Spectrum Monitoring Evolution: 5G and beyond

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5G Spectrum Monitoring Assumptions

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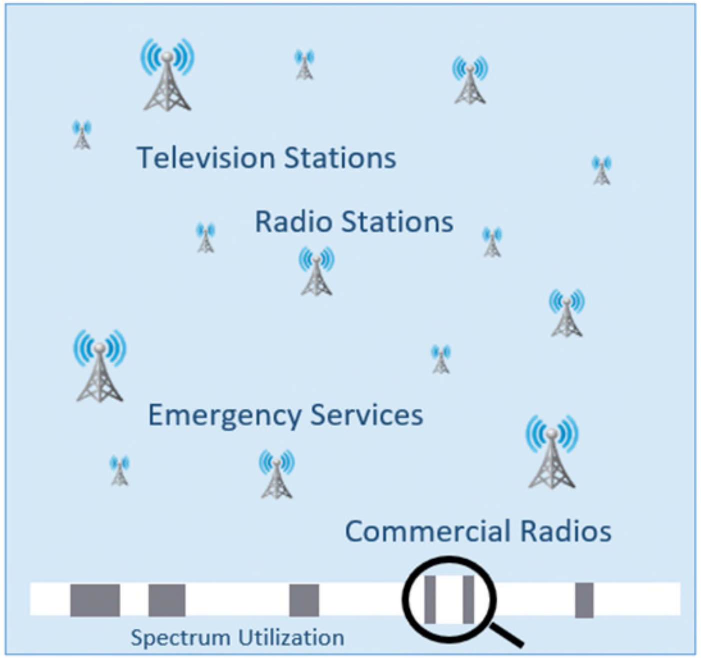

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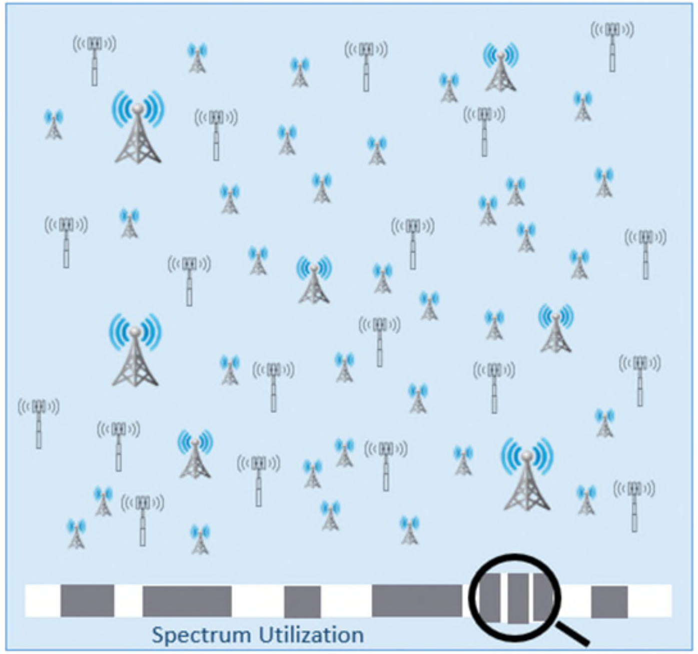


Direction of travel is a relentless drive to use the spectrum more efficiently

Key Assumptions

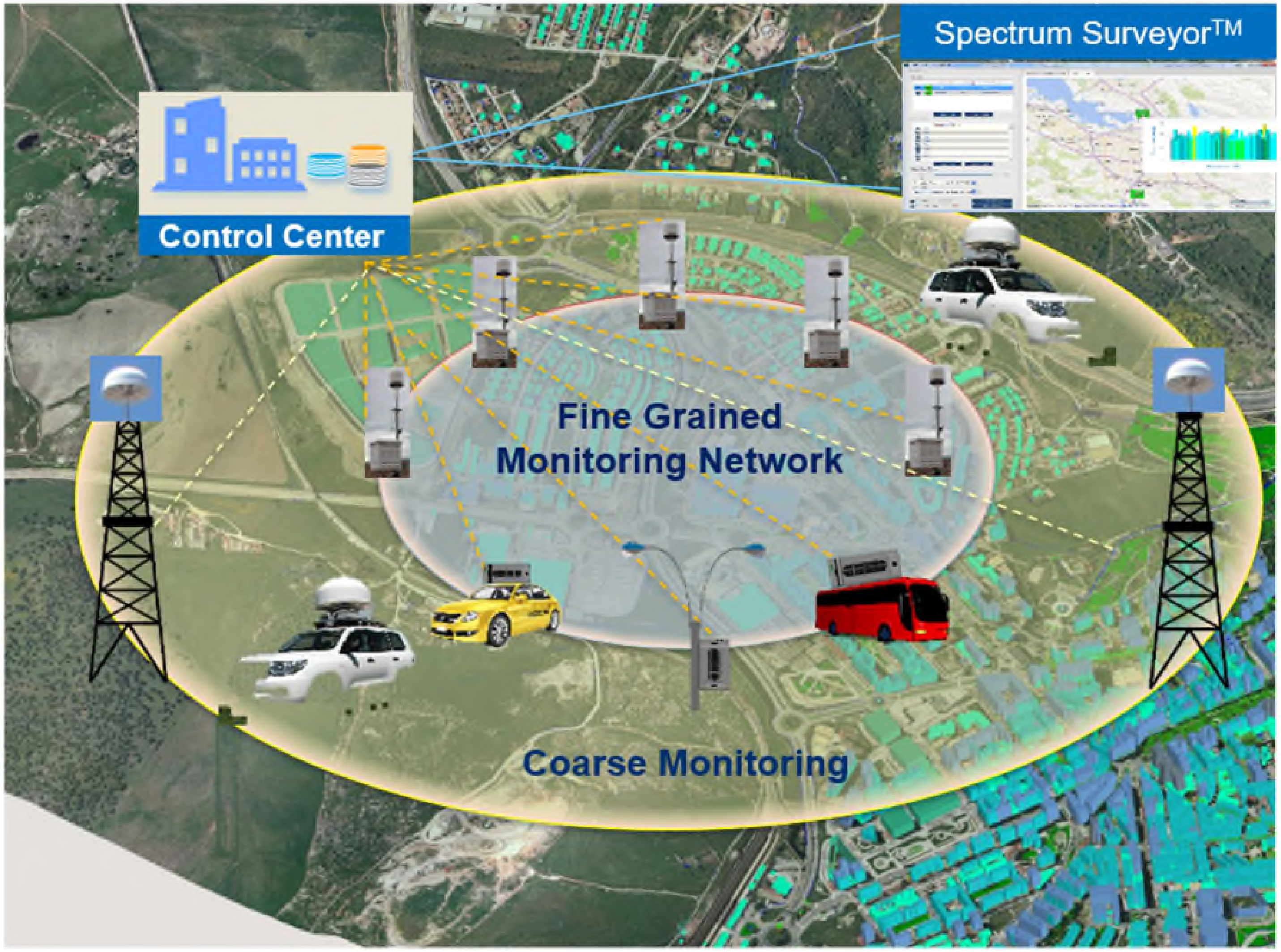
- The RF spectrum will continue to have high power emitters (e.g. radio/TV stations), but there will be many more low-power / directional emitters in the 5G environment
- Monitoring solutions must be modular and scalable to provide economical solutions for national monitoring networks operating at the local level, and over a much large range of frequencies

5G Spectrum Monitoring Assumptions

Key Assumptions

- Existing fixed monitoring systems will continue for monitoring high power emitters and providing broad-scale spectrum occupancy
- Transportable and semi-fixed spectrum monitoring systems required to cover local 5G operations – particularly where public hotspots receive heavy use
- Mobile and portable monitoring solutions required to address more localized 5G spectrum to detect and located low power emitters, and measure local spectrum occupancy
- Spectrum monitoring systems will need to monitor up to 26 - 40 GHz and beyond

5G Spectrum Monitoring – Mesh Networks



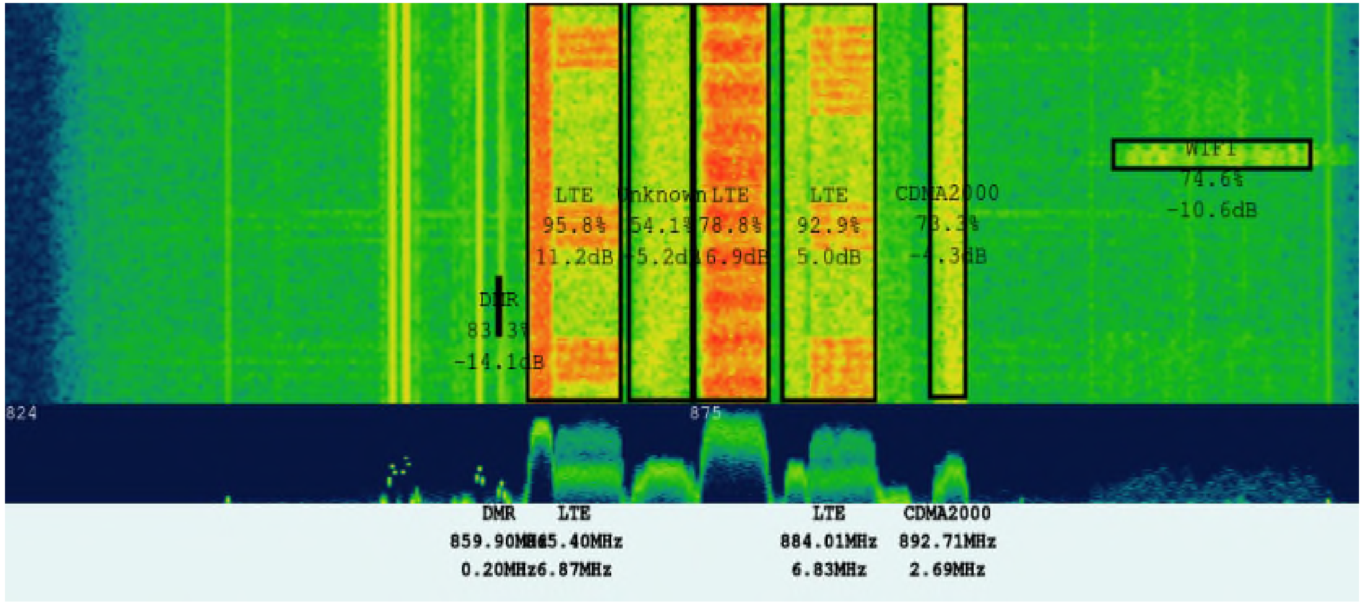
Key Assumptions

- Meshed monitoring networks will become common in the 5G world:
  - Centralized Database
  - Fixed AOA/TDOA stations (8 GHz) – EDGE Processing
  - Mobile monitoring stations (40 GHz) – EDGE Processing
  - Semi-fixed & transportable stations (multiple frequency)
  - Handheld “last mile” systems
  - Localized sensors – feed EDGE Processors

5G Spectrum Monitoring Implications –Artificial Intelligence

Key Assumptions

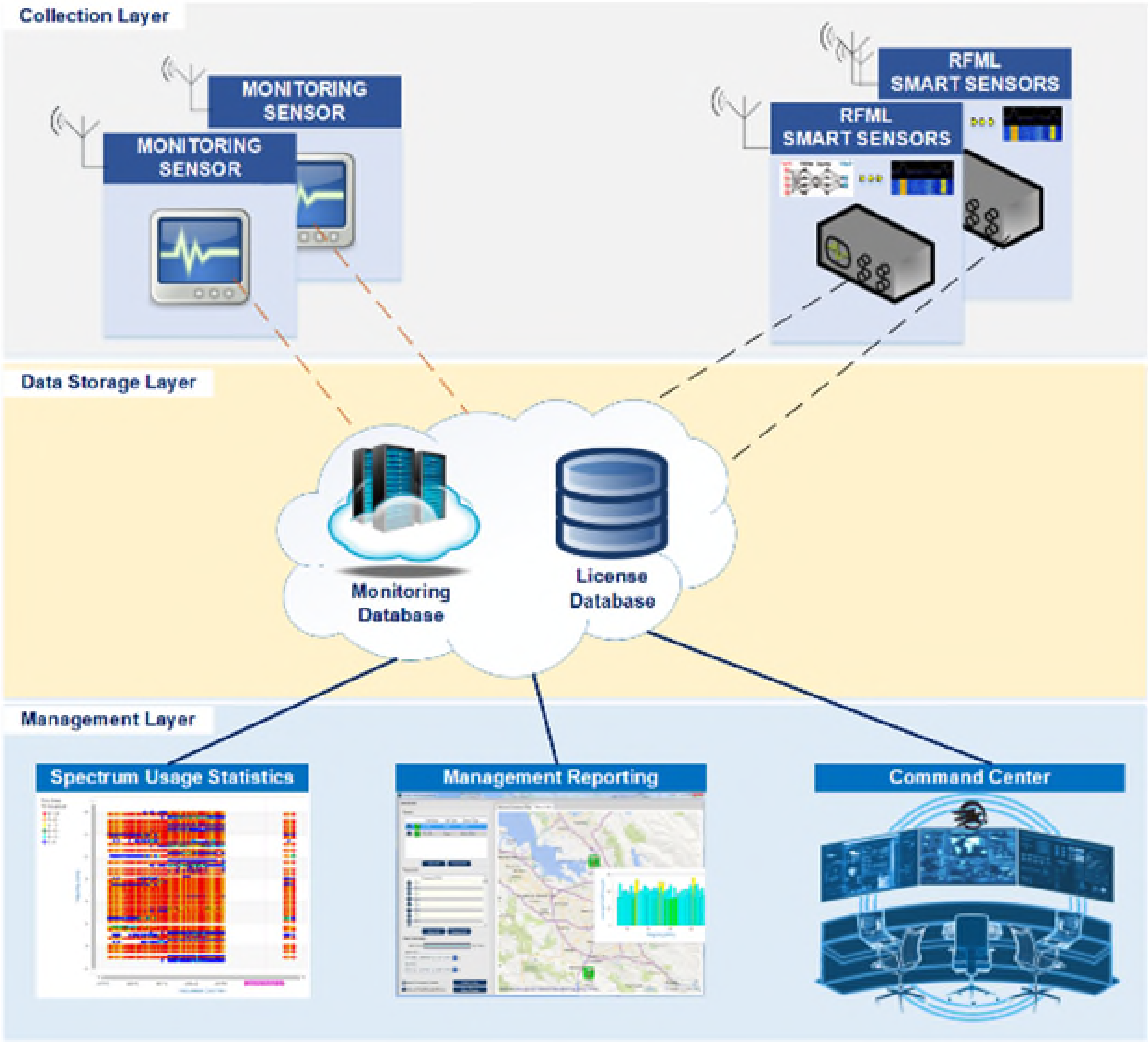
- Artificial Intelligence, particularly in the form of Radio Frequency Machine Learning (RFML), will become a necessity to handle the large volume of signals 5G will bring



Fully automated 24/7 signal detection and recognition from multiple monitoring sites to support:

- Confirmation that licensed protocols are being used
- Interference detection
- Spectrum white space assessment
- Learning new protocols from the data saved in the database – used to train the neural network

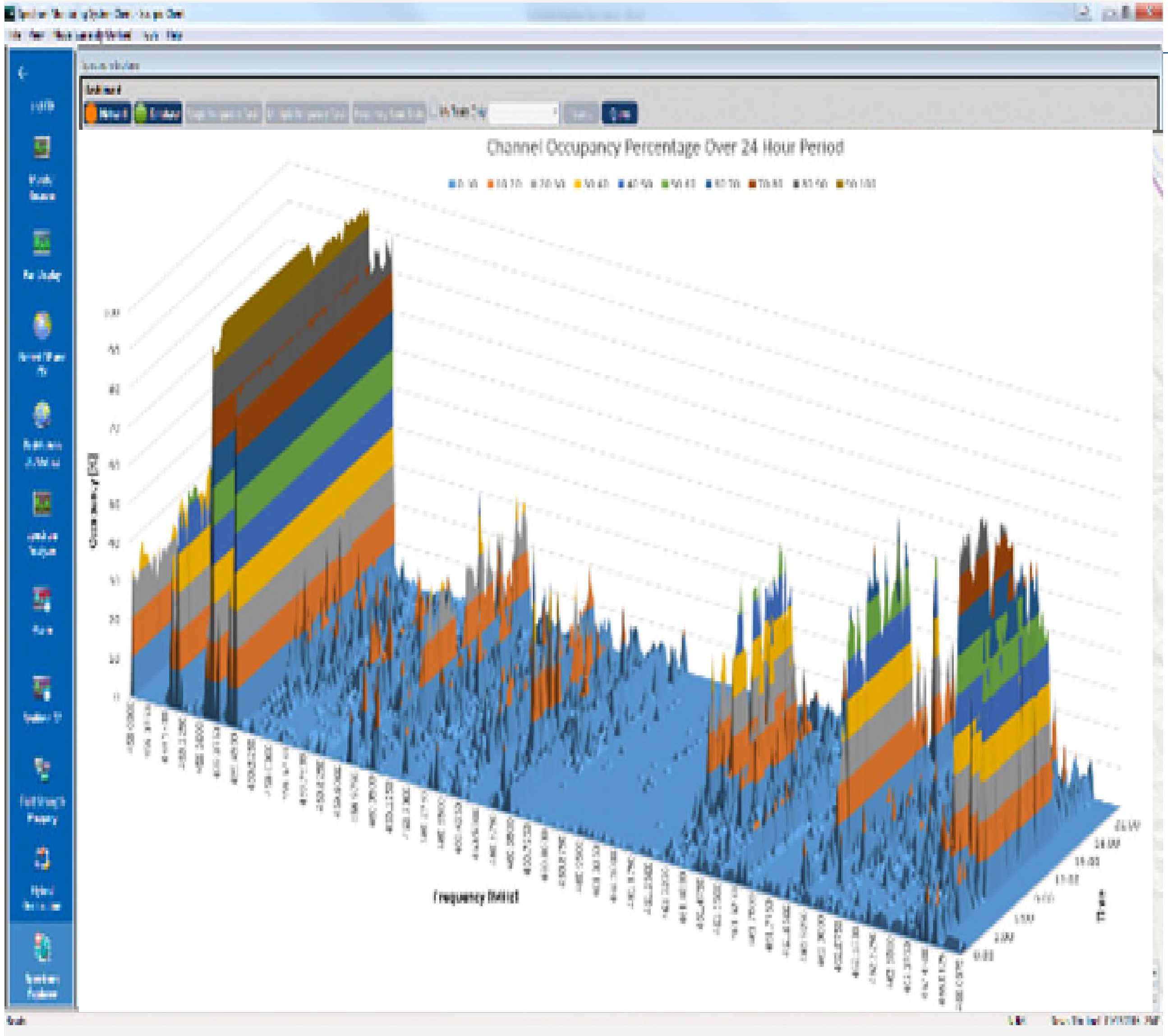
5G Spectrum Monitoring Implications – Layered Mesh Monitoring



Key Assumptions

- SMART Sensors will become the norm: sensors with RFML capabilities will process data at the local level (EDGE Sensors) and avoid large I/Q back haul requirements
- EDGE Sensors will be augmented with large numbers of less-capable secondary sensors to extend geographic coverage in the most economical way
- Some IQ data will still need to go back to control center for further processing
- Centralized databases and analytical tools with real-time dashboards critical

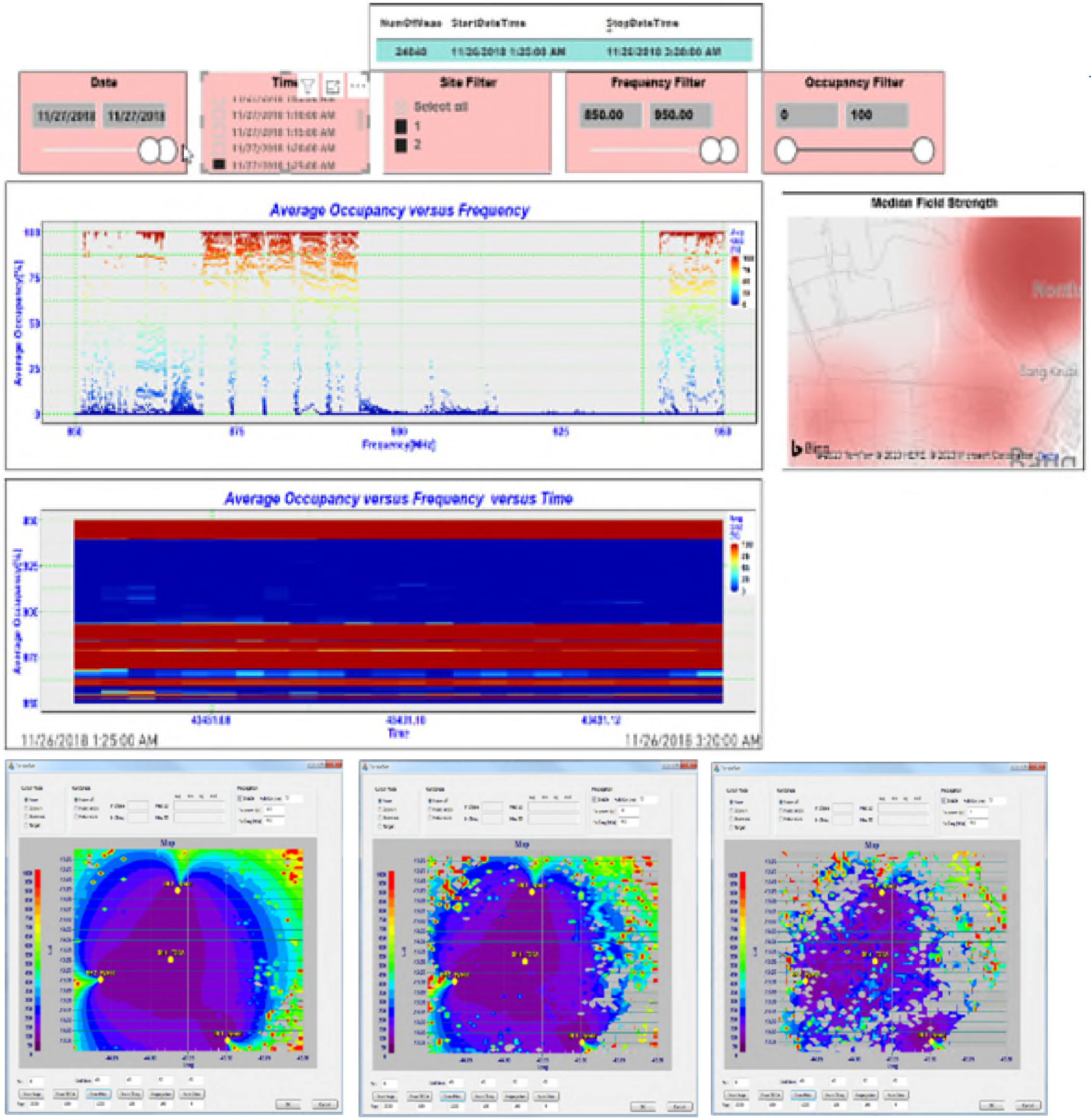
5G Spectrum Management Implications



Key Implications

- Spectrum usage information is only as good as the data provided by the monitoring nodes, requiring dense monitoring networks in urban/suburban areas and mobile systems driving the rural areas, particularly for SHF/EHF bands required for 5G, IOT, Smart Cities/Islands initiatives
- New monitoring tools such as Spectrum Surveyor provide centralised data for spectrum managers limited only by sensor reach
- Spectrum occupancy becoming one of the most important measurements to enable more efficient spectrum allocation at some local levels
- Data reduction, fusion, analysis of huge volumes of data into occupancy, coverage and geolocation blocks – edge/cloud computing solutions – data analytics

5G Spectrum Management Big Data Implications



Key Assumptions

Increasing the automaticy in collection measuring data from the monitoring stations

Developing intuitive mapping tools to visualise current and historical spectrum usage, showing coverage areas, interference areas, unused frequencies

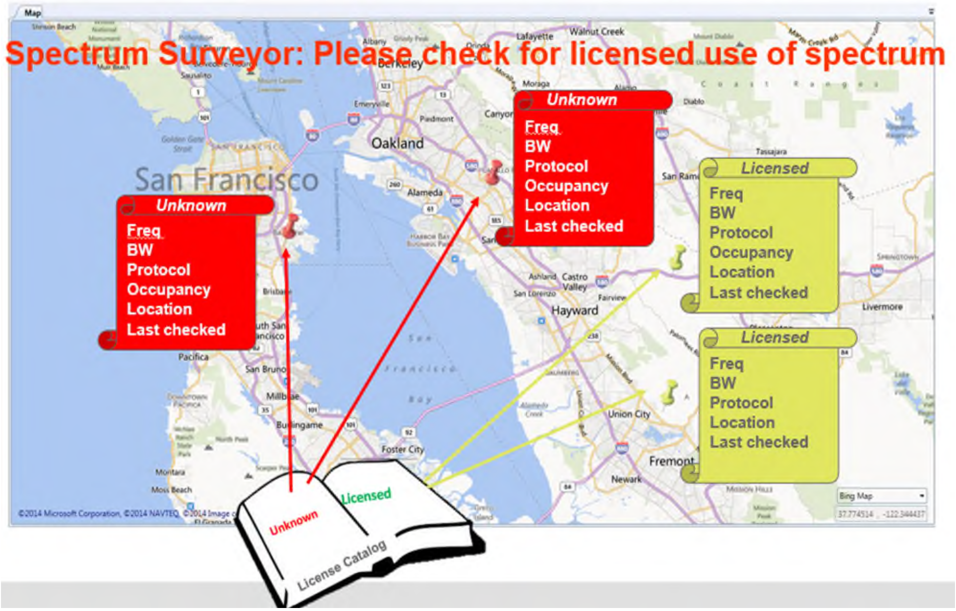
Applying AI (artificial intelligence) and ML (machine learning) techniques to learn the spectrum environment

- Automated intelligent interference and geolocation alerts with signal recognition
- Automated spectrum reports and maps of unused and under-used frequency bands
- Interfaces to automated frequency assignment systems

5G Spectrum Management Implications – Integrating with Spectrum Management Databases

Modern spectrum management systems/databases hold much information about spectrum users, frequencies, licences, fees, interference complaints, etc.

- Management reports and dashboards automatically produced
  - KPIs, applications pending, licences issued, fees collected
- Integrating monitoring data allows trend analysis to report on
  - Frequency bands becoming congested
  - Frequency bands under-utilised and empty
  - Refarming exercises prior to auction
  - Effectiveness of pricing mechanisms
  - Customer/licensee analysis
  - Compliance issues – licensed spectrum parameters, coverage
  - Detecting unlicensed use, revenue generation and protection
  - Interference issues – identifying and geolocating



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Thank you!