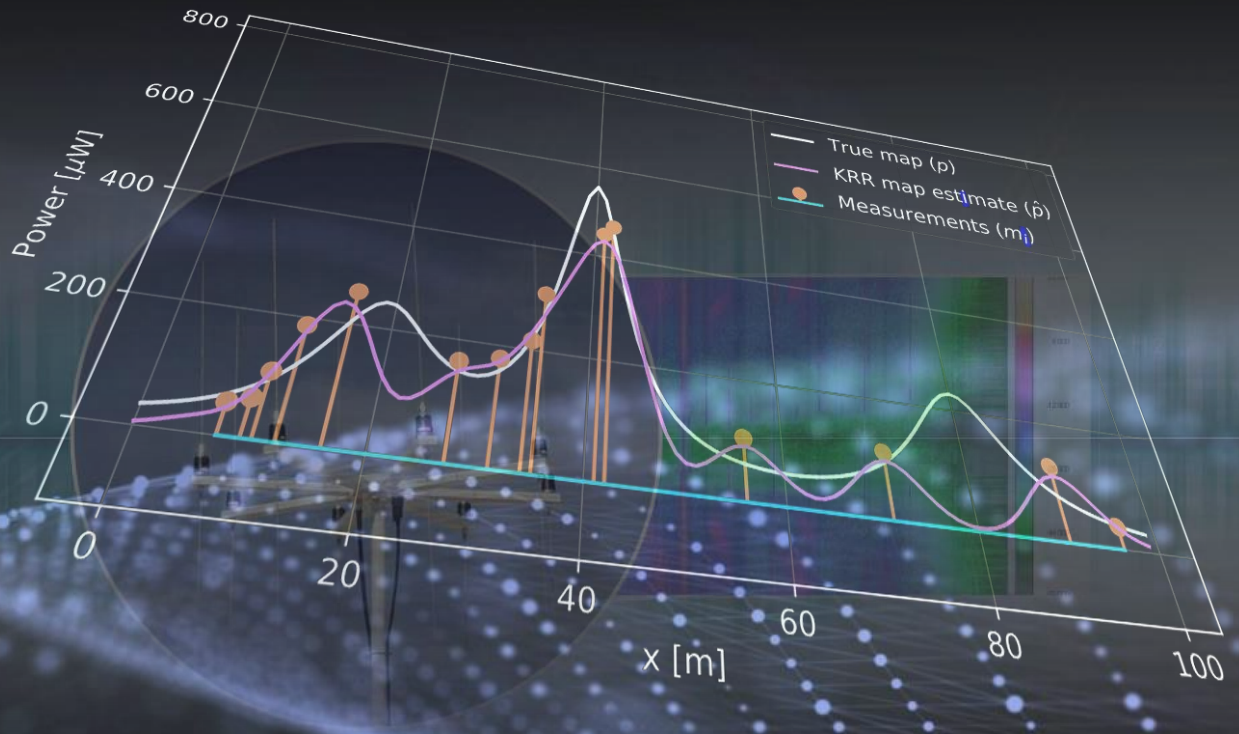
Depicting coverage from fixed monitoring sensor network-offered models

- There are several offered models for data driven spectrum cartography
  - Most of them dependant on external data for increased accuracy
  - Ranging from Linear Parametric
    - Mostly used as it compares and interpolates data from known transmitters with measured data
  - … to deep learning
    - Most promising in terms of accuracy
      - Dependant of quality maps
      - Excessive data and computational power needed during the learning process



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Indoor coverage

Getting indoor coverage right

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Indoor coverage

- Most of the traffic is generated indoors
  - 70-80 percent of traffic
- Lower frequencies better penetration less throughput
- Mid range frequencies (3,5 GHz) higher throughput
  - Traditional passive DAS less effective
  - Active DAS – significant CAPEX and increased OPEX
- Distributed indoor radio the way to go
- Getting indoor coverage right crucial to optimized coverage and CAPEX



Indoor coverage measurements challenges

- Geotagging and geolocation
- Interference and reflection
- Requires experienced operator

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Indoor coverage measurements

- What Netra brings into the game
  - Know how
  - Experience
  - Adequate equipment
  - Local support and availability
  - Cost effectiveness

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NETRA

Thank you

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