

ATDI

ICS MONITORING SDRN CONTROL ON THE PATH TO COGNITIVE EW

Advanced Spectrum Monitoring Software



ATDI SA

11 boulevard Malesherbes

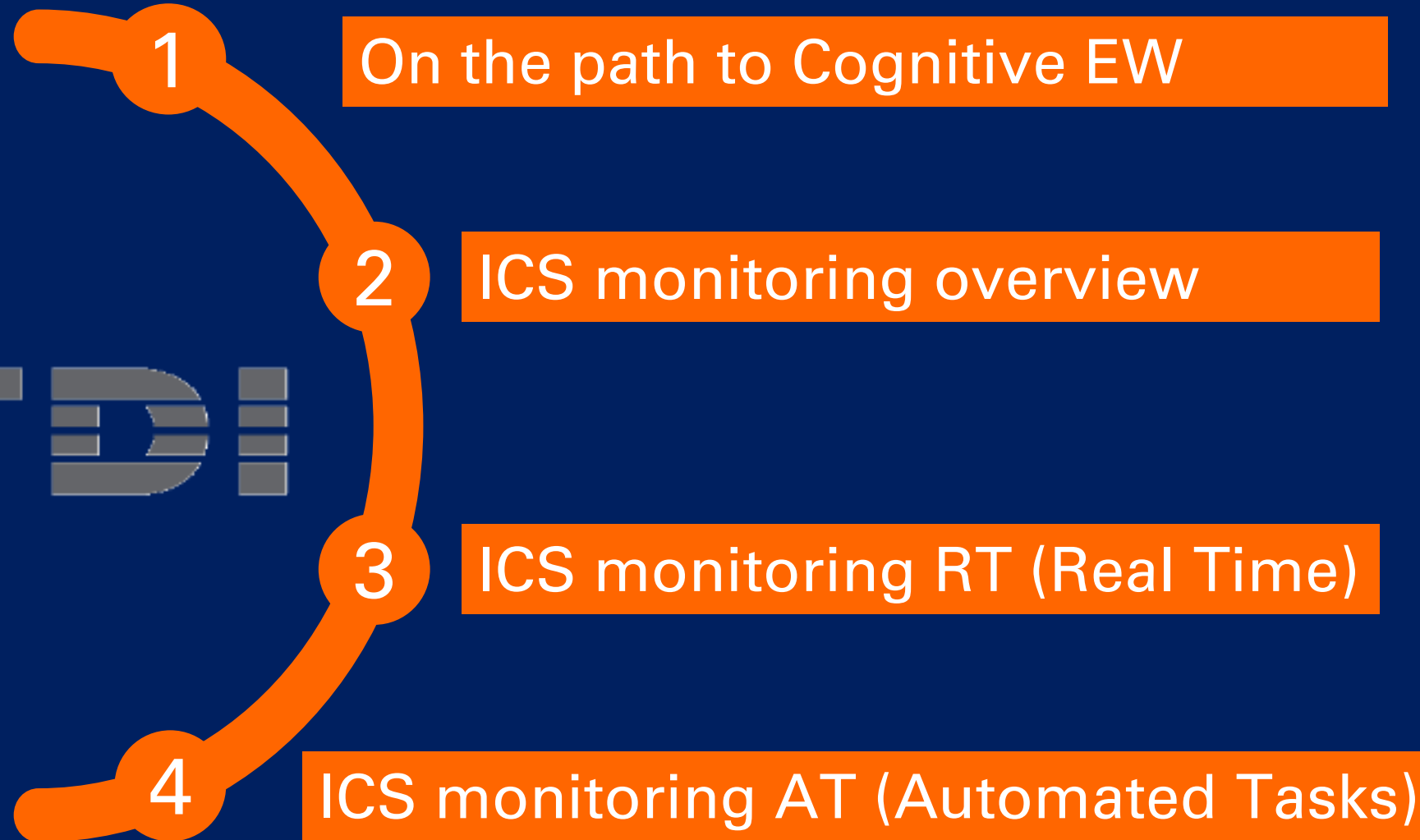
75008 Paris

FRANCE



ICS MONITORING

ADVANCED SPECTRUM MONITORING SOFTWARE PLATFORM

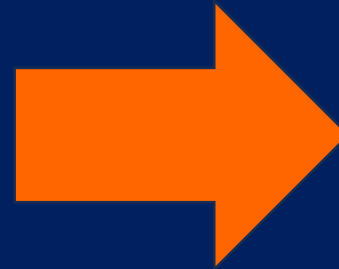


Approach to secure the
electromagnetic space: from assets
management to cognitive EW



MODERN EW CHALLENGES

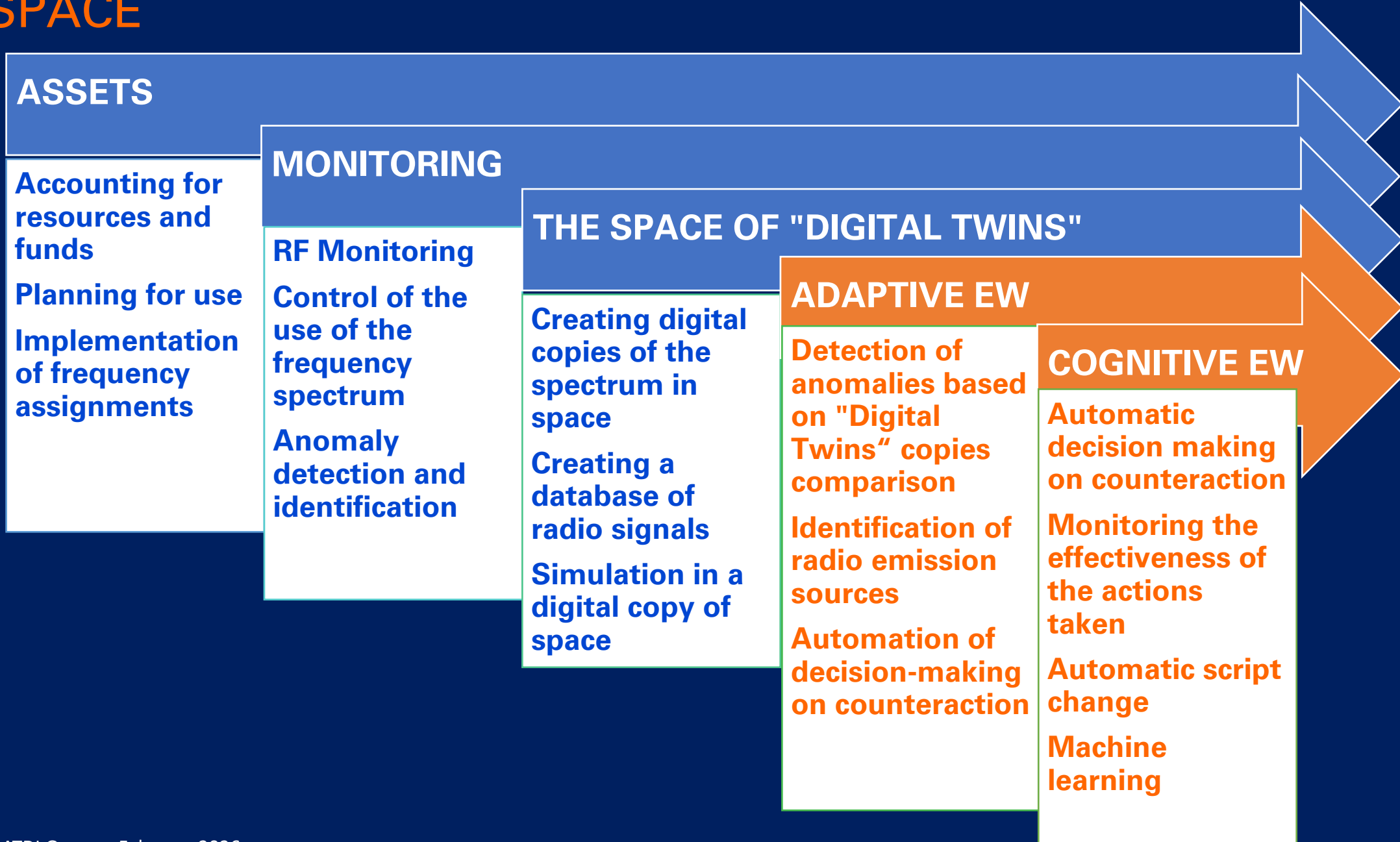
- **Very high number of simultaneous and changing threats in space/time/frequency/technology**
- **Fully occupied frequency band from 30 MHz to 8 GHz**
- **Signals with bandwidth up to 200 MHz**
- **Frequency hopping and direct spread spectrum systems**
- **Usage of a global country wide mesh communications systems between enemy drones**
- **Camouflage of military-use networks as civilian networks**
- **Low trust information about enemy EW equipment**



Need for a system that allows flexible and rapid sharpening of focus on specific threats here and now



APPROACH TO SECURE THE ELECTROMAGNETIC SPACE



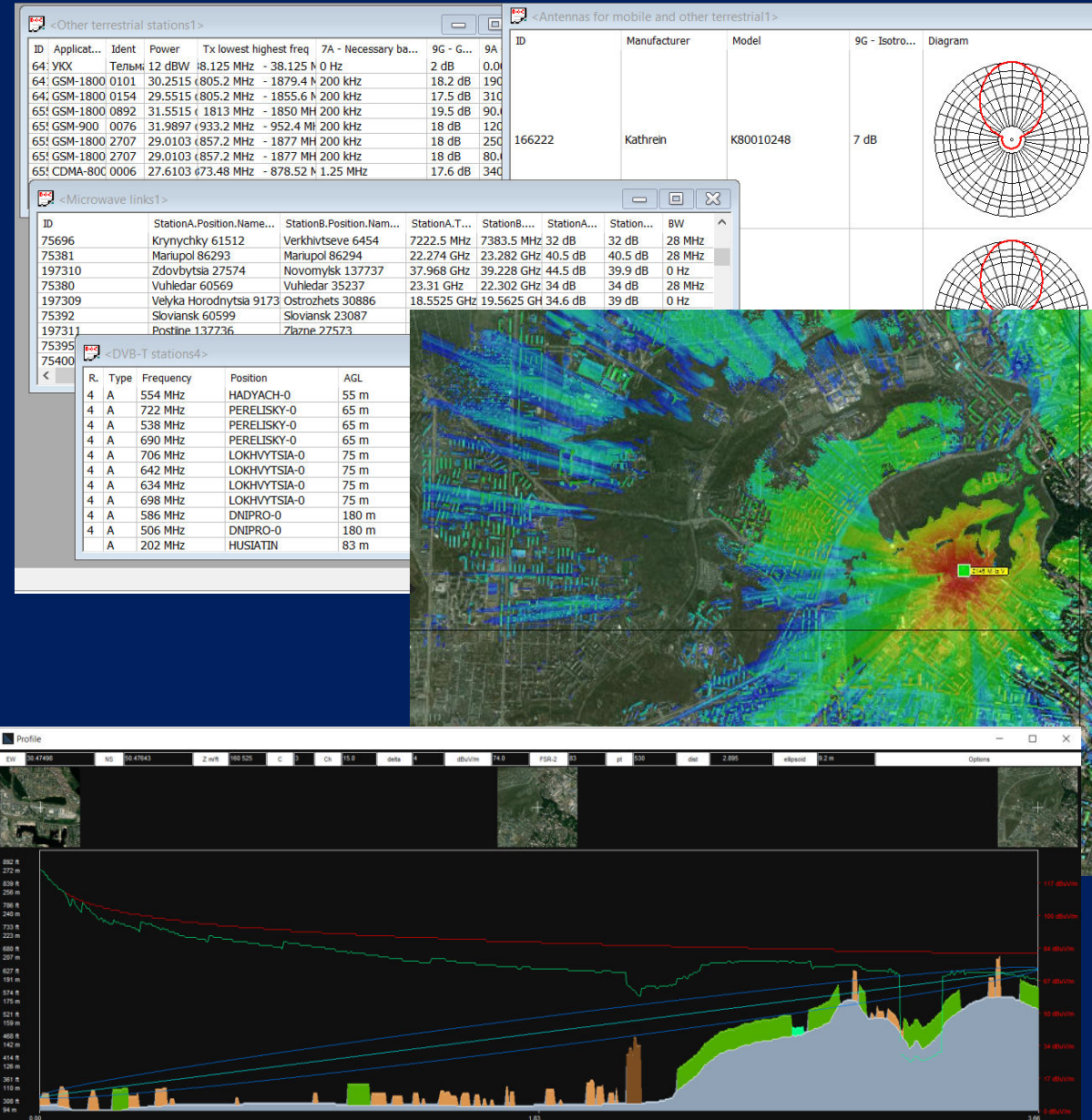
STEP 1: ESTABLISHING THE ELECTROMAGNETIC BASELINE

Includes:

- Database of own radio assets and spectrum assignments
- Tools for modeling nominal radio-system performance
- Digital terrain and environmental data

Enables:

- Planning of frequency usage and radio-assets deployment
- Prediction of how our systems *should* appear from any observation point
- Reference layer for comparing nominal vs. real behavior in later stages of cognitive EW



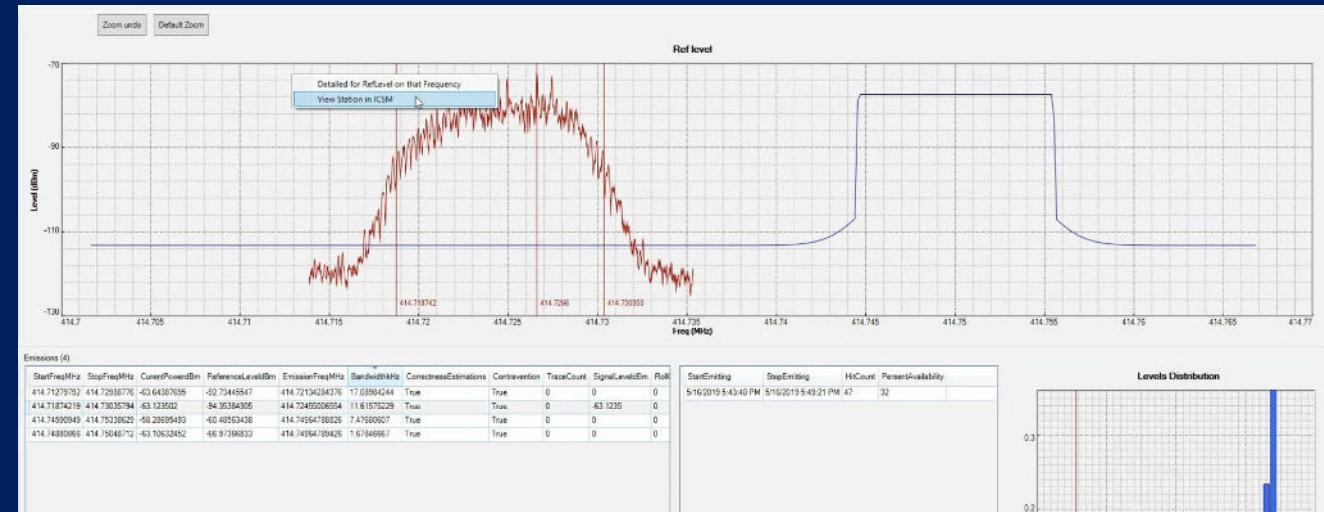
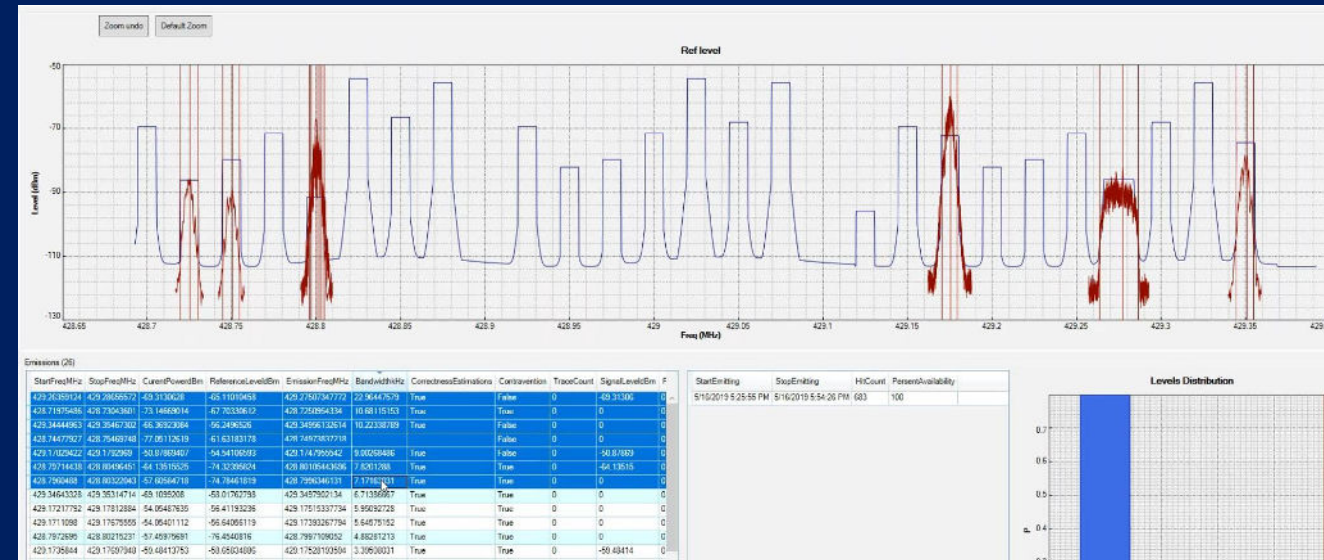
STEP 2: TERRITORY-WIDE SPECTRUM MONITORING

Includes:

- Continuous 24/7 monitoring across all frequency bands
- Distributed network of wideband sensors deployed across the country
- Collection of long-term statistics for every band, channel and service
- Comparison of measured signal levels against expected operational ranges

Enables:

- Full territorial assessment of spectrum usage
- Early identification of abnormal or unexpected signals
- Verification that own systems operate within planned parameters
- Reliable statistical foundation for further analysis in cognitive EW



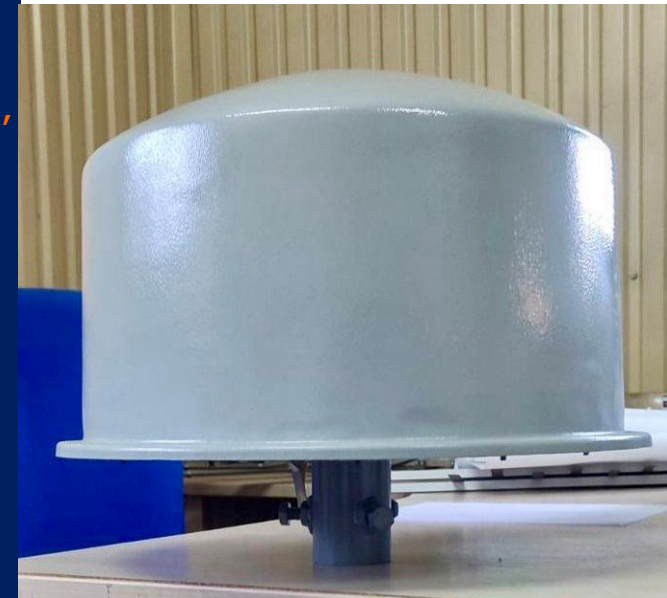
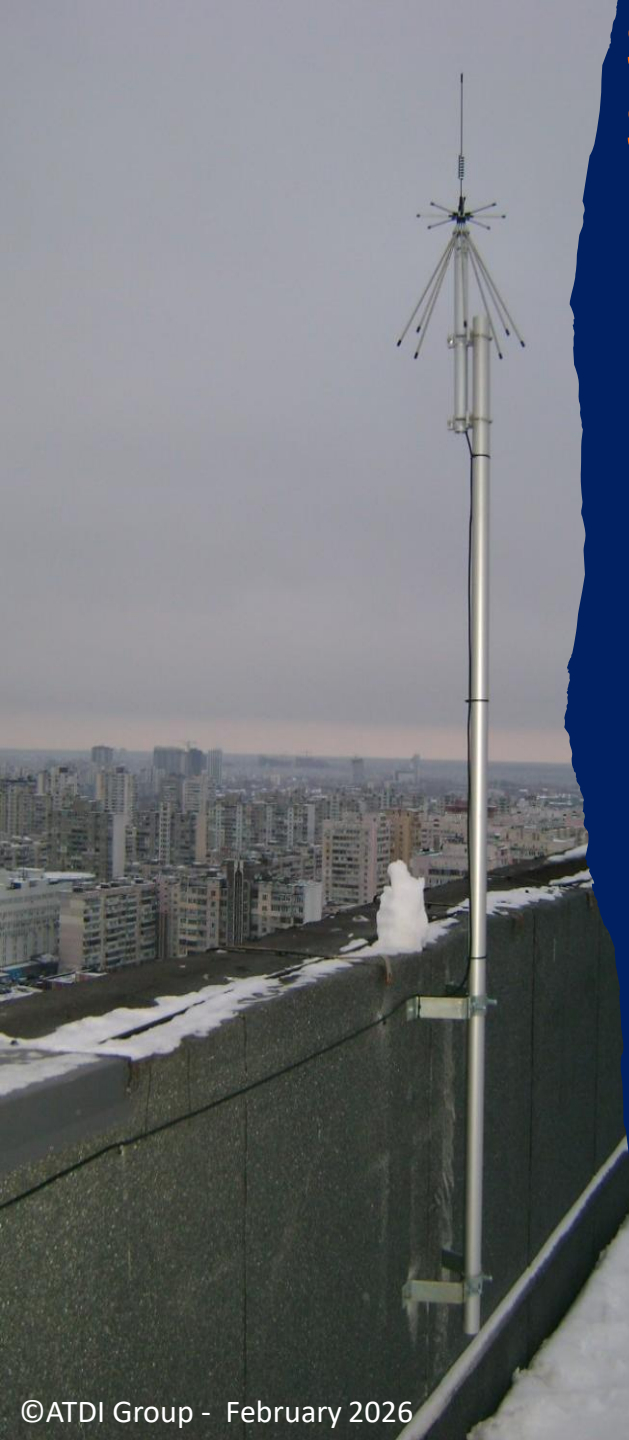
STEP 2: SPECTRUM-MONITORING SENSOR NETWORK

Includes:

- Mission-driven planning of a nationwide monitoring network based on specific threat profiles (PMR/LMR, tactical radios, UAV video/control links, radars, aviation comms, etc.)
- Coverage modeling for each technology/band using digital terrain data, propagation environment and equipment characteristics
- Selection of sensor installation sites based on required coverage, terrain constraints, infrastructure availability and operational considerations
- Preparation for deployment, including recommended locations, equipment configurations and connectivity requirements

Enables:

- A complete deployment-ready sensor network design aligned with operational threats and missions
- Verified coverage for each monitored technology under real geographic conditions
- Clear identification of territories where each threat type can be reliably detected



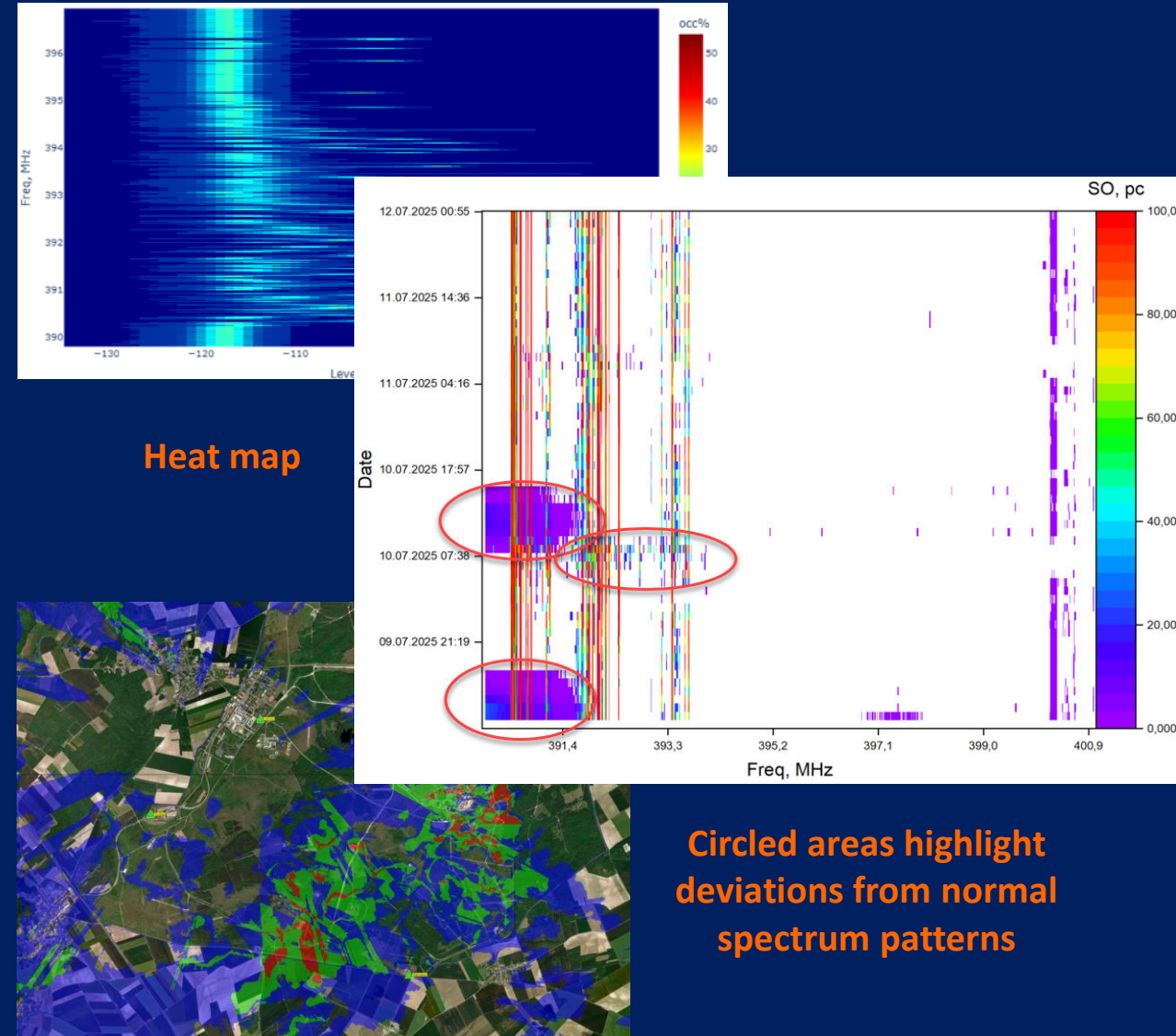
STEP 3: "DIGITAL TWINS" OF THE SPECTRUM

Enables:

- Understanding in which frequency bands and locations abnormal changes occur
- Identification of zones with potential threat concentration and/or emerging emitters
- Localization of areas of probable electromagnetic influence and assessment of their dynamics
- Establishing a foundation for advanced stages of cognitive EW (risk assessment, forecasting, recommendations)

Includes:

- Formation of temporal and statistical models of signal levels in each channel based on periodic measurements (heatmaps)
- Extraction of stable behavioral patterns of radio services across the spectrum
- Detection of deviations from established patterns in new measurements (anomaly detection)
- Building a digital representation of the spectrum that reflects normal and expected activity in every frequency band



Heat map

Circled areas highlight deviations from normal spectrum patterns

Probable geographic distribution of the detected anomaly



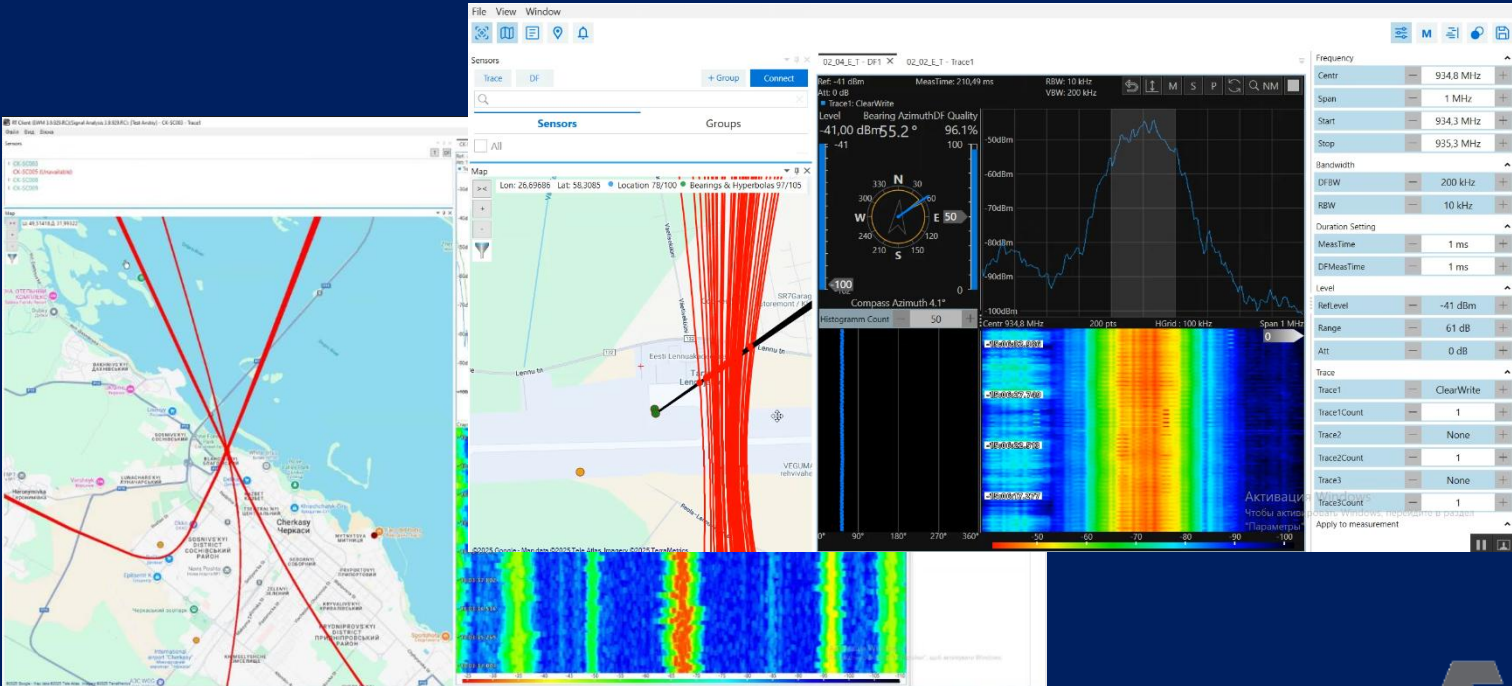
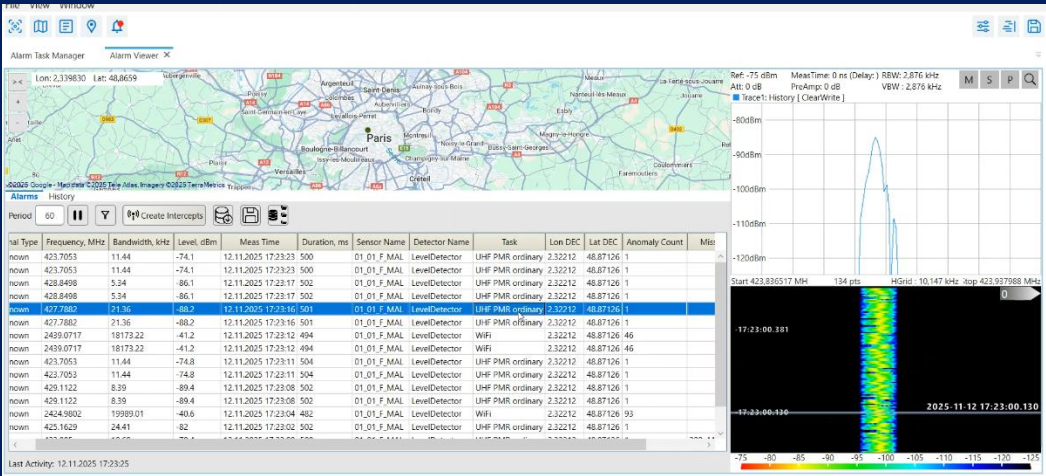
STEP 4: ADAPTIVE EW (REAL-TIME DETECTION & LOCALIZATION)

Real-time Alarming

- Automatic detection of new or unexpected emissions in the required frequency band
- Instant classification and operator notification

Localization

- High-accuracy emitter localization using TDoA (≈ 30 m)
- Hybrid AoA + TDoA localization supported
- Providing exact coordinates for EW response

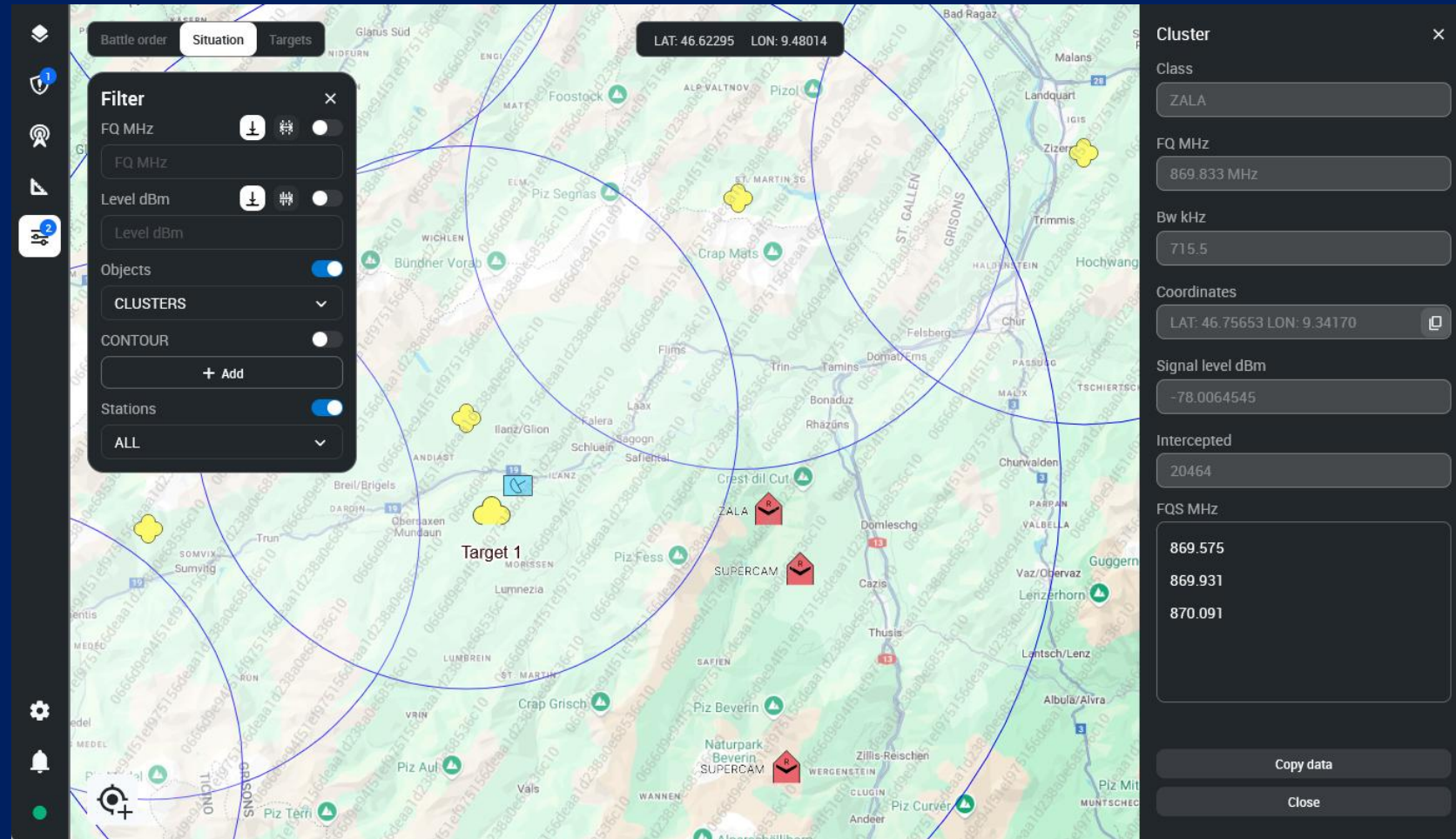


STEP 4: ADAPTIVE EW (ELECTRONIC WARFARE MAP)

Alarming System allows to automatically detect the signals
Need to depict them on the map
i.e. the system that provides situational awareness

Data fusion approach: objects of different nature obtained from different sources in the single interface in real time

- Signal clusterisation
- Signal classification
- Signal identification



To enable the classification of a signal source, many attributes of the detected signal are taken into account: measurement time, signal duration, signal cascade record, signal center frequency, bandwidth, and others.



STEP 5: COGNITIVE EW

Cognitive EW systems can:

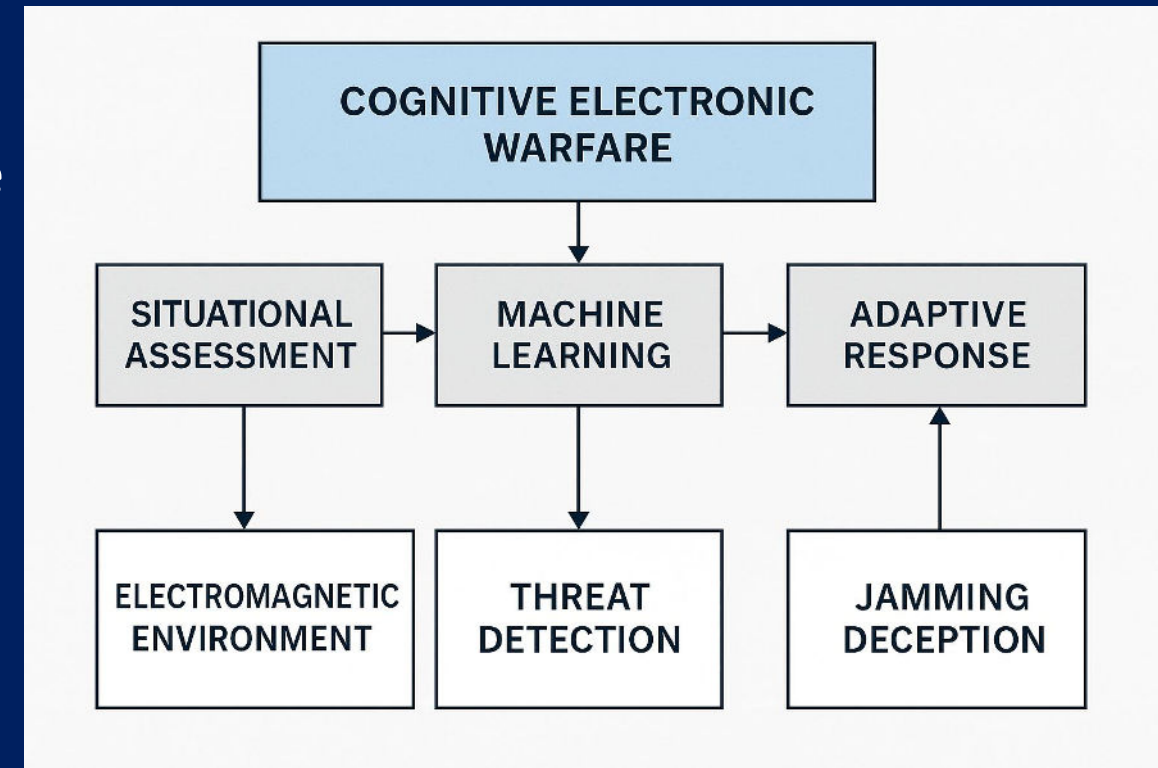
- Analyse the electromagnetic environment in real time using a continuously updated **knowledge base**
- Detect unknown or abnormal signals that fall outside established patterns
- Automatically choose the best countermeasure
- Adapt to enemy tactics through continuous learning

Knowledge Base includes:

- Digital-Twin spectrum models
- Historical activity patterns & anomalies
- Threat libraries
- EW response rules

Operational Cases:

- **Missile strike indicators** — surge in aviation comms prior to attack
- **Pre-attack radio silence** — disappearance of regular emitters

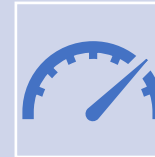


ICS MONITORING KEY FUNCTIONS

- Ability to integrate and support heterogeneous monitoring equipment
- Multi-service software architecture
- Software scalability
- Performing multiple tasks at the same time
- Personalization of workflows
- Localisation of transmitters (AOA analysis methods, TDOA, RSSI...)
- Automation and centralization of emissions identification (based on correlation analysis on a central server)
- Analysis of interference and unlicensed emissions
- Analysis of emission compliance with the frequency allocation conditions
- Centralized storage of measurement data and measurement results



INSPECTIONS



MONITORING



**SPECTRUM
EFFICIENCY**



ICS MONITORING: REAL TIME AND AUTOMATED TASKS

ICS monitoring is a software that provides advanced numerical and graphical analysis capabilities for spectrum and signal measurements.

The tool consists of the following software subsystems (which can be used separately or together):

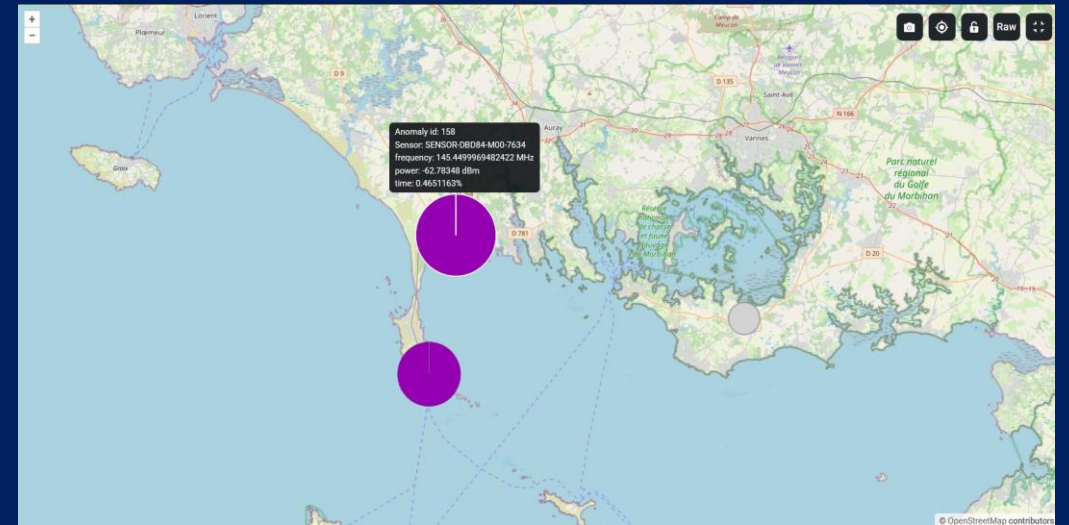
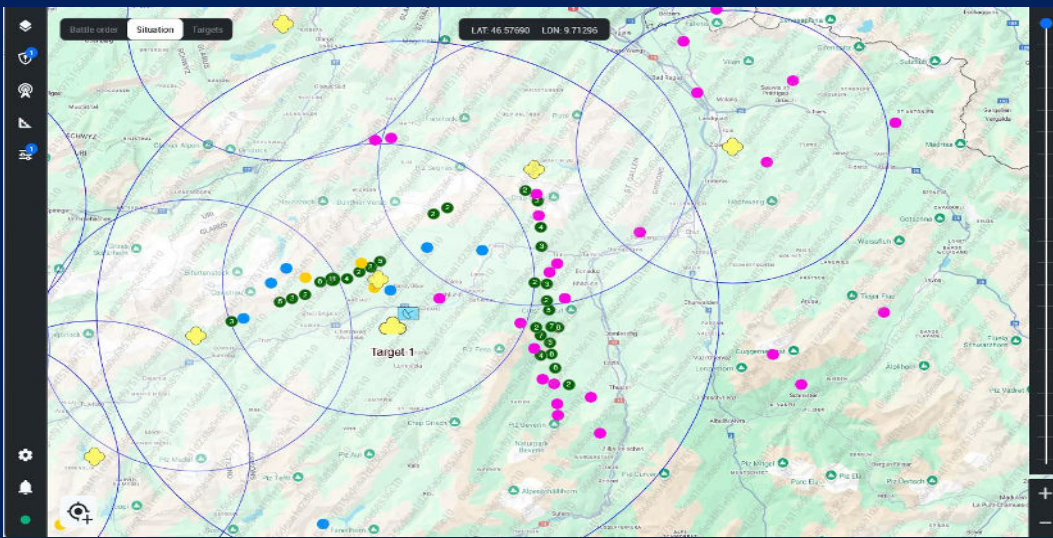
ICS Monitoring RT stands for real-time measurements

- Spectrum and signal analysis
- Alarming
- Signal classification
- Localisation
- Electronic Warfare Map (EWM)

ICS Monitoring AT stands for automatic long-term aggregate measurements

- Checking compliance with the conditions of assignment of frequencies
- Automated violation detection
- Frequency bands usage
- Channels occupation
- Study of interference cases
- Search for unauthorised emissions
- Localisation of emissions

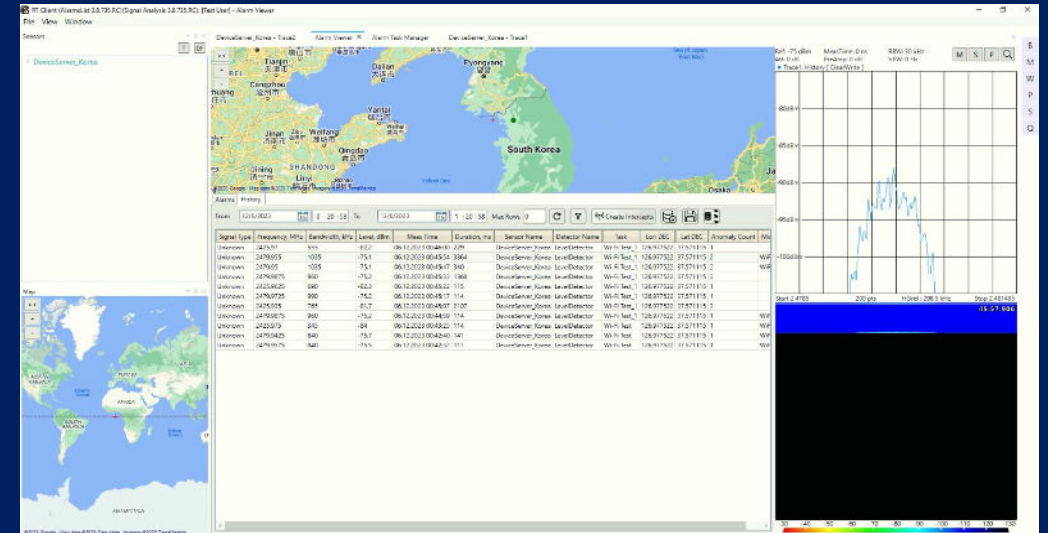




ICS monitoring RT

Real-Time Spectrum Analysis and Signal Localisation

Electronic Battle Management System



ICS MONITORING RT KEY ADVANTAGES

- Standardisation of measurement processes in a multi-manufacturer spectrum control system
- Complete vertical integrated solution:
 - Battlefield Level (Spectrum Analysis)
 - Tactical Level (Alarms)
 - Tactical-Operative Level/Electronic Battle Management System (Electromagnetic Environment/Electronic Warfare Map)
- Processing (statistics/big data/AI) of large volumes of data:
 - Real-time system example: 150+ DFs, 5 000 000+ interceptions/minute
 - Automated observation system example: 700+ sensors connected 24/7
- Integration with HTZ prediction system for continuous comparison of measurements vs. prediction and reverse simulation

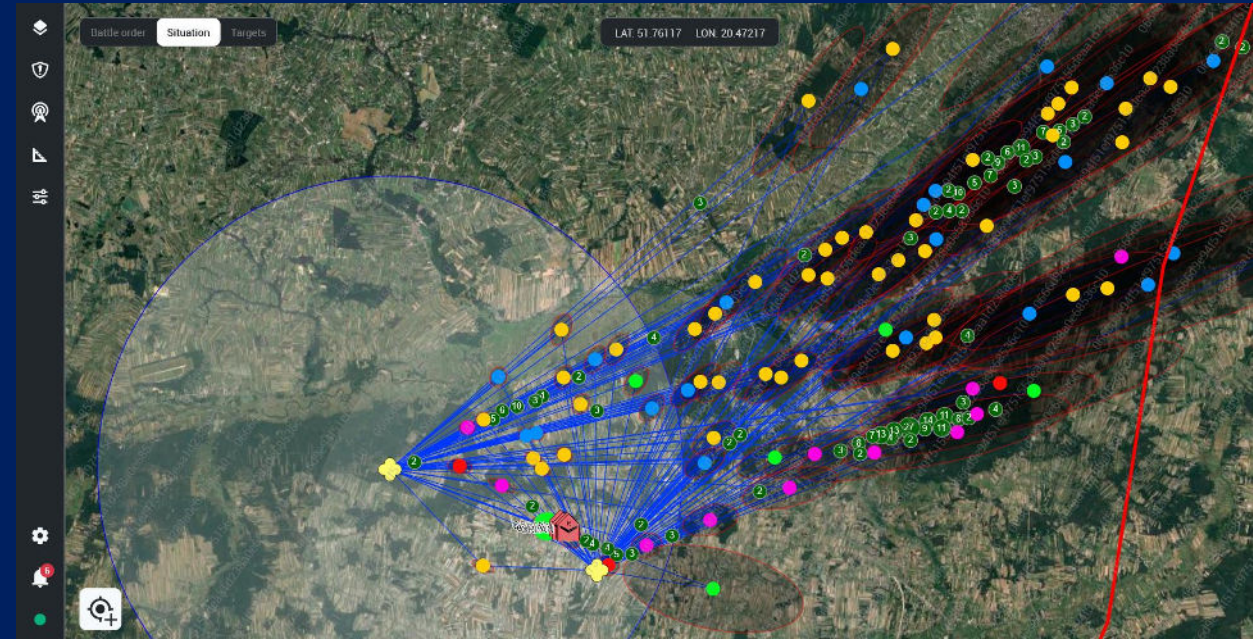


ICS MONITORING RT

Real-time mode provides a direct interface to the device and allows to perform instant tasks, which are executed and analyzed by a user.

The list of real-time measurements supported by **ICS MONITORING RT** includes the following:

- Spectrum observation
- Direction finding
- Recording of spectrum traces/waterfalls as image or as a text file
- IQ stream recording
- Alarming
- Managing white and black lists of signals in real time
- Localising (AoA/TDoA/PDoA) selected signals and viewing them on the map



- Clustering signals
- Classifying objects
- Identifying targets
- Supporting military activities at a battlefield in real time

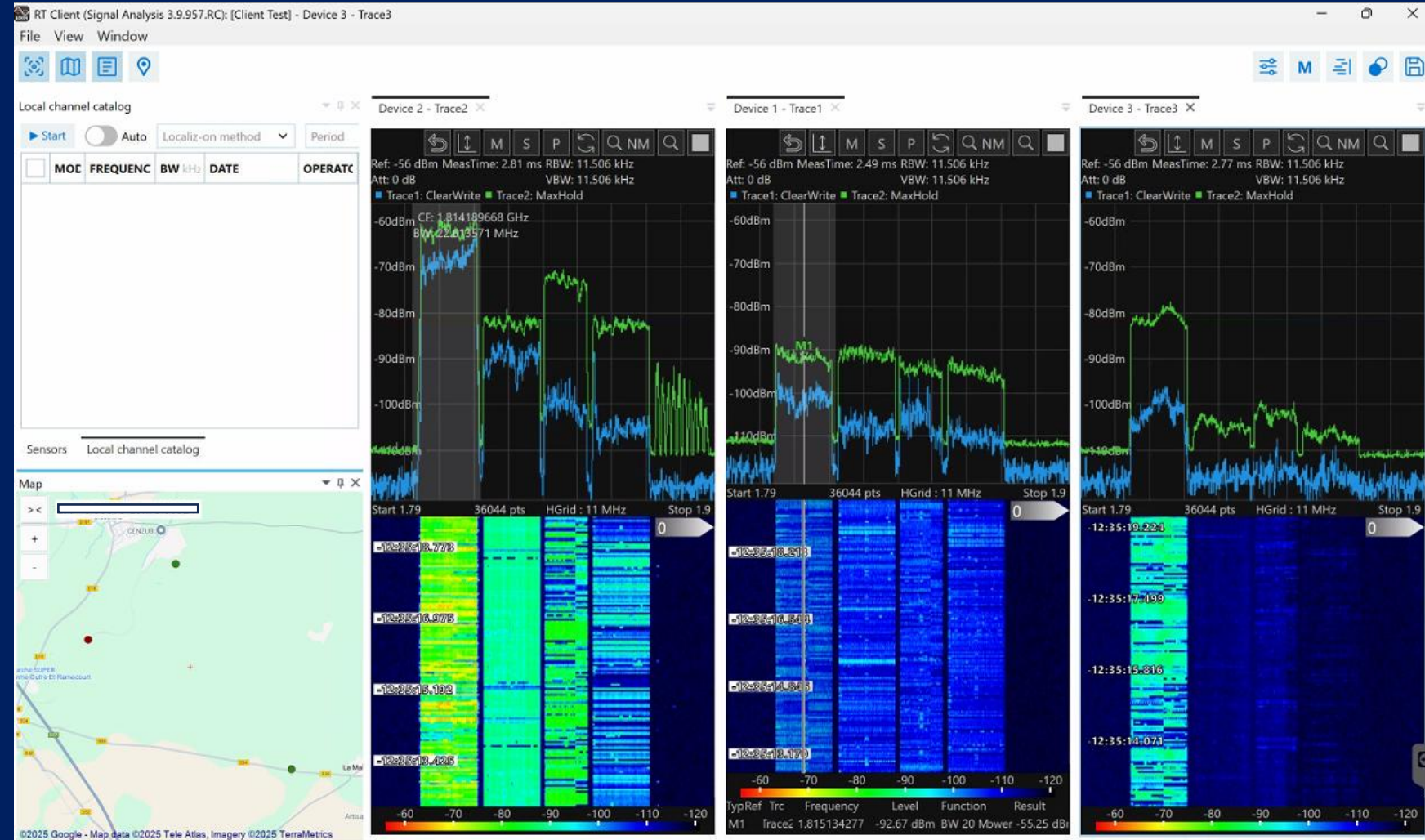


ICS MONITORING RT: SPECTRUM ANALYSIS

Spectrum Analysis

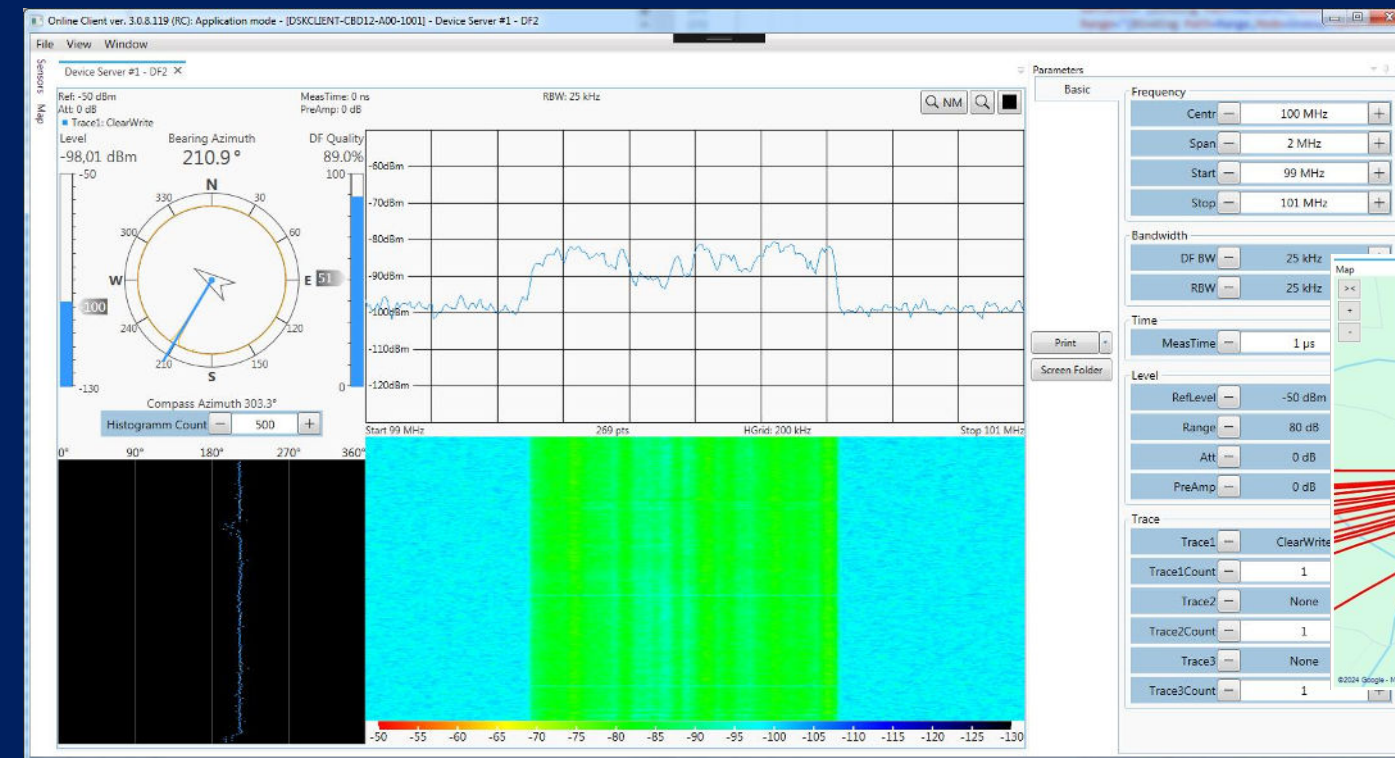
capabilities of the system allow to perform spectrum measurements and operation

- IQ stream recording
- Network analysis (constellation diagram calculation)
- Channel Scan (automatic channel measurements)
- Localisation (TDOA) and Direction Finding

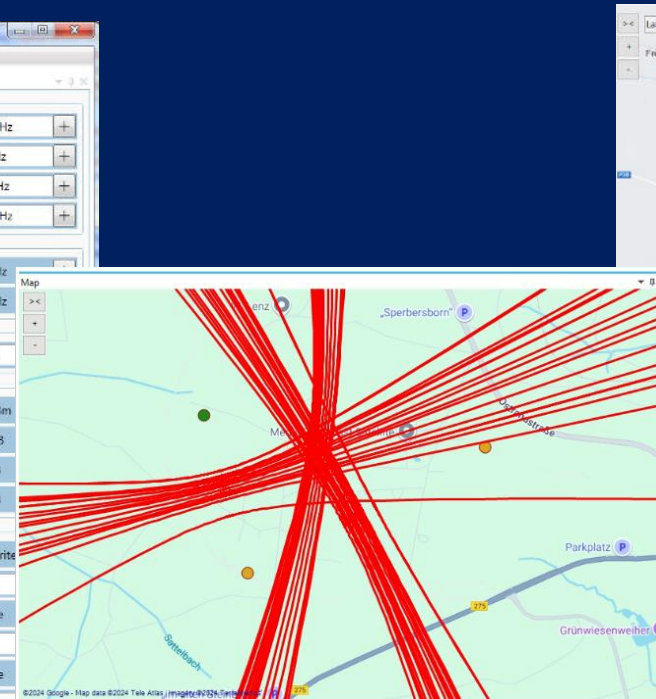


ICS MONITORING RT: LOCALISATION

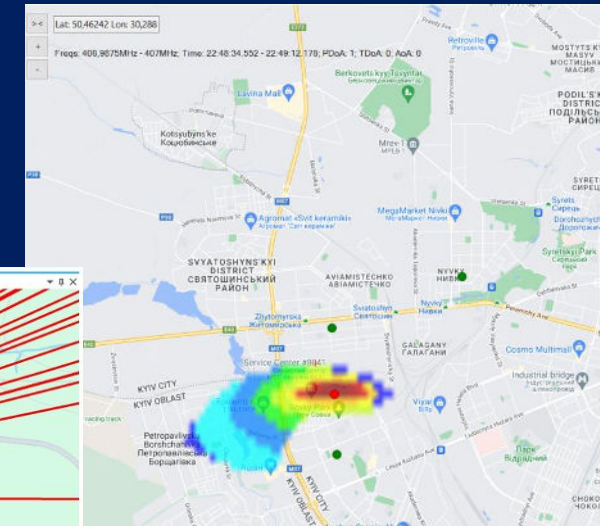
Three methods of localisation are available: PDoA (Power Difference of Arrival), TDoA (Time Difference of Arrival) and AoA (Angle of Arrival). Besides that, bearings can be added manually to the list of localization results to be used in localisation procedure.



Direction finding



TDoA localisation

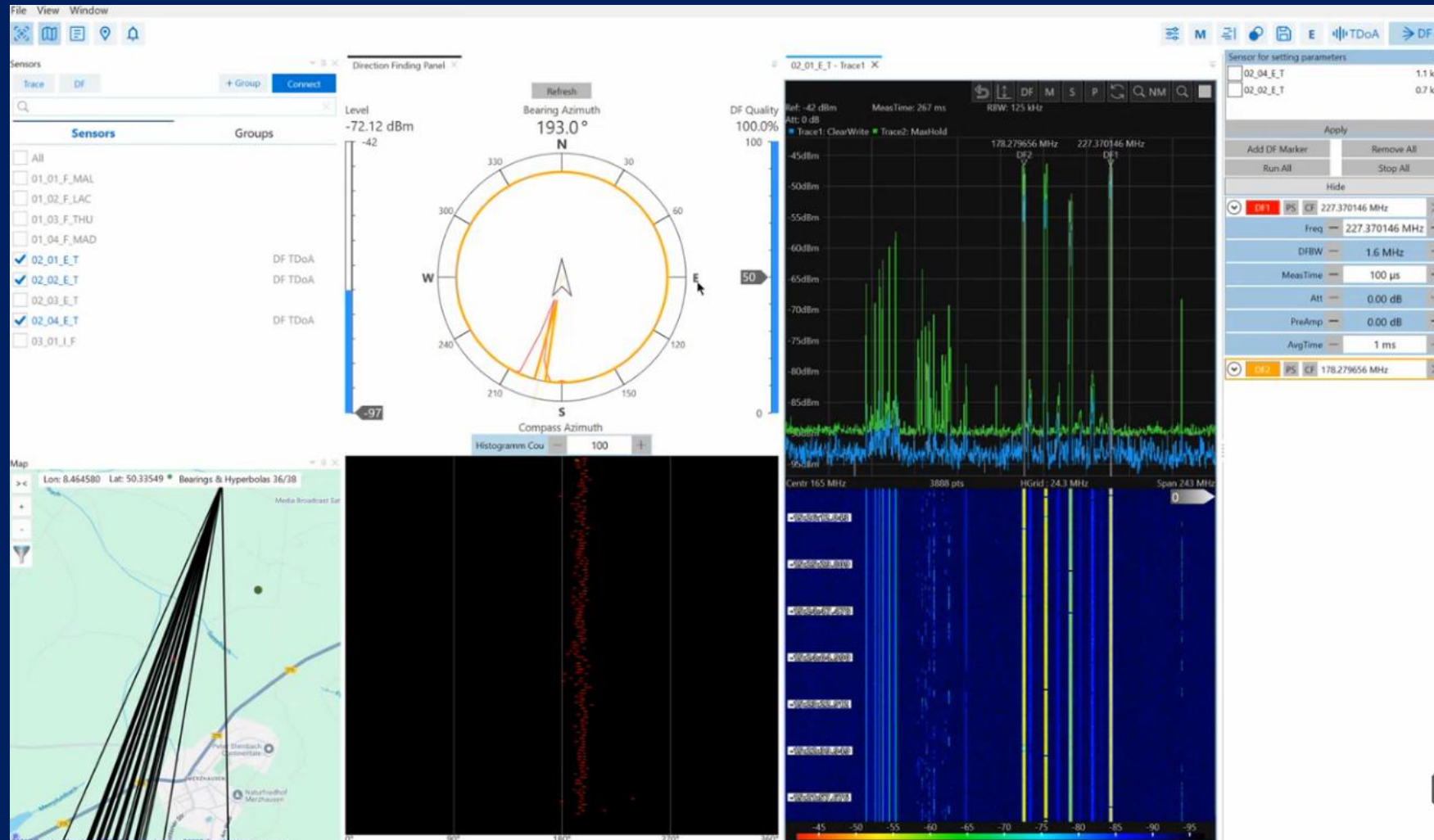


PDoA
localisation



ICS MONITORING RT: DIRECTION FINDING

Three methods of localisation are available: PDoA (Power Difference of Arrival), TDoA (Time Difference of Arrival) and AoA (Angle of Arrival). Besides that, bearings can be added manually to the list of localization results to be used in localisation procedure.

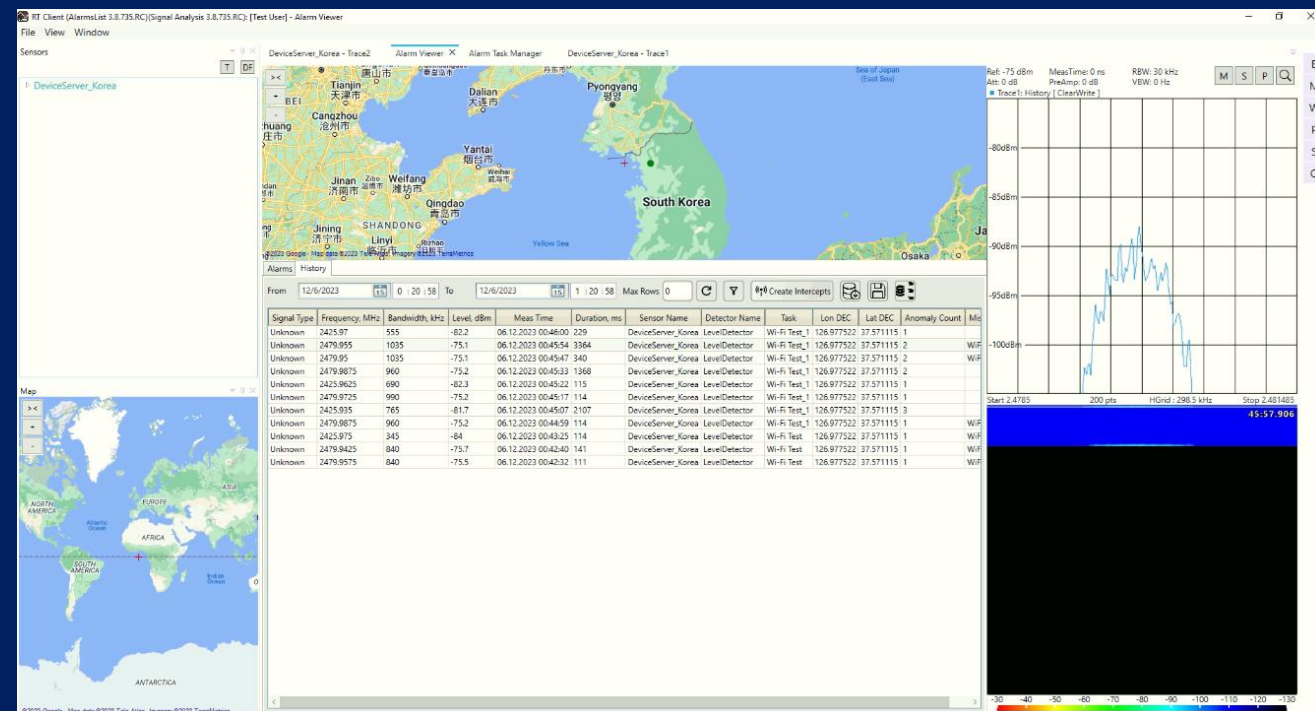


ICS MONITORING RT: ALARMING

Alarming is set of functions aimed at watchkeeping. It allows a user to detect all the cases when specified criteria were fulfilled, record the signal and store it for subsequent analysis.

An alarm is triggered when a specified alarm level is exceeded at any frequency within specified frequency band. The list of alarms can be viewed at “Alarm Viewer” tab. If several sensors are connected, it is useful to see the list of alarms directly on the map by hovering the sensor mark (green circle). List of alarms can be filtered and ordered by any field in the list.

For each alarm, a piece of received spectrum information during the defined period of time is automatically recorded. To examine an alarm information, a user can browse through the recorded waterfall section and export this information to a file.



ICS MONITORING CLIENT RT supports white and black lists of signals.

If a signal has no or “grey” status, it is always shown on the list of alarms. If a signal was marked as “Ignored”, it is never shown on the list of alarms. If a signal was marked as “Base”, it will also be shown on the top of the alarm list and highlighted, since this status is used for the most important signals that shall not be missed.



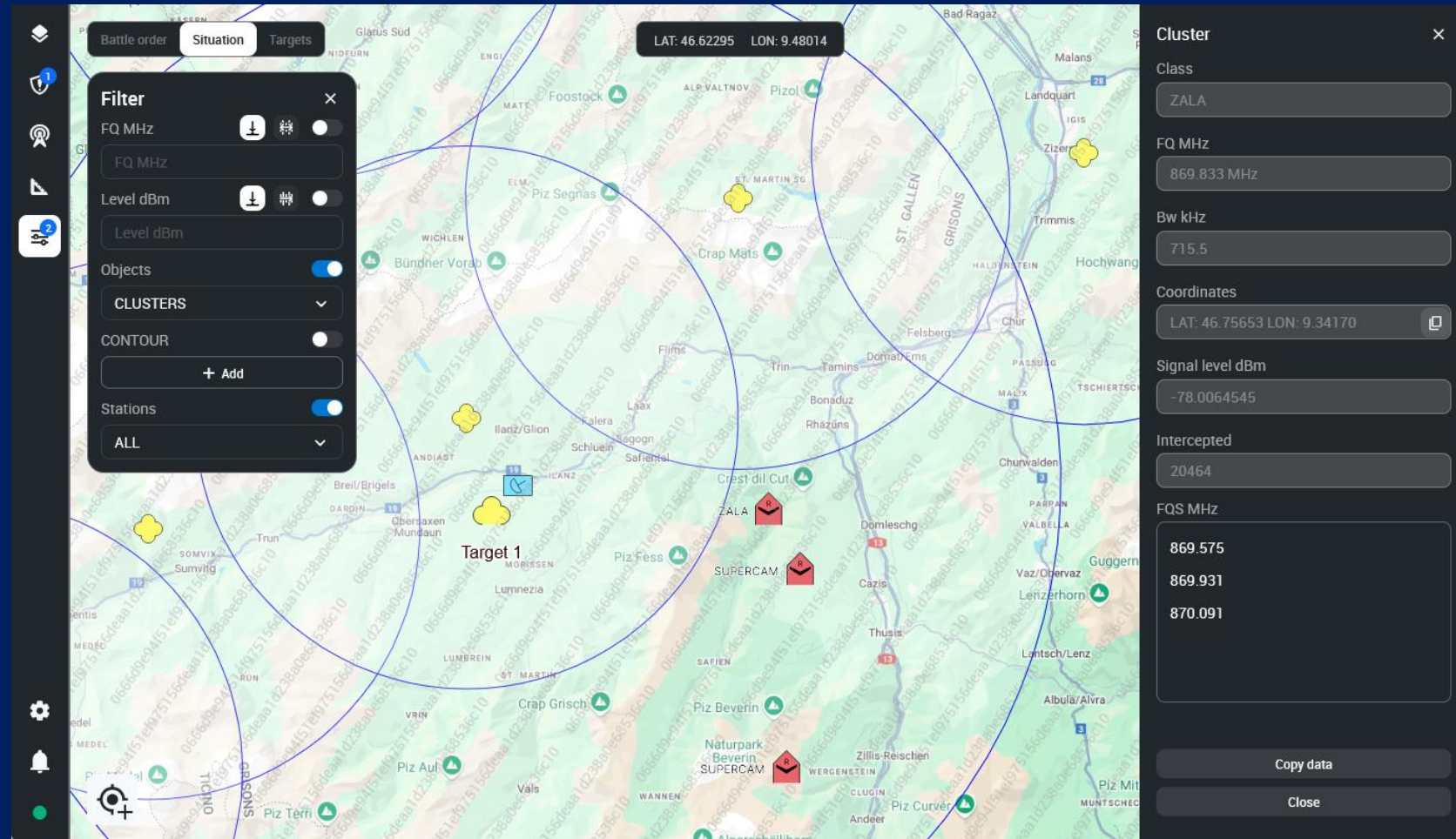
ICS MONITORING RT: ELECTRONIC BATTLE MANAGEMENT SYSTEM ELECTRONIC WARFARE MAP

Alarming System allows to automatically detect the signals
Need to depict them on the map
i.e. the system that provides situational awareness

Data fusion approach: objects of different nature obtained from different sources in the single interface in real time

- Signal clusterisation
- Signal classification
- Signal identification

To enable the classification of a signal source, many attributes of the detected signal are taken into account: measurement time, signal duration, signal cascade record, signal center frequency, bandwidth, and others.



ICS MONITORING RT: ELECTRONIC BATTLE MANAGEMENT SYSTEM SOFTWARE COMPONENTS

ICS MONITORING RT is distributed software, which may consist of several different software components. The following list presents the components of the software:

- **ICS MONITORING RT SA (SPECTRUM ANALYSIS)** is a client GUI application to provide interface between users and the software. It allows to configure and run measurement tasks, as well as to receive and view their results.
- **ICS MONITORING SERVER RT** is a server component for collecting, processing and broadcasting of measurement results.
- **ICS MONITORING CLIENT RT** is an client GUI application for the analysis of the results of measurements processed by **ICS MONITORING SERVER RT**.
- **ICS MONITORING CONTROL A** is a server component that provides measurements and control of measuring devices.
- **ICS MONITORING RT AGENT** is a lightweight piece of software which is aimed at organizing interaction with measuring devices via file exchange.

ICS MONITORING RT is independent of the measuring equipment used in the network, and any device can be integrated into the monitoring system.



ICS MONITORING RT: ELECTRONIC BATTLE MANAGEMENT SYSTEM SUPPORTED FUNCTIONS

Depending on the demands for measurements, **ICS MONITORING RT** system can be deployed using different configurations.

The measurement functions supported by **ICS MONITORING RT** are grouped into Function Sets, which are considered as independent options for configuration of the system. Therefore, it is possible to include only required functions in a realization of the system.

ICS MONITORING RT supports the following function sets:

- Signal Analysis
- Alarming
- Signal classification
- Localisation
- Electromagnetic Environment (EME)
- Electronic Warfare Map (EWM)



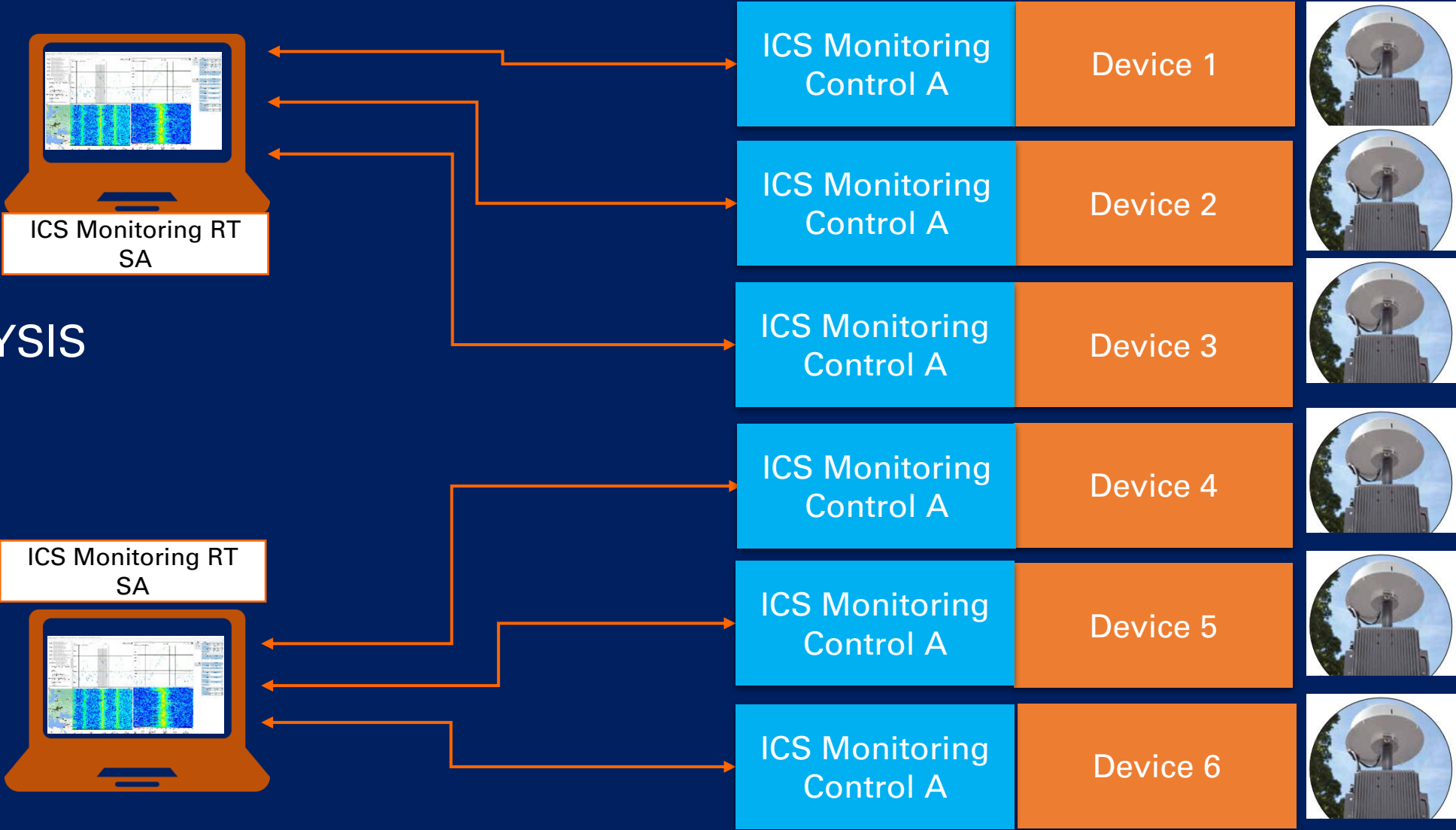
ICS MONITORING RT: FUNCTIONS VS SYSTEM ARCHITECTURE

#	Workplace	Number of Monitoring Stations	Options (Function Sets)	Software Components Used	Typical Configuration
1	Light	1	Spectrum Analysis, Alarming	RT SA, Control A	-
2	Battlefield	≥ 1	Spectrum Analysis, Localisation	RT SA, Control A	Fig. 1.1
3	Tactical Watchkeeping	≥ 1	Signal Analysis, Alarming, Localisation	RT SA, Control A, Server RT, Client RT	Fig. 1.2
4	Tactical-operative	≥ 1	Electronic Warfare Map (EWM)	RT SA, Server RT, Client RT, ICS Monitoring Control RT Agent	Fig. 1.3 and 1.4
5	Custom	≥ 1	Any	Any	Any



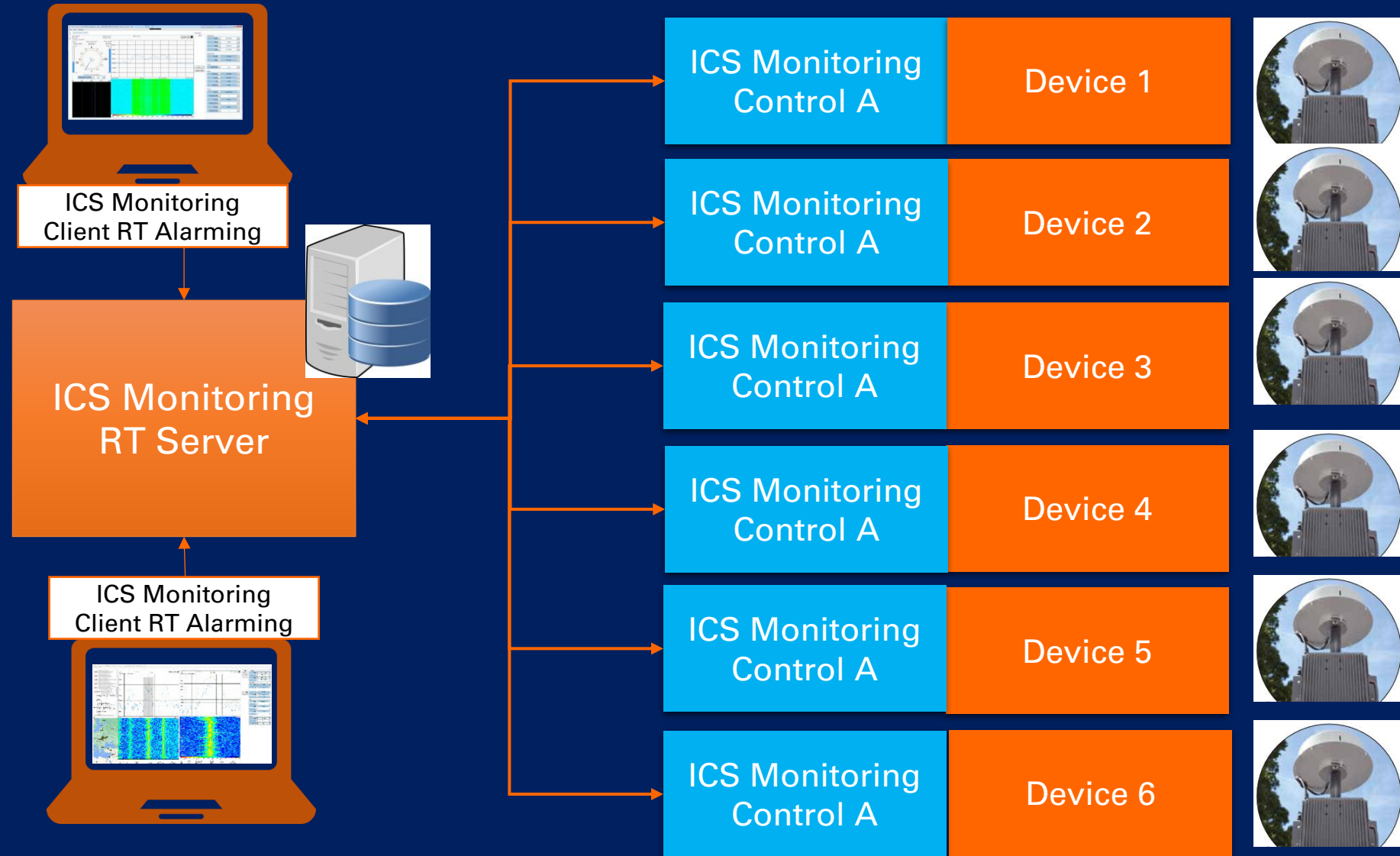
ICS MONITORING RT : « BATTLEFIELD » TYPICAL CONFIGURATION

- SPECTRUM ANALYSIS
- LOCALISATION



ICS MONITORING RT: « WATCHKEEPING - TACTICAL » TYPICAL CONFIGURATION

- SIGNAL ANALYSIS
- ALARMS
- LOCALISATION
- CLASSIFICATION



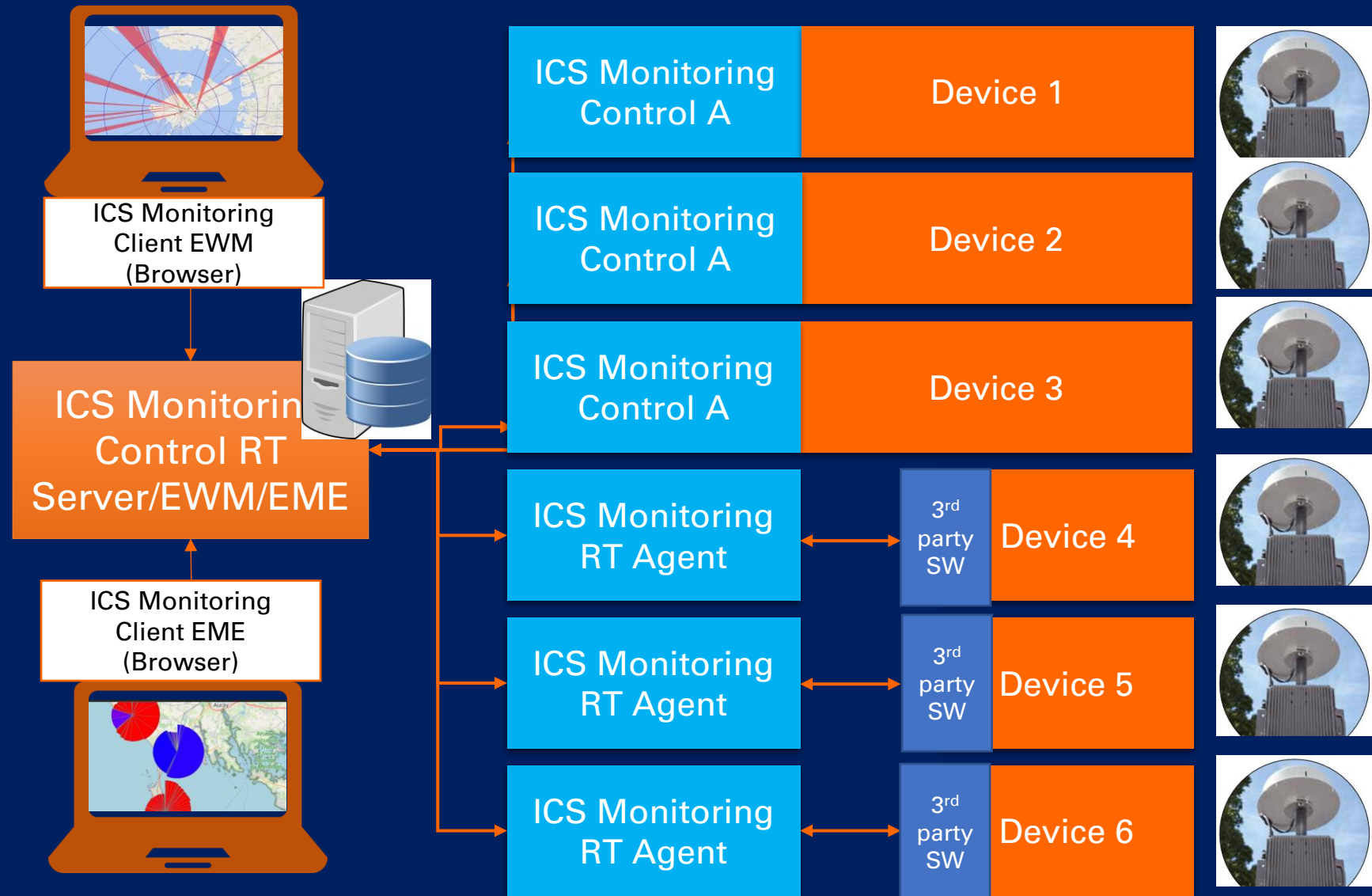
ICS MONITORING RT : «TACTICAL - OPERATIVE » TYPICAL CONFIGURATION

ELECTRONIC WARFARE MAP (EWM)

- LOCALISATION
- CLASSIFICATION
- IDENTIFICATION

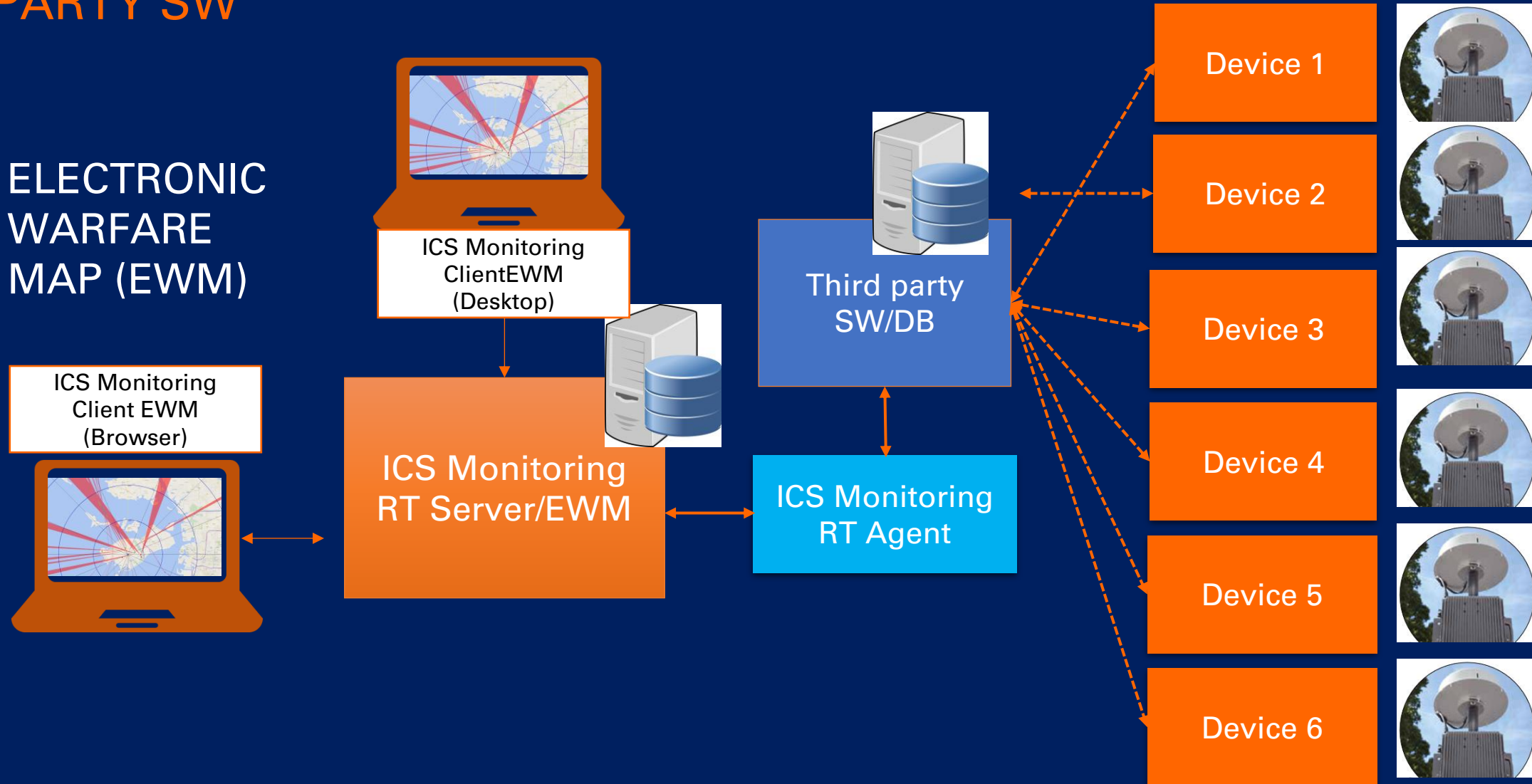
ELECTROMAGNETIC ENVIRONMENT (EME)

- ANOMALIES
- VARIATIONS
- STATISTICS



ICS MONITORING RT : «TACTICAL - OPERATIVE » TYPICAL CONFIGURATION VIA THIRD PARTY SW

- ELECTRONIC WARFARE MAP (EWM)



ICS MONITORING RT: SPECTRUM ANALYSIS

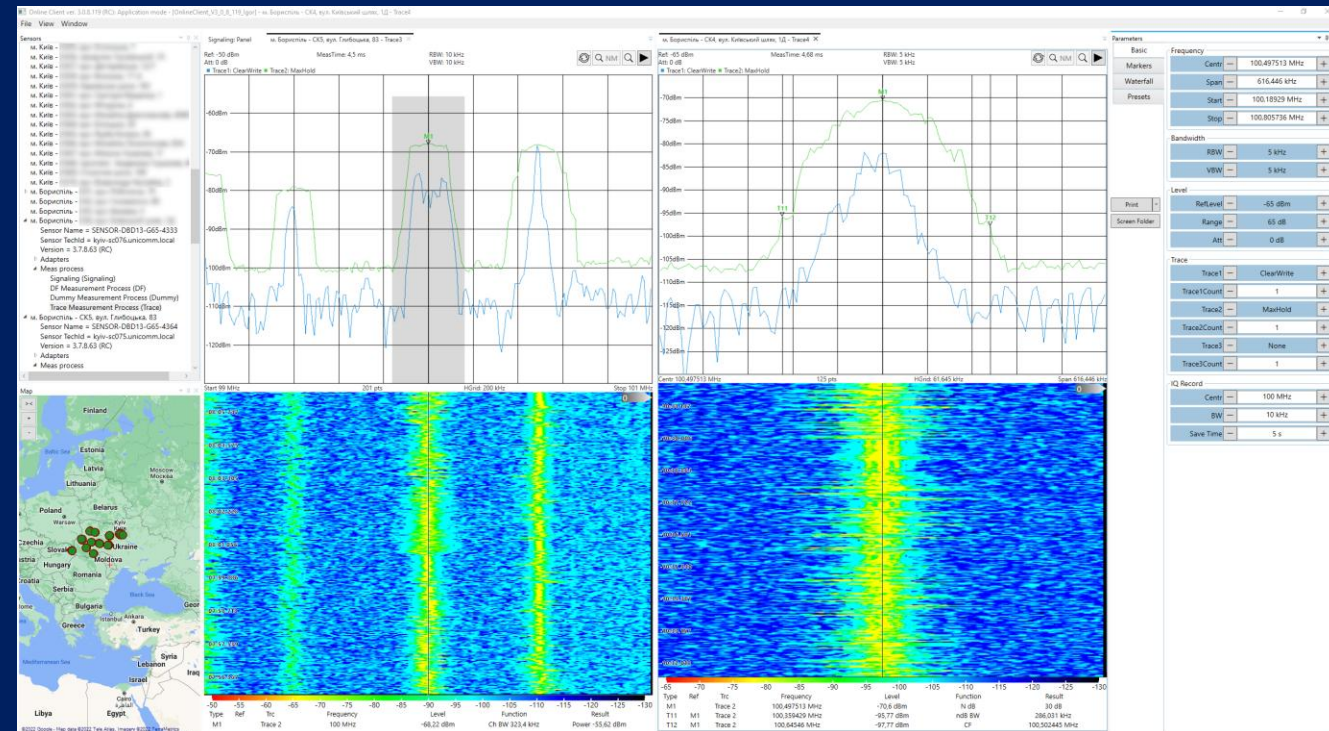
Viewing a few traces simultaneously. Each trace can be of one of the following types:

- ClearWrite: instant spectrum trace.
- Average: average values for a specified number of traces for each frequency is calculated.
- Tracking: maximum values within a sliding window are shown.
- MaxHold: maximum values for each frequency are shown from the beginning of a measurement.
- MinHold: minimum values for each frequency are shown from the beginning of a measurement
- View: in this mode, a trace is frozen to allow performing its analysis without stopping the measurement process.

Viewing waterfall for a selected frequency band. Waterfall tab allows to move and observe any trace in a buffer of traces. There are many options for editing waterfall and performing calculations with waterfall.

Saving IQ streams in .wav files.

Saving either separate traces or waterfalls in a .csv file or as an image.

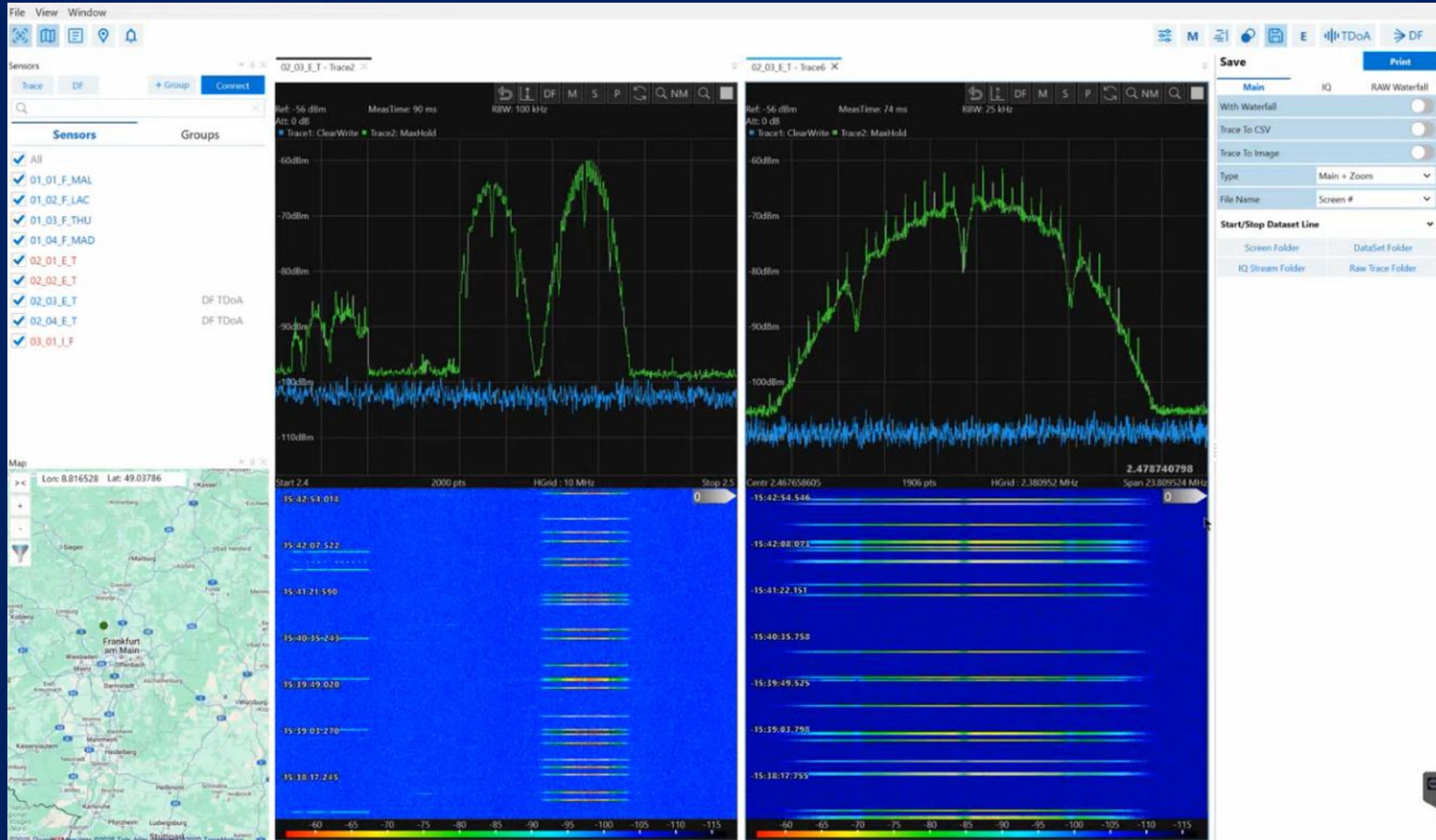


Supporting of markers:

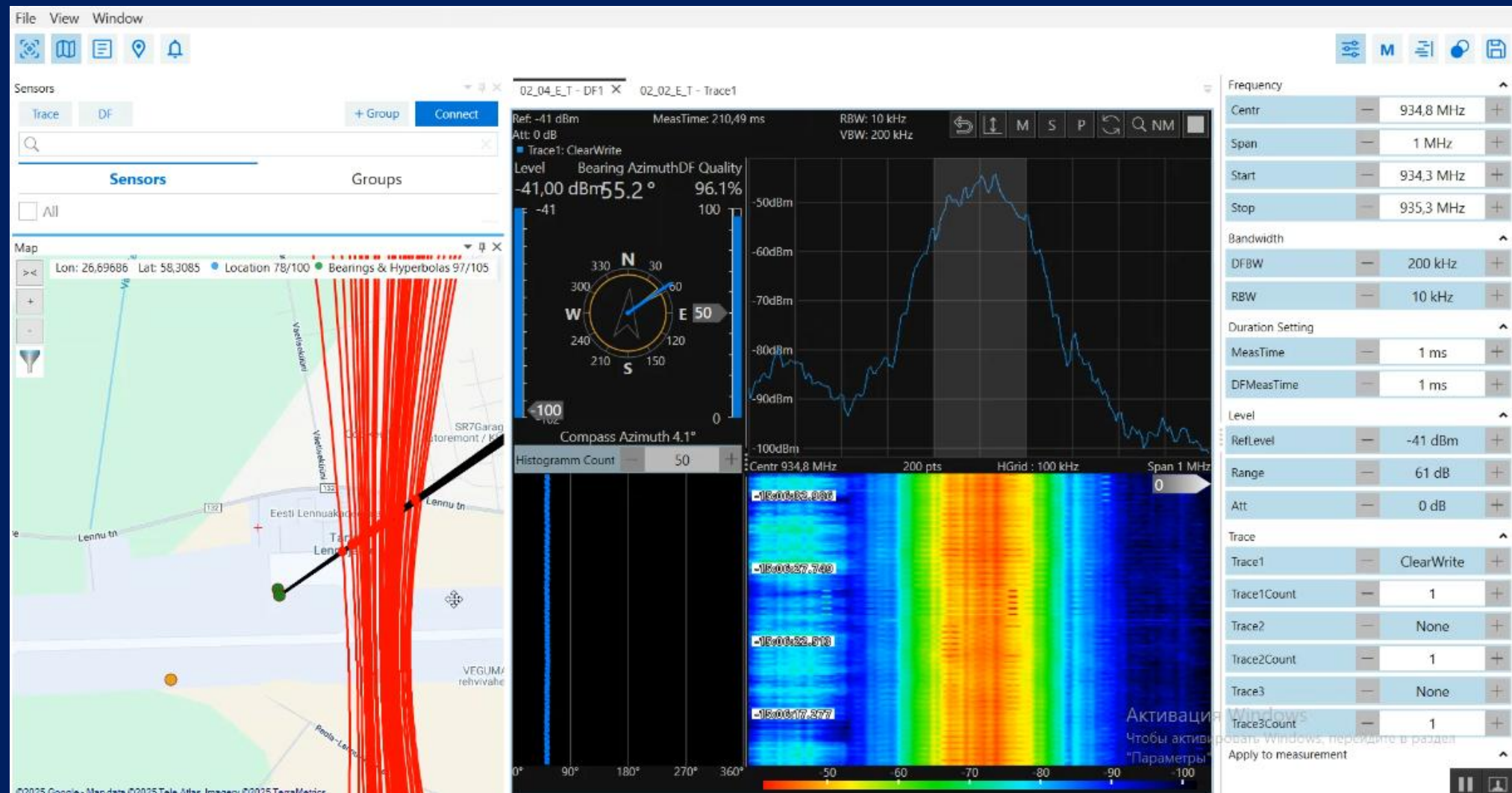
- Observe the power level at a selected frequency
- Use differential markers
- Calculate a signal's bandwidth using two available methods: "NdB down" and " $\beta/2$ "
- Calculate received power within a specified frequency range



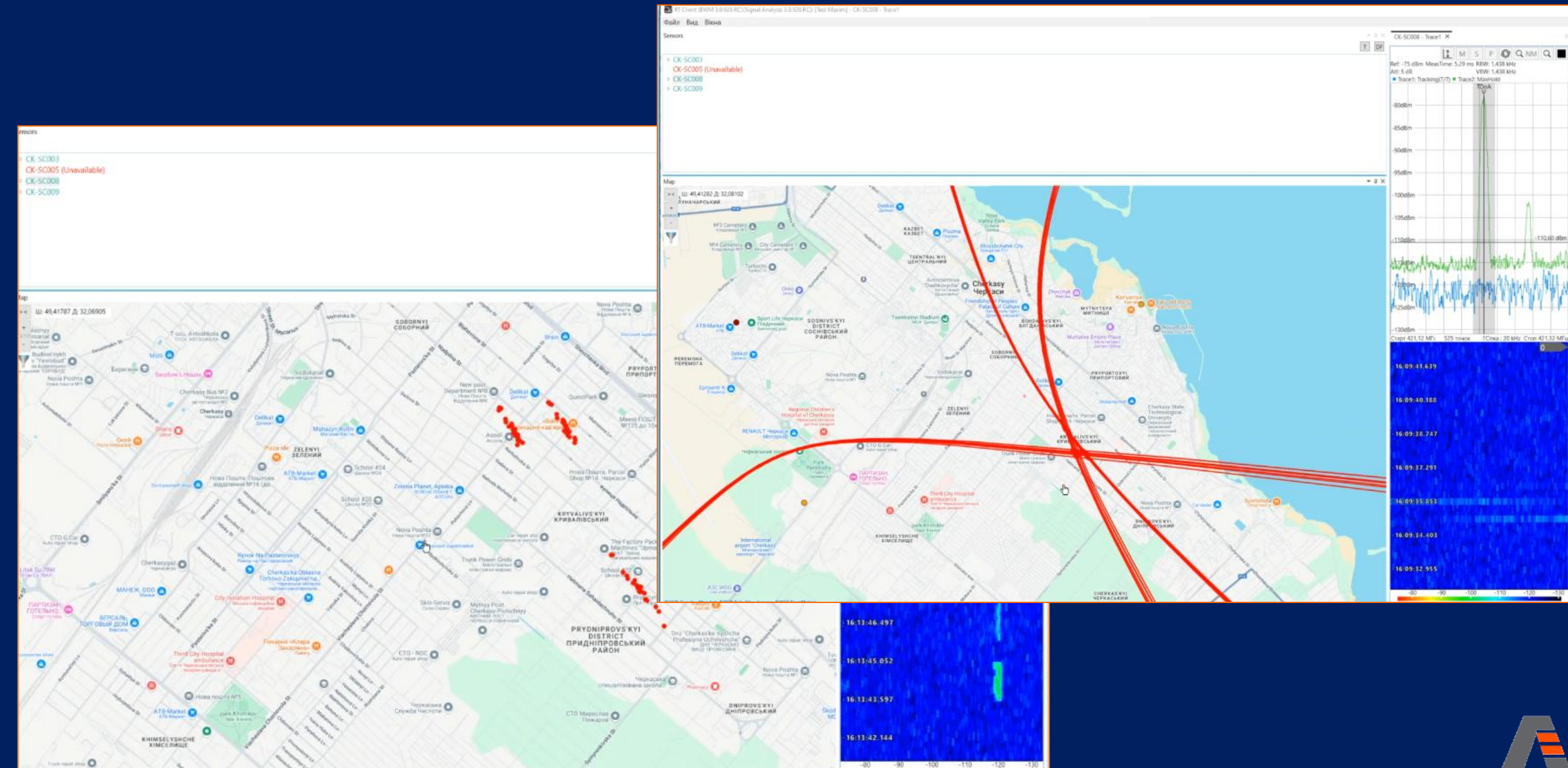
ICS MONITORING RT: SPECTRUM ANALYSIS



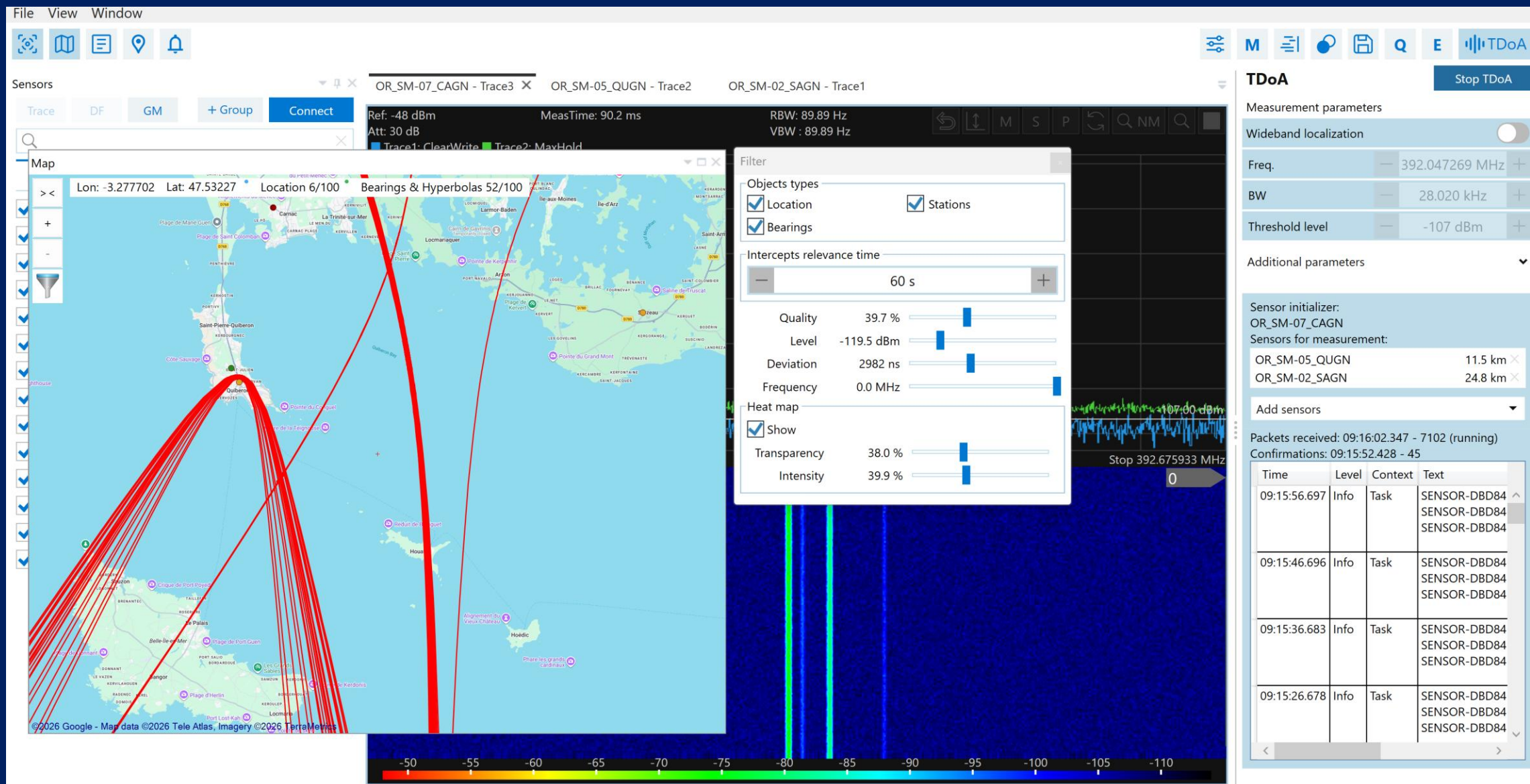
ICS MONITORING RT : HYBRID (TDOA – AOA) LOCALISATION



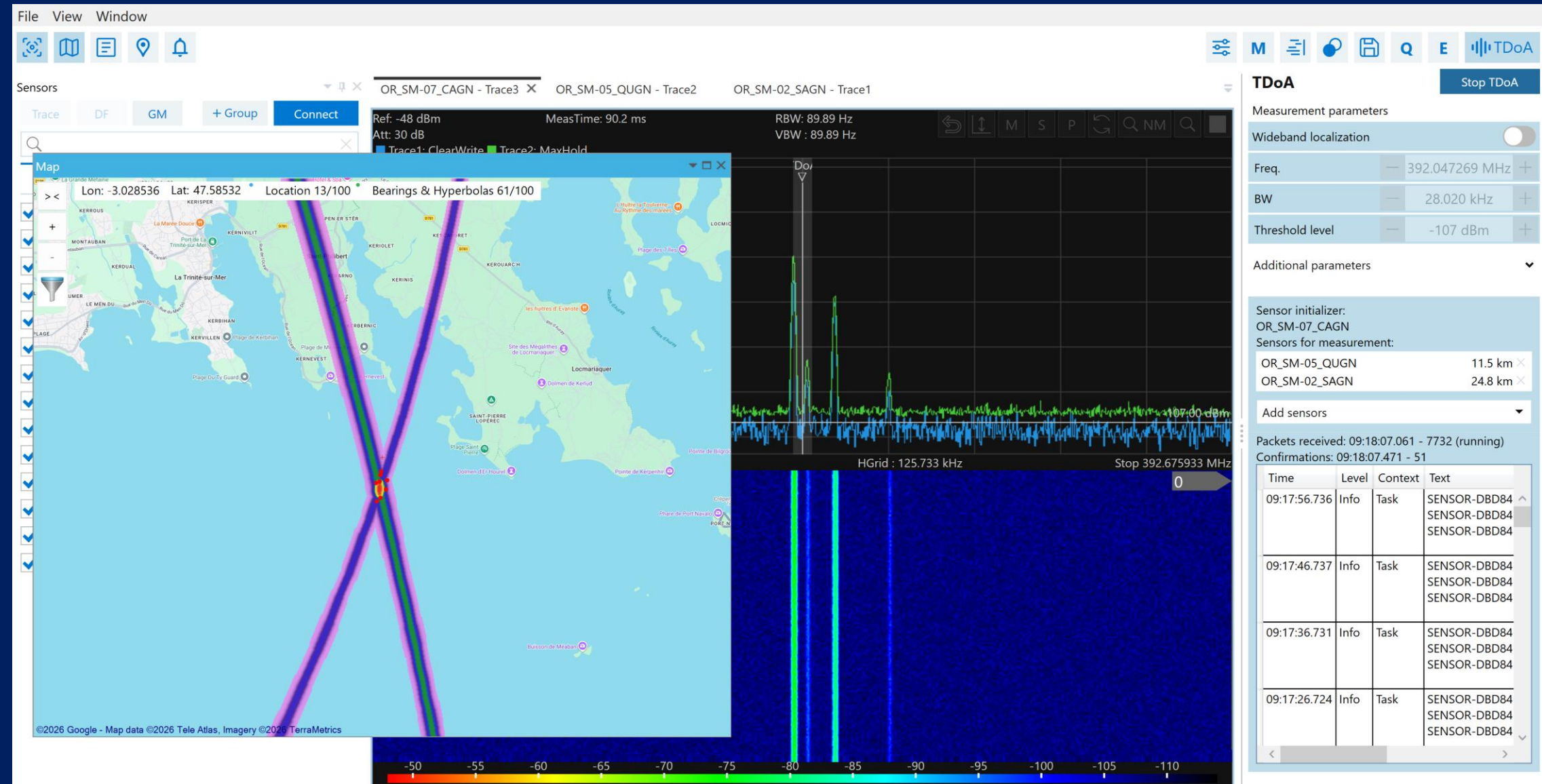
ICS MONITORING RT : TDOA LOCALISATION



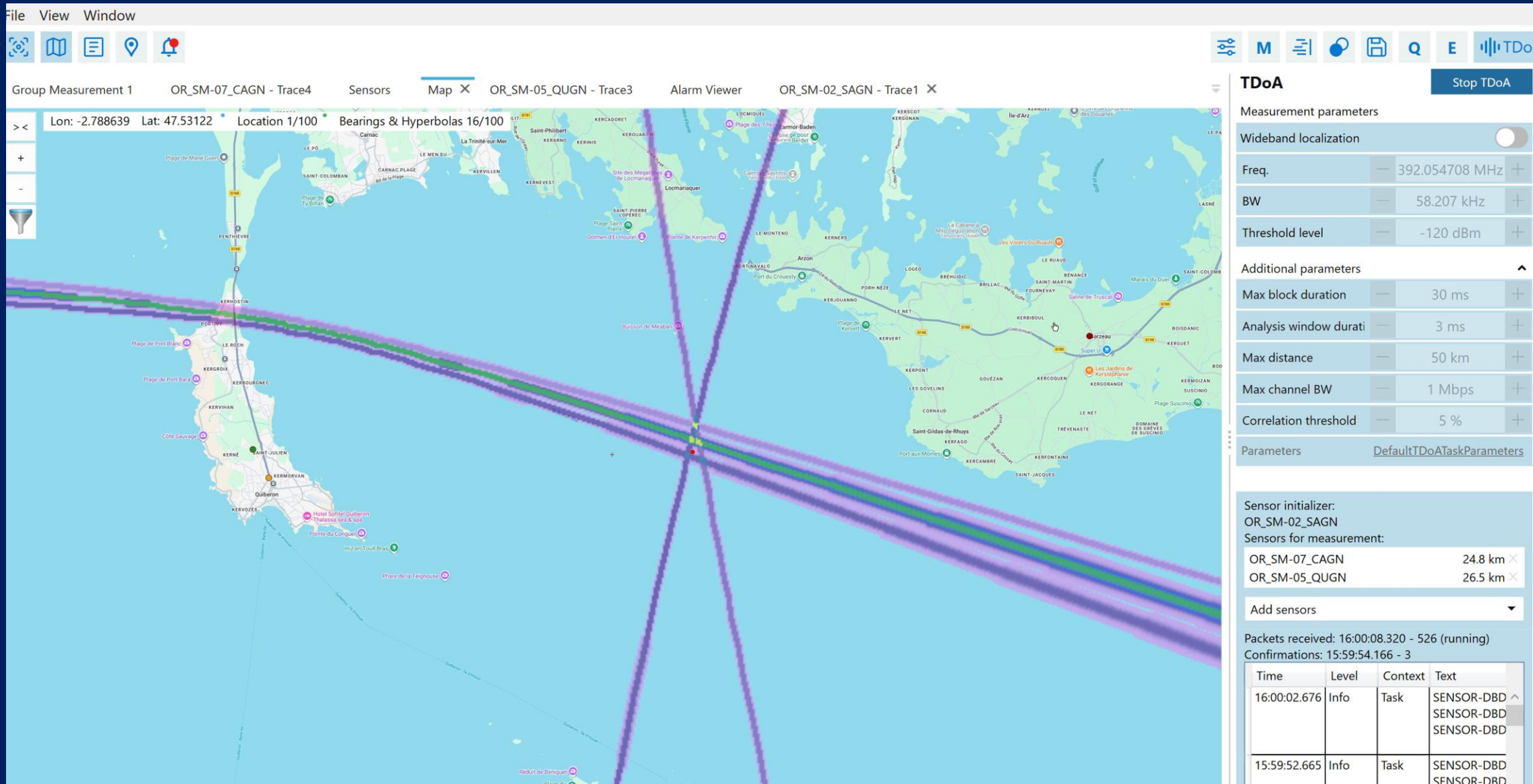
ICS MONITORING RT: TDOA LOCALISATION OF PMR (26 KHZ BW) SIGNALS



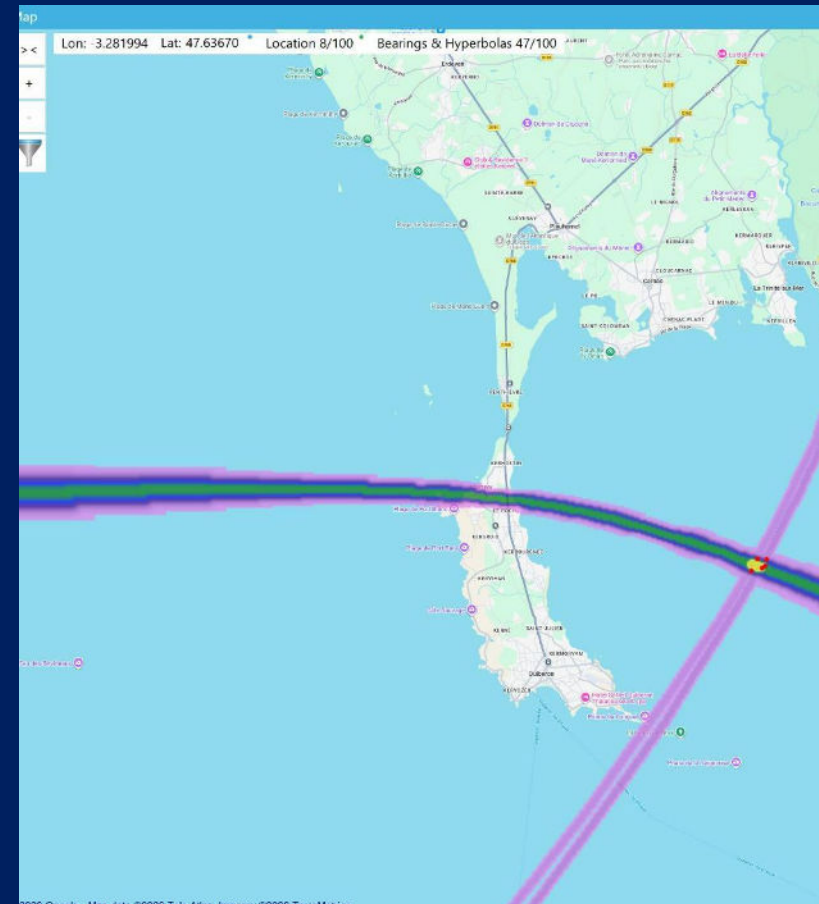
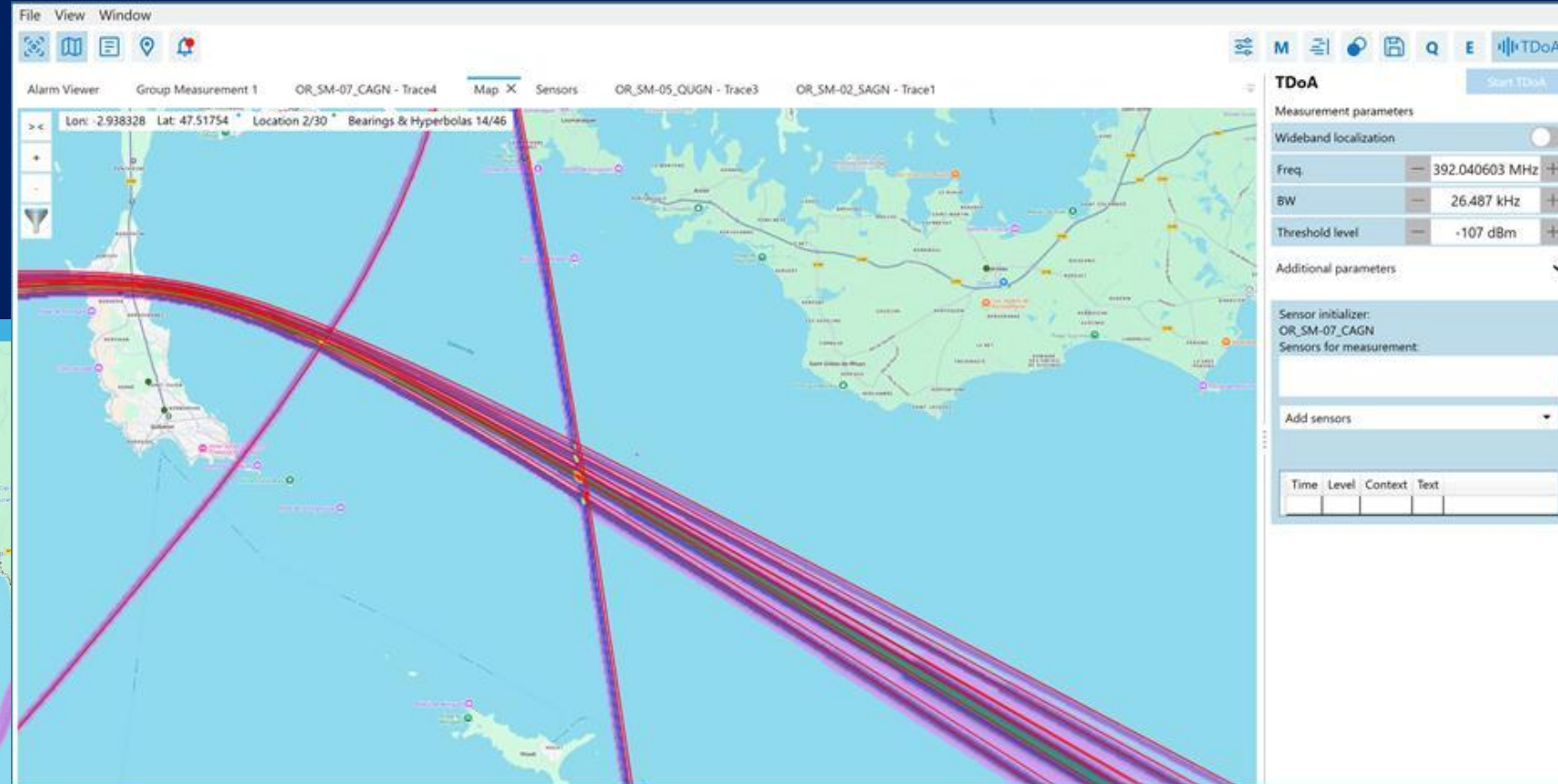
ICS MONITORING RT: TDOA LOCALISATION OF PMR (26 KHZ BW) SIGNALS



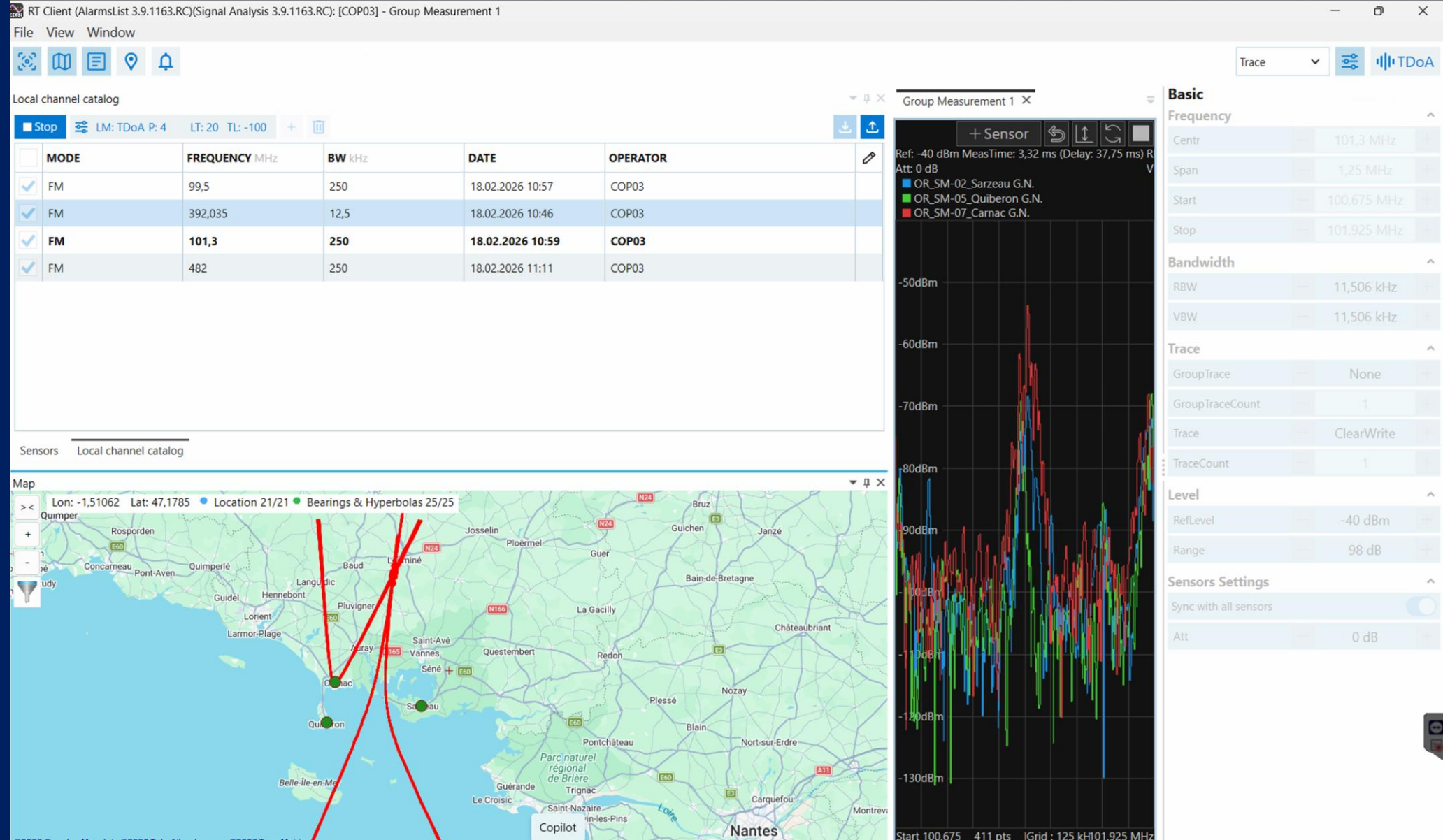
ICS MONITORING RT: TDOA LOCALISATION OF PMR (26 KHZ BW) SIGNALS



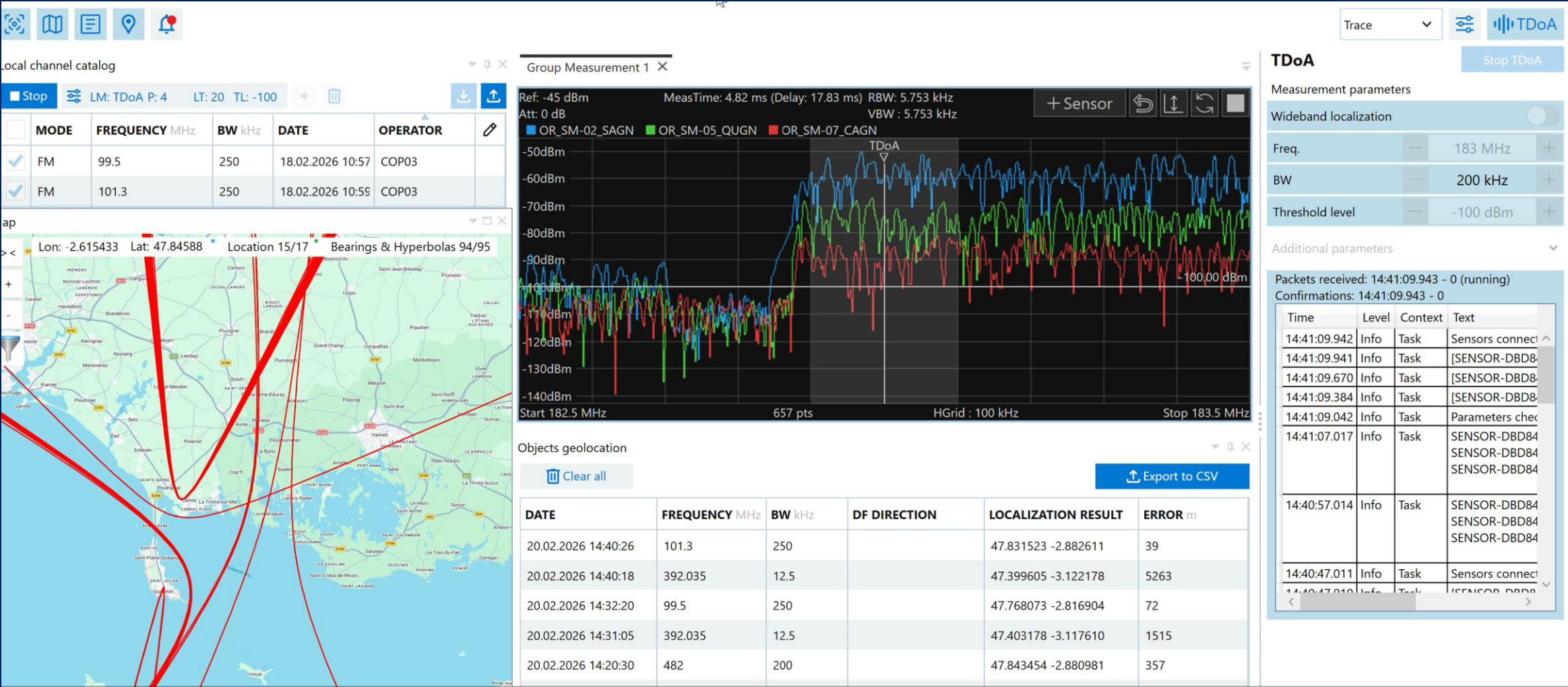
ICS MONITORING RT: TDOA LOCALISATION OF PMR (26 KHZ BW) SIGNALS



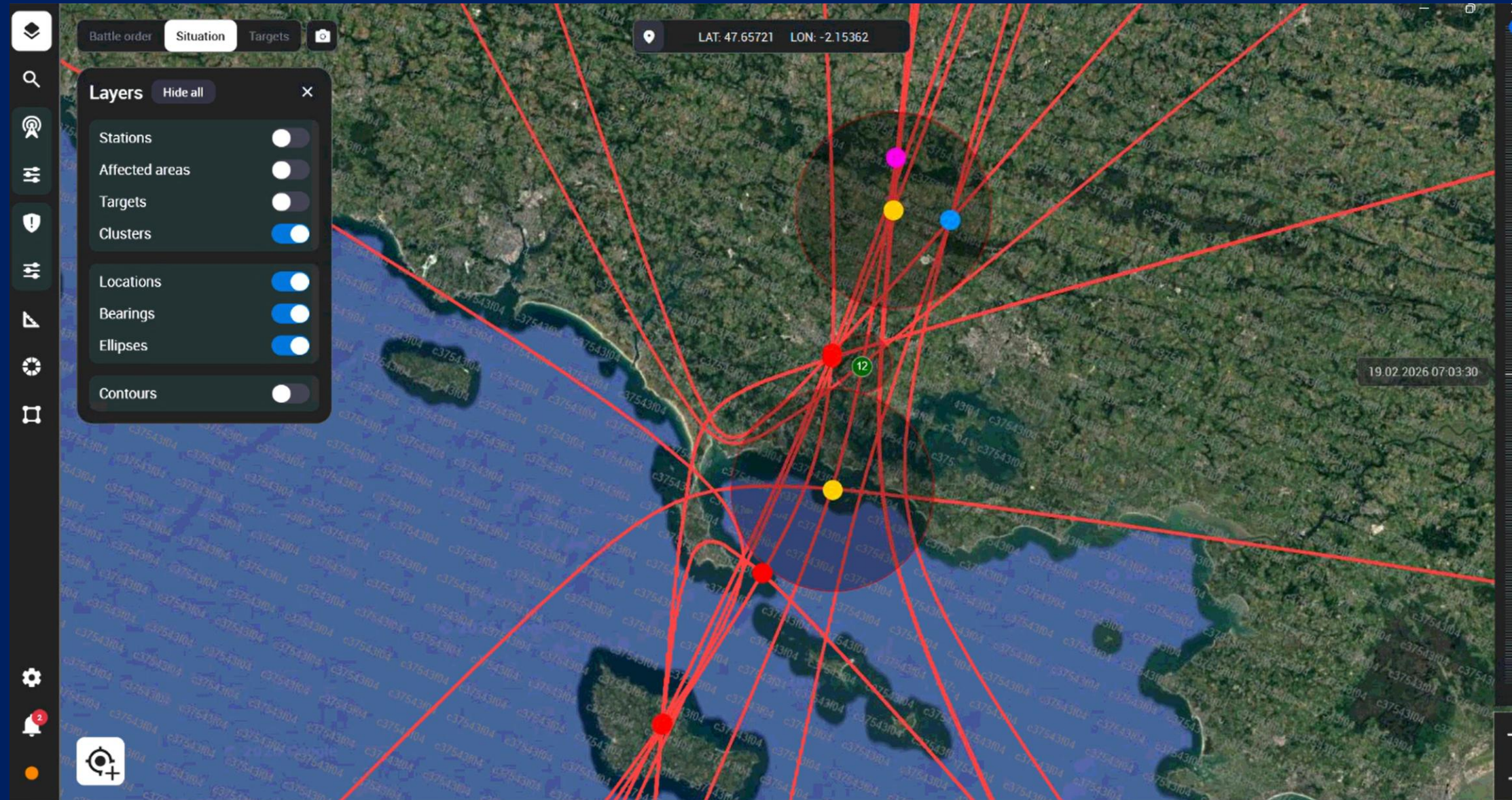
ICS MONITORING RT: AUTOMATED TDOA LOCALISATION FROM FREQUENCY LIST



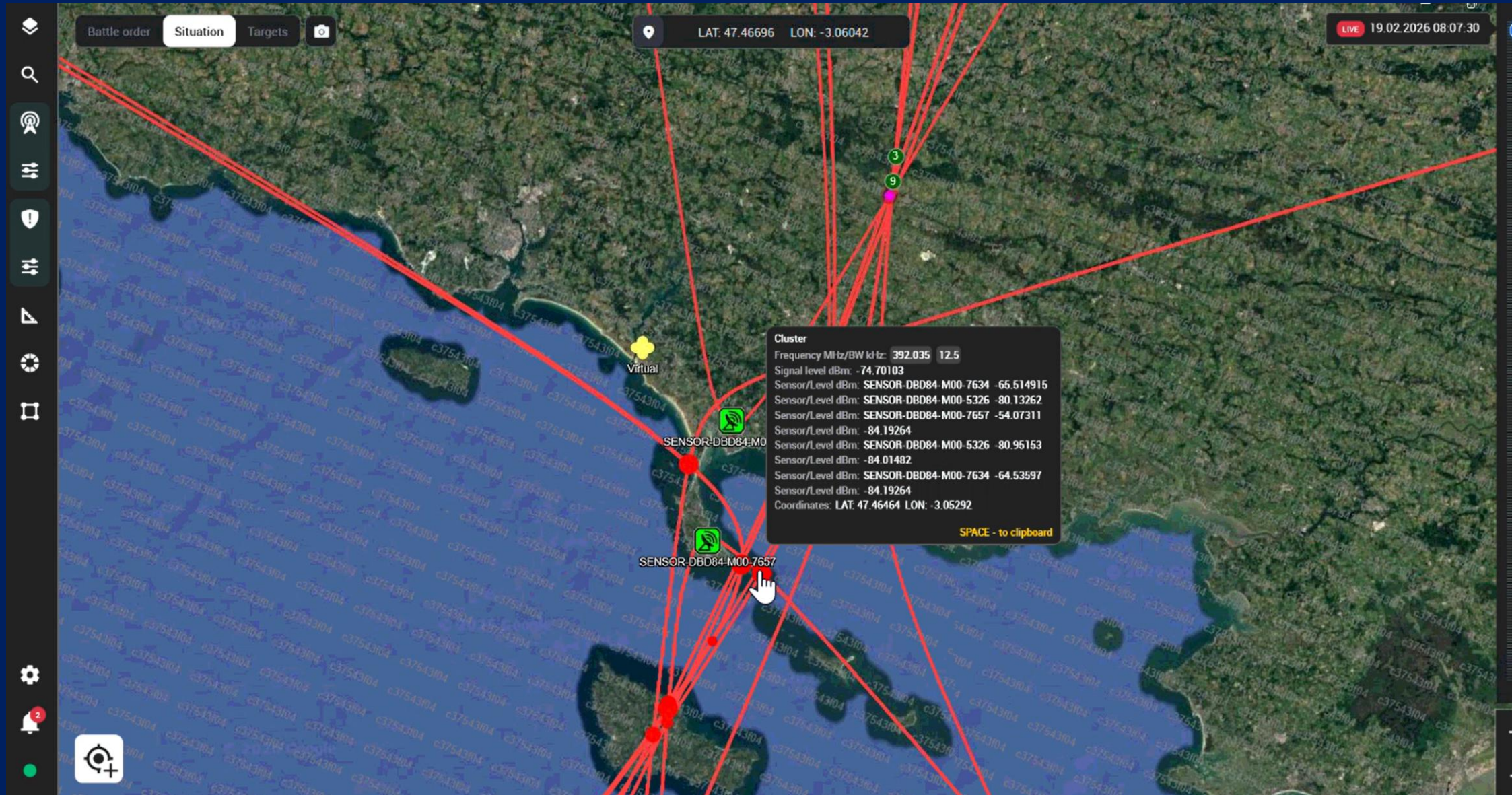
ICS MONITORING RT: AUTOMATED TDOA LOCALISATION FROM FREQUENCY LIST



ICS MONITORING RT: AUTOMATED TDOA LOCALISATION FROM FREQUENCY LIST IN EWM (ELECTRONIC WARFARE MAP)



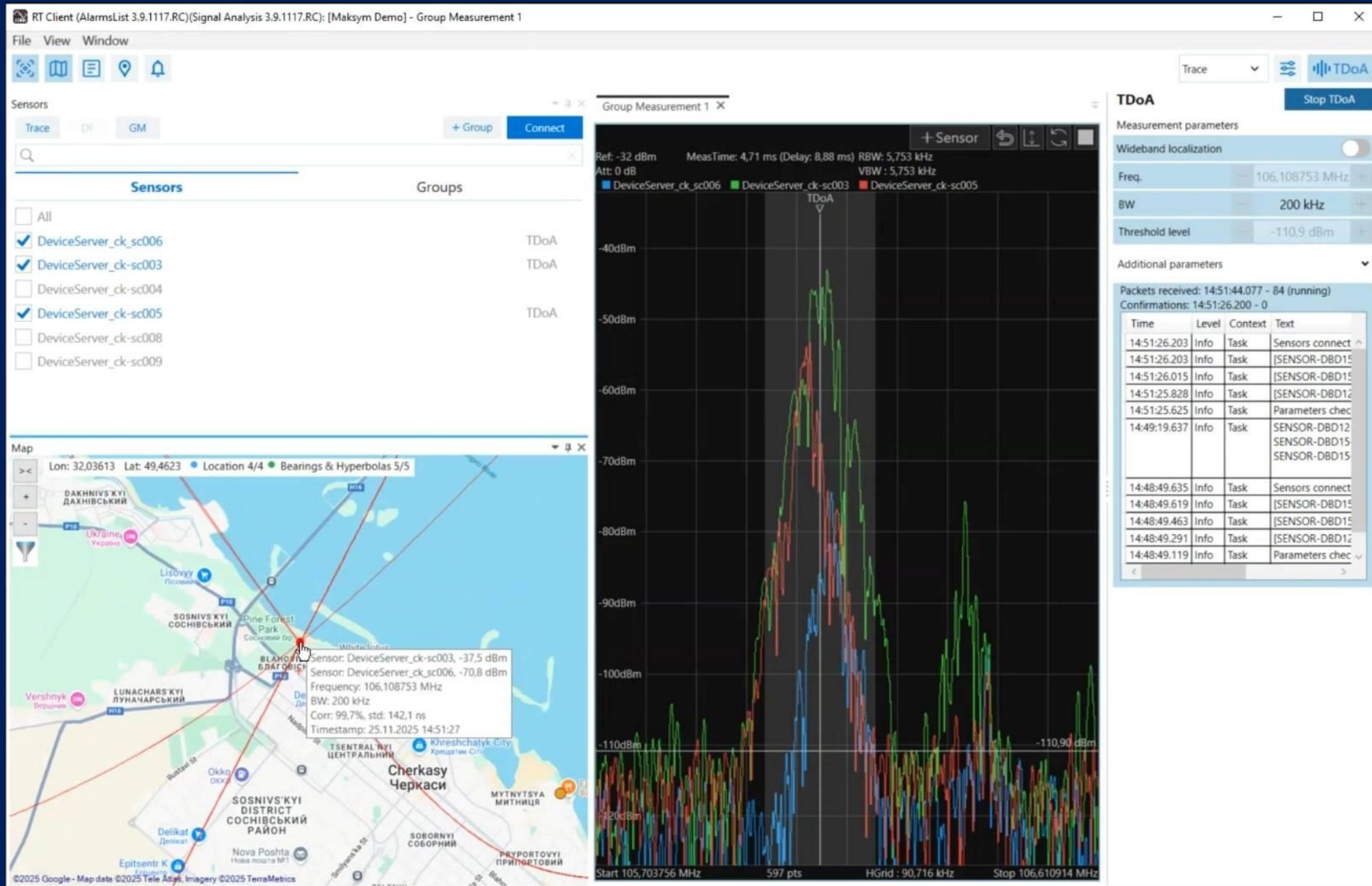
ICS MONITORING RT: AUTOMATED TDOA LOCALISATION FROM SIGNALS LIST IN EWM (ELECTRONIC WARFARE MAP)



ICS MONITORING RT: TDOA LOCALISATION FM SIGNAL 200 KHZ BW

Localisation
Accuracy: 50
meters

Throughput of
uplink channel
(from device to
server): 2
Mbit/sec



ICS MONITORING RT: TDOA LOCALISATION PMR SIGNAL 25 KHZ BW

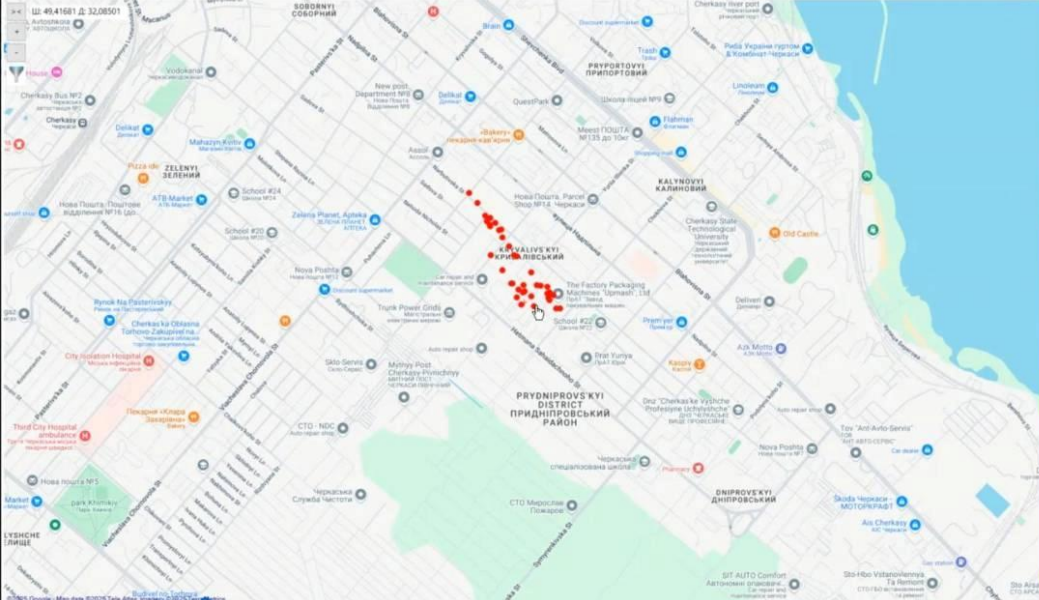
RT Client (EWM 3.8.929.RC) [Signal Analysis 3.8.929.RC] - CK-SC008 - Trace1

Style Вид Вектор

Sensors

CK-SC003
CK-SC005 (Unavailable)
CK-SC008
CK-SC009

Map



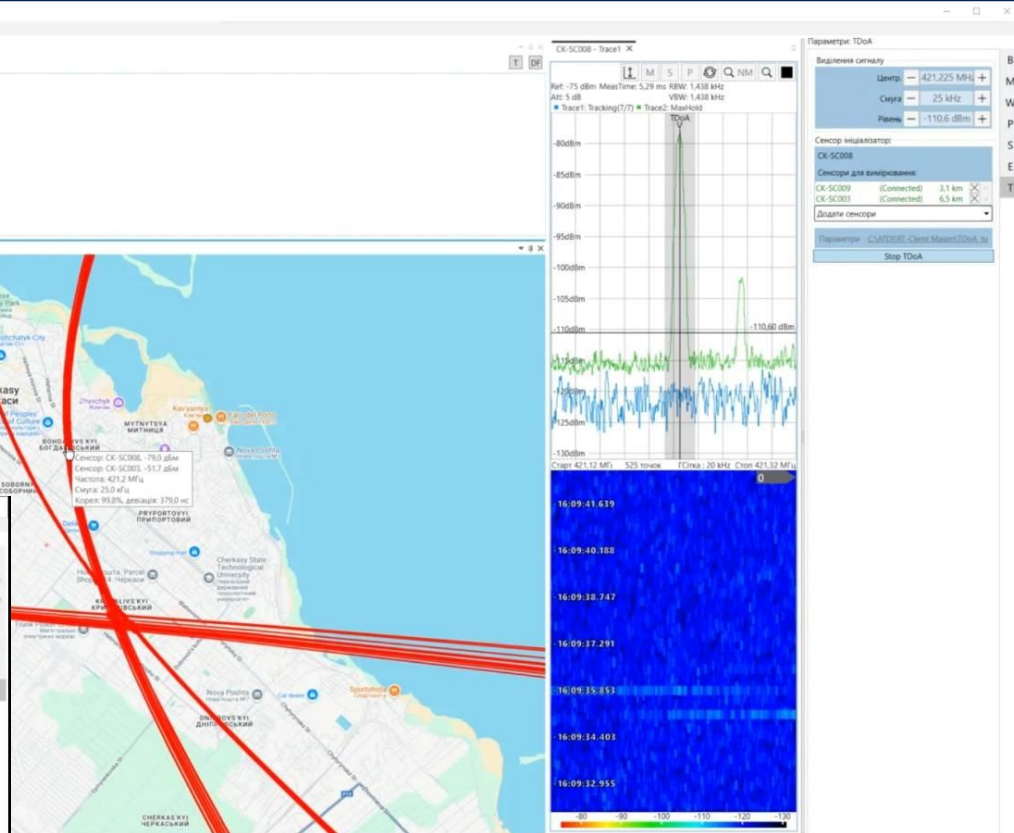
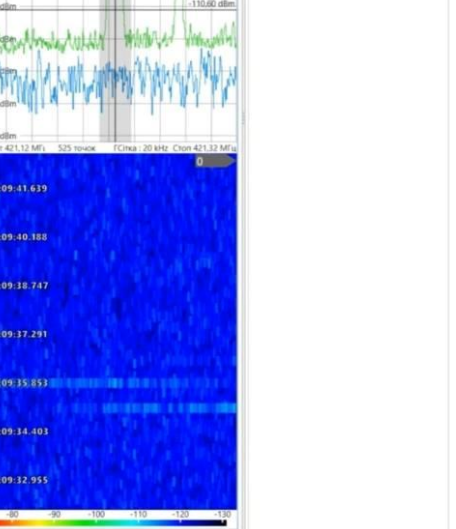
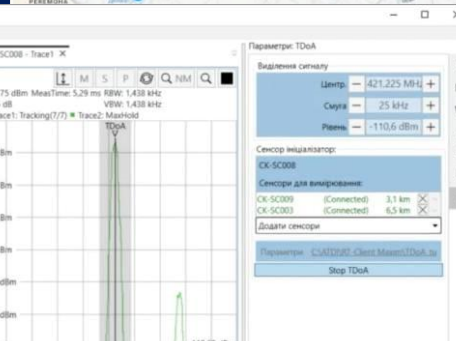
RT Client (EWM 3.8.929.RC) [Signal Analysis 3.8.929.RC] - CK-SC008 - Trace1

Style Вид Вектор

Sensors

CK-SC003
CK-SC005 (Unavailable)
CK-SC008
CK-SC009

Map

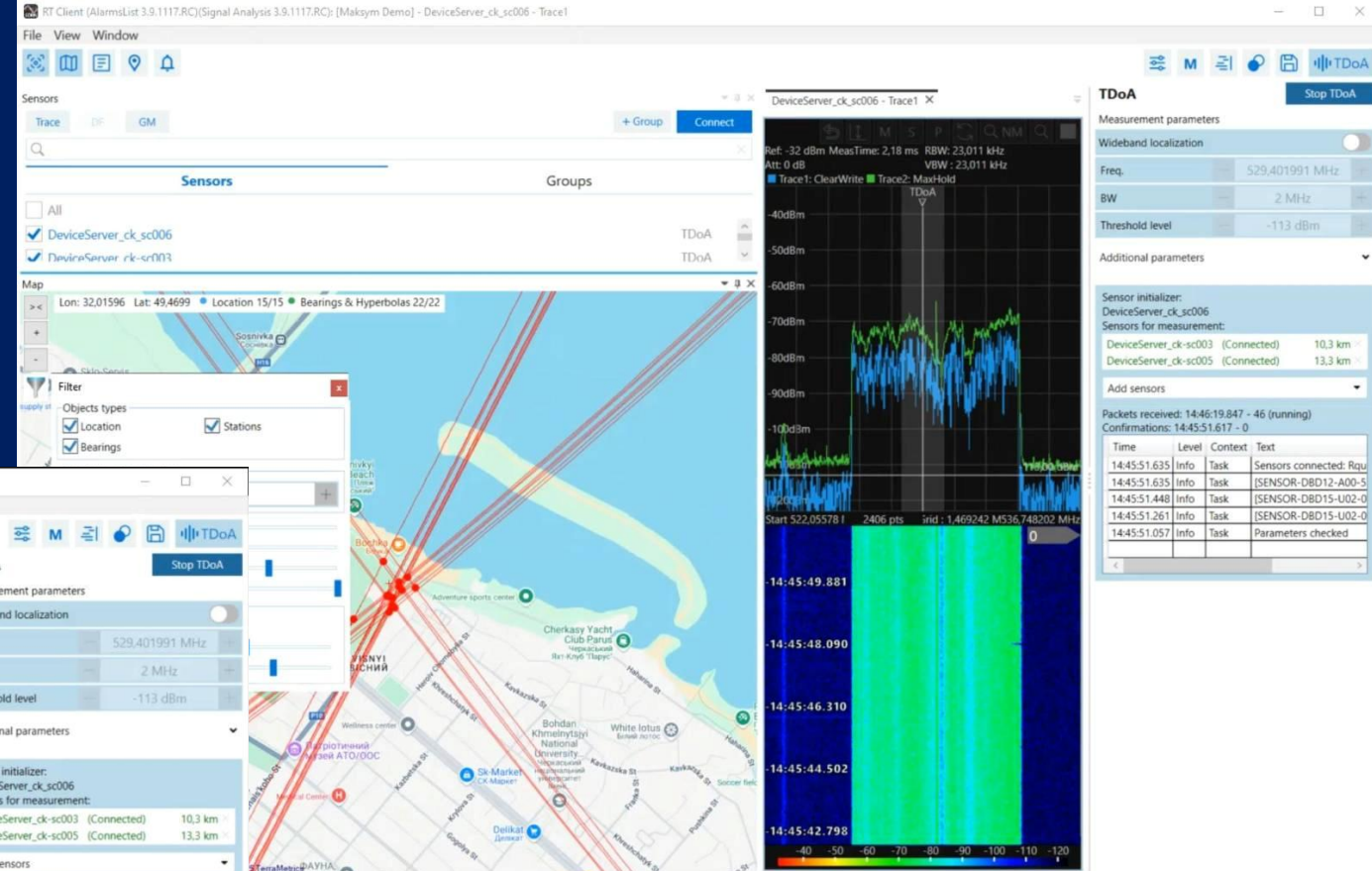
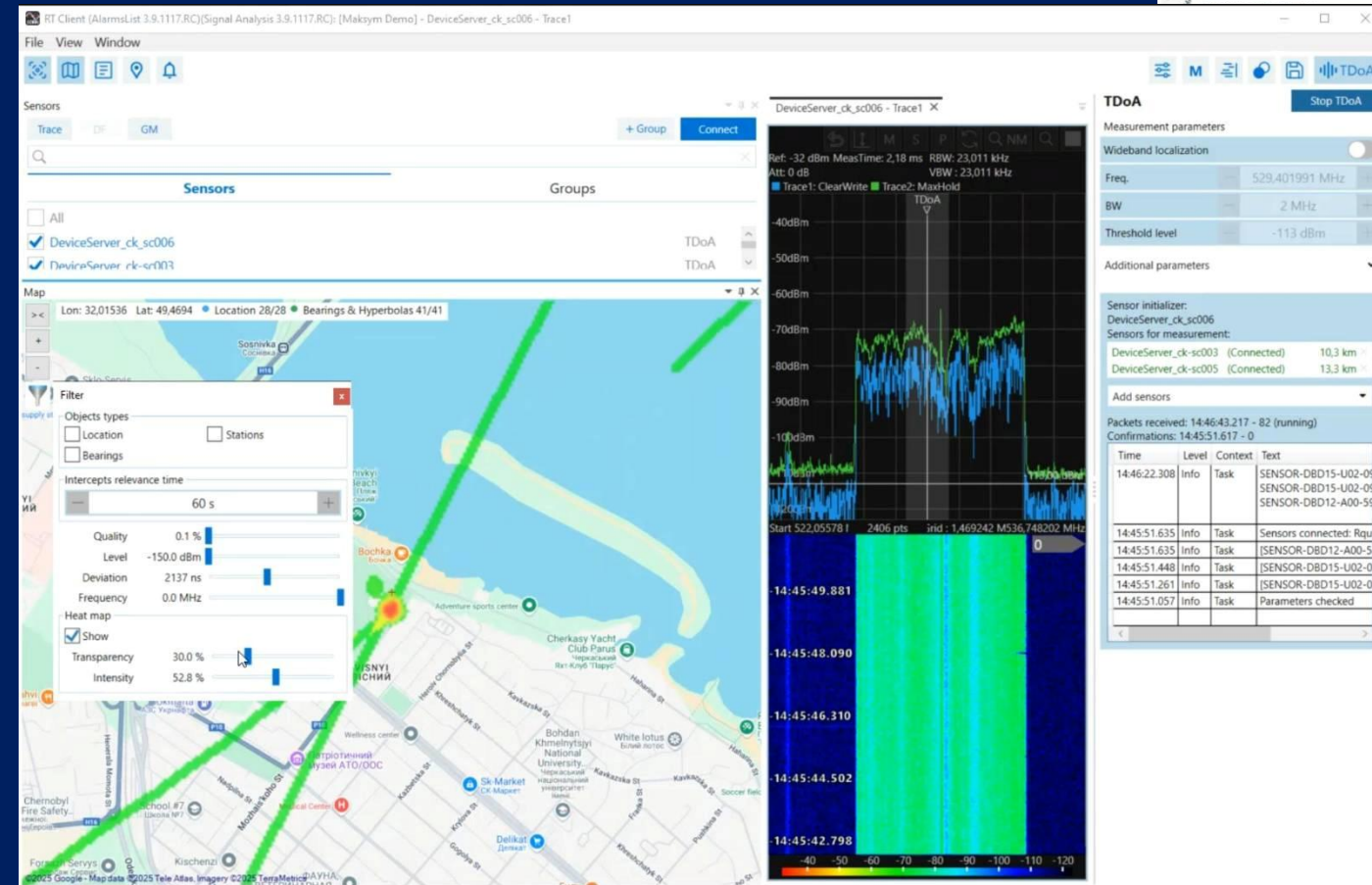


Localisation Accuracy: 100 meters

Throughput of uplink channel
(from device to server): 2 Mbit/sec



ICS MONITORING RT: TDOA LOCALISATION DVB-T SIGNAL 8 MHZ BW (ONLY 2 MHZ BW WAS USED FOR LOCALISATION)



Localisation Accuracy: 30 meters

Throughput of uplink channel (from device to server): 2 Mbit/sec

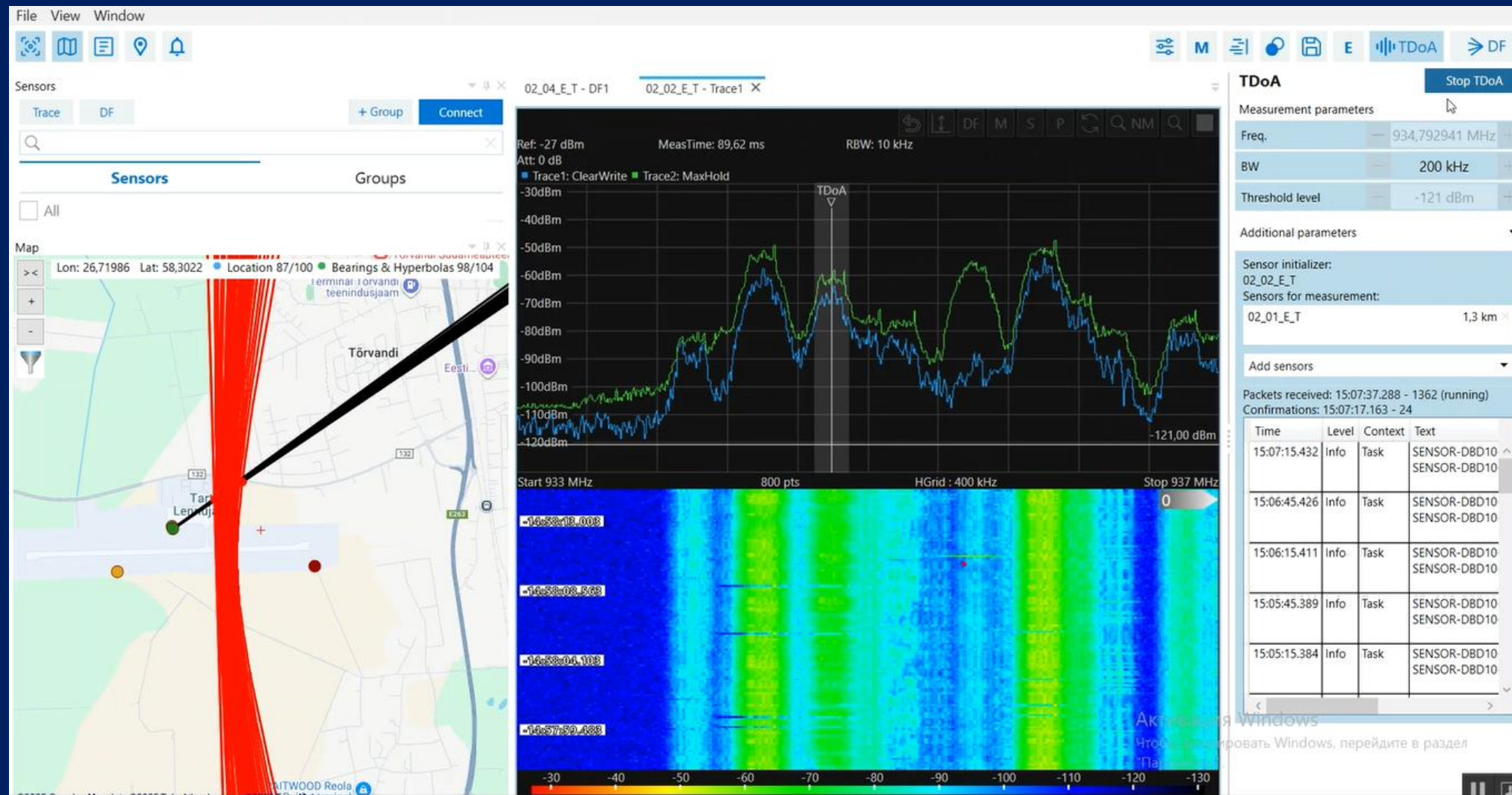


ICS MONITORING RT: GSM SIGNAL 200 KHZ BW HYBRID (TDOA/AOA) LOCALISATION

Localisation
Accuracy: 100
meters

Remark: GSM
channel is
interfered

Throughput of
uplink channel
(from device to
server): 2 Mbit/sec

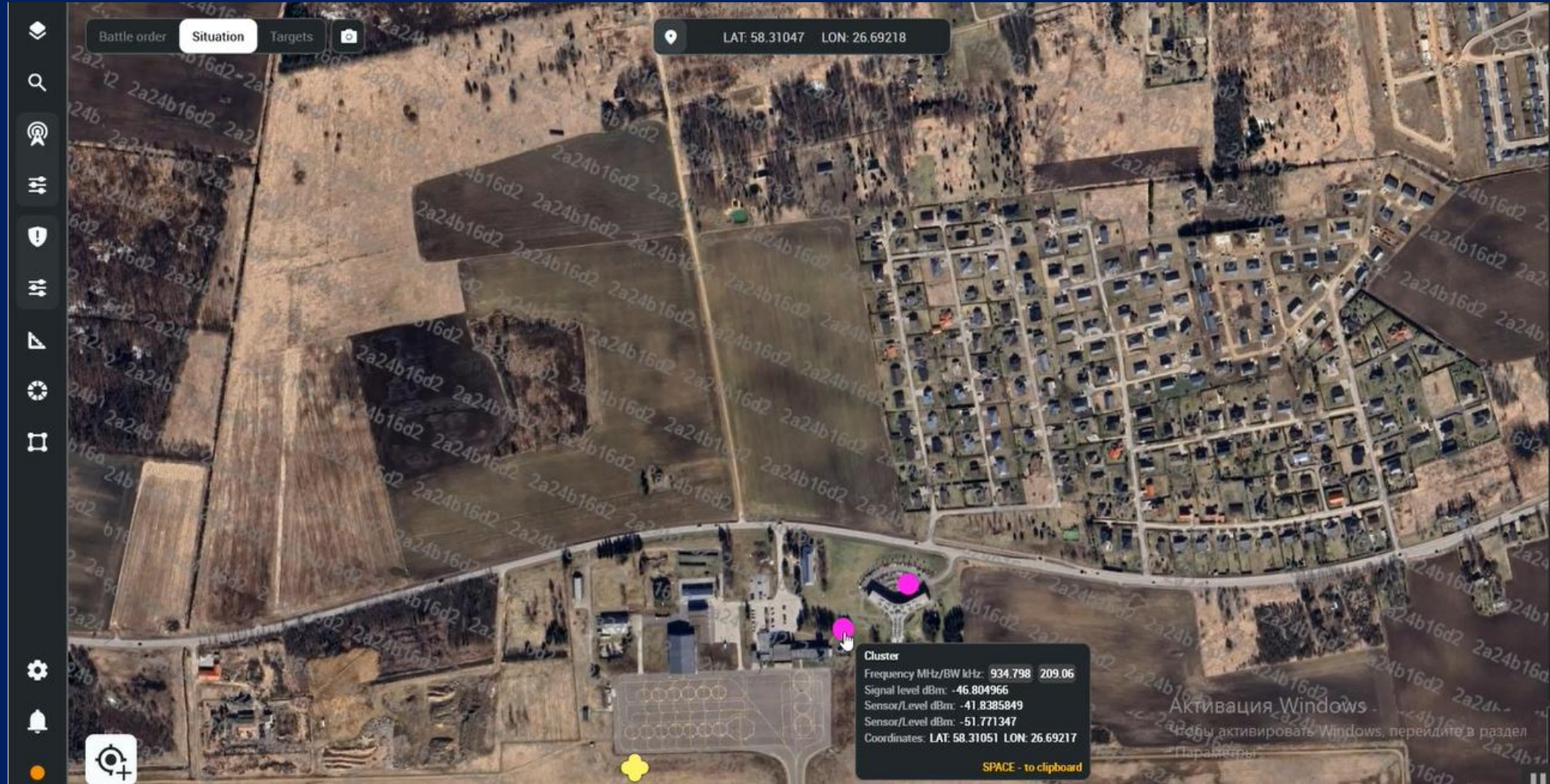


GSM SIGNAL 200 KHZ BW HYBRID (TDOA/AOA) LOCALISATION

Improvement of Localisation Accuracy by using clusterisation techniques: 70 meters

Remark: GSM channel is interfered

Throughput of uplink channel (from device to server): 2 Mbit/sec

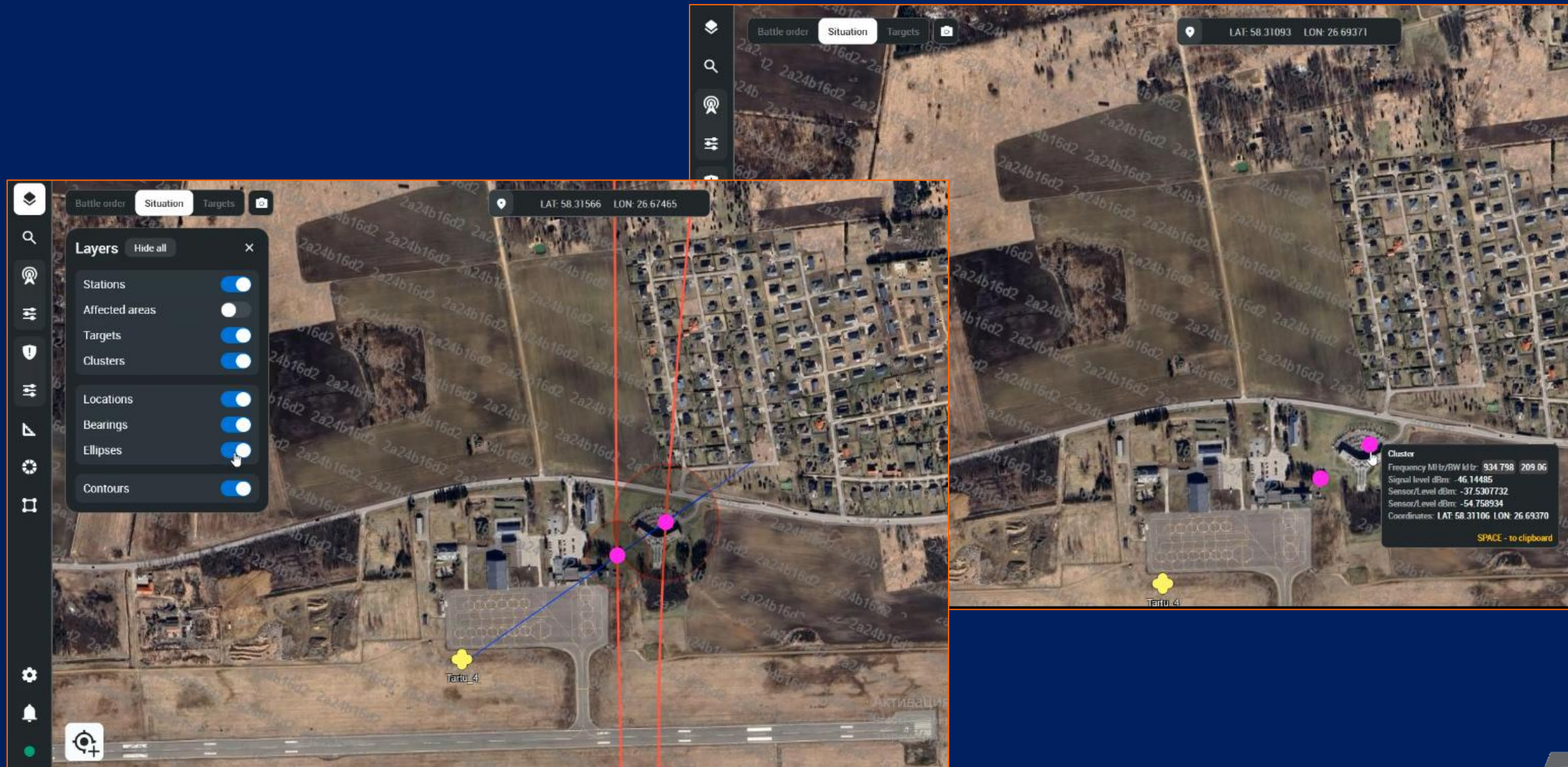


CONCLUSIONS ABOUT TDOA LOCALIZATION QUALITY

- Signal bandwidth linearly affects localization quality of TDoA method for broadband signals
- In principle, localization of narrow-band signals (10 kHz BW) is possible at the level of reception of signals with a Signal/Noise level of 15 dB – 20 dB
- By narrowing of the spectrum, there is an increase in the dispersion of the results, but the center of mass is almost constant, in principle this allows for an increase in the accuracy of localization due to the accumulation of results and post-processing (EWM module of ICS Monitoring)



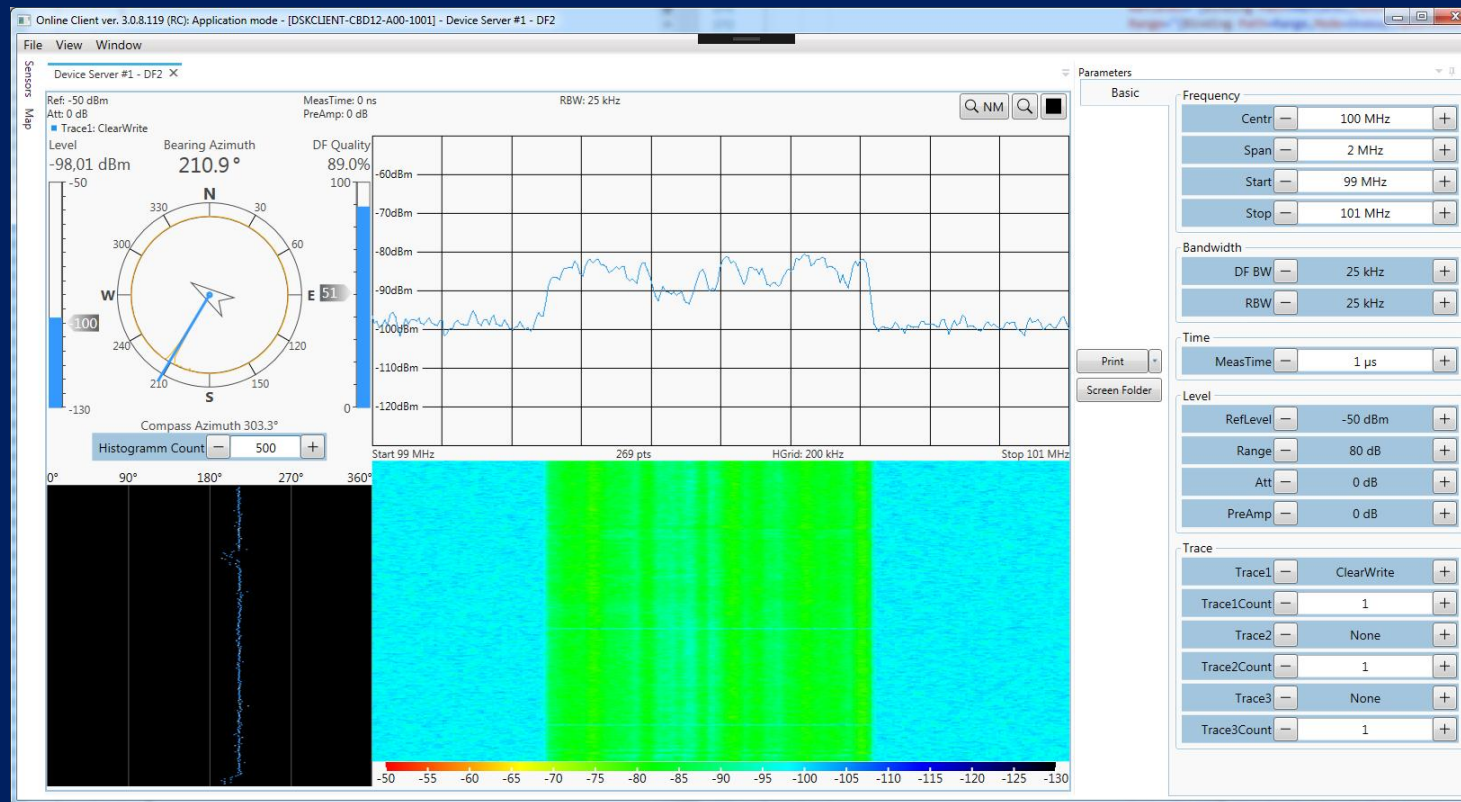
ICS MONITORING RT : HYBRID (TDOA – AOA) LOCALISATION



ICS MONITORING RT: SPECTRUM ANALYSIS

DIRECTION FINDING

If a measuring device (and antenna equipment) of a sensor feature direction finding function, it can be viewed directly in **ICS MONITORING RT SA**.



RECORDING OF SIGNALS

Besides observing signals, they can be recorded using the following options:

Recording of spectrum: the spectrum traces can be saved in a file. This file contains also meta information (parameters of receiver, date/time of receiving etc.). This file can be later opened in **ICS MONITORING Client RT** to provide the same measurements as for live-received signals.

Recording of IQ stream: the IQ data can be recorded in a file. IQ data can be used to demodulation/decoding of signal later.



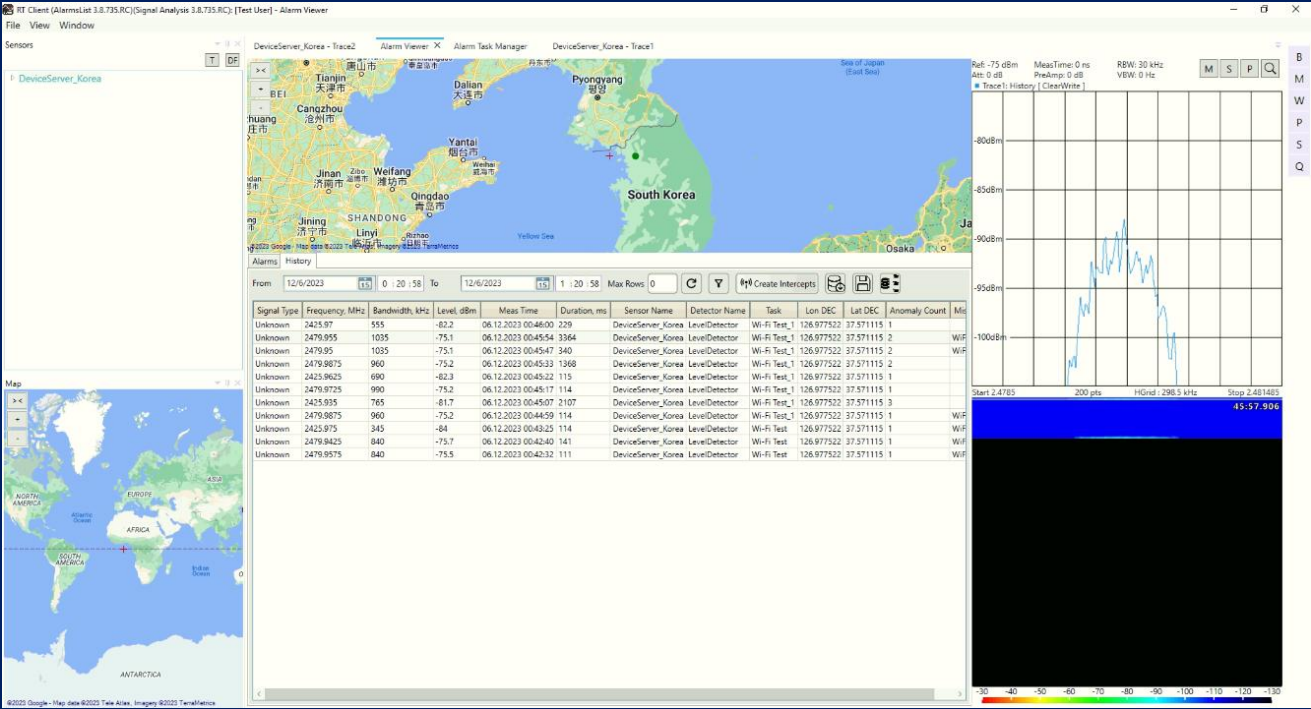
ICS MONITORING RT: ALARMING

Alarming is set of functions aimed at watchkeeping. It allows a user to detect all the cases when specified criteria were fulfilled, record the signal and store it for subsequent analysis.

An alarm is triggered when a specified alarm level is exceeded at any frequency within specified frequency band. The list of alarms can be viewed at “Alarm Viewer” tab. If several sensors are connected, it is useful to see the list of alarms directly on the map by hovering the sensor mark (green circle). List of alarms can be filtered and ordered by any field in the list.

For each alarm, a piece of received spectrum information during the defined period of time is automatically recorded. To examine an alarm information, a user can browse through the recorded waterfall section and export this information to a file.

If a signal has no or “grey” status, it is always shown on the list of alarms. If a signal was marked as “Ignored”, it is never shown on the list of alarms. If a signal was marked as “Base”, it will also be shown on the top of the alarm list and highlighted, since this status is used for the most important signals that shall not be missed.



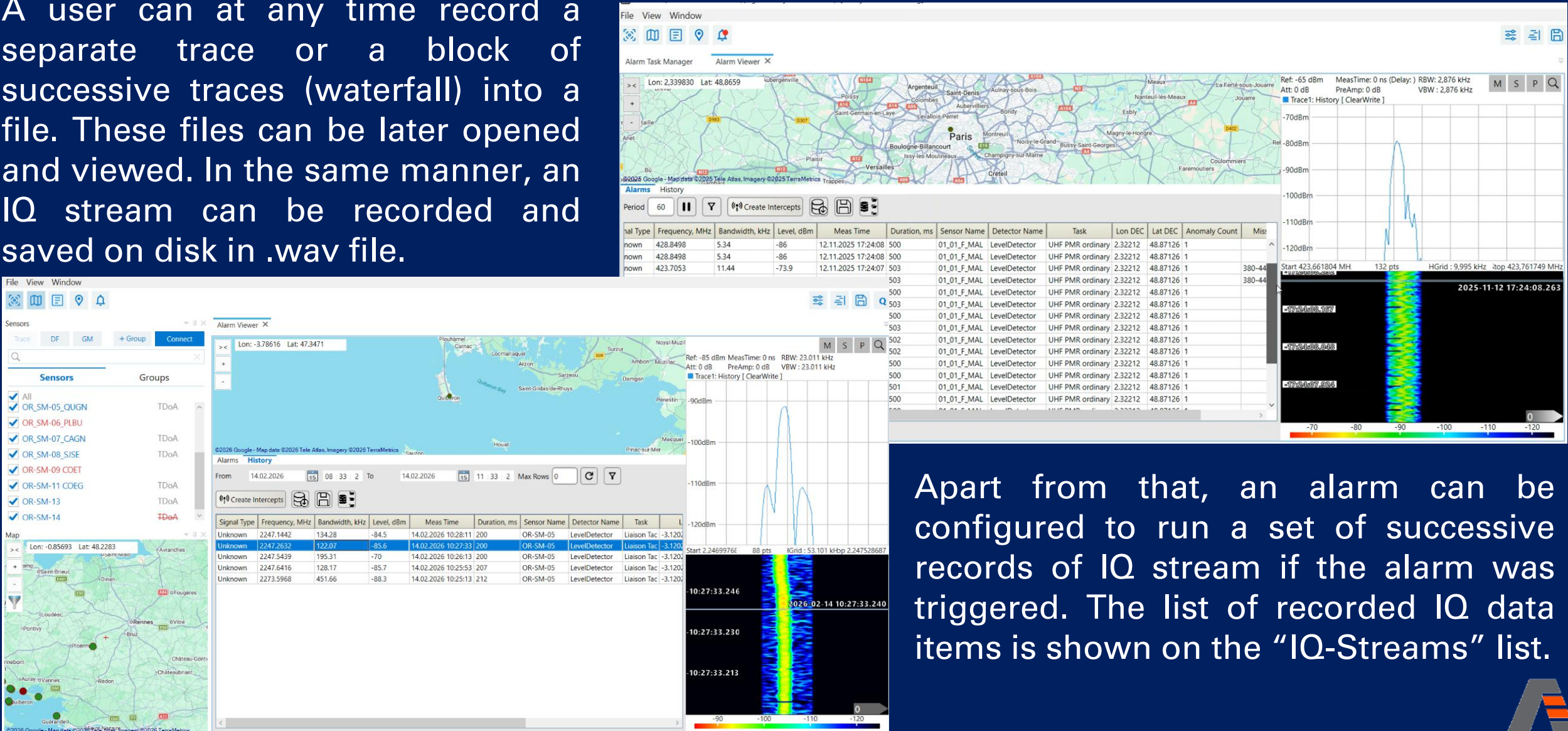
Missions management

Server: Alarm_France

Name	State	FreqMin, MHz	FreqMax, MHz	Json	Create By	Date create	Al
830_860	Created	830	860	False	Client France	08.09.2025 11:31	0
test	Stopped	90	100	False	Client France	05.09.2025 14:58	0
Task 1	Stopped	400	410	False	Client France	05.09.2025 15:02	44
380-440 MHz	Stopped	380	440	False	ICS Monitoring Client	26.06.2025 09:02	30
380-430 MHz	Stopped	380	430	False	ICS Monitoring Client	09.06.2025 16:08	23
GSM_UL_874-916 MHz	Stopped	874	916	False	ICS Monitoring Client	09.06.2025 15:51	0
test	Stopped	940	950	False	ICS Monitoring Client	30.06.2025 11:56	0
test	Stopped	90	110	False	ICS Monitoring Client	20.06.2025 20:10	35

ICS MONITORING RT: ALARMING RECORDING OF SPECTRUM TRACES AND IQ STREAMS

A user can at any time record a separate trace or a block of successive traces (waterfall) into a file. These files can be later opened and viewed. In the same manner, an IQ stream can be recorded and saved on disk in .wav file.

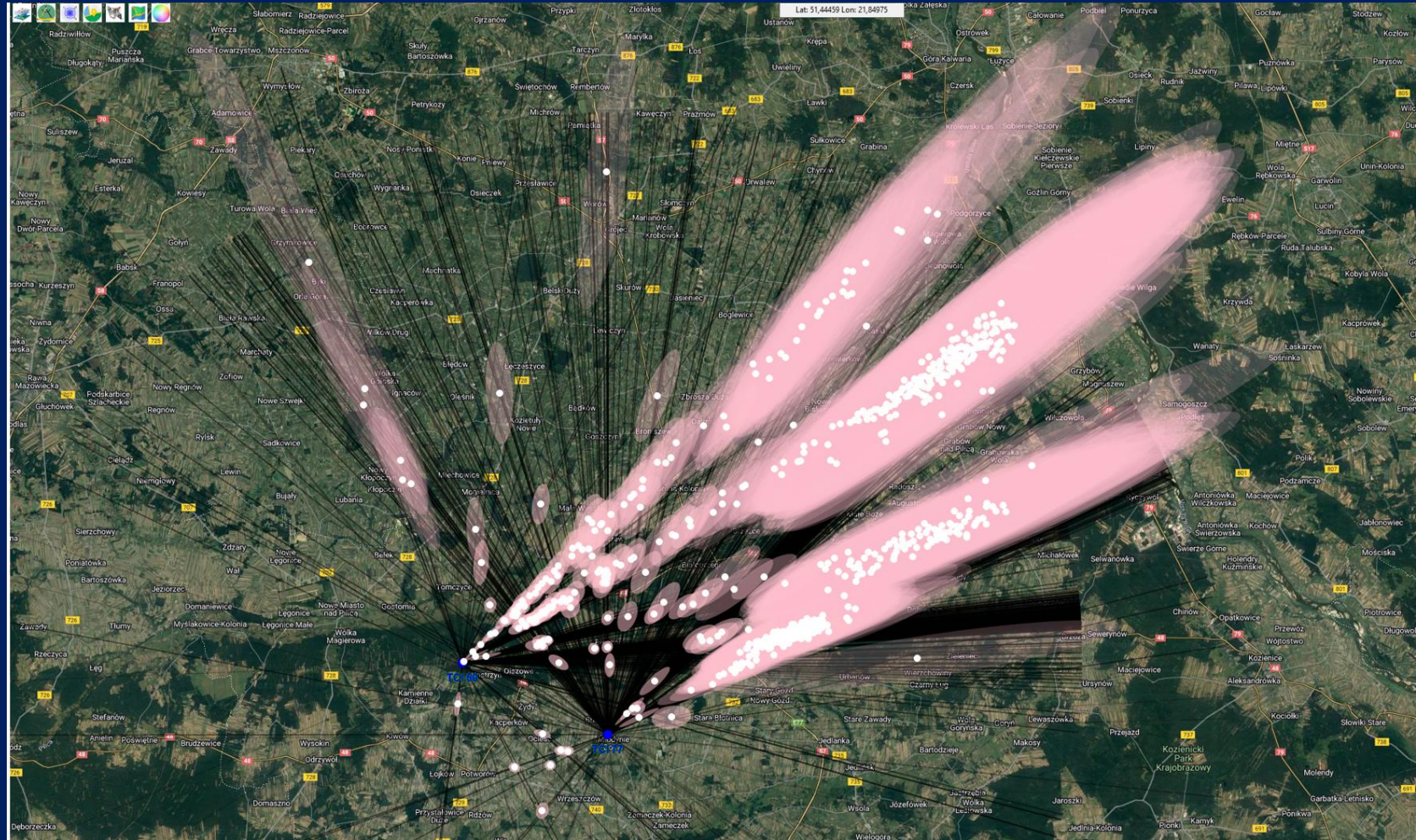


Apart from that, an alarm can be configured to run a set of successive records of IQ stream if the alarm was triggered. The list of recorded IQ data items is shown on the "IQ-Streams" list.



ICS MONITORING RT: ELECTRONIC WARFARE MAP

Electronic Warfare Map (EWM) is an option for ICS MONITORING CLIENT RT. It can be delivered as an independent software, when other functions of ICS MONITORING Client RT are disabled. The aim of this optional functionality is to support military actions for localization of the detected objects at the battlefield. EWM is a tool that collects the direction-finding information from multiple direction finders and then calculates the possible locations of the detected signal sources. It also provides the functionality for adding targets and sending the information for jamming of selected targets. The functionality of EWM is optimized for fast detection, selection and making a decision on the detected target in real time.



ICS MONITORING RT: ELECTRONIC WARFARE MAP

All actions in **EWM** are performed on map, which is an underlayer. All other information is organized as a set of additional layers that contain specific information. The following layers with the corresponding functionality are supported:

- Map layer depicts a map of a selected area. It can be switched between satellite, graphical or combined mode.
- Sensor layer (blue points) shows the sensors (i.e. direction finders) that are connected to the system and provide the information of bearing to detected signals.
- Bearing layer (black lines) contains the directions (bearings) from sensors to detected emission sources.
- Ellipse layer (pink ellipses) shows the previously calculated probability ellipse for probable location area of a detected emission source.
- Location layer (white circles) shows the probable location points, which are calculated by ICS MONITORING RT from the bearing information.

- Target layer allows a user to manually mark some points as targets. The user can manage targets (mark by different statuses, create, delete, filter) from the Targets panel (shown in the left bottom of the interface window).
- Contour layer allows to create and manage zones of responsibility. If a user is responsible for a particular sector of area, the information in other zones shouldn't be shown to this user. The zone of responsibility is created by a Supervisor of the system and is shown by blue line.
- Neighbor layer shows the information from the zones of responsibility that are adjacent to the zone of responsibility of the current user.
- Relief layer shows the relief in the selected area. It is important to take the relief shape into account during the analysis of detected objects and making decisions.

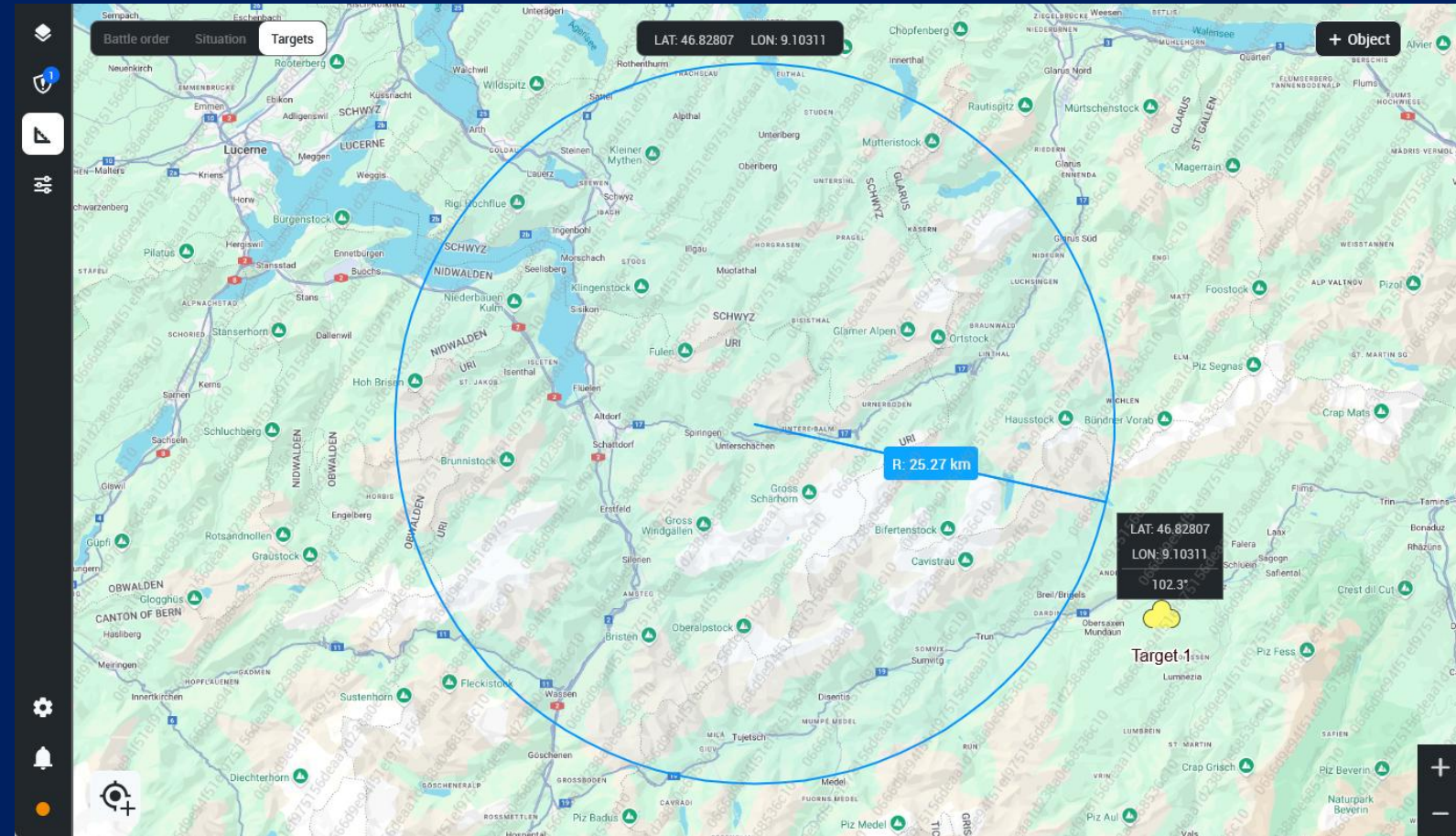
All abovementioned layers can be shown or hidden independently to support the most suitable view for the analysis.



ICS MONITORING RT: ELECTRONIC WARFARE MAP

EWM also provides time management for object analysis and classification. A user can work with the software in 2 modes:

- Real-time mode: in this mode, all the data received from direction finders are depicted on the map in semi-real time. Namely, a user observes the results detected during last 30 seconds.
- Time-selection mode: in this mode, a user can manually select a moment of time from measurement history, for which the information should be viewed. Another parameter that can be specified is the time period, within which the results will be depicted. For example, a user can select a moment of time 25 minutes ago, and time window of 3 minutes.



Once an object has been detected and classified, a user can send a command to jammers (if they are connected to the system, their location and parameters are also shown) for starting jamming selected areas. The command may contain the parameters of jamming: bearing, sector, frequency, bandwidth, radiated power etc.

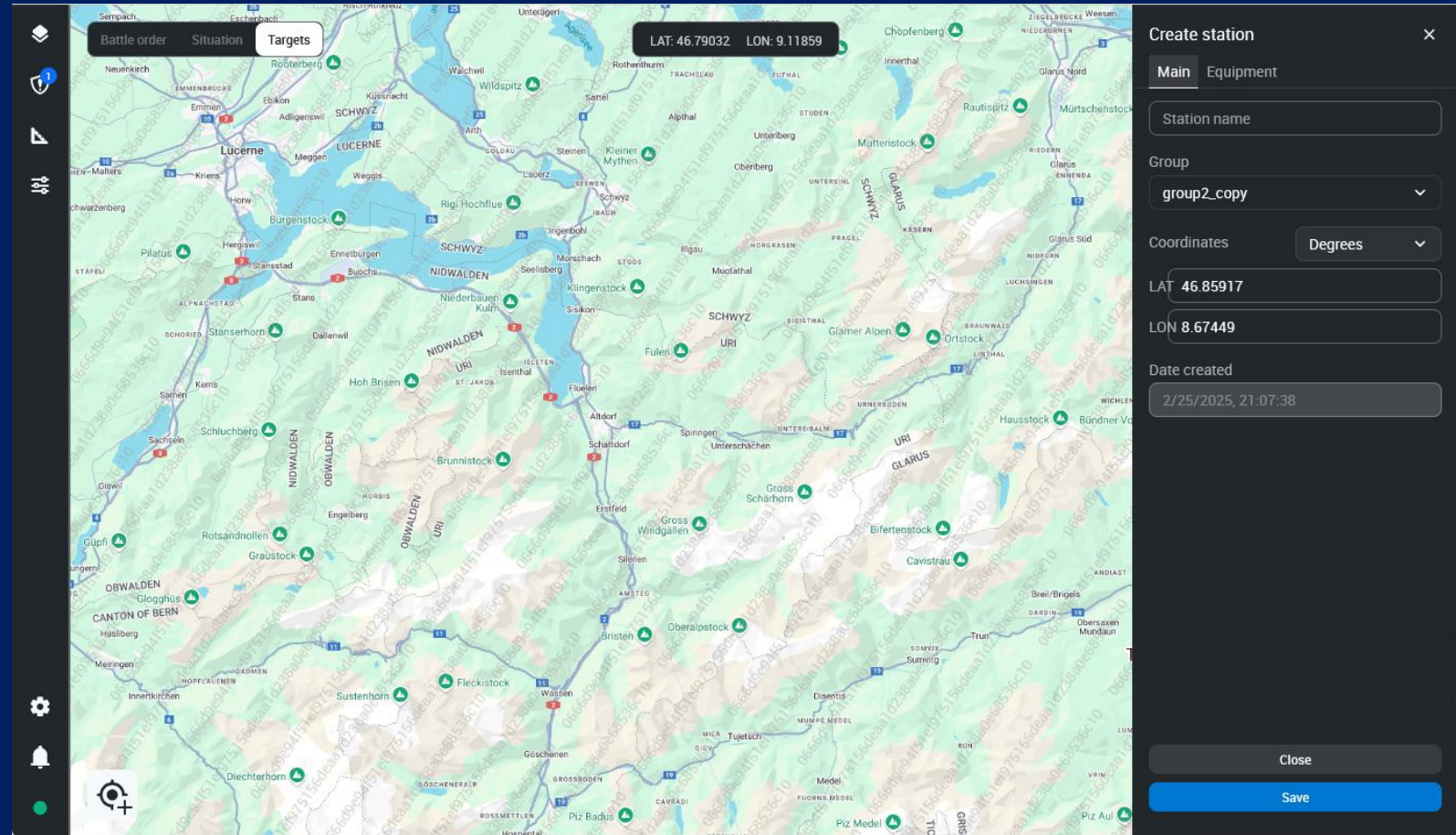


ICS MONITORING RT: ELECTRONIC WARFARE MAP

EWM supports order of battle functions:

- Time-selection mode: in this mode, a user can manually select a moment of time from measurement history, for which the information should be viewed. Another parameter that can be specified is the time period, within which the results will be depicted. For example, a user can select a moment of time 25 minutes ago, and time window of 3 minutes.
- Once an object has been detected and classified, a user can send a command to jammers (if they are connected to the system, their location and parameters are also shown) for starting jamming selected areas.

The command may contain the parameters of jamming: bearing, sector, frequency, bandwidth, radiated power etc.



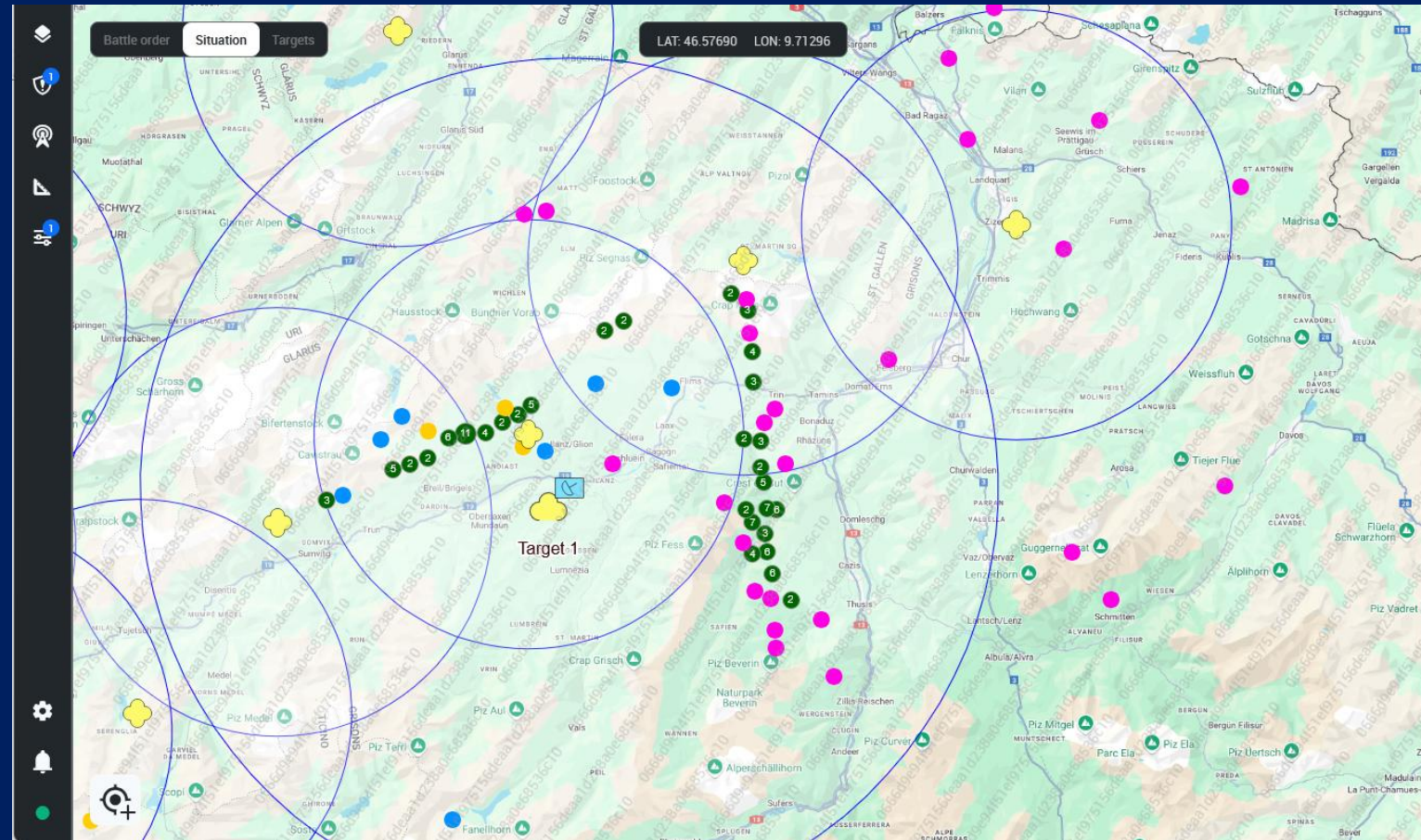
ICS MONITORING RT: ELECTRONIC WARFARE MAP

CLUSTERING OF SIGNAL SOURCES

During direction finding measurements, the same signal can be measured several times. Since each measurement is made with a certain finite accuracy, the measurement process produces multiple results for the single signal source. The more productive the measurement system, the more viable this effect becomes.

Multiple points (each point represents the result of locating the signal source) can probably represent the same signal source.

Since the purpose of such a measurement is to determine the position of the signal source on the map, the system user must process these multiple results manually to decide on the most likely location of the signal source.



Manual analysis of multiple data, even if supported by different software tools, does not take into account all the important factors that cause the results to be scattered.

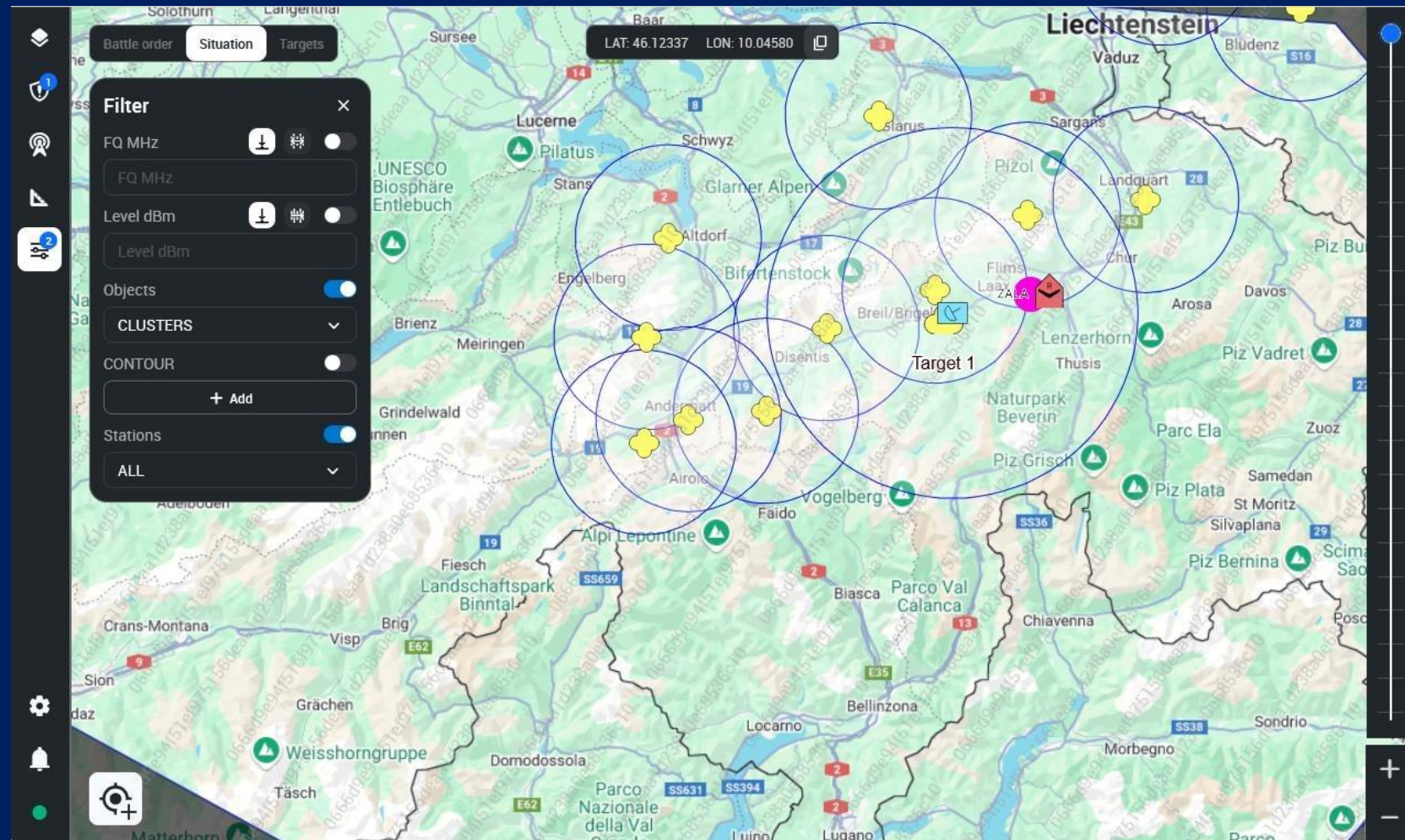


ICS MONITORING RT: ELECTRONIC WARFARE MAP

CLUSTERING OF SIGNAL SOURCES

In order to avoid the need to manually determine the location of the signal source, **ICS MONITORING/EWM** introduces intelligent clustering methods that automatically determine the location of the most likely signal source.

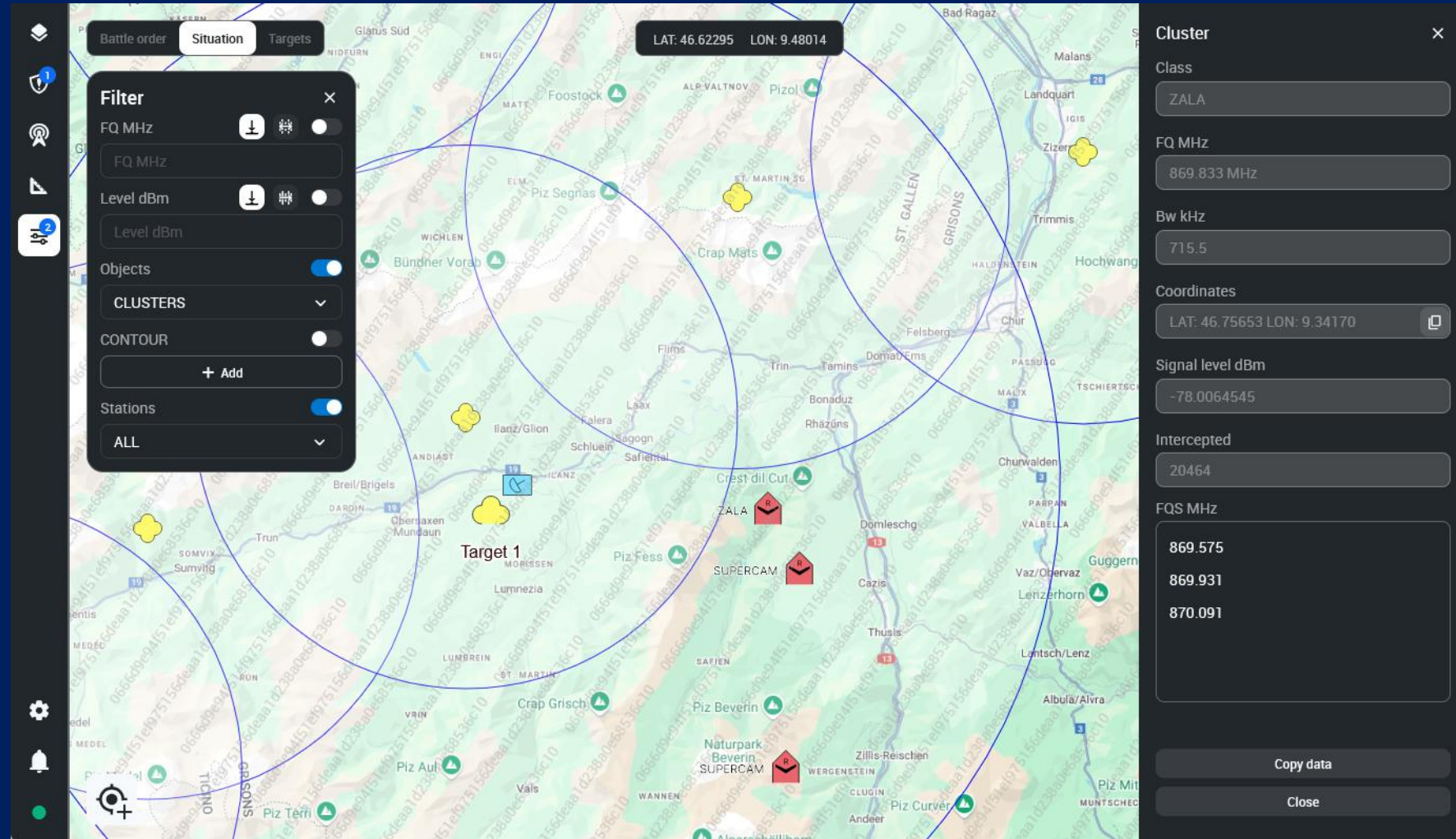
Through the application of sophisticated data processing algorithms, multiple measurement results are analyzed and converted into a single object, called a signal cluster, which aggregates a set of signal source locations and presents the user with information about the probable location, center frequency, bandwidth, level, level accuracy, and other information about the signal source.



ICS MONITORING RT: ELECTRONIC WARFARE MAP SIGNALS CLASSIFICATION

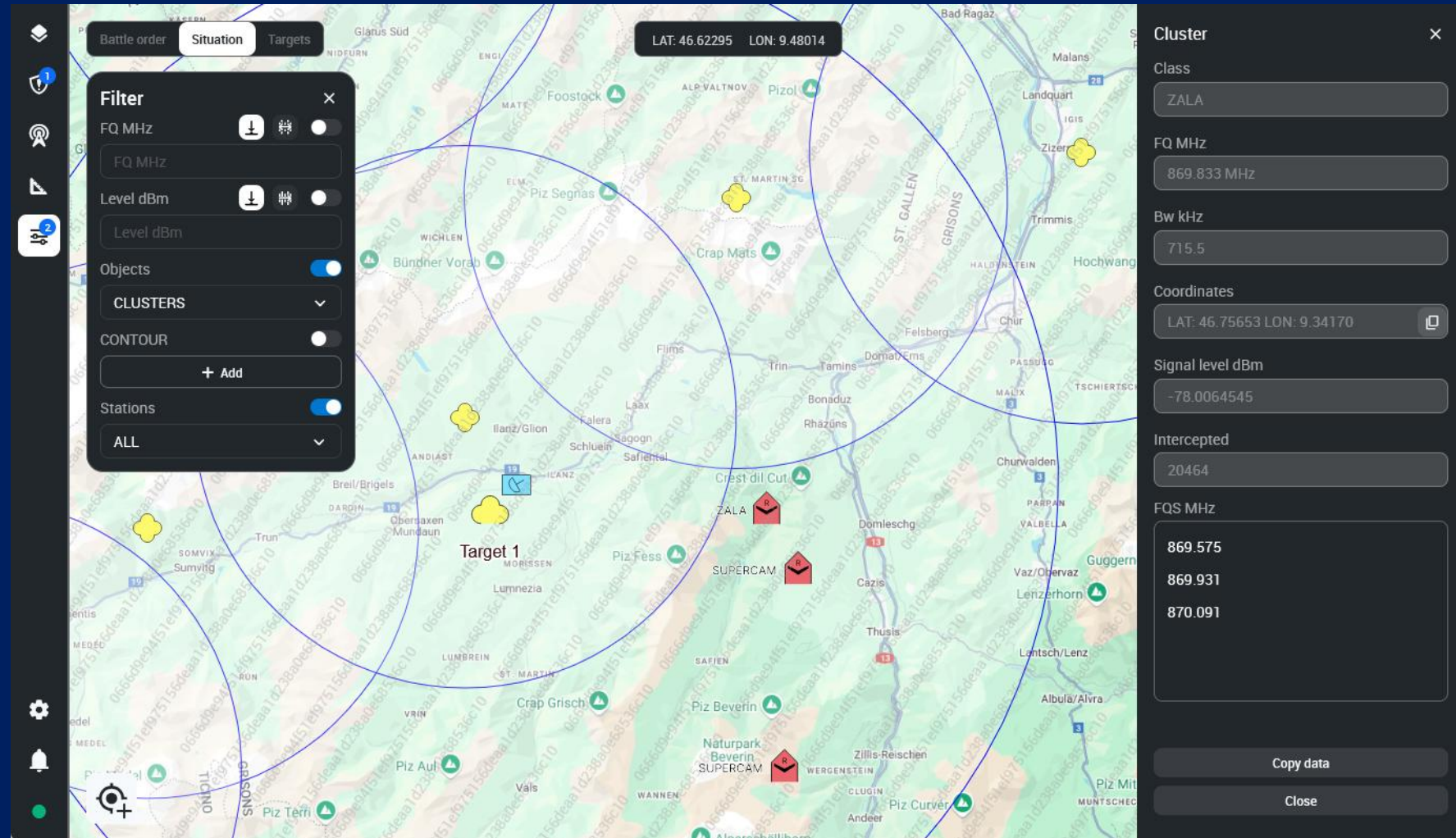
Signal classification involves determining the type of transmitter used to generate the signal. Signal classification presents the user with information about the likely pattern of the object whose signal is being received and estimated.

To enable the classification of a signal source, many attributes of the detected signal are taken into account: measurement time, signal duration, signal cascade record, signal center frequency, bandwidth, and others.



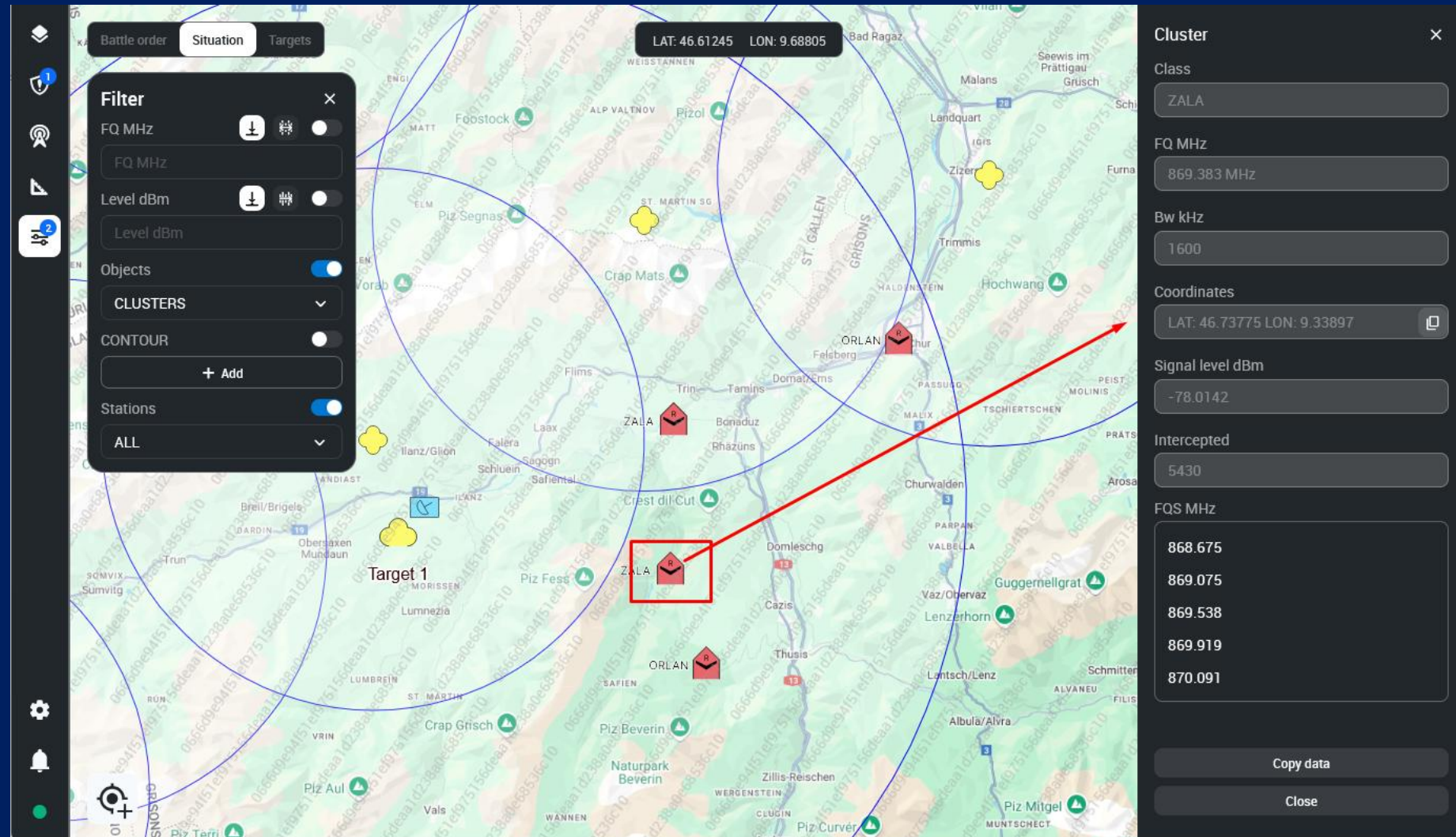
ICS MONITORING RT: ELECTRONIC WARFARE MAP SIGNALS CLASSIFICATION

Sophisticated data processing algorithms are used to determine the set of attribute values, which are unique for a certain type of transmitter (communication standard). Therefore, once the signal is grouped together, it can be classified, i.e., the information about the object type can be determined. Such an approach makes it possible to classify even impulse signals, including Frequency-Hopping Spread Spectrum (FHSS) signals and linear frequency modulation (chirp) signals.



ICS MONITORING RT: ELECTRONIC WARFARE MAP SIGNALS IDENTIFICATIONS

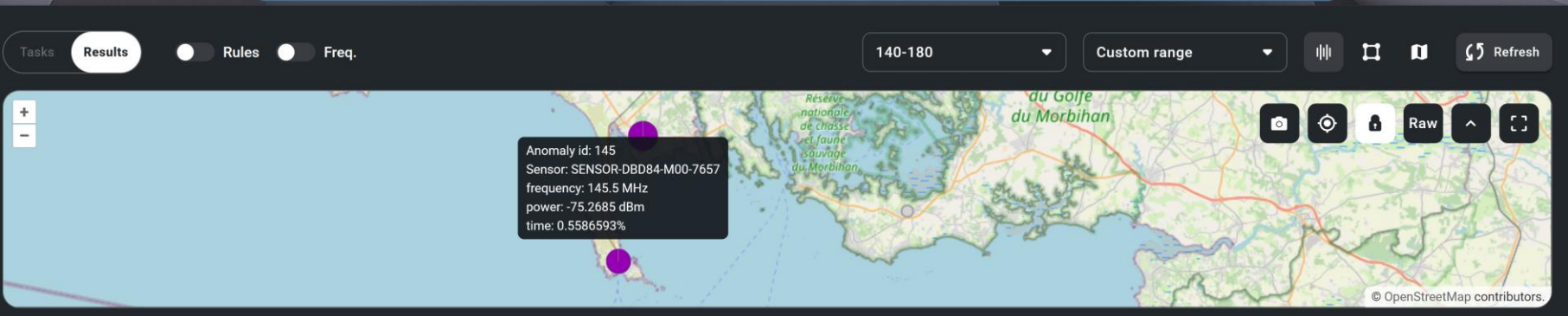
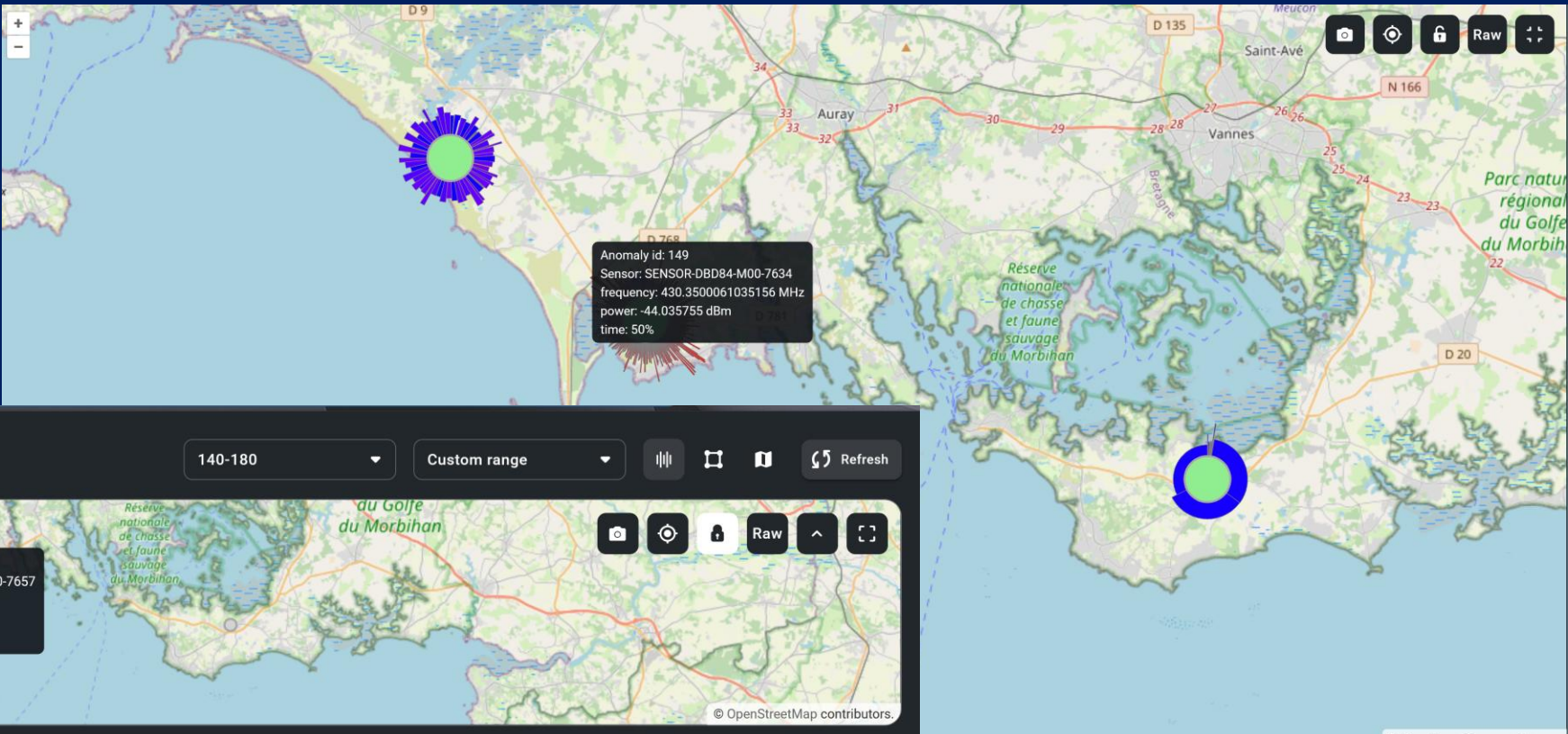
The information about the signal groups (large circles) contains the result of the signal classification, which includes the type of transmitter and the estimated probability of the classification. For example, the field "99.82% (name) of UAV" means that the source of the signal is a UAV (name) with a probability of 99.82%.



ICS MONITORING AT: ELECTROMAGNETIC ENVIRONMENT (EME)

Automated identification of "significant" variations in the Electromagnetic environment (EME)

Automated creation of reference spectrum for sensors according to a predetermined schedule



ANOMALY Anomaly Events Statistics

Search + Freq. + Rule

AG	AFFILIATION	CENTER FREQ MHZ	BANDWIDTH KHZ	POWER NOW MAX DBM	ACTIVITY NOW	ACTIVITY PREV	START MEAS	STOP MEAS	ACTIVITY ABSOLUTE CHANGE TAG	ACTIVITY RELATIVE CHANGE
	Unknown	145.5	100	-75.269	0.559	99.435	17.02.2026, 11:22	17.02.2026, 11:53	DecreasedBelowThreshold	Decreased
	Unknown	145.5	100			99.435	17.02.2026, 11:52	17.02.2026, 12:24	DecreasedBelowThreshold	Decreased
	Unknown	145.45	200.006	-62.783	0.465	0.952	17.02.2026, 14:41	17.02.2026, 15:11	DecreasedBelowThreshold	Decreased
	Unknown	145.45	200.006			0.952	17.02.2026, 15:11	17.02.2026, 15:41	NoChange	Decreased

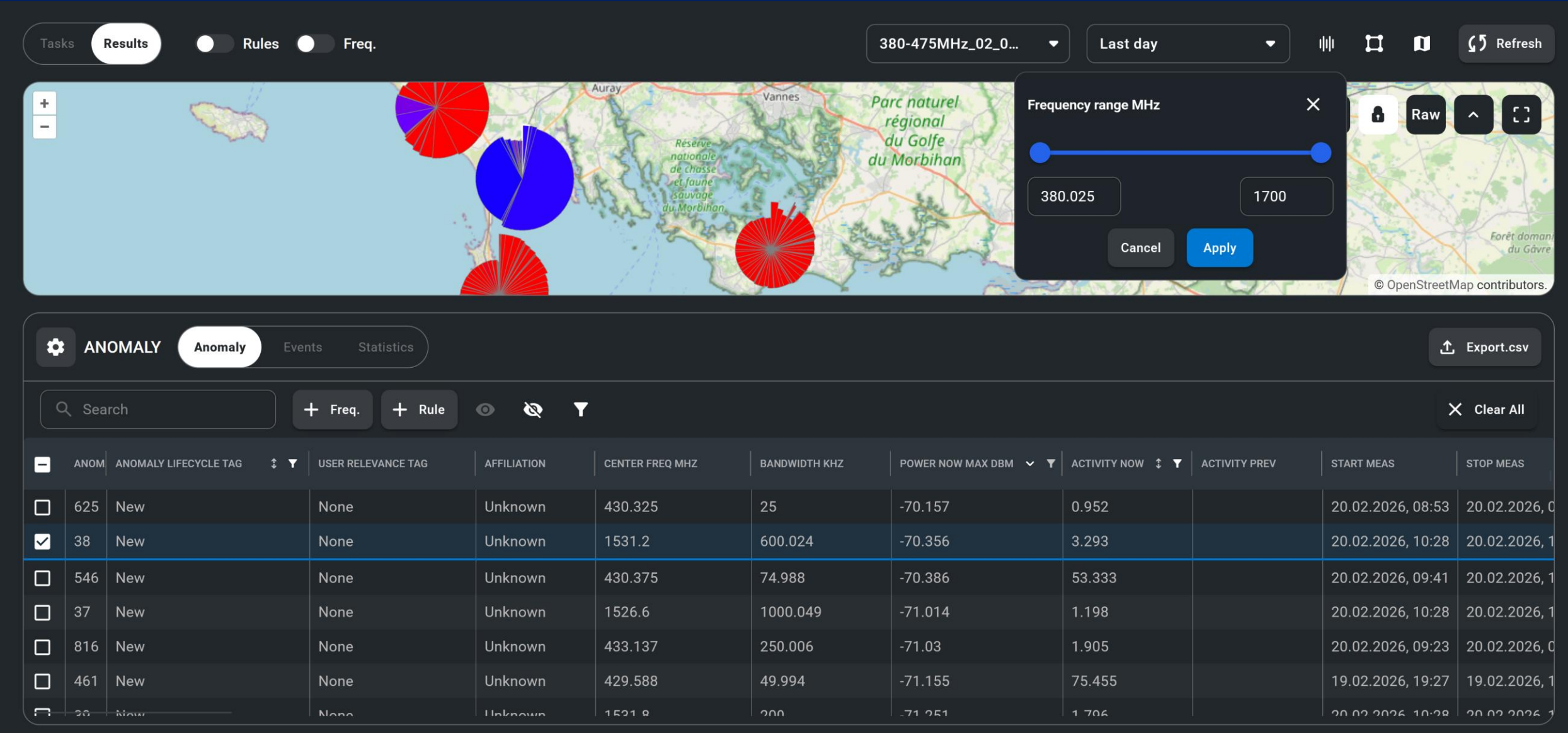
Export.csv Clear All

Automated electromagnetic environment assessments on a schedule

Statistical detection of anomalies and spectrum patterns



ICS MONITORING AT: ELECTROMAGNETIC ENVIRONMENT (EME)



INTEGRATION WITH EXTERNAL SYSTEMS

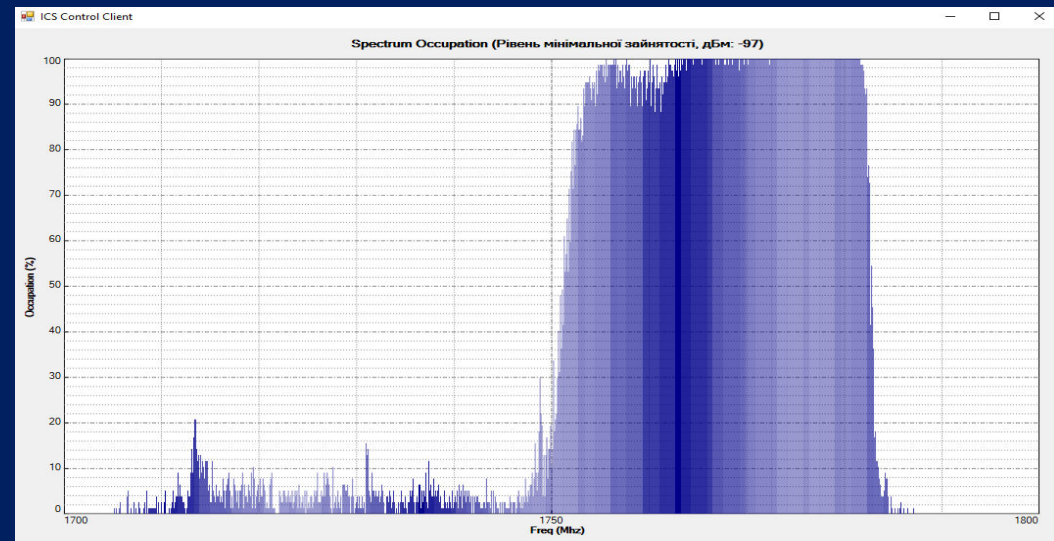
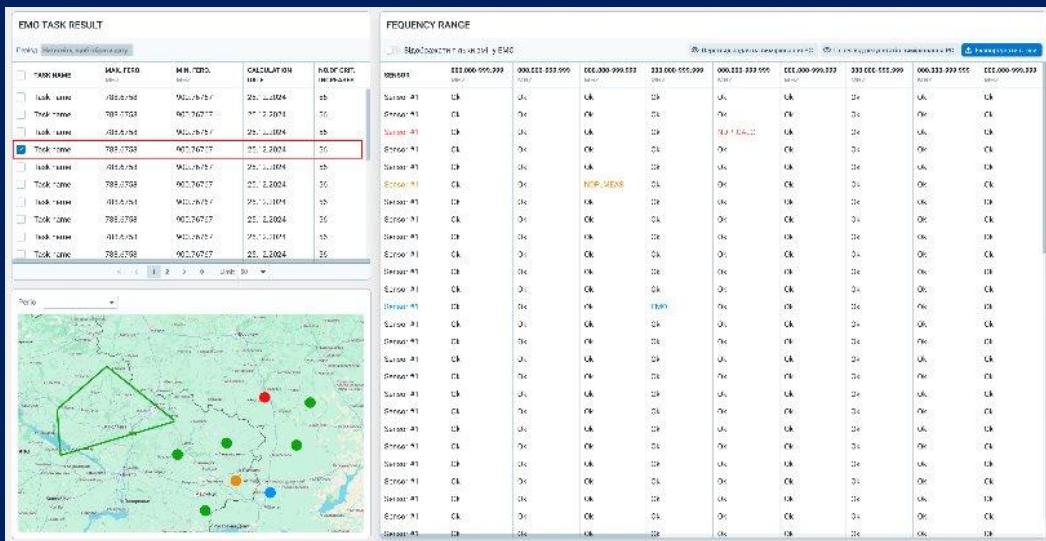
Types of Integration

- Integration with measurement equipment
Examples: R&S, TCI, Narda, Keysight, SignalHound, ...
- Integration with highly specialized systems
Examples: Airfence, Argus, ...
- Integration with acoustic sensing systems
- Integration with radars
(air-defense radars, battlefield surveillance radars, counter-battery radars)
- Integration with external information systems
Examples: Palantir ...

Purpose of Integration

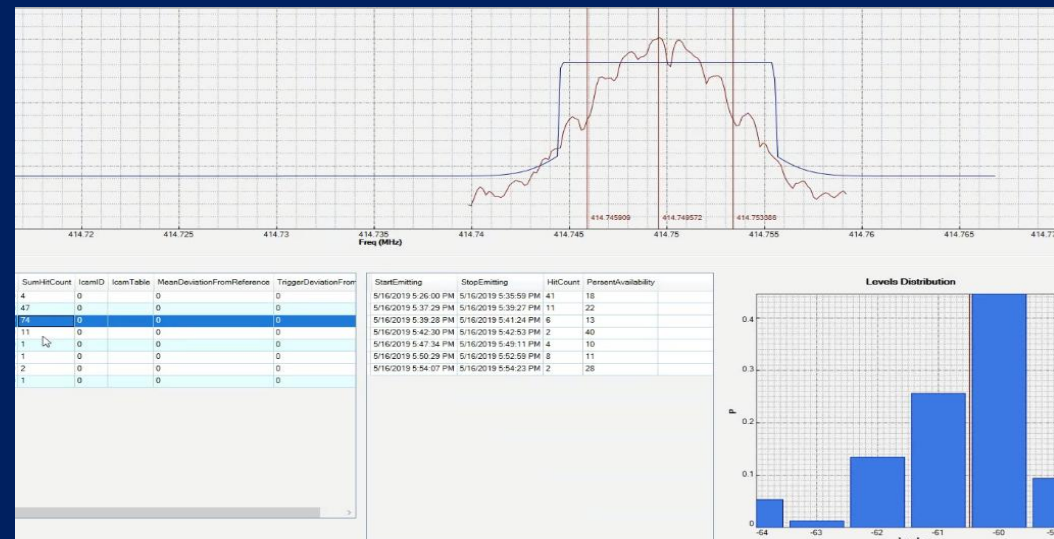
- Data acquisition: receiving real-time or batch measurement data from external platforms
- Equipment control: remote tasking, triggering, configuration and operational management
- Exchange of specialized data streams:
(telemetry, threat indicators, classification metadata, situational-awareness information)





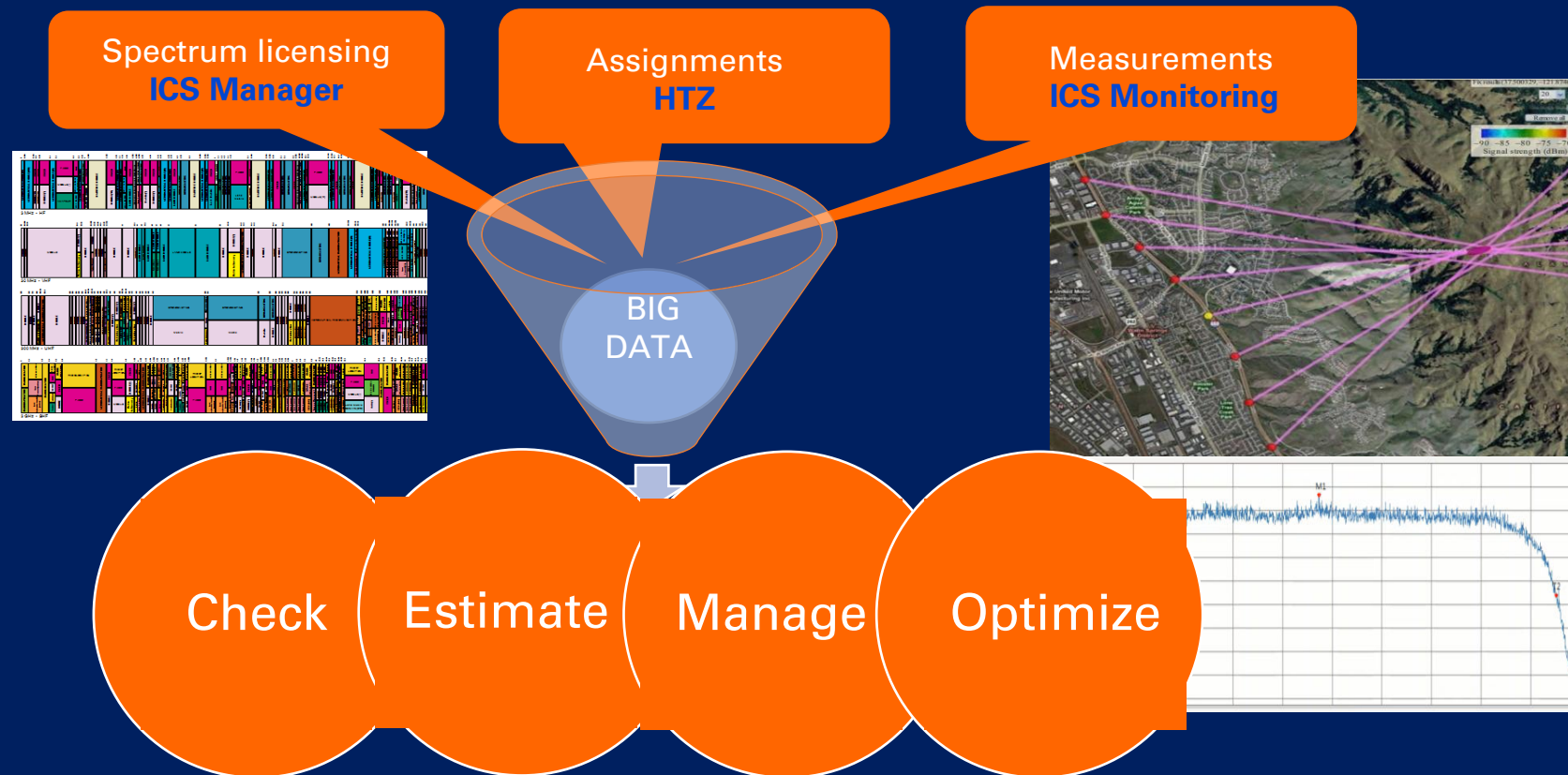
ICS monitoring AT

Long term data collection and statistical analysis



ICS MONITORING AT: PART OF ATDI SPECTRUM MANAGEMENT SYSTEM

GATHERING BIG AMOUNT OF DATA FROM VARIOUS SOURCES



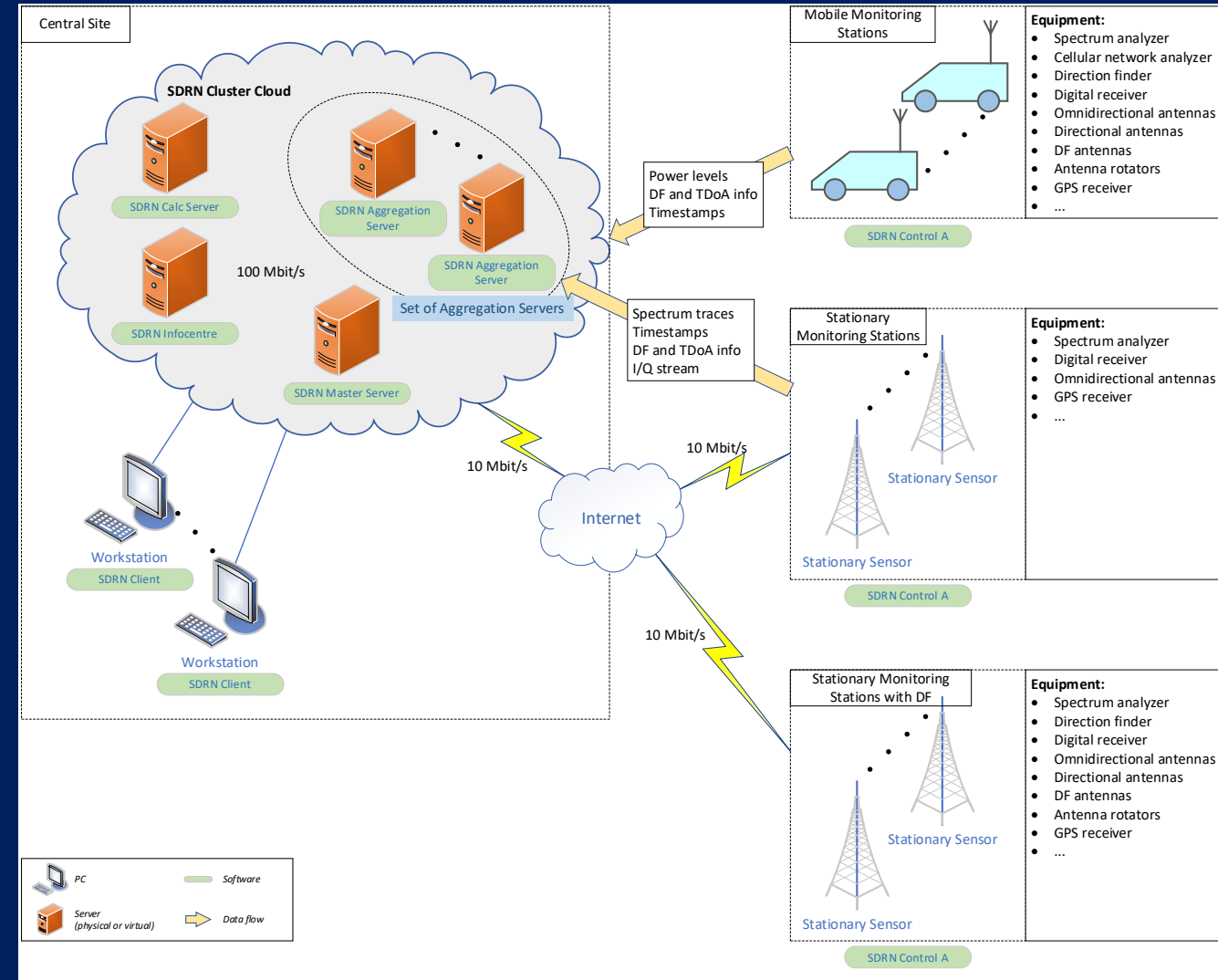
ICS MONITORING AT: SENSOR NETWORK CONFIGURATION

The tasks that shall be solved by the modern spectrum monitoring systems are as follows:

- Spectrum occupancy estimation
- Detection and characterisation of signals
- Technical control: estimation of the parameters of transmitters and their comparison to the expected values

The modern approach to solve these tasks implies deployment of a **sensor network**.

To maintain a large sensor network, a corresponding software should be used.



ICS MONITORING AT: EMISSIONS MONITORING

- Parallel measurements performed on a large number of geographically distributed sensors in 24/7 mode
- Simultaneous measurements in multiple frequency bands according to the national frequency allocation plan
- Automatic comparison of measurement results with masks from authorised transmitters
- Saving measurement results in a central database

Channel allocations

ID	CUST_IDR1	CUST_IDR3	CUST_TXT1	USE_TYPE	STANDARD	CHANNELS	Channeling plan	STATUS	BUSE_DATE	EO
73038	1724		signalization, test, al	M			YXX CT3 (410-430) 10	dur		
73035	2341		TestSignalization8	M			YXX CT3 (410-430) 10	dur		
73034	2304		TestSignalization7	M			YXX CT3 (410-430) 10	dur		
73033	1601		TestSignalization6	M			YXX CT3 (410-430) 10	dur		
73032										
73031										

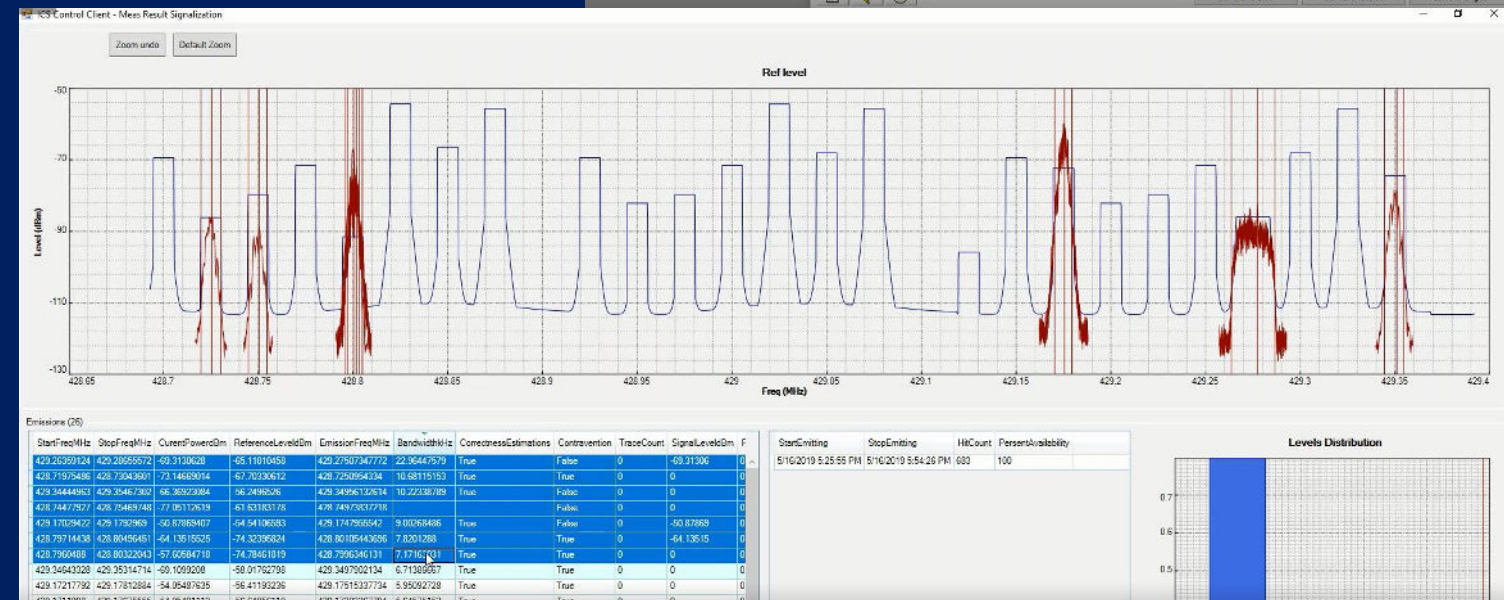
General Process Custom Accesses in Attachments

Search for a Channeling plans record - Step 2 of 2

ID	Ident	Name	Frequency range
1561	1561	A3M JX (148.5-283.5 xF u)	149.0 kHz - 287.0 kHz
1495	1495	PCP (233.5-325 xF u)	283.25 kHz - 325.25 kHz
1568	1568	PECC (HABTEKC 400-518 xF u)	489.75 kHz - 518.25 kHz
1562	A3M CX	A3M CX (526.5-1606.5 xF u)	523.0 kHz - 1610.0 kHz
1567	1567	PPK CT3	993.75 kHz - 1000.00 kHz
1491	1491	PECC (2-26)	1623.0 kHz - 2278.0 kHz
1522	1522	PECC (2-26)-294k	1715.0 kHz - 2140.0 kHz
1523	1523	PECC (2-26)-295k	1796.0 kHz - 2062.0 kHz
1430	1430	XX CT3	2042.5 kHz - 2642.5 kHz
1524	1524	PECC (2-26) TACB8	2174.25 kHz - 26100.75 kHz
1583	1583	PECC (HABTEKC 2650 xF u)	2648.0 kHz - 2651.4 kHz
1570	1570	PECC (2-26) HN	4352.5 kHz - 8720.5 kHz
1424	1424	PPK CT3 (33-40)	33.19375 MHz - 48.48125 MHz
1422	1422	YXX CT3 (33-38)	33.19375 MHz - 58.00625 MHz
1458	1458	PPK CT3 (33-40)	38.24375 MHz - 48.48125 MHz
1200	ATM5	Agonistive ATM 7 MF u	47.0 MHz - 69.0 MHz
1621	1621	YXX CT3 6.25	48.99875 MHz - 470.003125 MHz
9	ATM4	(52.5-858) 8 MF u	58.0 MHz - 862.0 MHz
15	A3M1	(65.9-100) 0.3 MF u	65.01 MHz - 108.05 MHz
242	242		107.95 MHz - 111.95 MHz
1455	1455	PPK CT3 (150-168)	150.04375 MHz - 167.76875 MHz
1459	1459	PPK CT3 (150-168)	150.04375 MHz - 167.76875 MHz
1478	1478	YXX CT3 (150-168)	150.04375 MHz - 167.76875 MHz
1535	1535	LYXX CT3 (150-168)	150.04375 MHz - 167.76875 MHz

* Click= Return selected record; Right click= Edit record

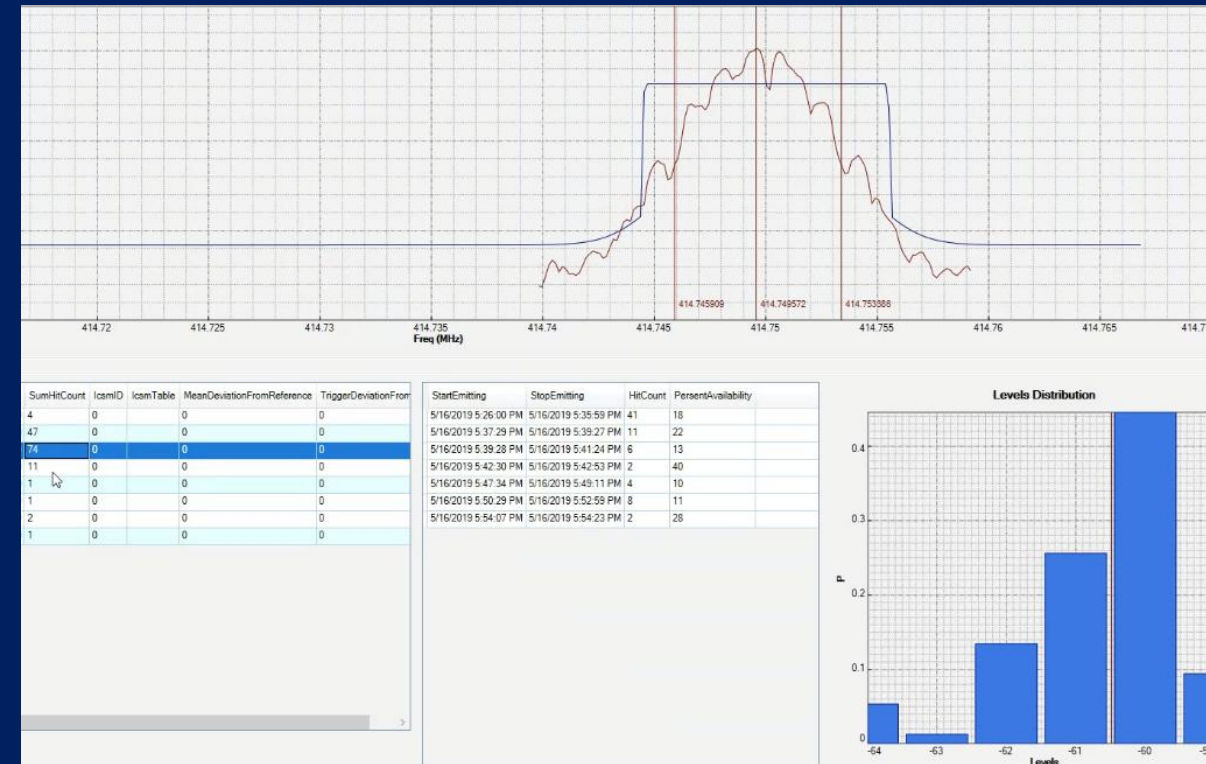
Cancel < Back Next > OK



ICS MONITORING AT: STORAGE AND BACKUP OF EMISSION MONITORING MEASURES

For each detected emission, recording of:

- Emission spectrogram
- Transmission parameters (frequency, bandwidth, call sign, etc.)
- Time intervals during which the emission was identified
- Statistical distribution of the level of the received signal
- Location and conditions of the recording of programs



ICS MONITORING AT: ASSESSMENT OF OCCUPATION OF RADIO FREQUENCY BANDS

Sensor 1

Level, dBm	Occupancy, %
- 48	0
- 52	5
- 56	10
- 60	25
- 64	40
- 68	55
- 72	56
- 76	57
- 80	58
- 84	59
- 88	60
- 92	80
- 96	85
- 100	90
- 104	95
- 108	100

Sensor 2

Level, dBm	Occupancy, %
- 48	0
- 52	5
- 56	15
- 60	30
- 64	45
- 68	60
- 72	61
- 76	62
- 80	63
- 84	64
- 88	65
- 92	80
- 96	85
- 100	90
- 104	95
- 108	100

The principle of analysis is based on the collection and processing of signal level statistics

	Thresholds about e meaning _	Sensor 1	Sensor 2
First case	-84 dBm	59 %	64 %
Second case	-64 dBm	40 %	45 %

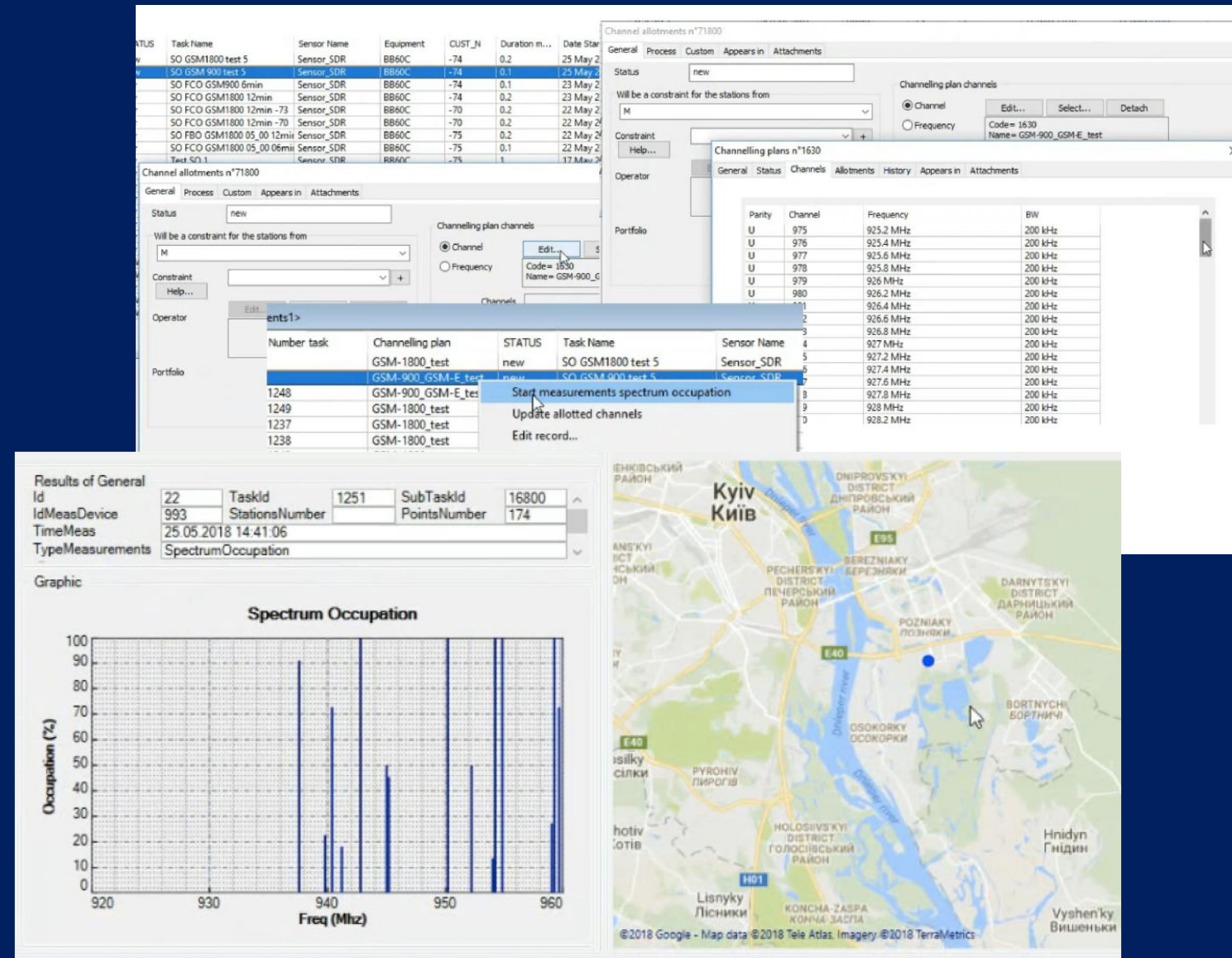
Possibilities:

- Accumulation of statistical distribution of signal levels;
- Assessment of RF bandwidth occupancy with the ability to analyze data collected from 1 year to 1 hour, which will allow you to evaluate subscribers by territorial and time distribution;
- Provides data for making decisions about the efficiency of using a radio frequency resource.



ICS MONITORING AT: SPECTRUM OCCUPANCY MEASUREMENTS PRINCIPLE

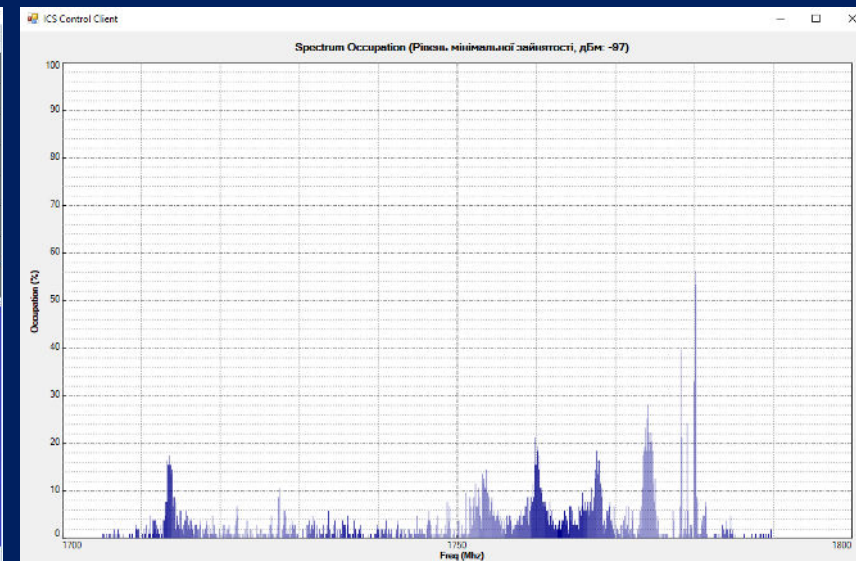
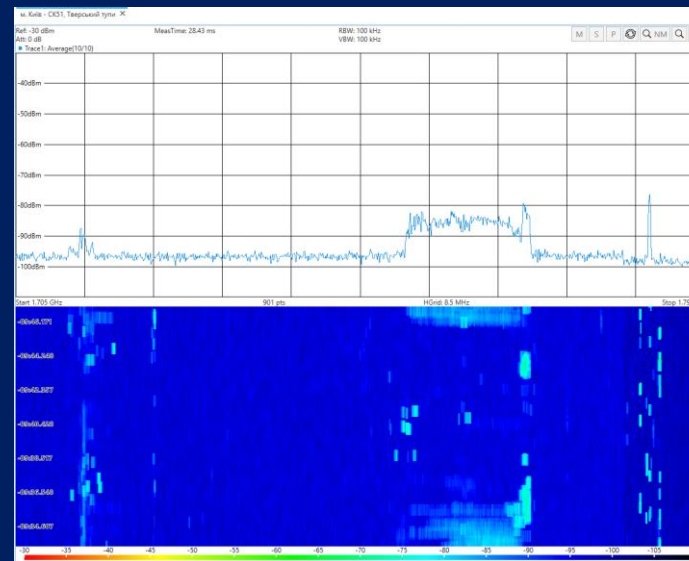
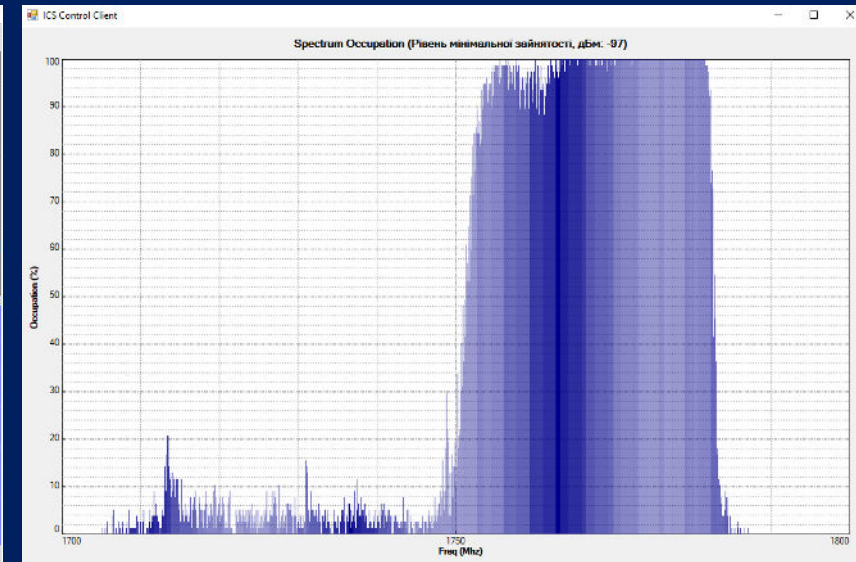
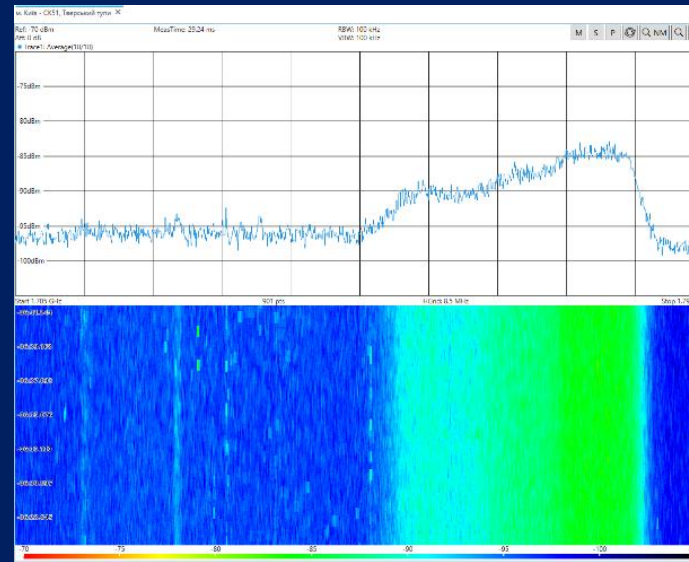
- Parallel measurements performed on a large number of geographically distributed sensors in 24/7 mode
- Measurements made in accordance with multiple channel plans
- Complies with ITU-R SM.1880-1 and ITU-R SM.2256



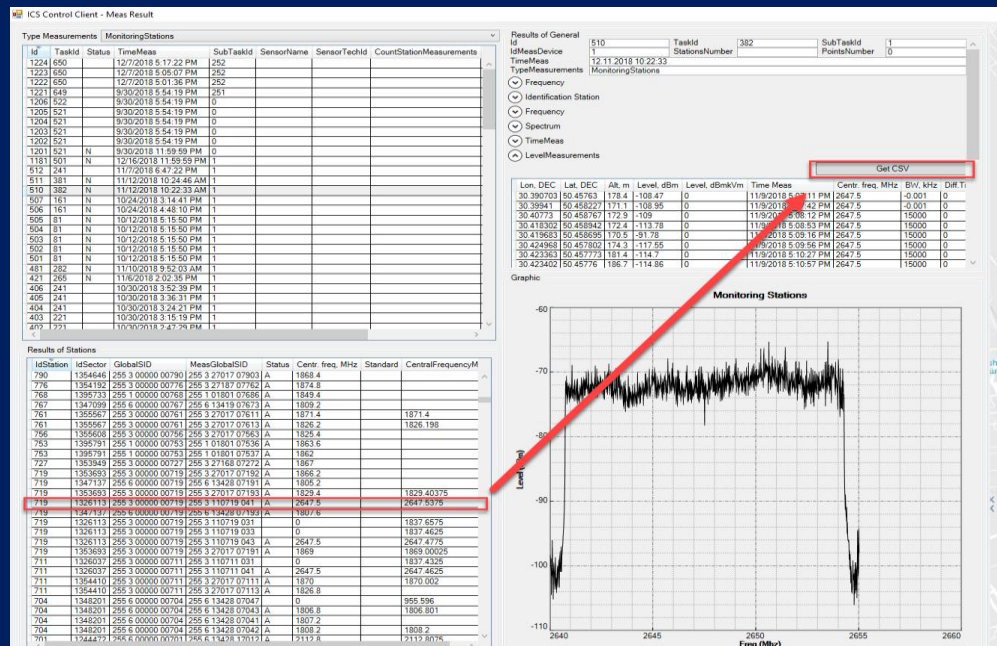
ICS MONITORING AT: SPECTRUM OCCUPANCY MEASUREMENTS STORAGE AND BACKUP

For each channel, the following information is stored:

- Occupancy (FBO/FCO) over time
- Statistical distribution of signal levels in the channel, allowing occupancy to be recalculated for different thresholds
- Location and conditions of signal recording



ICS MONITORING AT: IDENTIFICATION AND CORRECTION OF EMITTERS PARAMETERS



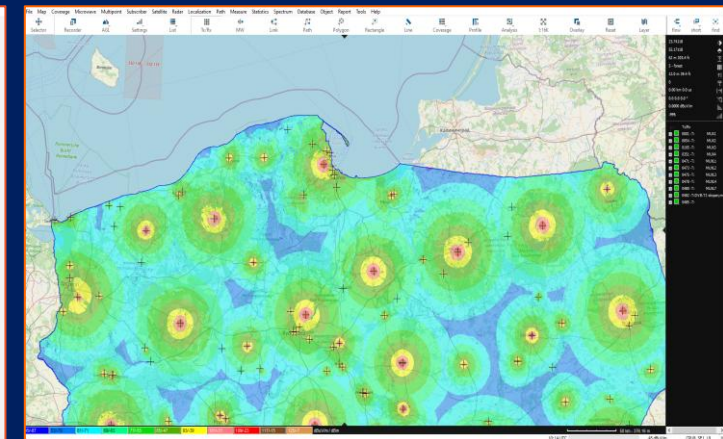
ICS MONITORING AT: IDENTIFICATION AND CORRECTION OF EMITTERS PARAMETERS

PLAN the mission

DO the mission process via comparison of prediction and real time measurements

CHECK unknown parameters by reverse simulation

ACT by modifying mission according to identified parameters



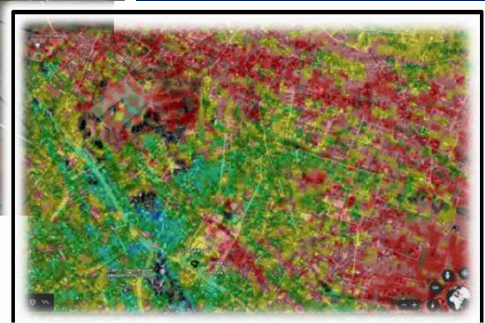
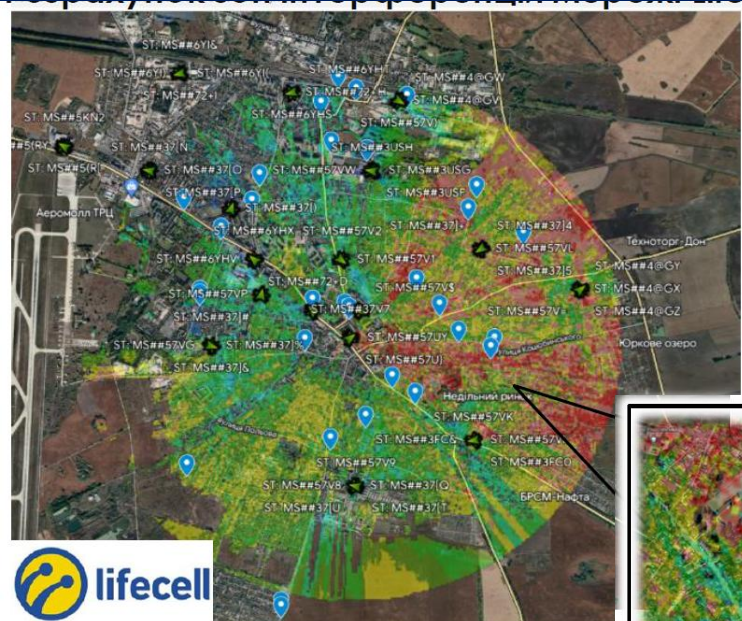
- Measurement processing
- Emission monitoring
- Automatic data management

- Propagation model tuning
- Reverse identification of emitters parameters

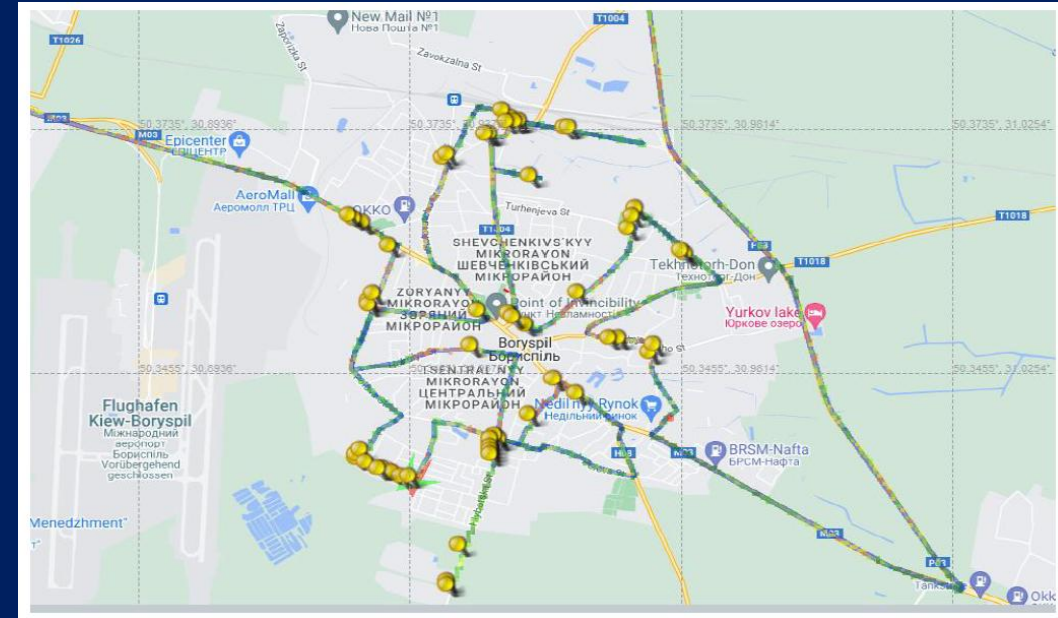


ICS MONITORING AT: MOBILE NETWORKS INTERFERENCE CALCULATIONS

Calculation of network interference zones



Confirmation of interference areas using a mobile radio monitoring station



Possibilities:

- Determines a low signal-to-noise ratio, which affects the quality of service provision.

Causes:

- Signs of intra-system interference in radio frequency ranges;
- Interference during radio wave propagation;
- Differences between the technical parameters of base stations and the declared ones.



ATDI SA

11 boulevard
Malesherbes
75008 Paris
FRANCE

+33 1 53 30 81 41
contact@atdi.com

