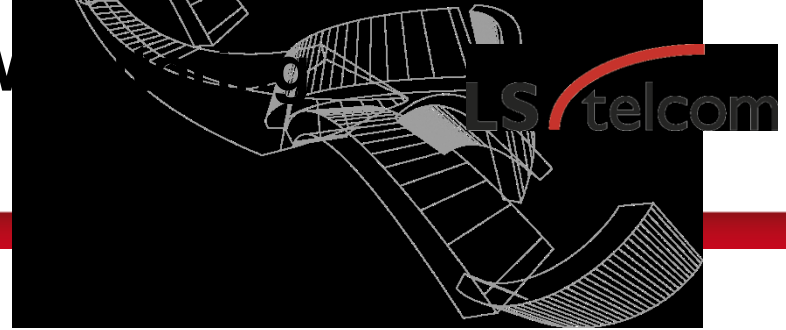


Bringing the worlds of Spectrum Management, Policy, and Monitoring together through Big Data analysis

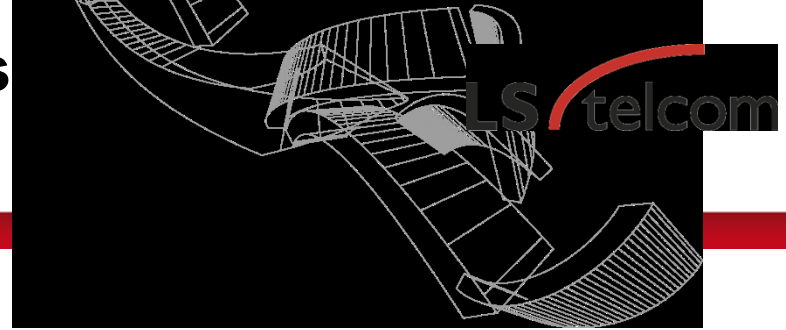
R Thelen-Bartholomew

Modern Operational Spectrum Monitoring Requirements



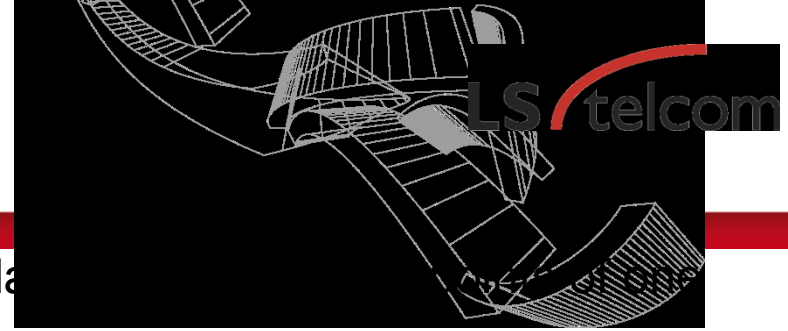
- A distributed monitoring system that covers everything, everywhere.
- Flexible design, packaging, performance so devices can be matched to operational environment / requirement.
- Rich storage of spectrum data so historical picture can be built up.
- Small monitoring devices that can be placed anywhere, both antennas and receivers etc.
- Able to use equipment remotely, “other side of the world” as if we were directly connected to it.
- Purchase and running costs of monitoring system kept low.

Existing approaches to sensors / monitoring analysis and use

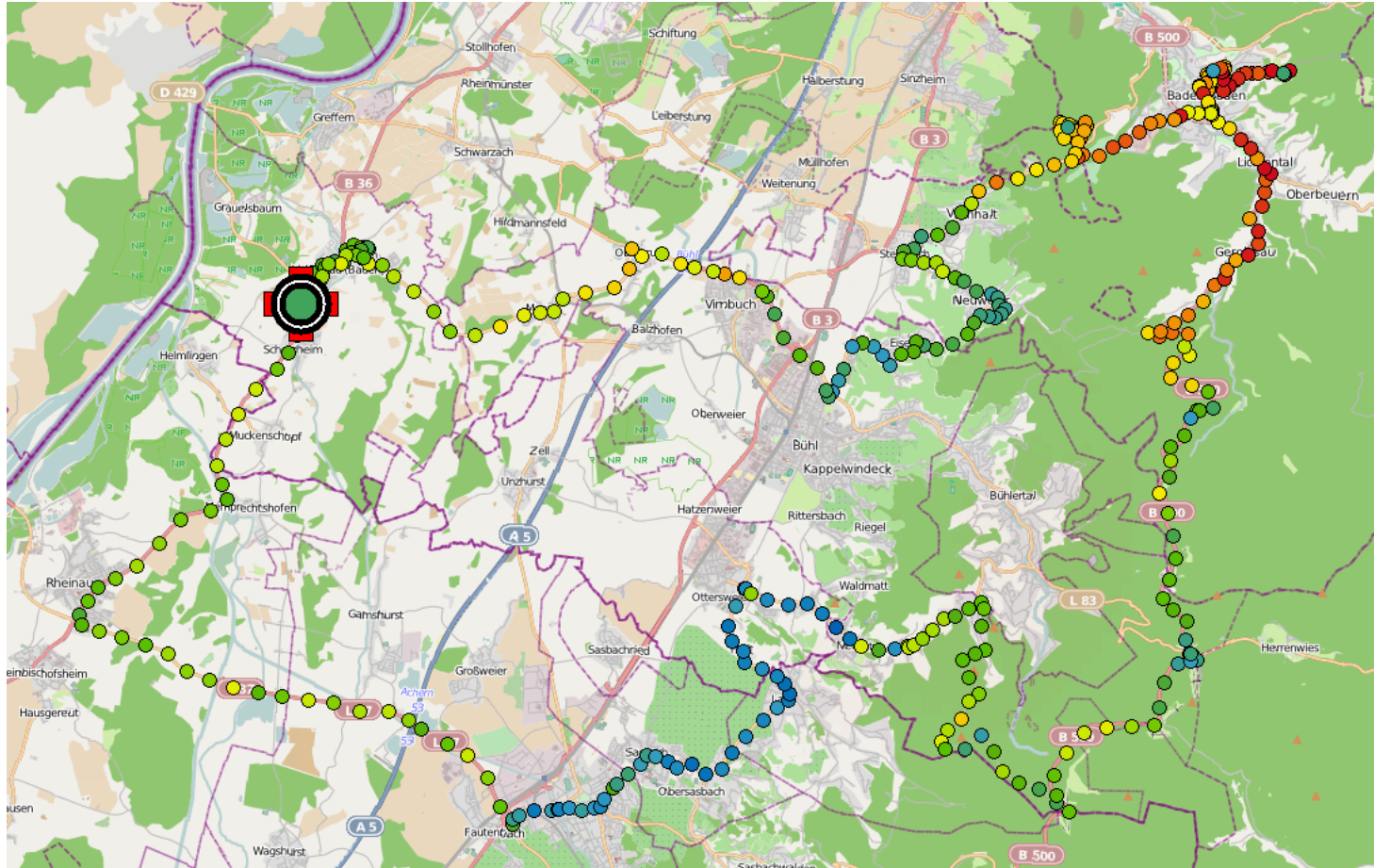


- Many organisations are moving from large scale monitoring sites to multiple sensors / portable or drive test approaches.
- There are mixtures of equipment types, makes and models.
- Software is often tied to an individual manufacturer and so several programs are required to make use of these mixed systems
- Although remote control is quite normal, its often a one to one relationship that is one control station accesses one device at a time to make measurements or analysis having to access devices sequentially.
- Software is installed onto individual machines meaning either limited people having access or high costs / complexity of licensing.

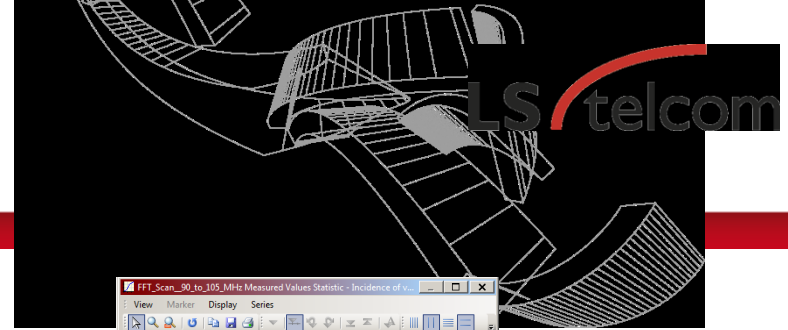
Measurement drive



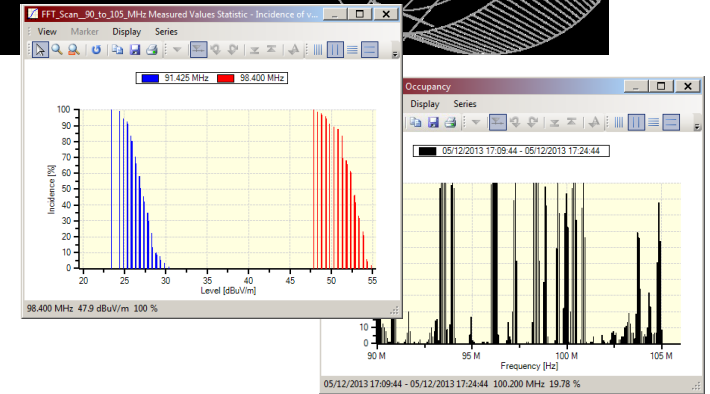
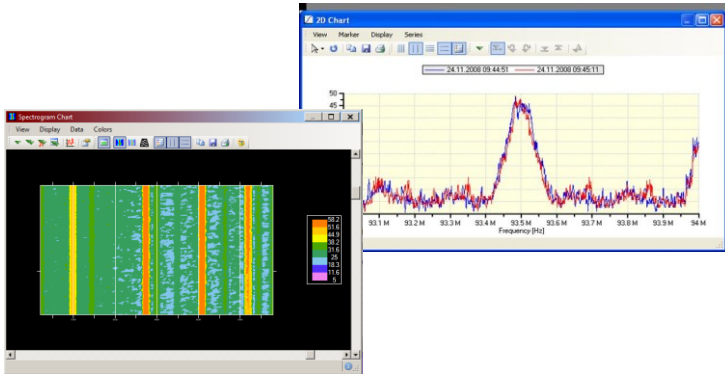
- Trace on Map for drive tests.. Typical display drive test.



What analysis is done already?

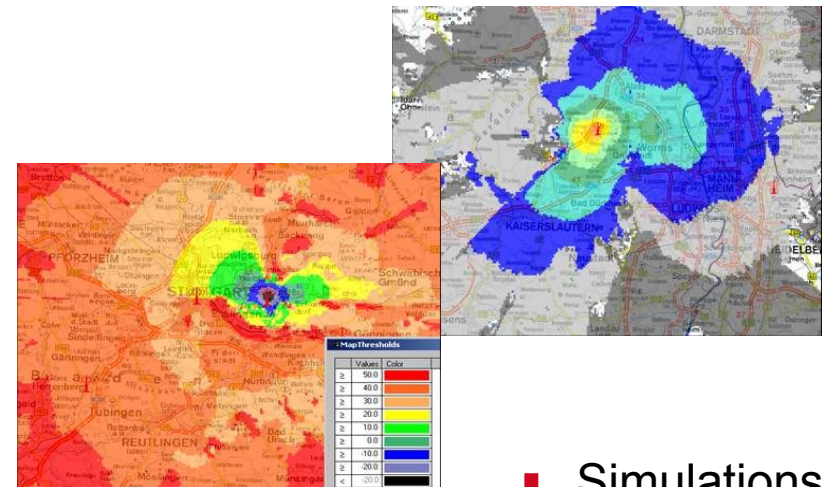


- Visualisation of Raw Data



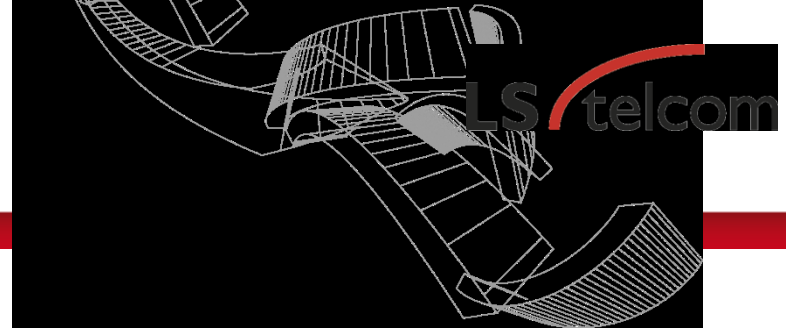
- Analysis of Data / Technical Calculations

- Control Monitoring Systems
- Control Monitoring Devices
- Again a one to one relationship



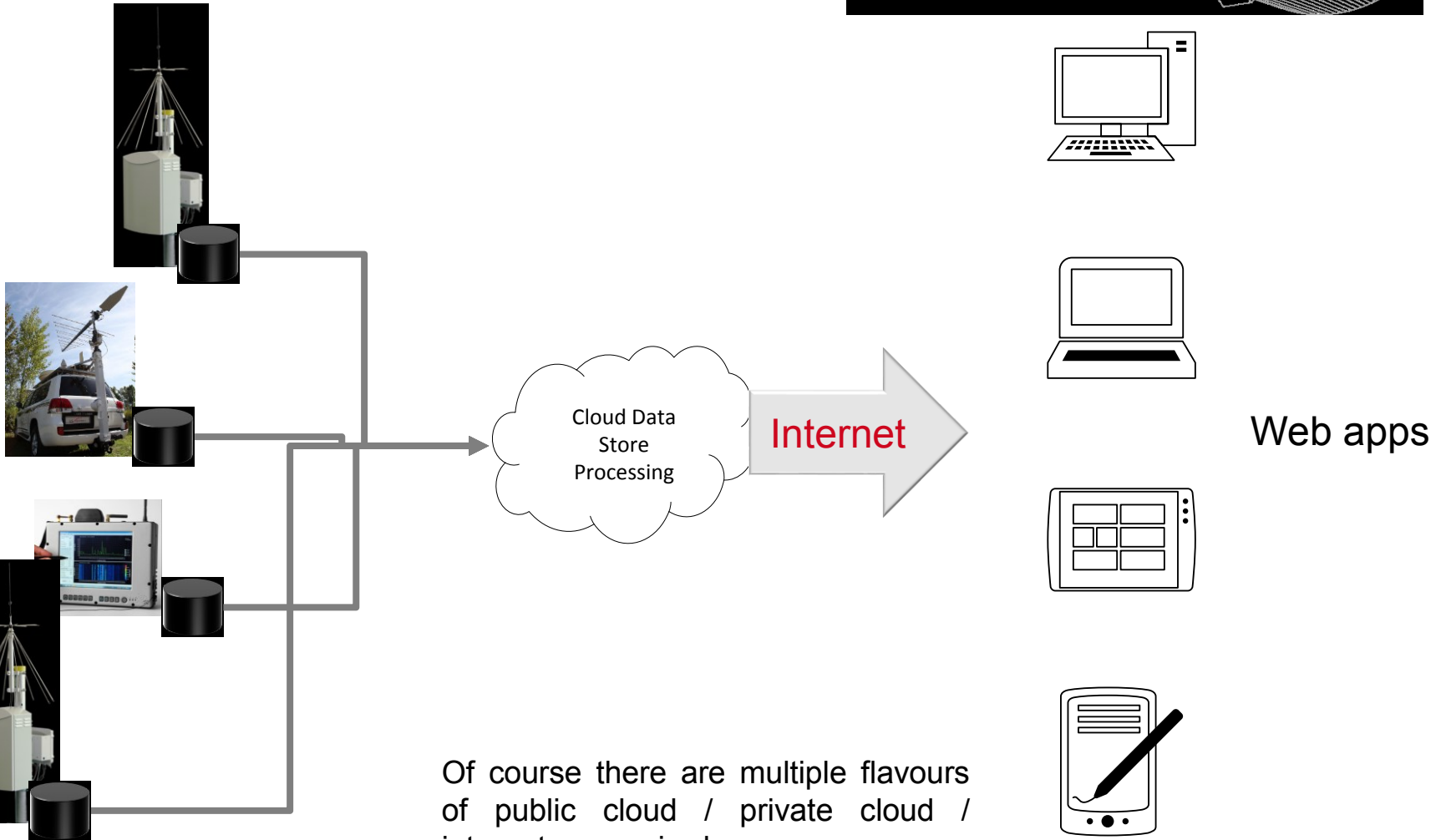
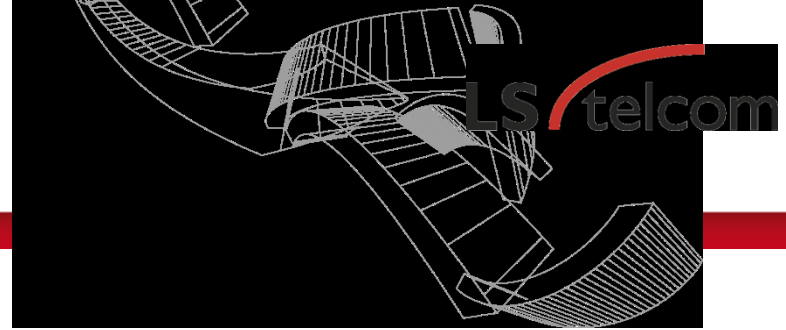
- Simulations

What If....

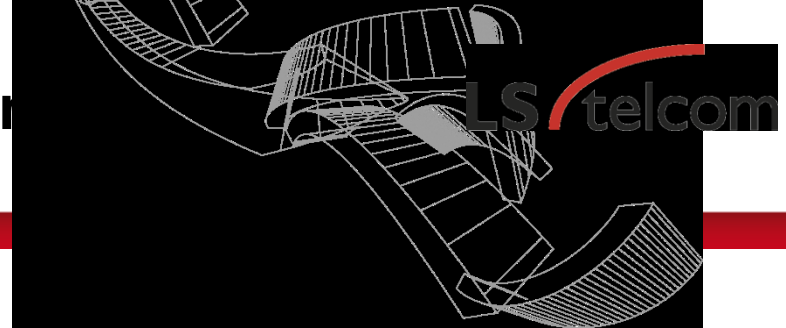


- You've a sensor network of hundreds of devices
- You don't care what the device is you just want to analyse the spectrum
- You have multiple vendors multiple types and a mis-fit network of fixed, transportable, mobile, portable sensors
- You want a big data approach of merging different sources of data
- You want to quickly model, adapt and analyse the data based on differing requirements (location / time / frequency / coverage / interference)

Cloud monitoring data platform

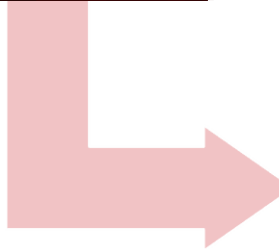


Of course there are multiple flavours of public cloud / private cloud / intranet as required.



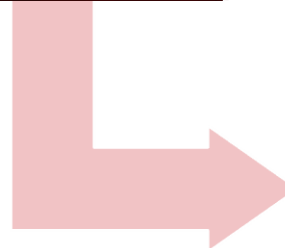
RF Data Collection

- Fixed Stations
- Grid Monitoring nodes
- Vehicle/UAV Measurement
- Other RF Sensors



Data Mining / Fusion

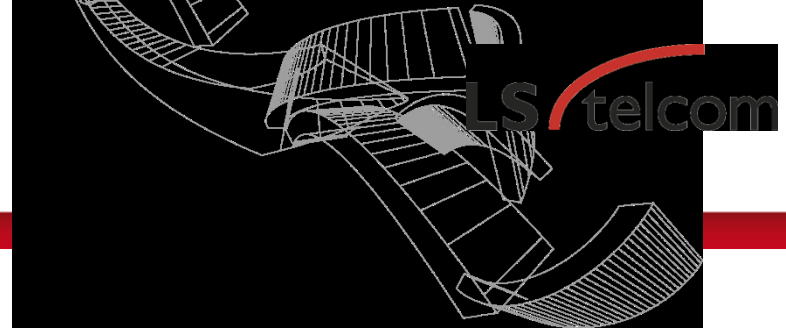
- Data Processing
- Fusion on Location
- Fusion on Time
- Fusion on Frequency



Data Rendering / Visualization

- 2D/3D Display
- Dynamic Display
- Comparison on Time/Frequency Domain

What is the point to this?



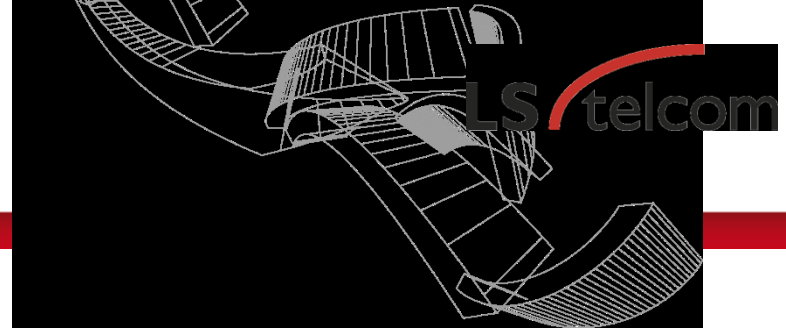
For Policy teams

- Ability for desk officers to access off air measurements from the monitoring network
- Provide evidence based decisions
- Evaluate the real use of spectrum not a modelled forecast
- See real usage in the temporal domain
- Validate licensing policies are active and useable such as use of spectrum, distribution of service
- In a DSA environment establish the use, impact and opportunity for dynamic assignments etc.

For Enforcement and field teams

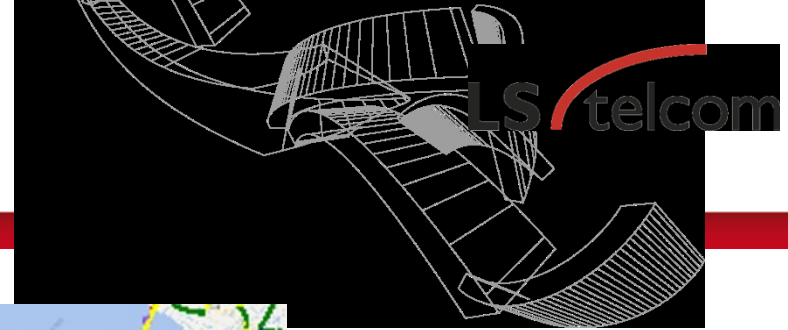
- Access to monitoring data to all field engineers and desk staff
- Undertake spectrum view of use, interferences
- Identify misuse or mis-licensing
- Confirm coverage is as expected from monitored data not modelling.
- Reduction in time spent undertaking monitoring exercises for policy teams
- Increased value of monitoring data and the overall value of spectrum monitoring.

Real World....

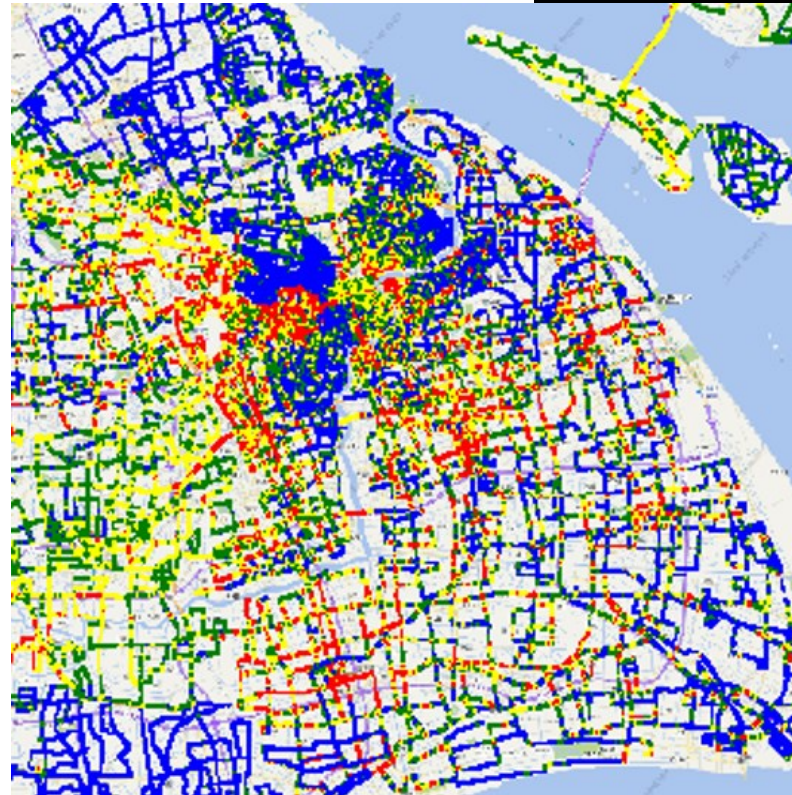


The following is an example of real world cloud big data approach used by a regulator, developed by LS telcom.

Spectrum Map Apps

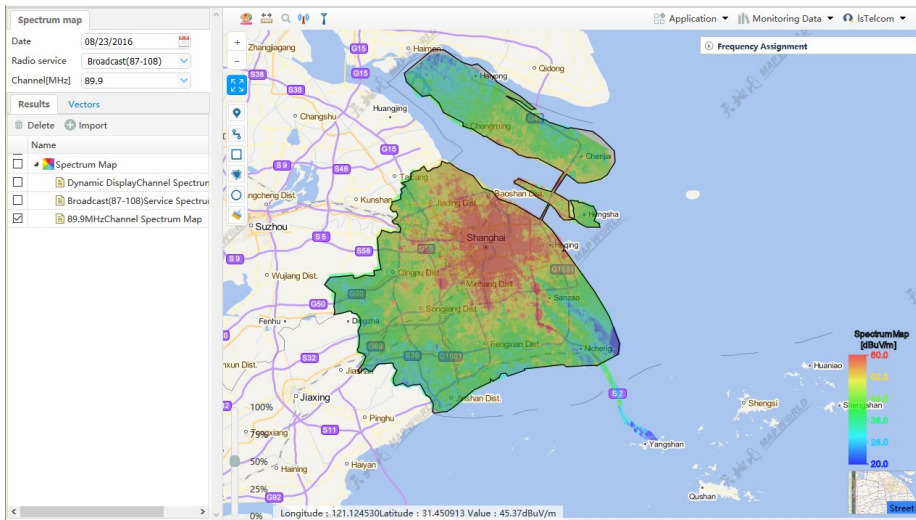
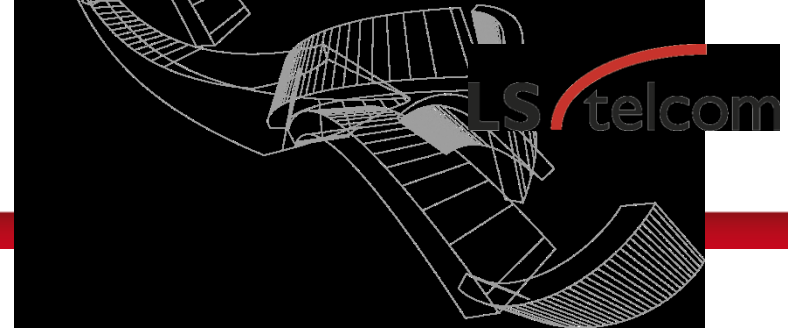


Data from multiple sources can be aggregated seamlessly.

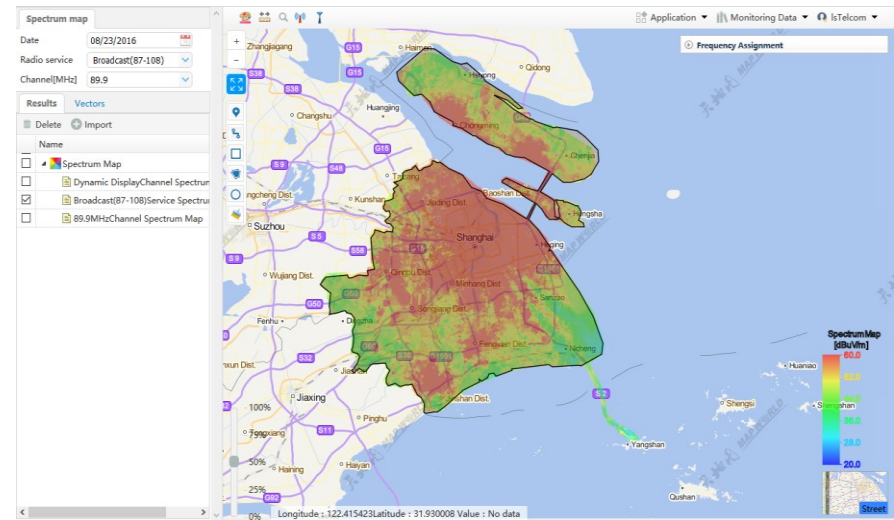


Vehicle Measurement Data
Aggregating all drive tests

Spectrum Map Apps

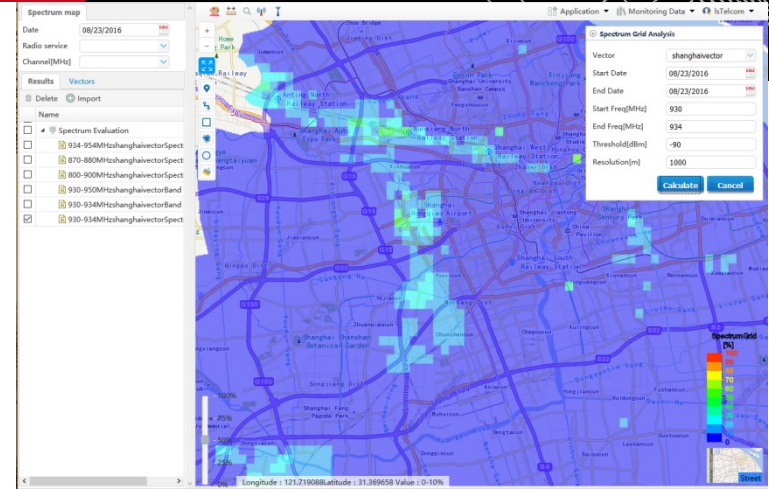
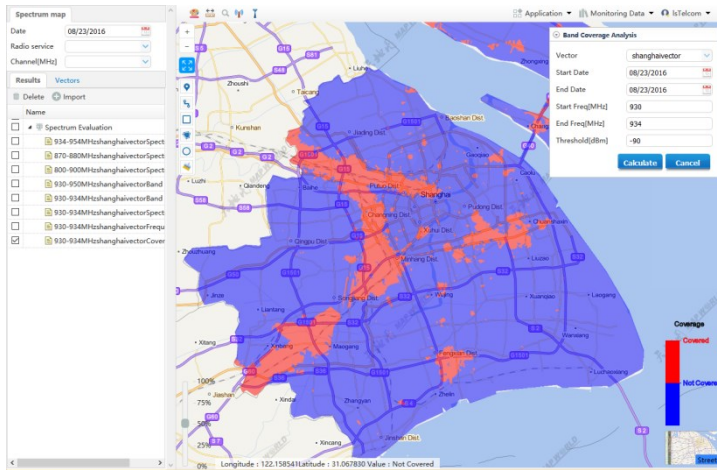
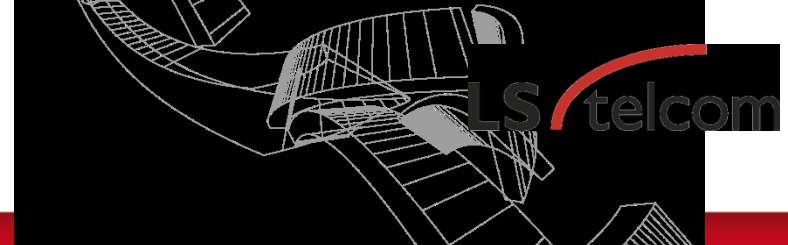


Field Strength of a Single Frequency
(89.9MHz)



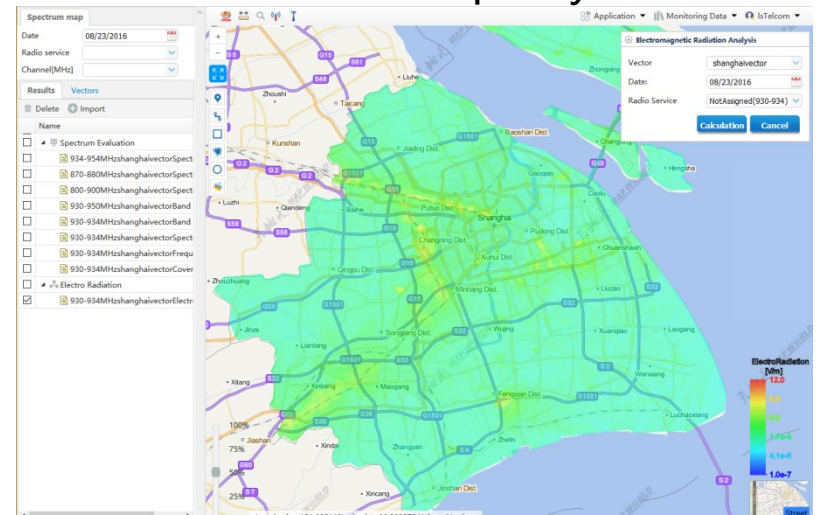
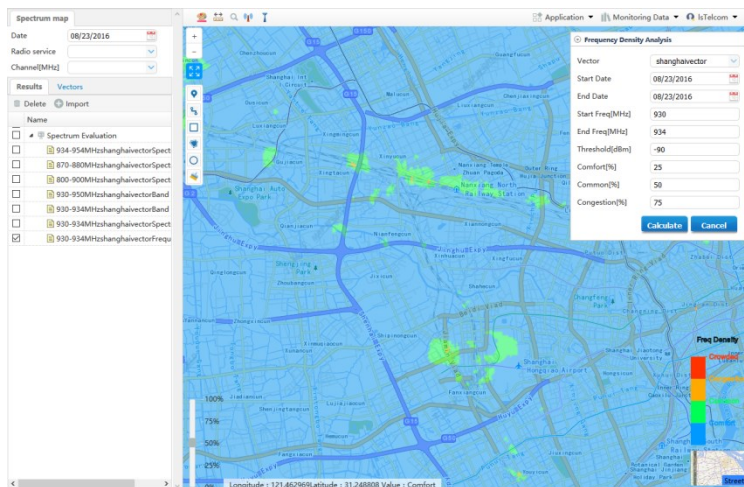
Field Strength of a Frequency Band
(Broadcast)

Spectrum Map Apps



Coverage of a Frequency Band

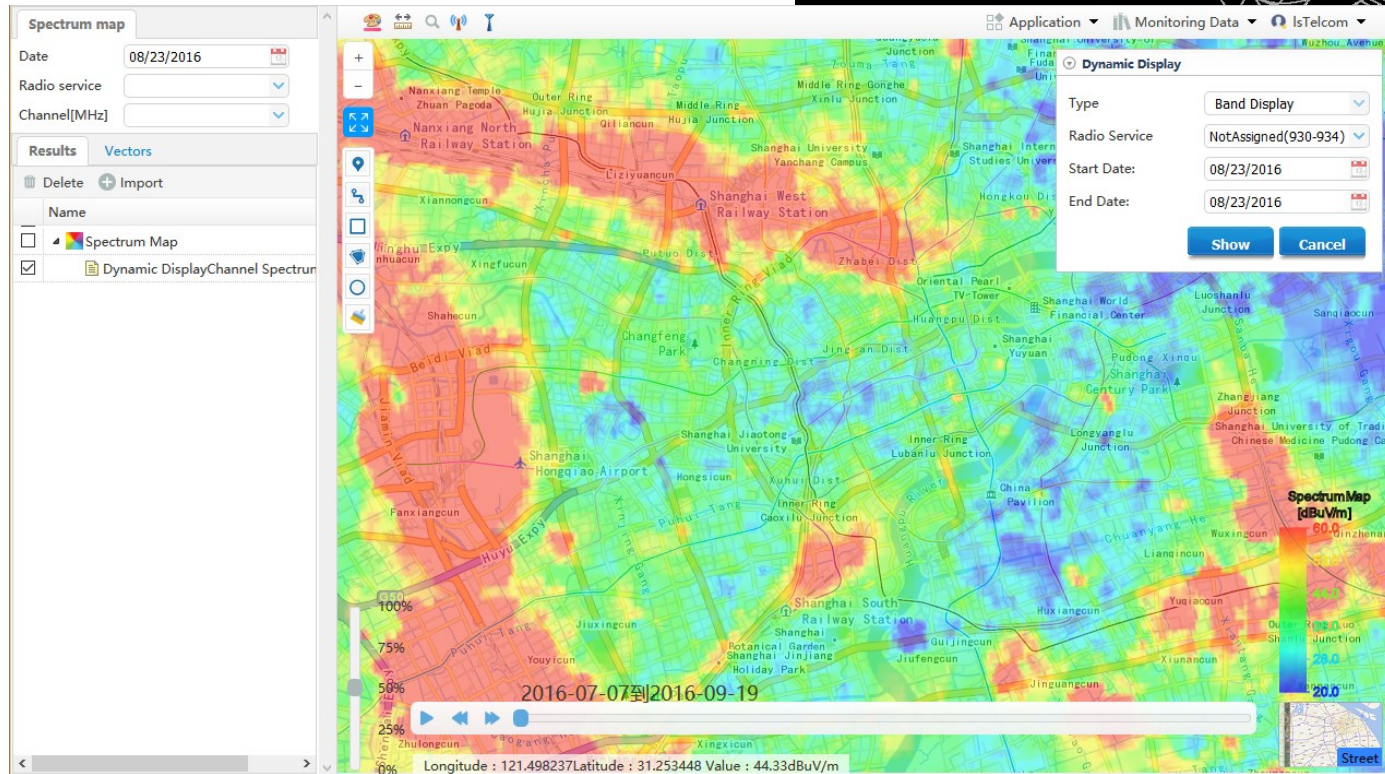
Band occupancy



Spectrum Utilisation

Radiation hazard

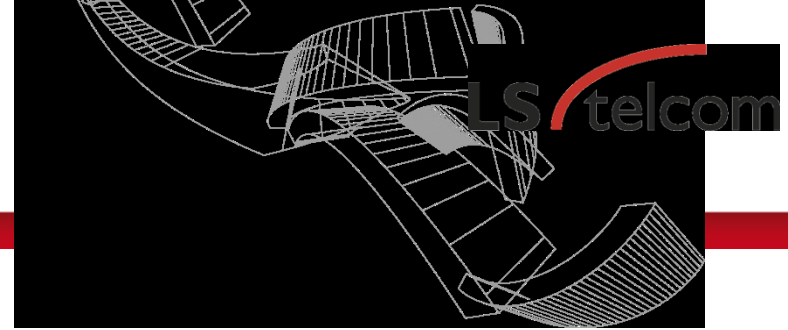
Spectrum Map



Dynamic Display (930MHz to 934MHz, Step: 100kHz)

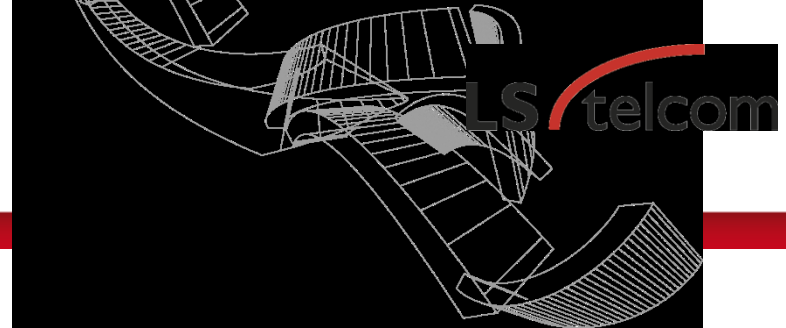
Dynamic display allows you to “step” through a band at desired increments

Spectrum Map



- The apps make **full use of all data from all sensors. This is not a propagation prediction**
- **Visualization of radio spectrum** as web GIS.
- Display the field strength distribution and spectrum usage on the **energy/time/frequency/spatial** domains.
- It makes **full use of monitoring data** and integrates existing equipment incl. fixed stations, grid monitoring nodes and sensors.
- **Powerful data analysis capabilities** to generate spectrum maps from a huge amount of data.
- **Fast data processing capabilities** benefiting from cloud computing.
- **A variety of applications** can be implemented based on the spectrum map.
- **In use** by a customer for a major sensor / drive test network for over 6 months

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