Airport Communications Network Design Using HTZ Communications

ADVANCED SOLUTIONS IN RADIOCOMMUNICATIONS

ATDI

1.1 INTRODUCTION

ATDI solutions address radio navigation and telecom experts involved in wireless systems deployed in Airports and RF spectrum management.

The ATDI's solutions dedicated to CNS (Communications, Navigation and Surveillance) allows to ensure :

- Radio planning and optimization activities for all wireless systems deployed in airports;
- Aeronautical frequency spectrum management in order to ensure sufficient access to the resource for the provision of aeronautical communication, navigation and surveillance services in an efficient and safe manner.
- Administrative and technical spectrum management procedures ;
- Consistency with international obligations and standards ;
- Efficient management and coordinated assignment of frequencies at national and regional level

1.2 ATDI in a few words

Military/Security/Civil Spectrum management Solution with over 30 years experience

Provides software and services in radio communication

- Radio planning and spectrum engineering
- Spectrum management and monitoring
- Digital cartography
- Communication electronic warfare

A significant number of clients

More than 2 000 clients in every sector of radio from regulation , Civil Aviation Authorities, military and civil networks

1.3 Solutions in Radio Communication

ATDI provides software and services in all area of radio communications

- Radio network planning & management (civil & military)
- Communication electronic warfare
- Spectrum management
- Digital cartography

Main markets

- Telecom operators / Broadcasters
- Regulators / Civil Aviation Authorities
- Military forces / Emergency services
- Telecom Equipment Manufacturing
- Engineering Services consulting firms

1.4 Active member of ICT organizations

Our team of experts fully supports your organization addressing all spectrum management issues

ATDI is a full member of many information and communications technology (ICT) organizations:

- Working Group on HCM ("Harmonised Calculation Method")
- ITU (International Telecommunication Union)
- Working Group NATO - STCCT (Spectrum Tools Configuration Control Team)
- EBU (European Broadcasting Union)
- Working Group - COPIC/ANFR
- Working groups for new technologies (IoT, 5G, ITS, etc.)
- Partnerships with around thirty universities worldwide (CNAM, INSA, ISEP, etc.)

1.5 ATDI contributions in Spectrum Management domain

ATDI is a regular participant of ITU events, international meetings and regional ITU Telecom exhibitions, and gives the company greater influence over ITU-T policy, scope of study groups. Spearheading ATDI's involvement is company spectrum.

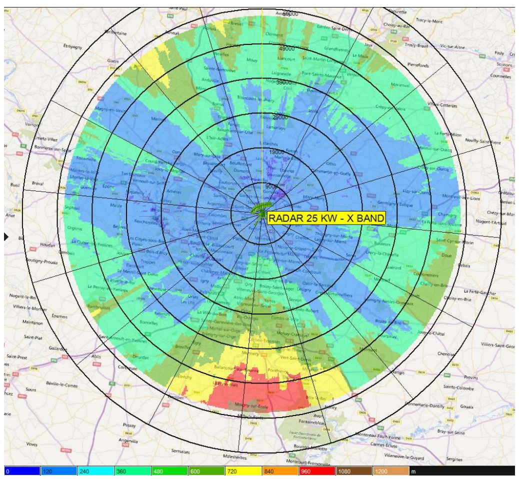
ATDI has played a role in the work of ITU-R which deals with issues such as spectrum management, cognitive radio, and propagation. ATDI is also a member of ITU-D which works to advance radio systems in the developing world. ATDI's contribution to the world's radio communications has been recognized by the International Telecommunication Union.

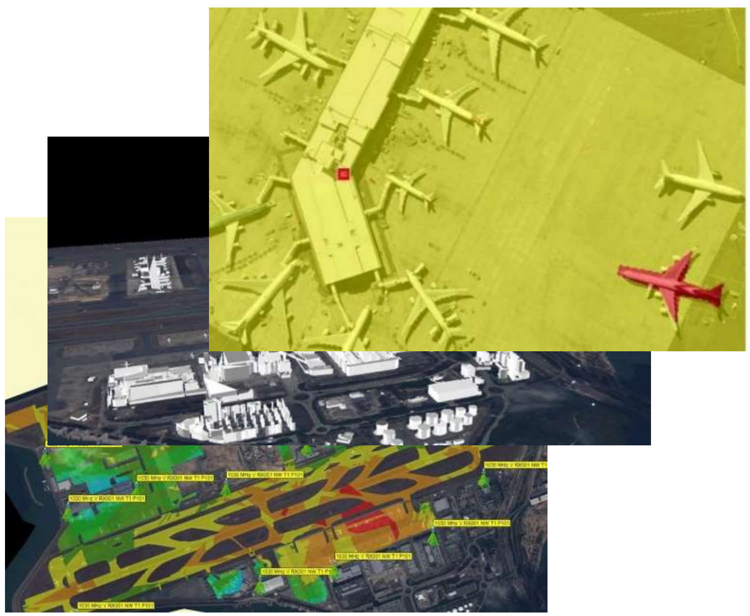
The organization honored ATDI for the company's "long-time participation and support to ITU Telecom World events" with a certificate of appreciation presented at ITU Telecom World 2017 at Busan, Korea.

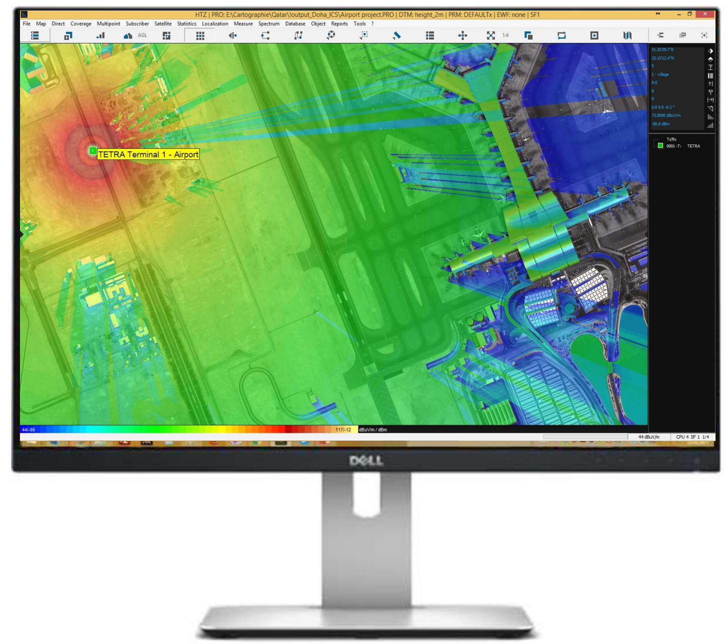
2.3 HTZ communications – General overview (1/3)

DUE TO ITS ARCHITECTURE, HTZ COMMUNICATIONS IS TECHNOLOGY-NEUTRAL AND ANY TYPE OF SYSTEM WITHIN THE RADIO SPECTRUM RANGE CAN BE SIMULATED AND STUDIED.

HTZ communications is the first airport network planning solution for Radio Communications, Navigation, Surveillance (Aircraft and Ground Stations systems) and spectrum management.







2.3 HTZ communications – General overview (2/3)

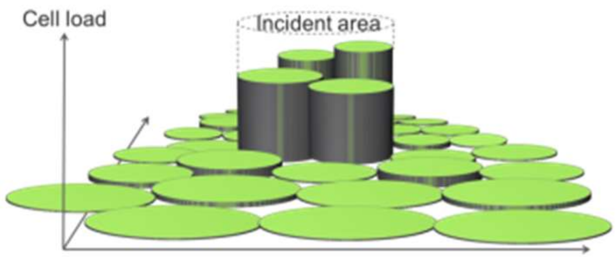
Technologies

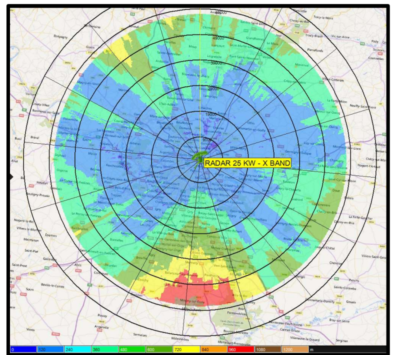
- Very High Frequency (VHF) communication
- High Frequency (HF) / LF/MF communications
- Microwave links, Point To Multi-Point
- Mobile technology (2G/3G/4G/TETRA/PPDR)
- Instrument Landing System (ILS)
- Conventional VHF Omnidirectional Range (CVOR)
- Doppler VHF Omnidirectional Range (DVOR)
- Distance Measuring Equipment (DME)
- Primary Surveillance Radar (PSR)
- Secondary Surveillance Radar (SSR)
- Multilateration/Wide Area Multilateration (WAM)
- Satellite, Sensors, IoT,
- Ground Based Augmentation System (GBAS)

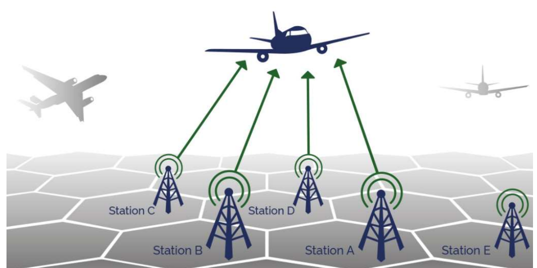
Technical capabilities

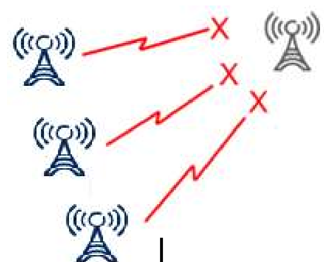
- Reports generation for analysed networks and systems or technologies.
- CNS systems base station configuration
- CNS systems database management
- Coverage analysis for CNS systems sites/base stations
- CNS systems networks analysis
- Obstacles evaluation (due to new buildings)
- Harmful interference, Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC), Wind farms impact evaluation, Coexistance SM1009, Out Of Band, coexistence between different systems.
- Capacity and traffic analysis
- Automatic Frequency Assignment
- Radio Network Optimisation

2.3 HTZ communications – General overview (3/3)









Traffic/capacity & reliability

MLAT analysis

Coverage and radio planning network analysis

Frequency management planning

Co-ordination for Radar and Navigational Aids.

Co-ordination of services in the communications band

Any systems covering the spectrum band from Few KHz until 350 GHz

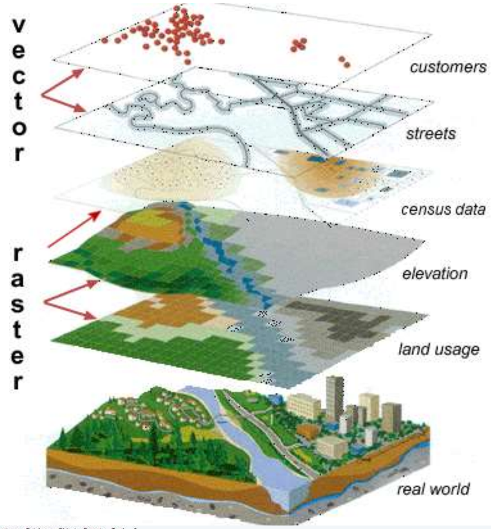
HTZ communications

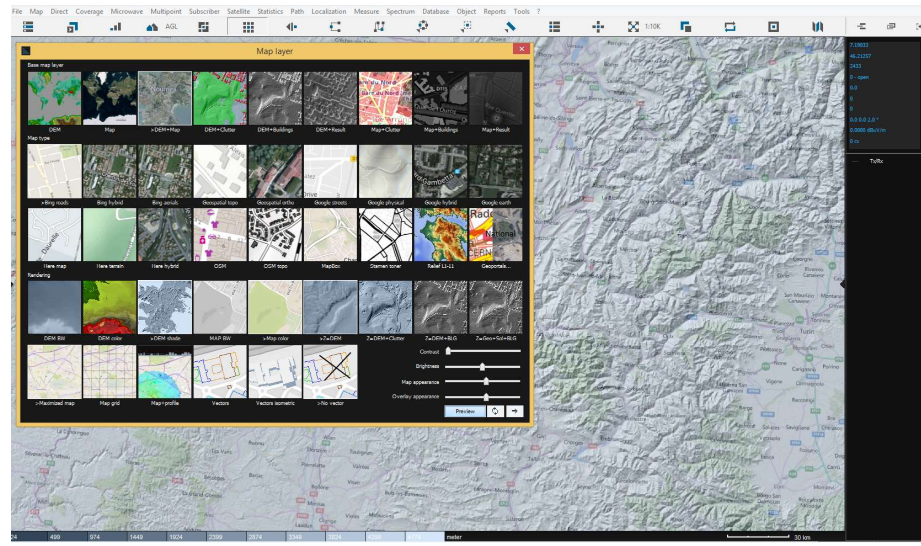
- 3.1 . GIS interface
- 3.2 . Propagation models
- 3.3 . Aeronautical Communication Systems
- 3.4 . Navigation systems (ILS/VOR/DMS…)
- 3.5 . Surveillance (Radar) and Multilateration systems
- 3.6 . EMC/Harmful interference capabilities
- 3.7 . Coexistance analysis
- 3.8 . Frequency assignment
- 3.9 . Protection against intrusive drones inside airports

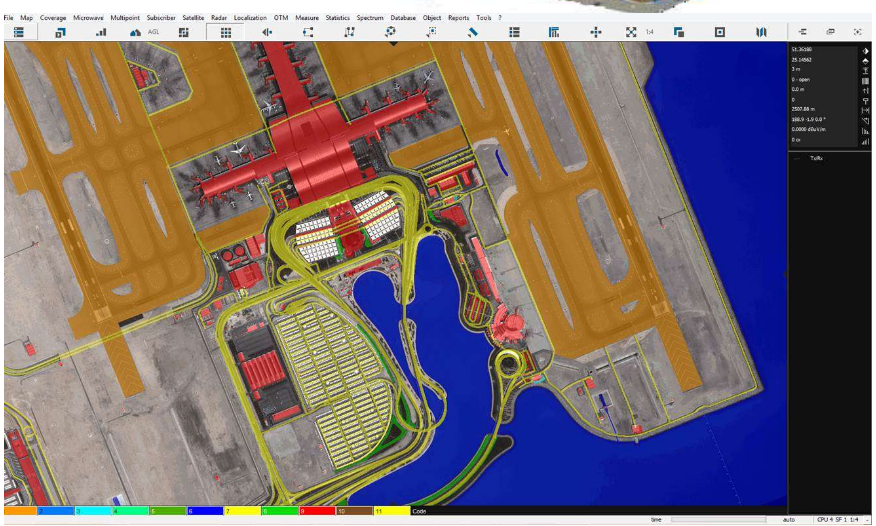
3.1- GIS Interface – Cartographic layer (1/2)

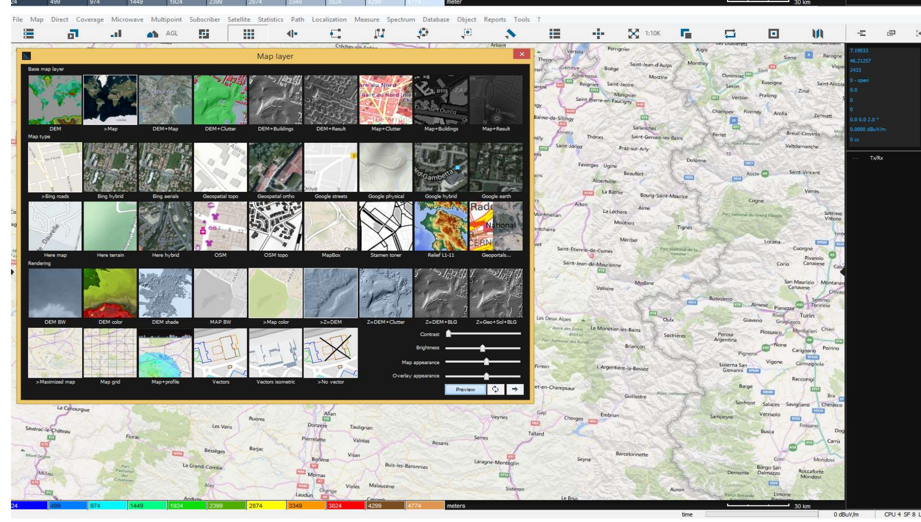
HTZ communications can manage up to 5 cartographic layers that are necessary for the propagation calculation and display:

- **Digital elevation models**
- **Raster Images**
- **Clutter files**
- **Vector files**

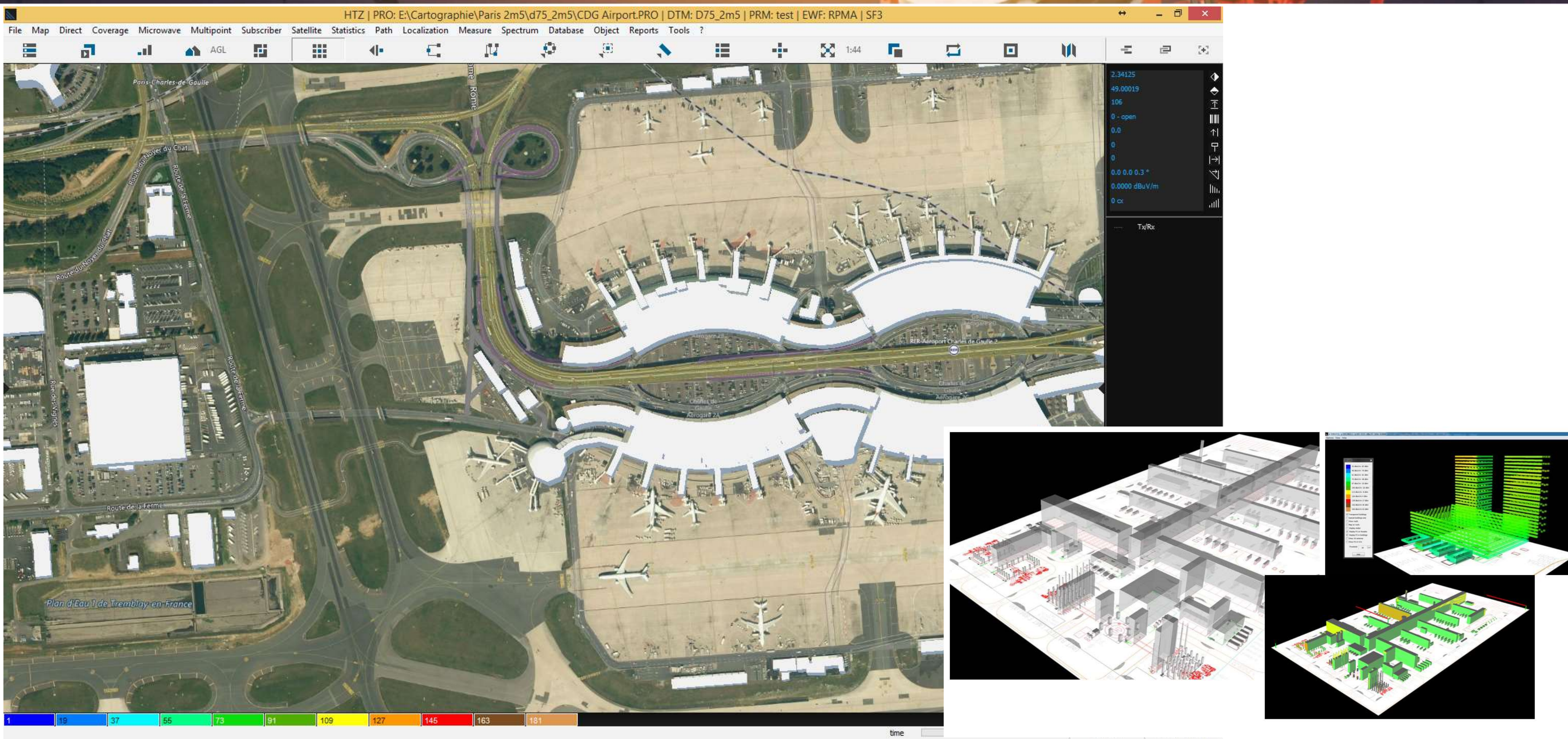








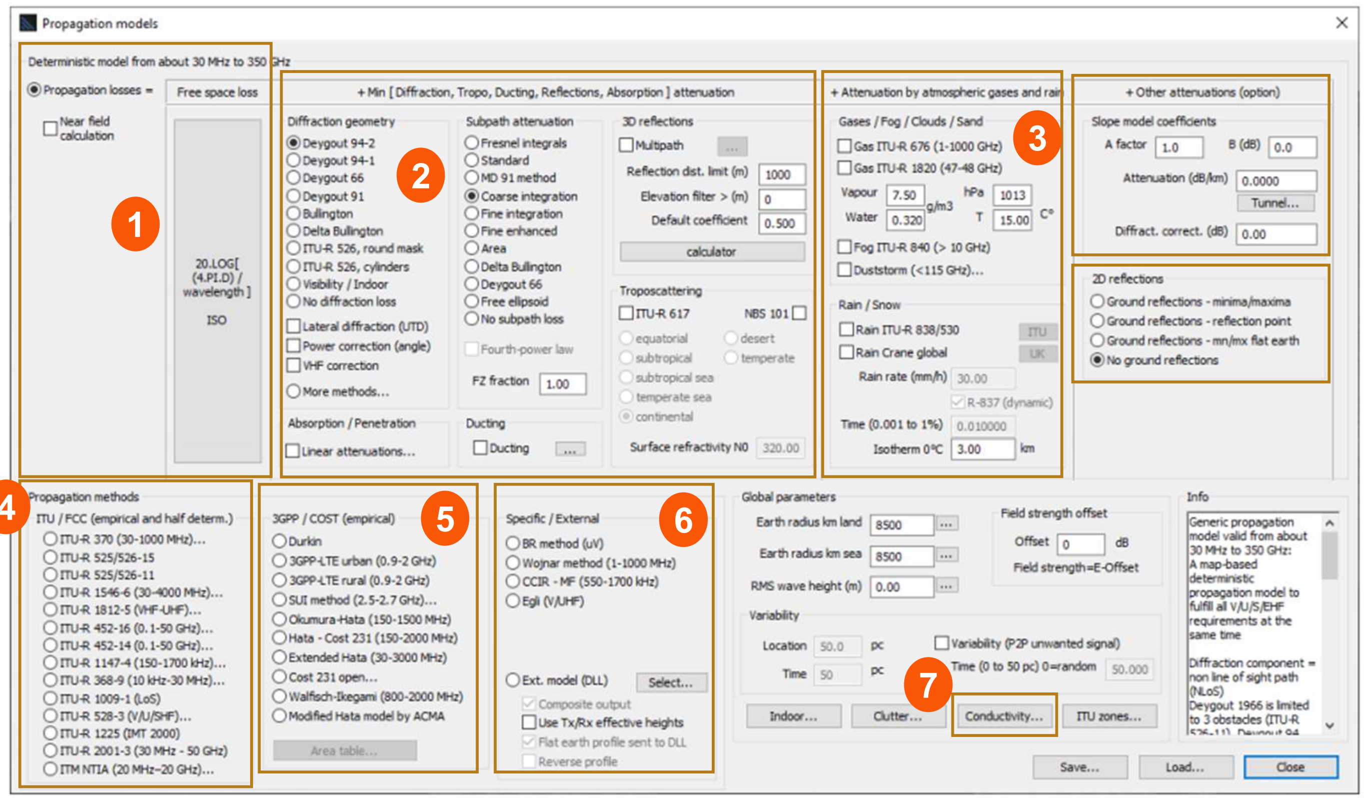
3.1 - GIS Interface – 3D Building layer (2/2)



3.2- PROPAGATION MODELS

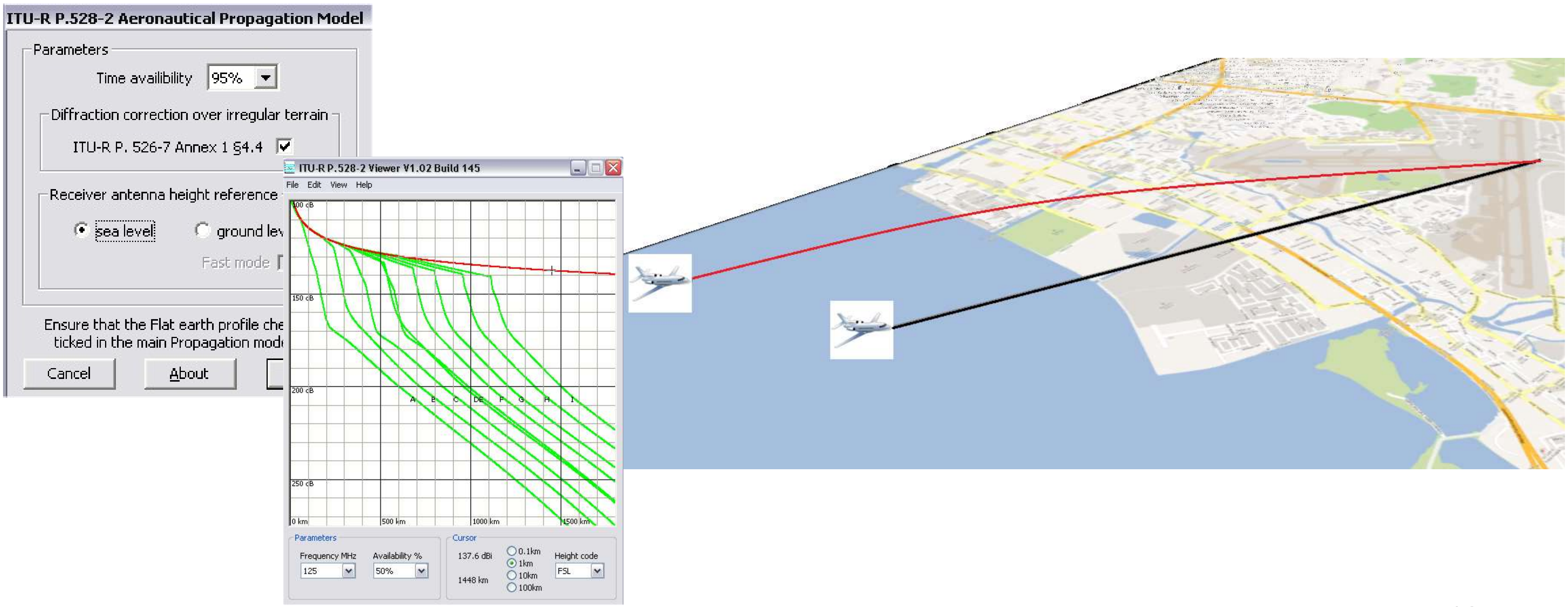
HTZ has a complete propagation model library including all ITU-R recommendations and industry standards such as 3GPP, COST models. It supports 3D ray-tracing in various modes and atmospheric effects also can be simulated. If one has a customised propagation model, it can be imported in .dll.

1. Free Space model
2. Diffraction models
3. Tropo-scattering models
4. Deterministic ITU Recommendations
5. Industry standard models including aeronautical models
6. Specific/external & custom-built models
7. HF conductivity model

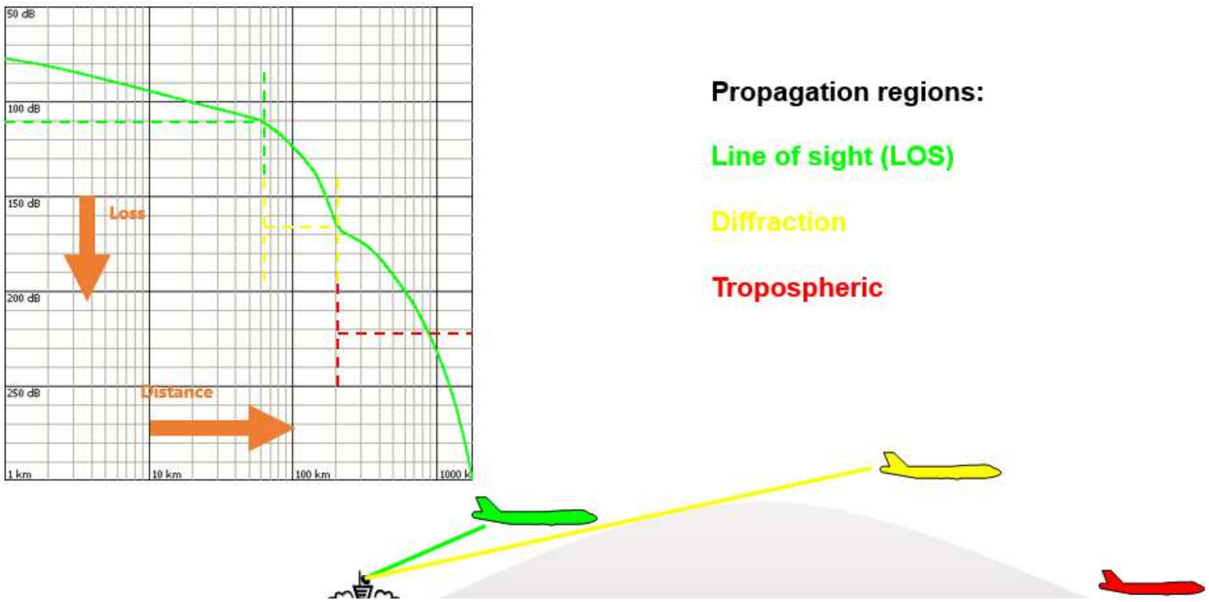


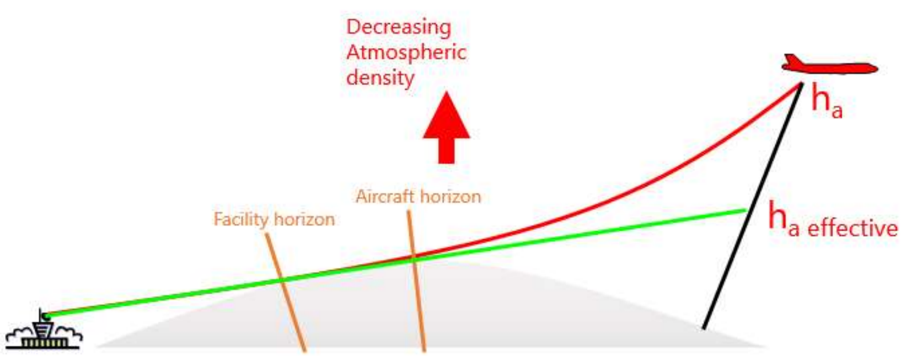
3.2 - AERONAUTICAL MODEL (1/3)

ITU-R P. 528-2 + ITU-R P.526-7 (diffraction)



3.2 - AERONAUTICAL MODEL (2/3)

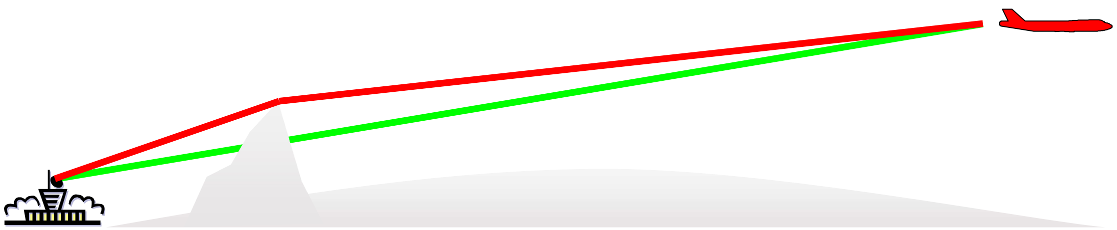


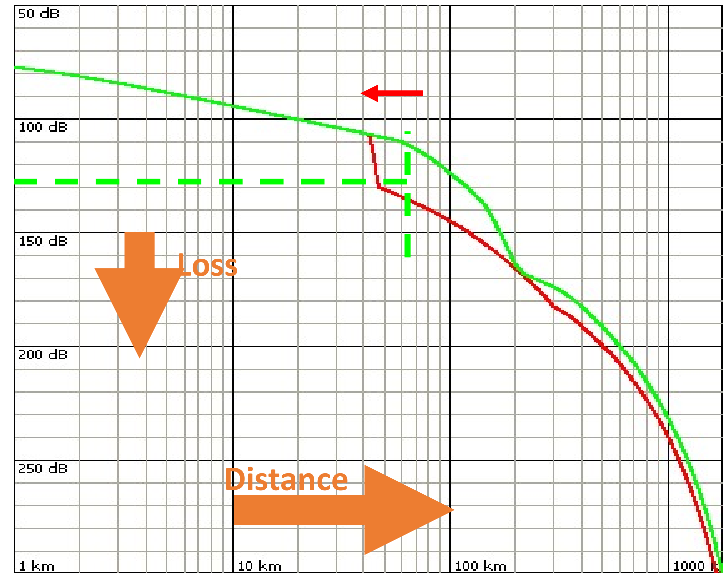


Effective height geometry

- Atmospheric density decreases with height
- Other models simplistic using a K effective
- Ray tracing using exponential height density

3.2 - AERONAUTICAL MODEL (3/3)





Based upon ITS IF-77

- The main engine

Constrained to ITU-R P. 528-2

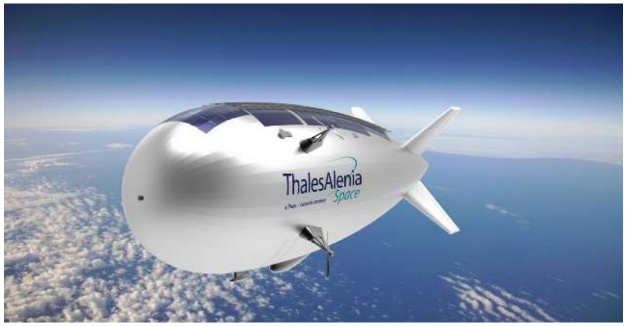
- Continuous curve set
- Frequencies: 100MHz – 20GHz
- Heights: 0 – >100,000ft
- Availability: 5 / 50 / 95% time

Terrain Obstacle Horizon Limiting

- Limits LOS region
- Less relevant in mid paths when in troposcatter

3.3 - Aeronautical Communication Systems

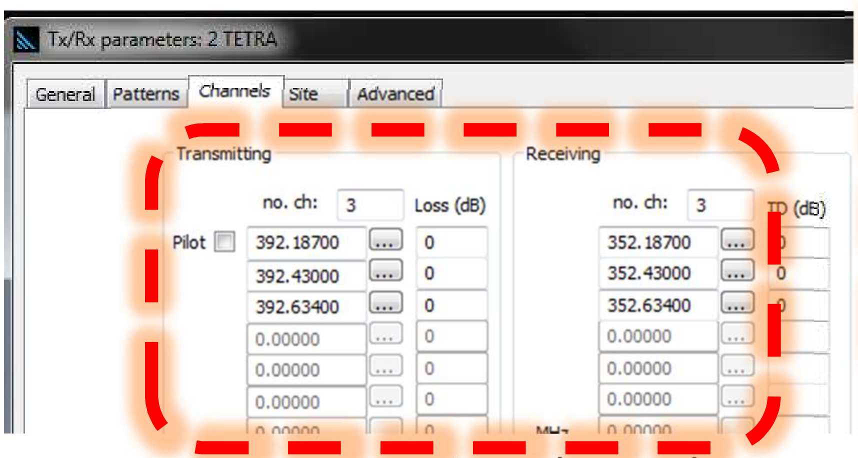
- TETRA/VHF/UHF
- HF
- Satellite systems
- LF/MF
- Microwave links
- Broadband LTE A2G (Air To Ground)
- HAPS (High Altitude Station Platform)



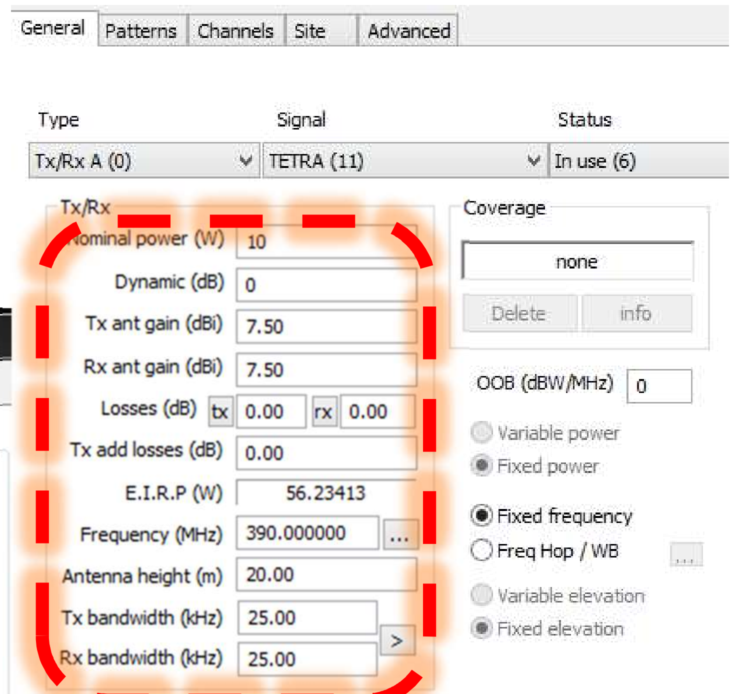
3.3 - GROUND TO GROUND COMS

BASE STATION CONFIGURATION

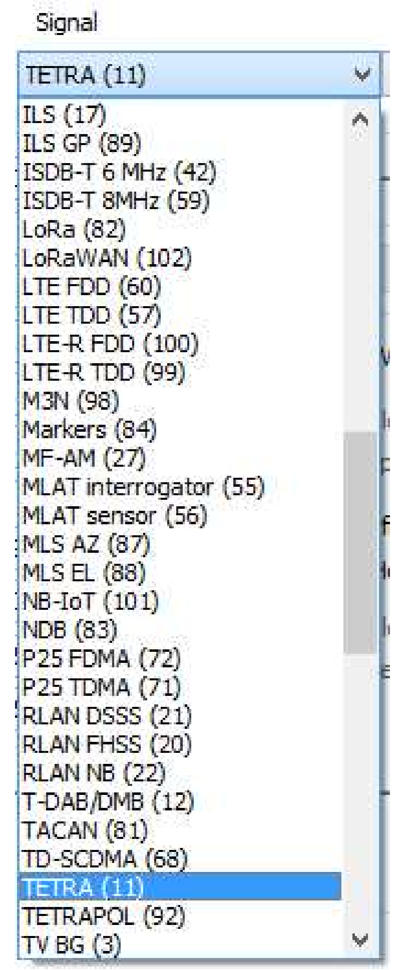
- PMR
- TETRA
- Land mobile



Communication channels



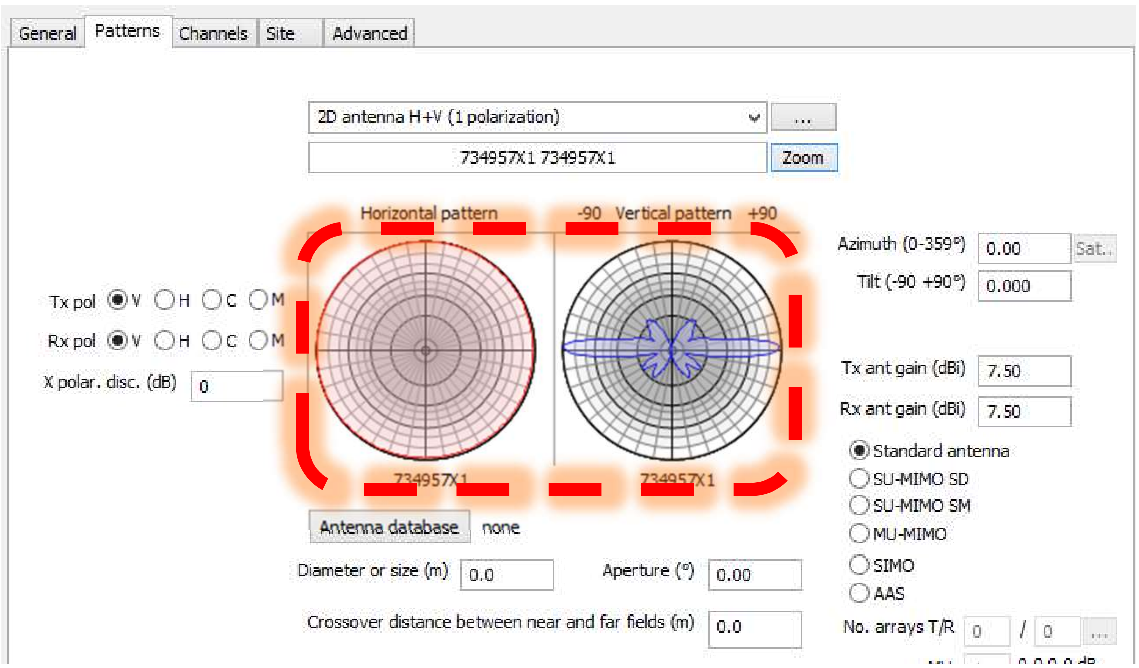
General parameters

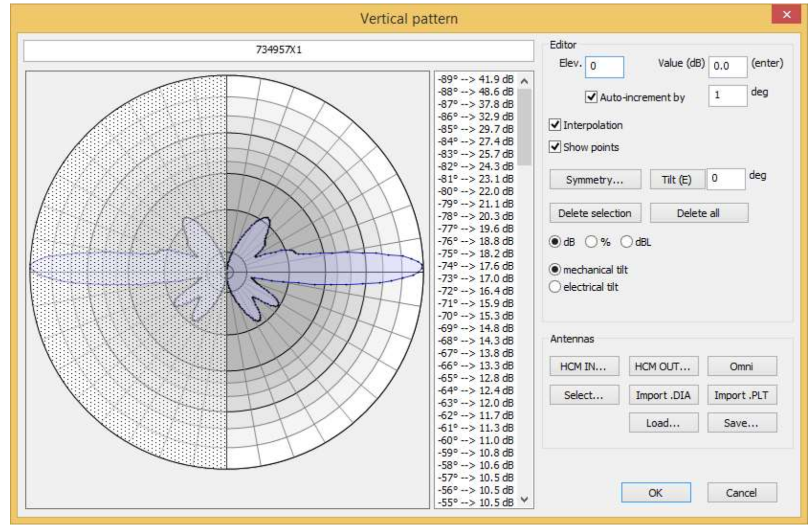


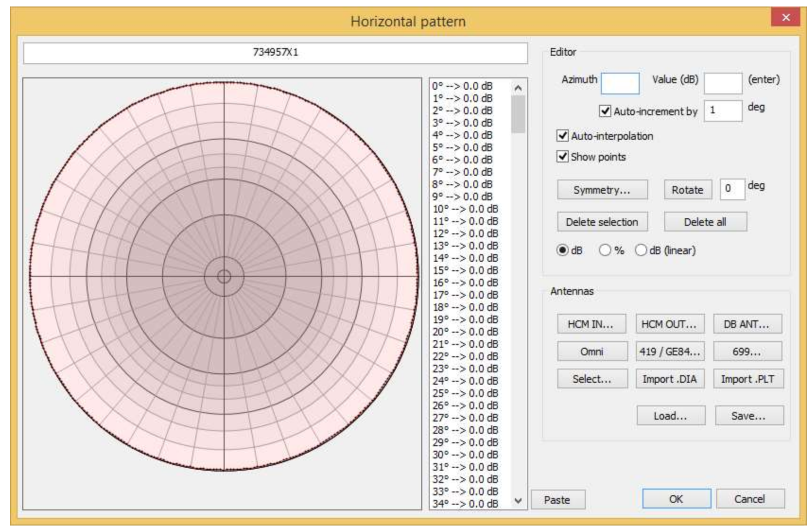
3.3 - ANTENNA SETTING

BASE STATION CONFIGURATION

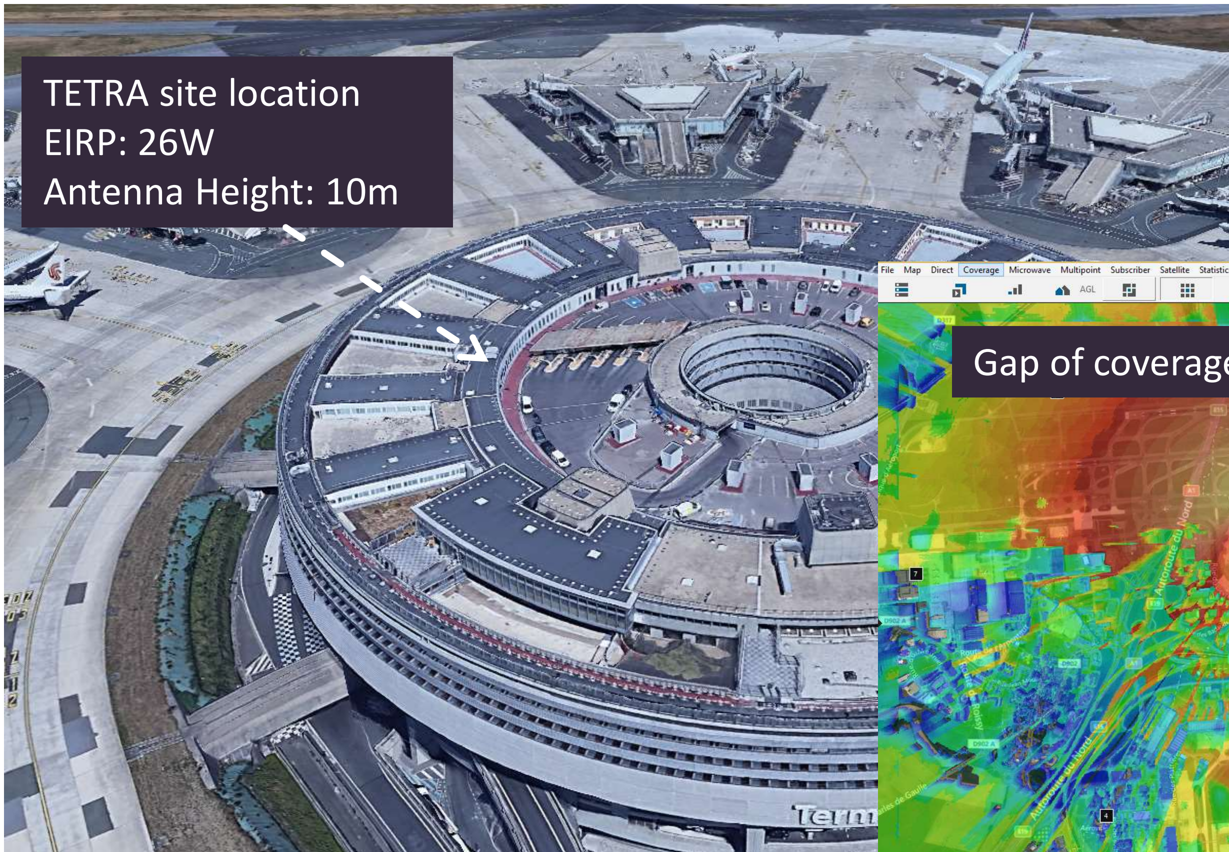
Antenna diagrams (Horizontal & Vertical)

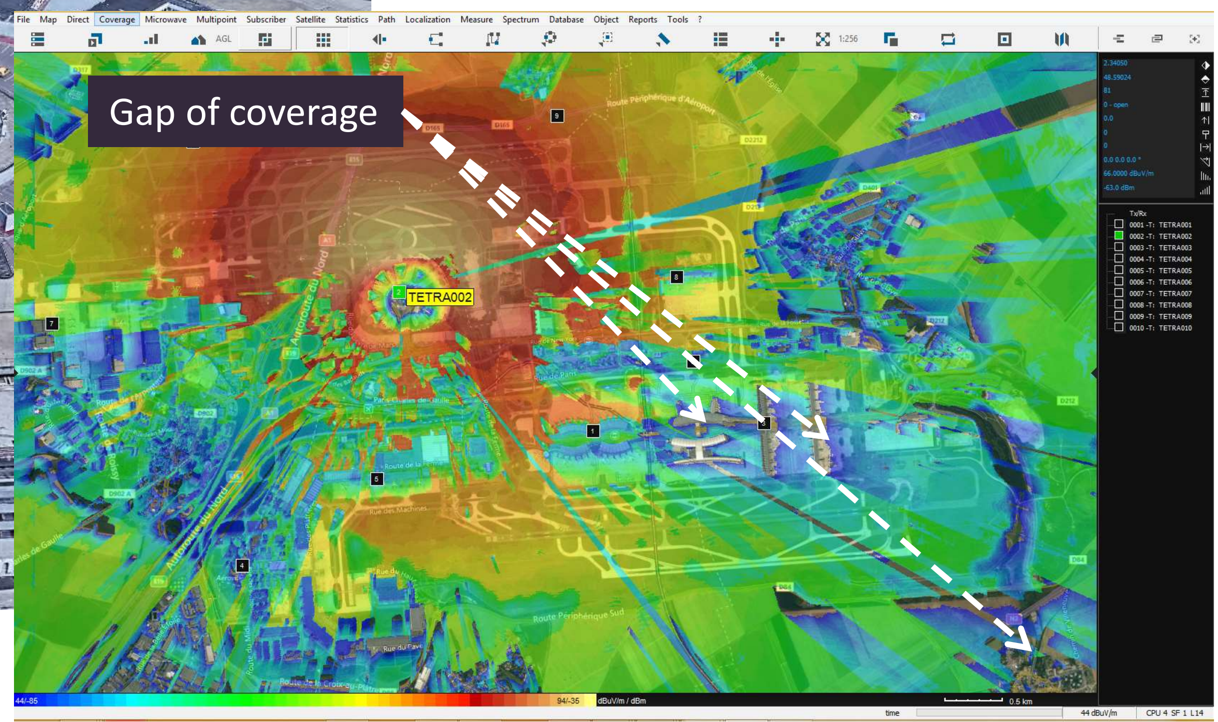




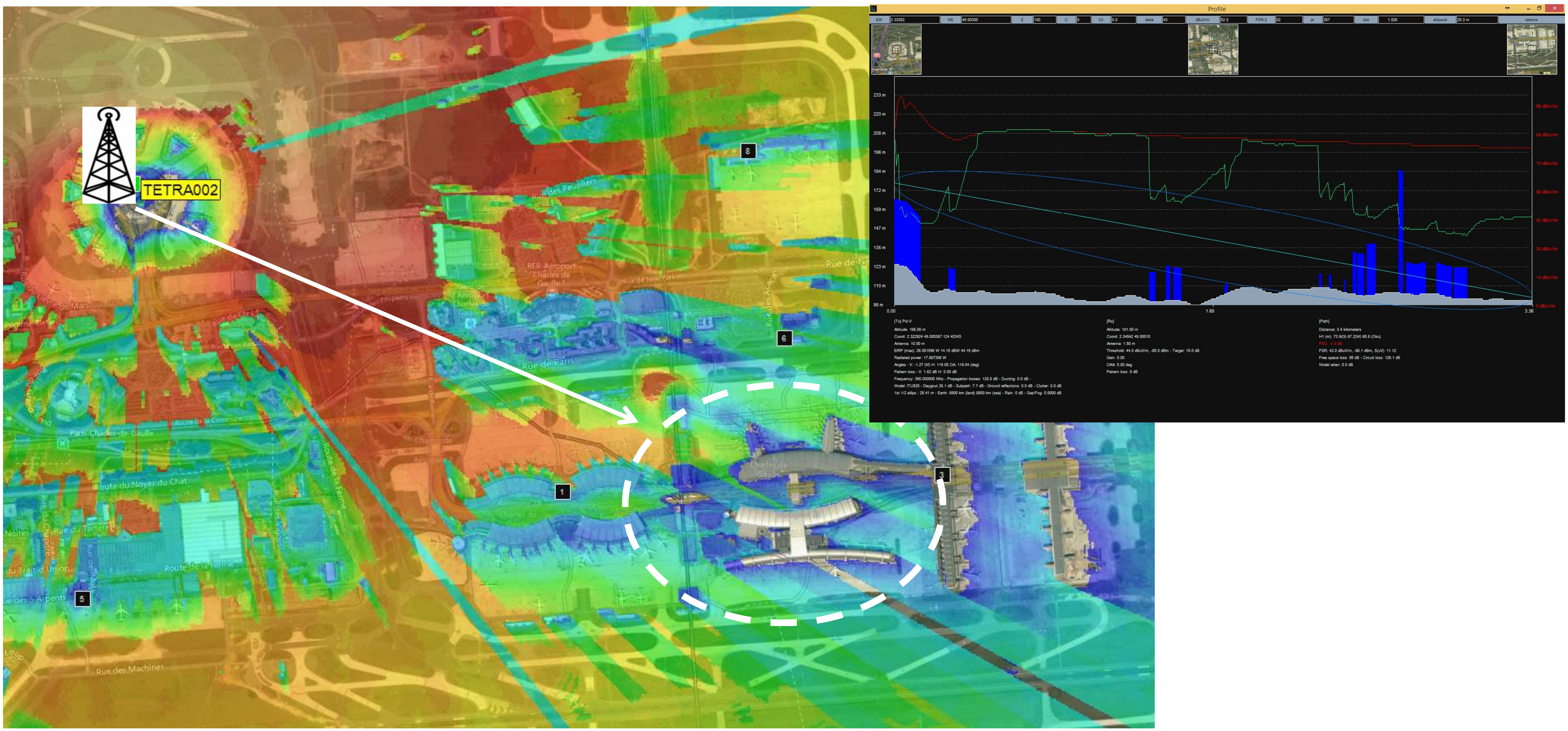


3.3 - Reception foot print prediction



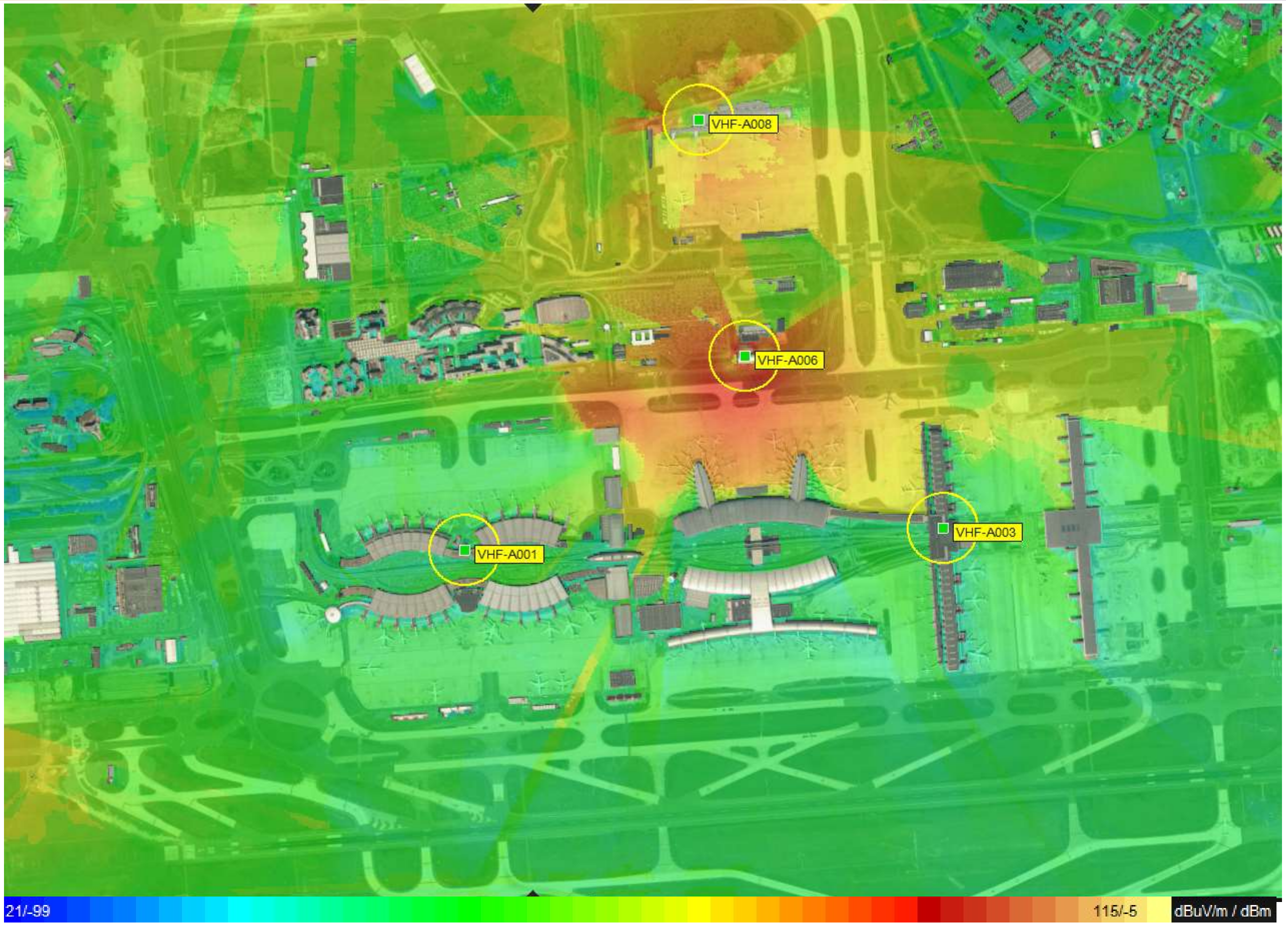


3.3 – Coverage prediction



3.3 VHF GROUND TO GROUND (AM- Voice) COVERAGE SIMULATION

- Site locations : CDG Airport (Paris)
- Receiver antenna height : 1.5m
- Tx power:
- Rx Sensitivity: 20dBµV/m



VHF outdoor coverage (CDG airport)

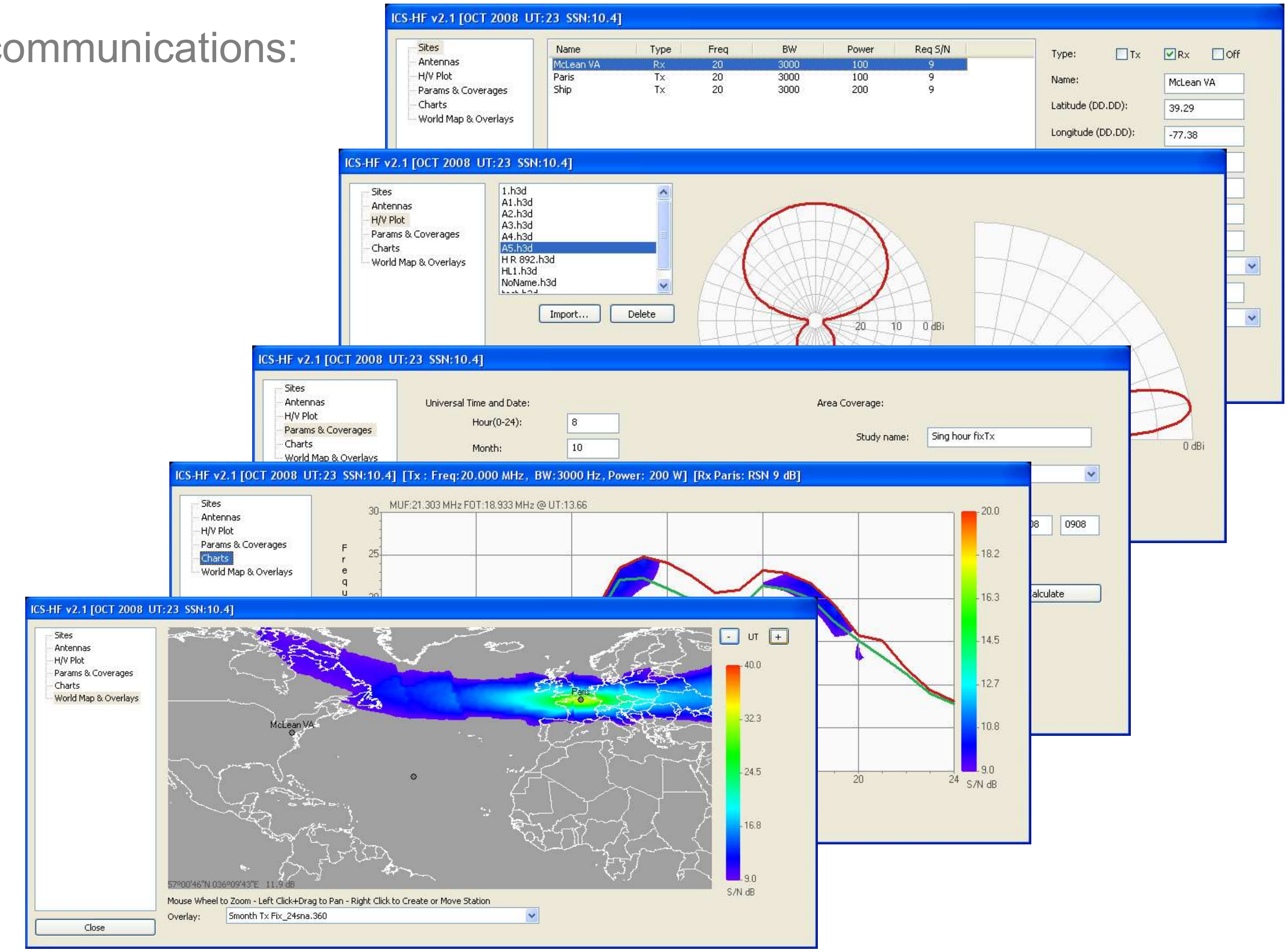
3.3 HF Module

HF planning features in HTZ communications:

MODE	OPTIONS
COMMUNICATION STATISTICS	IN DOWNLINK
	IN UPLINK
	IN NIGHT TIME
	IN DAY TIME

MODE	Equipments
SINGLE HOUR COVERAGE	FIXED TRANSMITTER
	MOBILE TRANSMITTER
SINGLE MONTH 24h COVERAGE	FIXED TRANSMITTER
	MOBILE TRANSMITTER

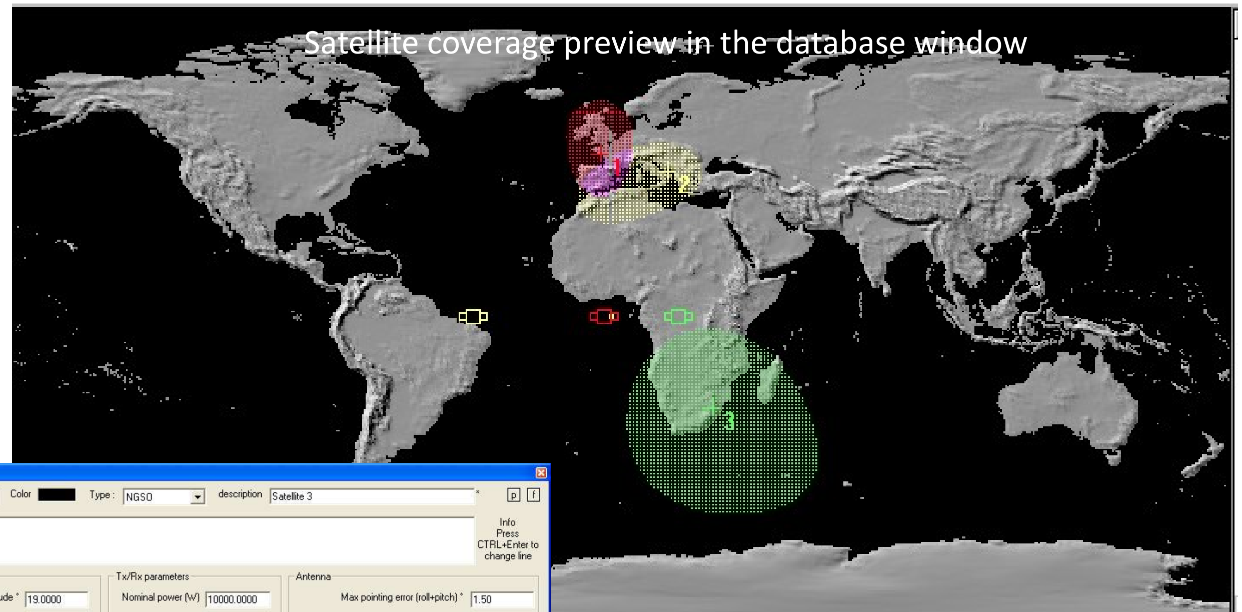
CHART ANALYSIS
MUF (Maximum Usable Frequency)
FOT (Frequency of Optimal Transmission)

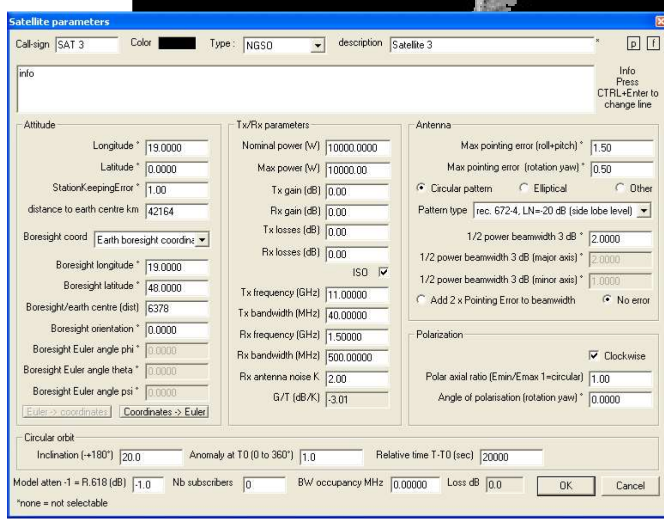


3.3 Satellite

Features :

- GSO/non-GSO satellite coverage planning and link budget (EIRP, G/T, C/N)
- Wide-beam and HTS beam planning across all satellite frequency bands
- Automated frequency planning
- GSO vs GSO and GSO vs non-GSO interference analysis (ΔT/T, C/I, PFD and EPFD masks)
- Satellite vs terrestrial co-existence analysis /Earth station coordination (ITU APP 7)
- DTH network planning /VSAT network planning and optimization
- Covers all satellite services: FSS, BSS, MSS, Earth-exploration, meteorological and more





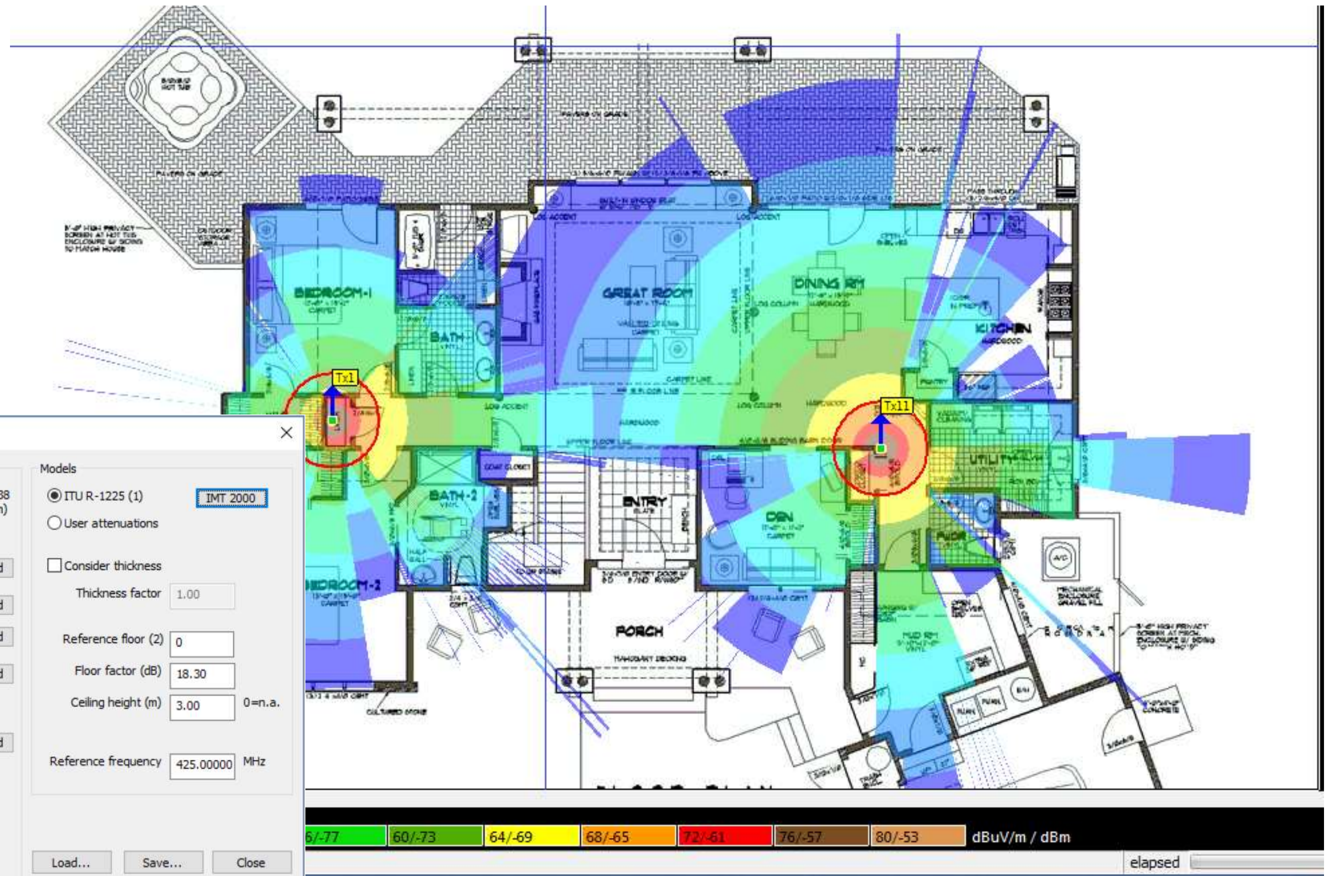
ATDI

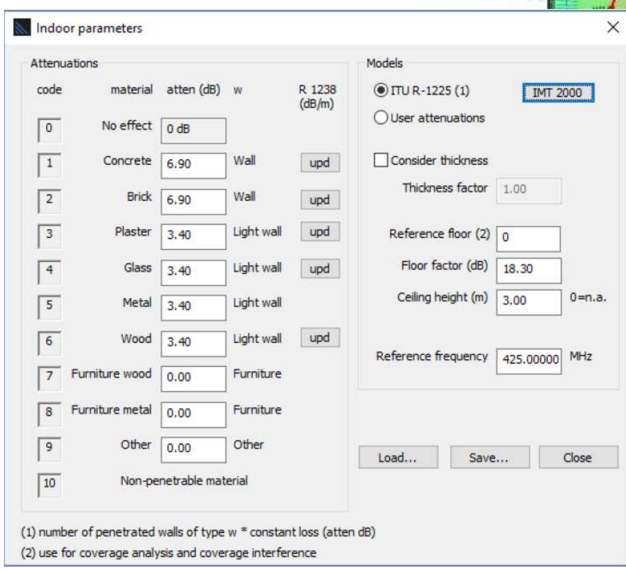
3.3 Indoor coverage

Indoor network deployment functions for 2G/3G/4G/Wi-Fi/TETRA systems :

Building data can manually extracted using ATDI tools from a **basic digitized floor plan.**

Based upon the material (wall in concrete, separation in brick on the same floor….) standards and manual attenuations can be applied , as well attenuation when a celling/floor is crossed.





3.3 Radio planning and Optimization features

TETRA/VHF/UHF GSM/UMTS-HSDPA/LTE (Release.13)/WiMAX

Coverage calculation and analysis

- DL/UL automatic link budget calculator
- Composite coverage
- Best server, second best server, overlapping
- …

Automatic Optimization module

- Automatic search site location
- Automatic antenna parameter optimization (height, azimuth, tilt, model…)

Traffic & capacity analysis

- Traffic congestion analysis
- Traffic dimensioning (pilot and traffic channels)
- Traffic map plot

Interference:

- Interference analysis
- Automatic Frequency Assignment

KPIs

- Link budget analysis
- LTE: RSRP,RSRQ,SNIR
- UMTS: RSCP, Ec/I0,Eb/N0, Ec/Nt
- GSM: RSSI, C/I,
- …

Handover and neighbor list analysis

- Handover map (Intra-Inter system)
- Neighbor list calculation
- BSIC, PCI allocations
- …

Monte Carlo Module

- Interference analysis
- Capacity
- Throughput
- ….

Microwave link

MW link features

- Profile budget calculations
- Frequency and space diversity
- Multi-K factor calculations
- Climate and rain parameters
- Reliability calculations
- Automatic antenna orientation
- Link optimization
- Automated frequency planning
- Interference calculations
- Quality objectives calculations (ITU-R F. 1703 and ITU-T G.827

Radio navigation Satellite

Global fight tracking for Civil Aviation Resolution 185 (Busan, 2014)

- Coexistence with other radio systems
- Interference/loss of tracking

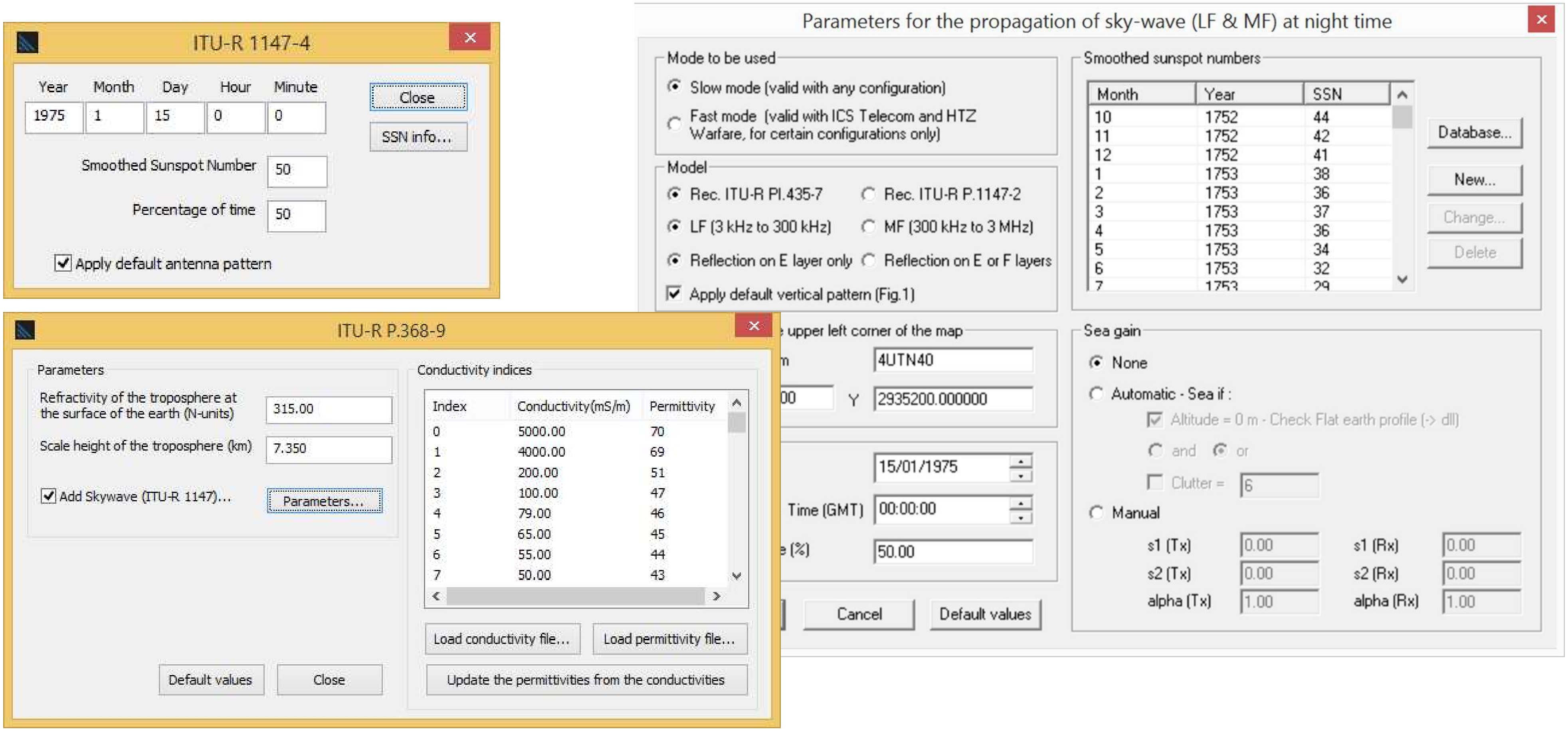
Wireless Avionics Intra-Communications (WAIC) – WRC 2015

- Parameters and Operational objectives for WAIC systems: Are systems in use when cabin doors are open?
- Fuselage attenuation and other surface attenuation above and below 15.7GHz.

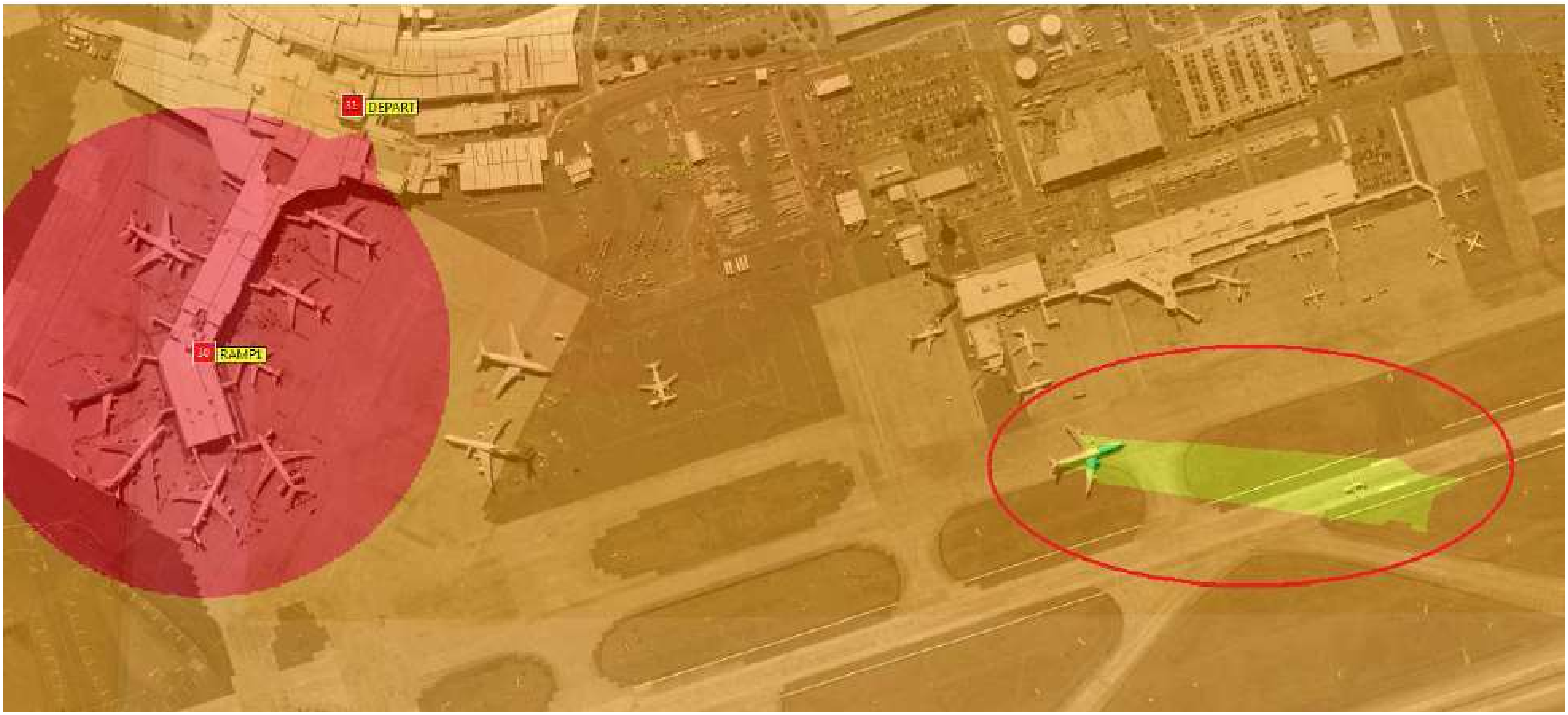
Interference into Earth station

- Earth station vs. microwave
- Earth station vs. satellite

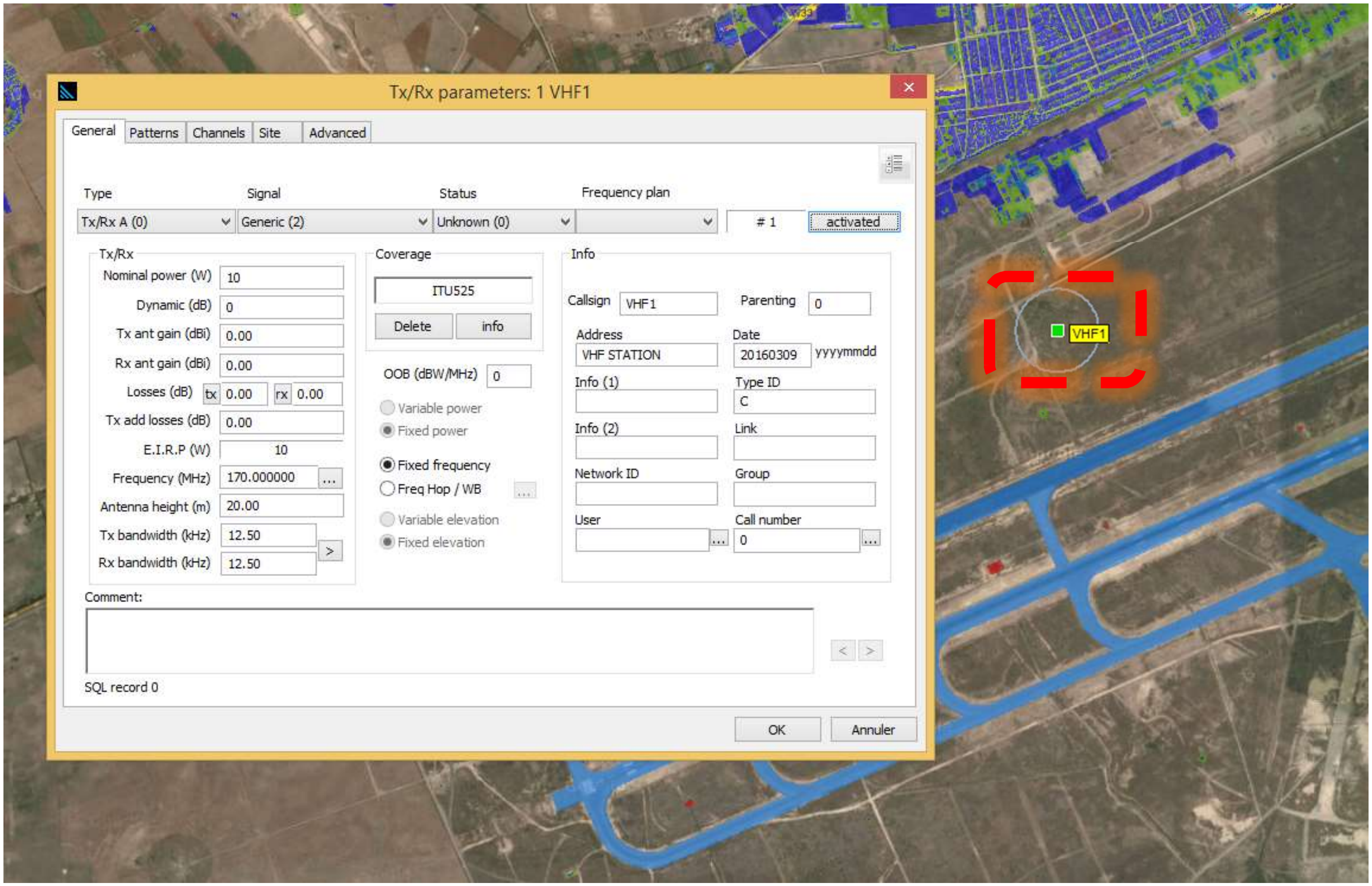
3.3 LF-MF coverage



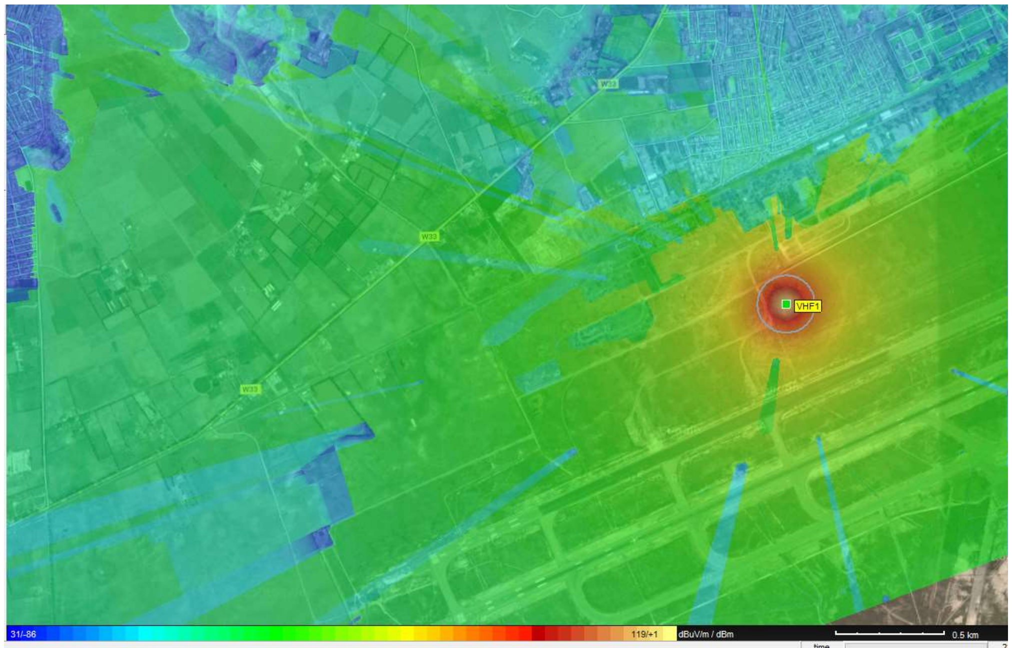
3.3 AIRPORT OBSTRUCTION

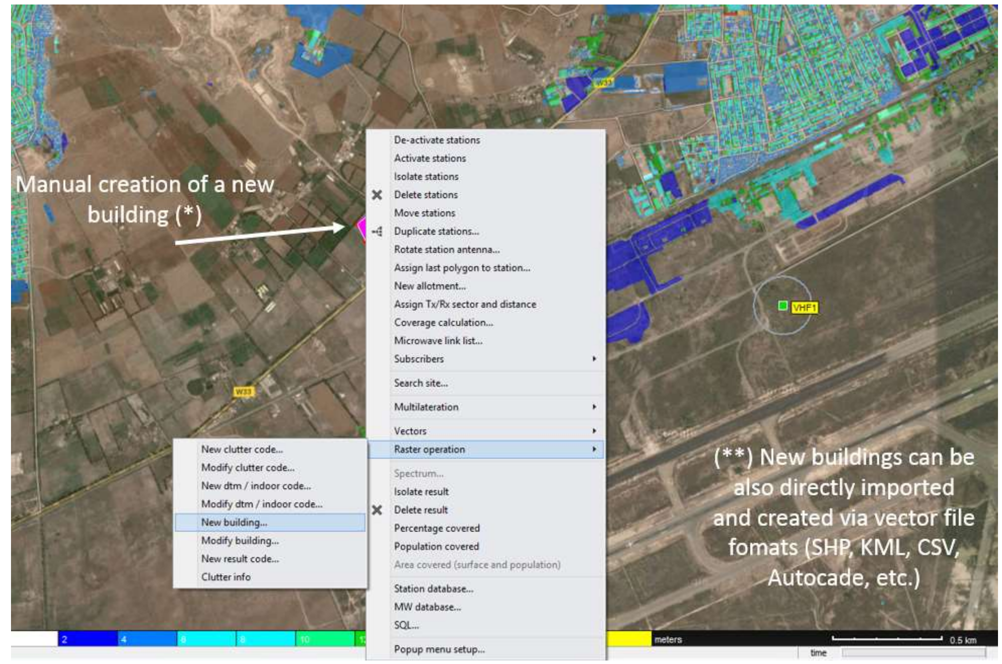


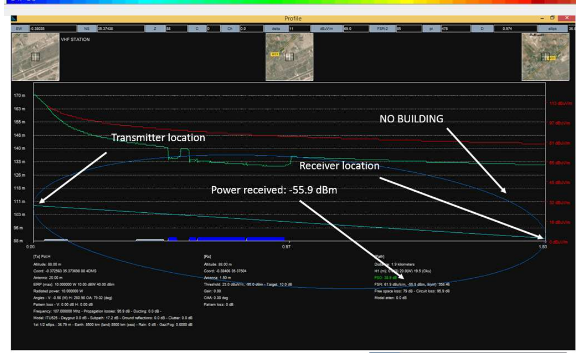
3.3 - IMPACT DUE TO NEW BUILDINGS



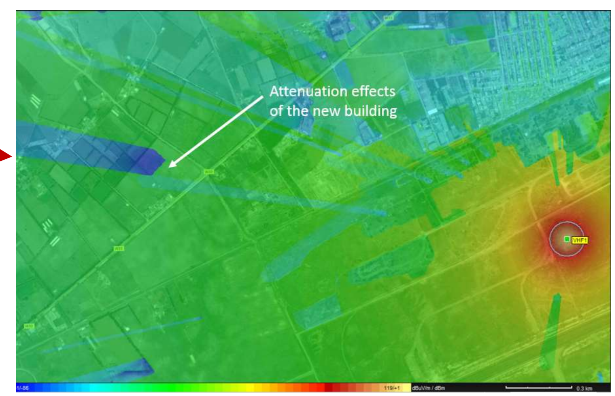
3.3 - Obstacles evaluation





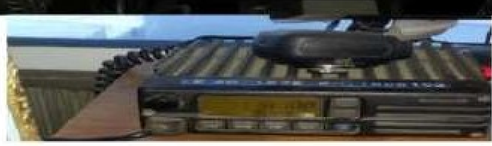


Signal attenuation due to new building



3.3 – VHF Coverage (Abha Airport in KSA)

ITEM	CH FREQ. (MHZ)	USE
1	CH 1: 133.500	Ground to Ground communication
2	CH 2: 121.700	Operation room to Tower communication
3	CH 3: 118.100	Monitor in operation room from Air to Ground communication

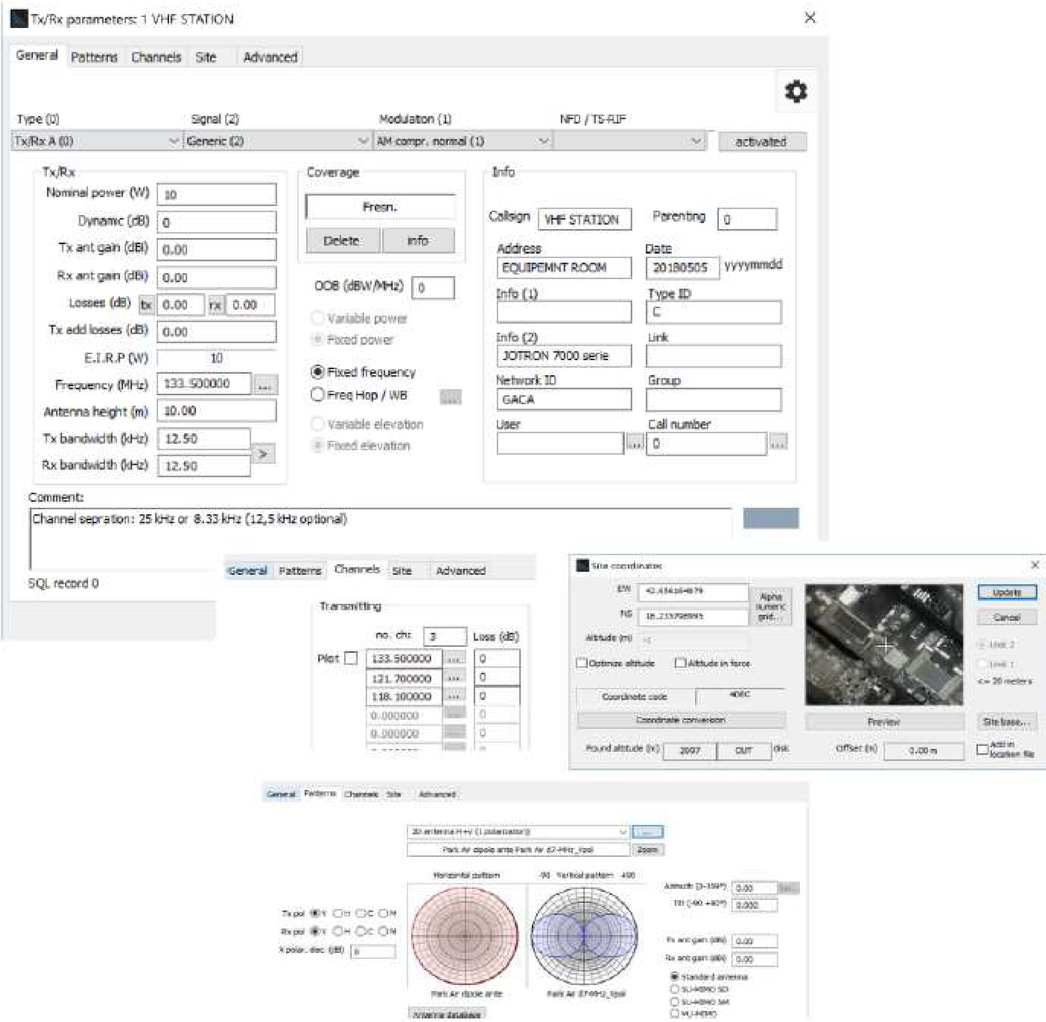


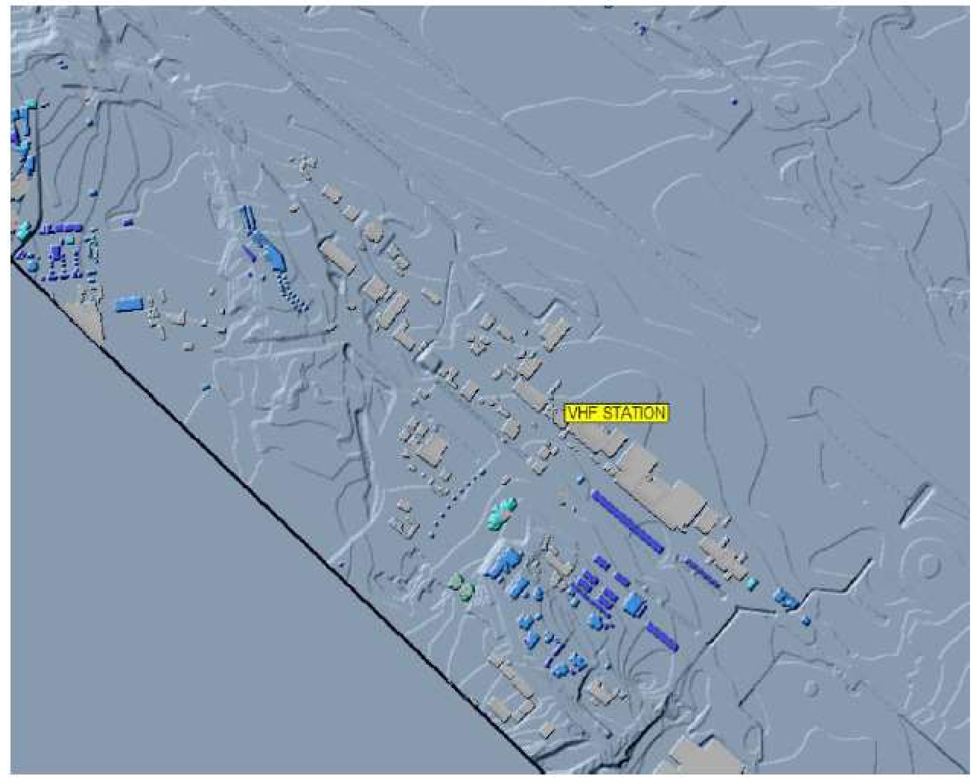
Monitoring Air to ground

VHF AM radio base station JOTRON (TR-7550)

- Portable Radios (ICOM)
- Mobile Radios (ICOM)

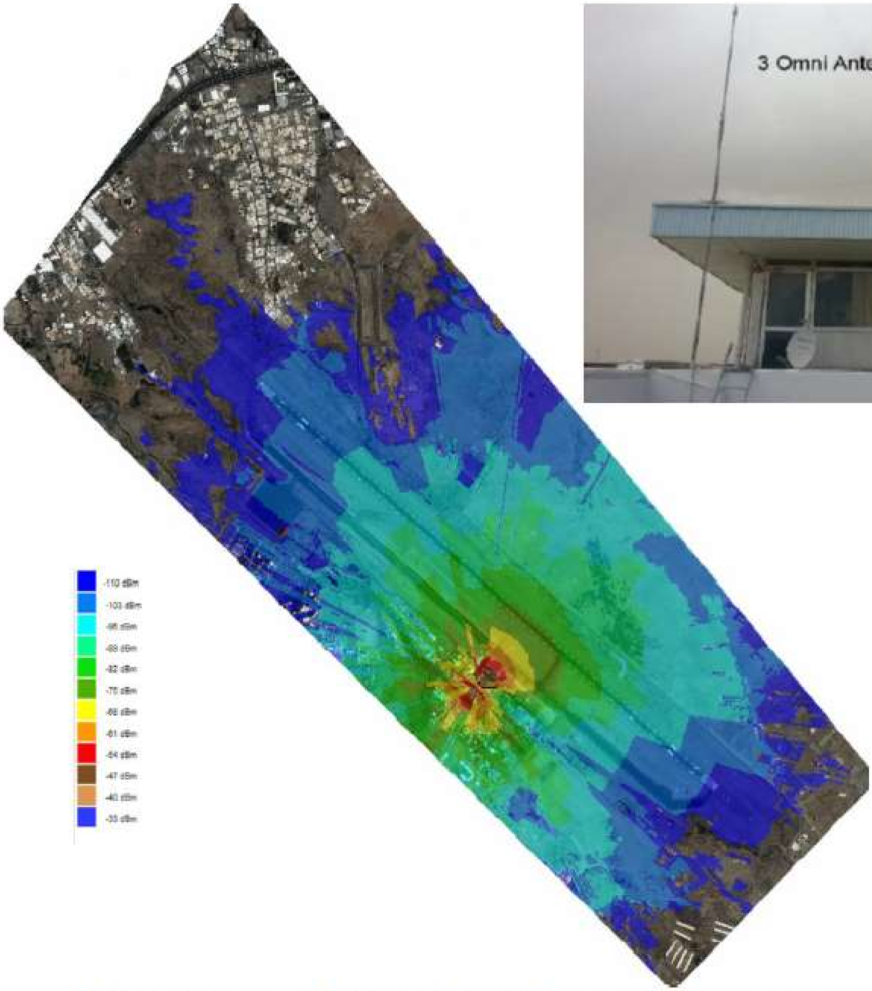
3.3 – VHF Coverage

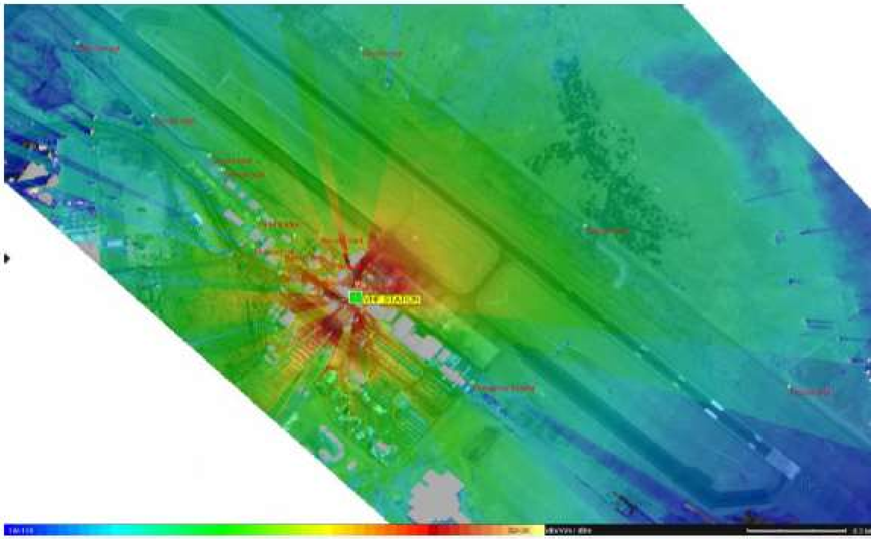


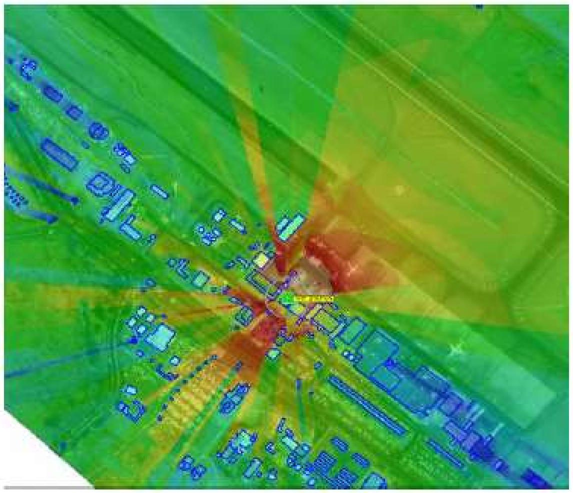


Building layer view of the Abha'airport

3.3 – VHF Coverage



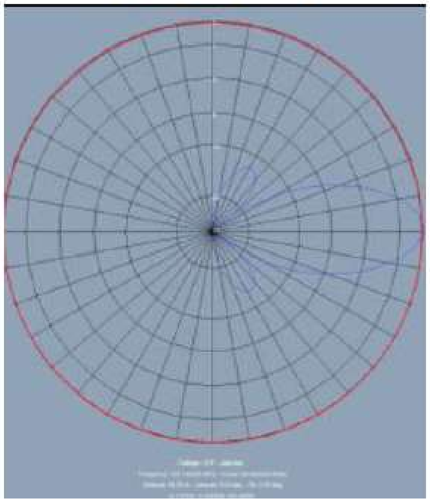


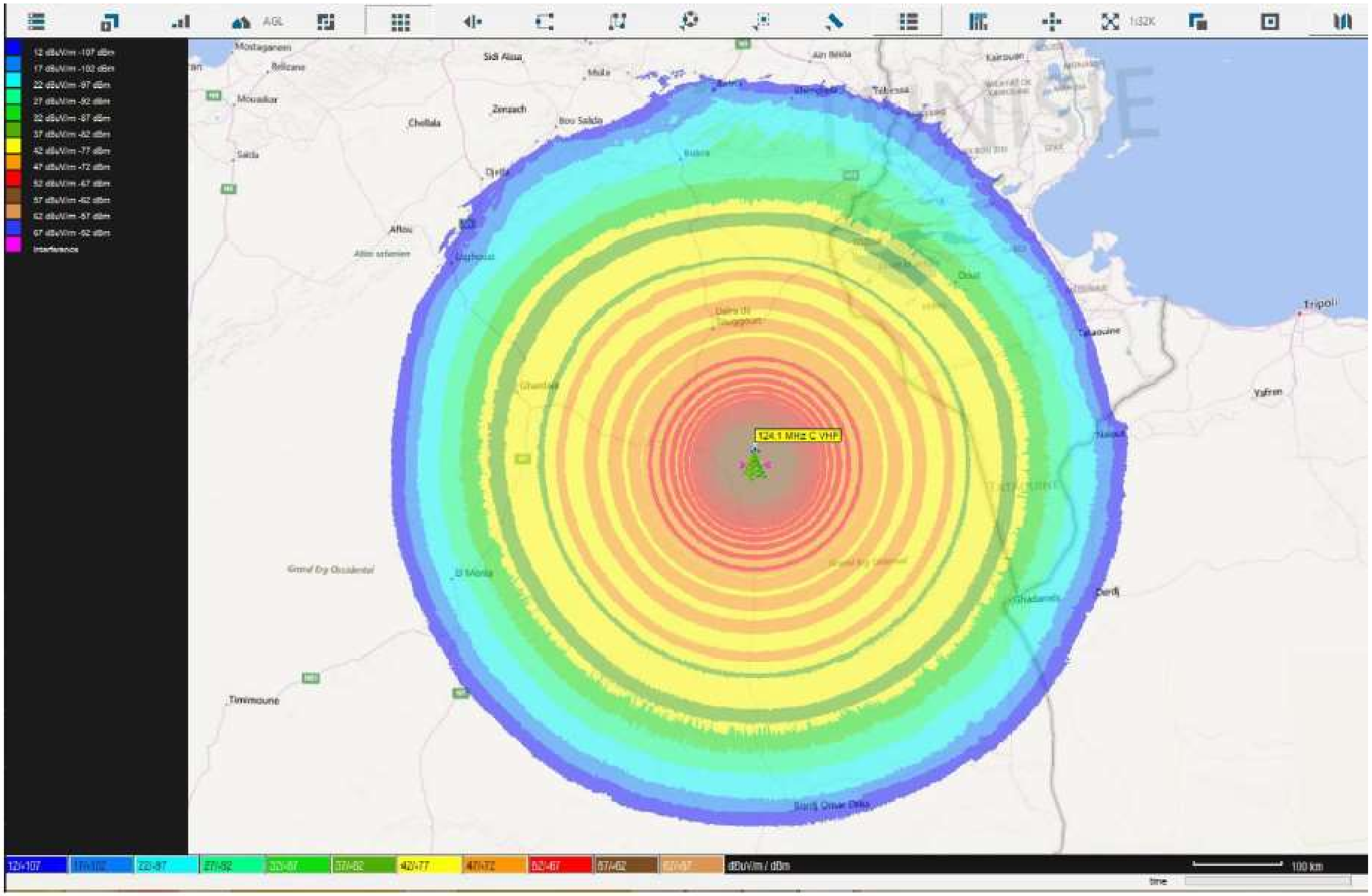


RSSI coverage plot with -100dBm as minimum coverage threshold

3.3 – VHF Ground To Air simulation (Hassi Messaoud – Algeria)

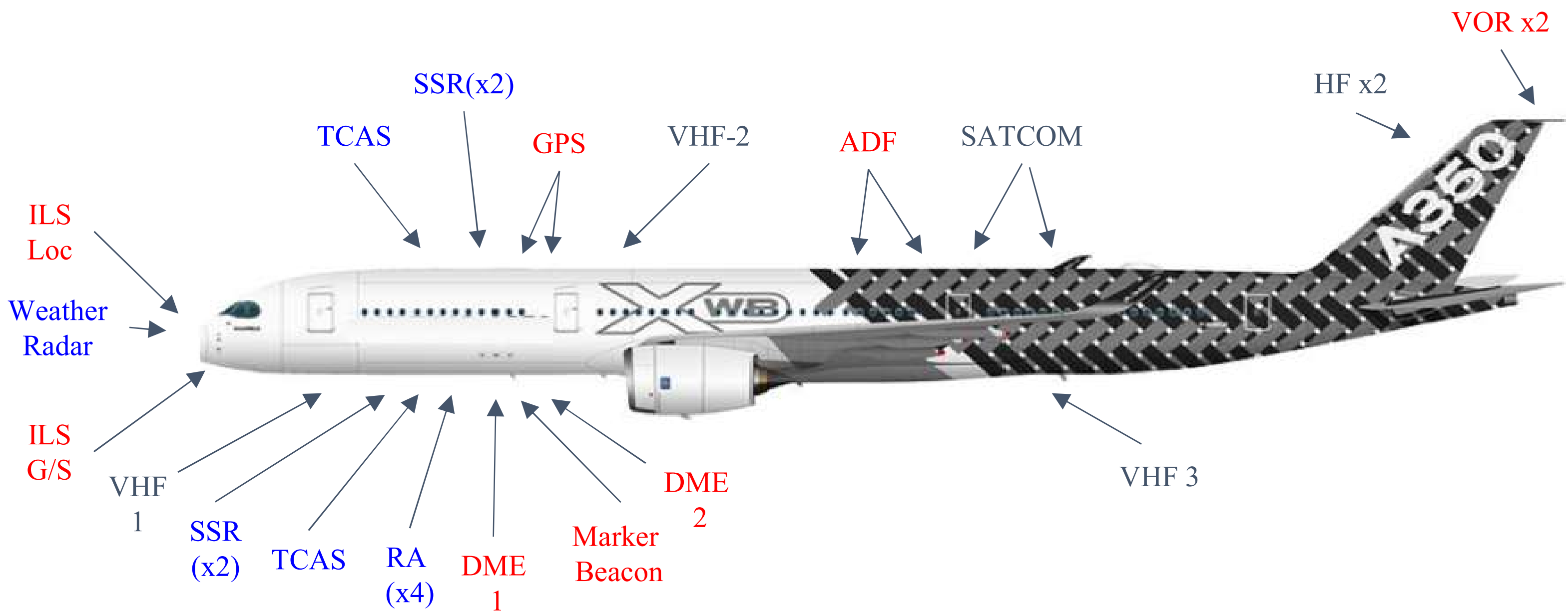
- Site location : Hassi Messaoud, Ouargla (Algeria)
- AGL Height (Aircraft receiver): 30 000 ft.
- Nominal power: 50W
- Rx Sensitivity: -107dBm
- Freq: 124,1 MHz
- Omni antenna: K-717265_0127MHz_Vpol





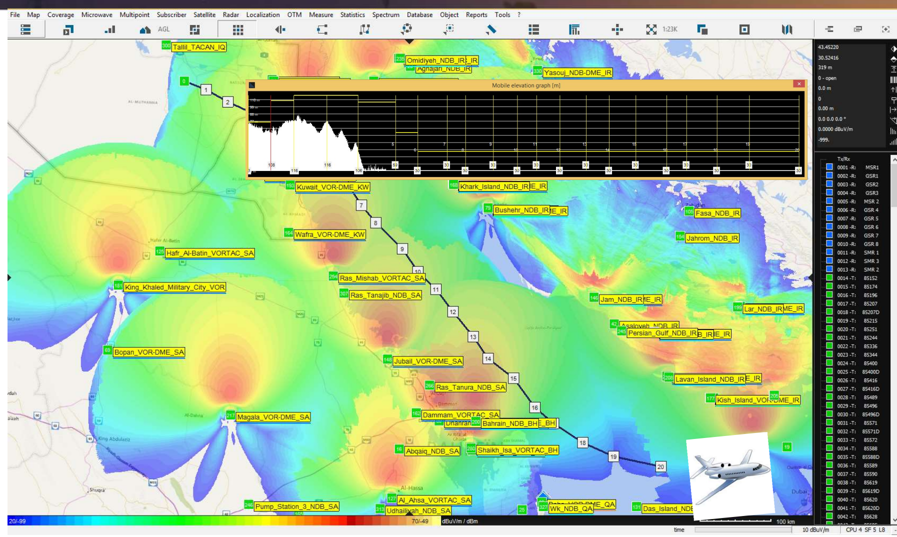
3.3 - AIRCRAFT TRANSMITTERS

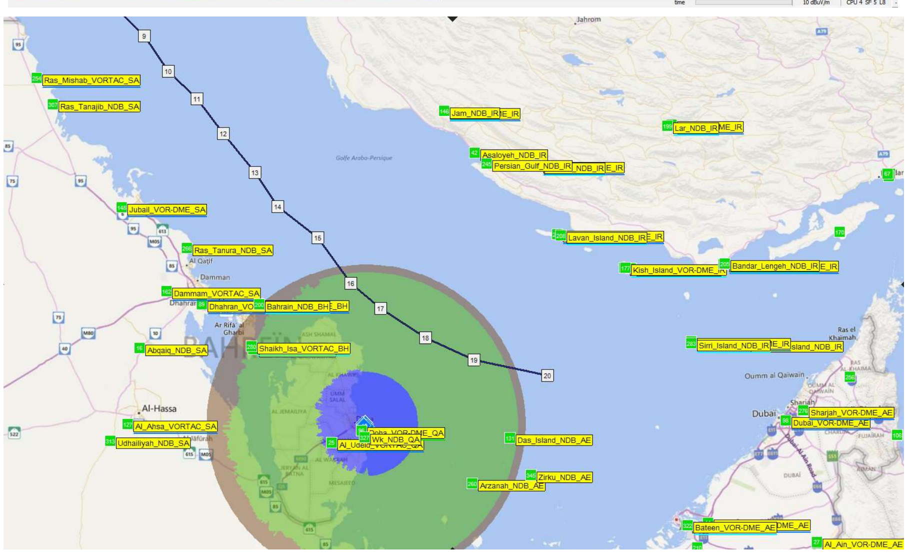
Modeling aircrafts transmitters/receivers systems with HTZ communications…



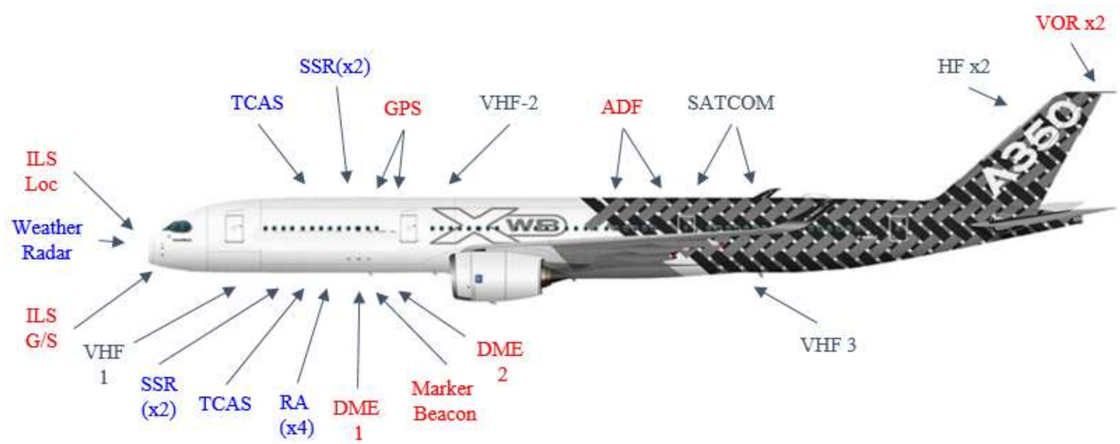
ADF :	Automatic Direction Finder	Loc	Localizer
DME:	Distance Measuring Equipment	RA:	Radio Altimeter
GPS:	Global Positioning System	SATCOM:	Satellite Communication
G/S:	Glide Slope	SSR:	Secondary Surveillance Radar
HF:	High Frequency	TCAS:	Traffic Collision Avoidance System
ILS:	Instrument Landing System	VOR:	VHF Omni ranging

3.3 AIRCRAFT TRANSMITTERS MODELLING





Modeling aircrafts with all radio navigation equipments with HTZ communications…

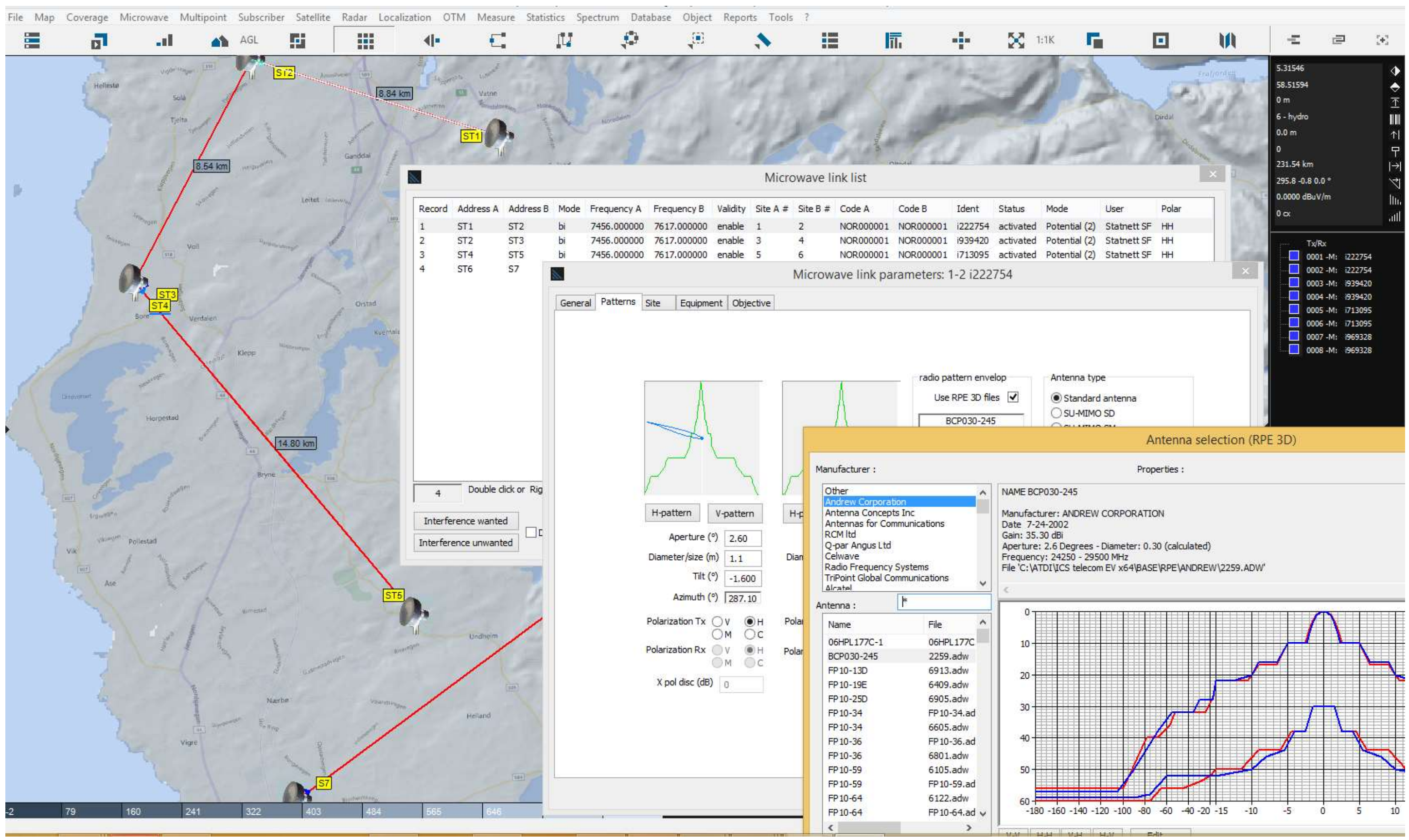


ADF :	Automatic Direction Finder	Loc	Localizer
DME:	Distance Measuring Equipment	RA:	Radio Altimeter
GPS:	Global Positioning System	SATCOM:	Satellite Communication
G/S:	Glide Slope	SSR:	Secondary Surveillance Radar
HF:	High Frequency	TCAS:	Traffic Collision Avoidance System
ILS:	Instrument Landing System	VOR:	VHF Omni ranging

3.3 – Microwave links

MW links features:

- Profile budget calculations
- Frequency and space diversity
- Multi-K factor calculations
- Climate and rain parameters
- Reliability calculations
- Automatic antenna orientation
- Link optimization
- Automated frequency planning
- Interference calculations
- Quality objectives calculations (ITU-R F. 1703 and ITU-T G.827
- MIMO Antenna systems



3.3 – Broadband LTE A2G (use case)

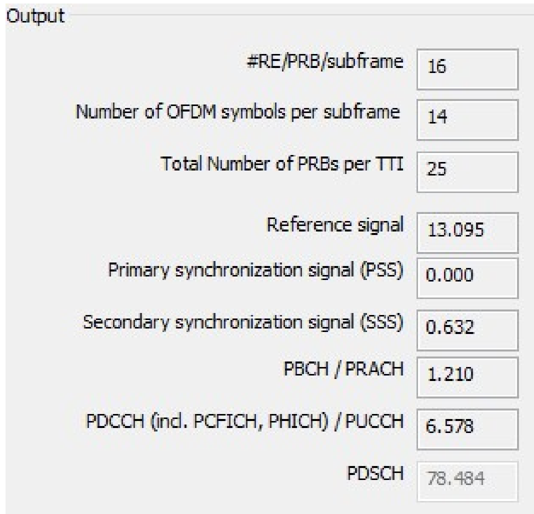
LTE configuration:

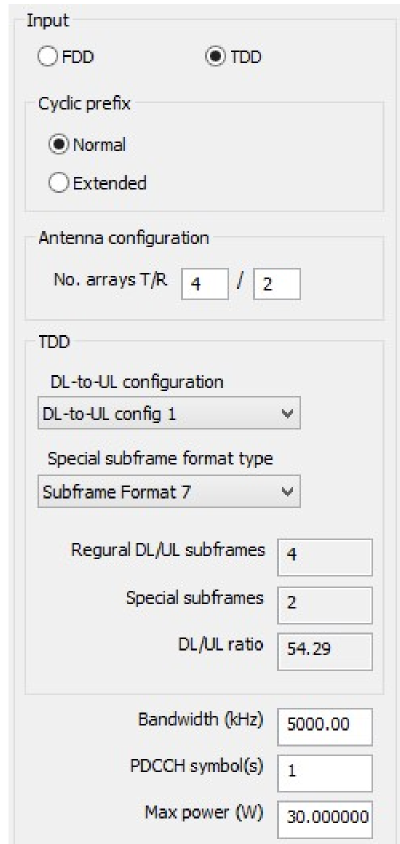
- Freq: 2325 MHz
- Bandwidth: 5MHz
- TDD mode (config 1/ Subframe format 7)
- MIMO 4x2 system

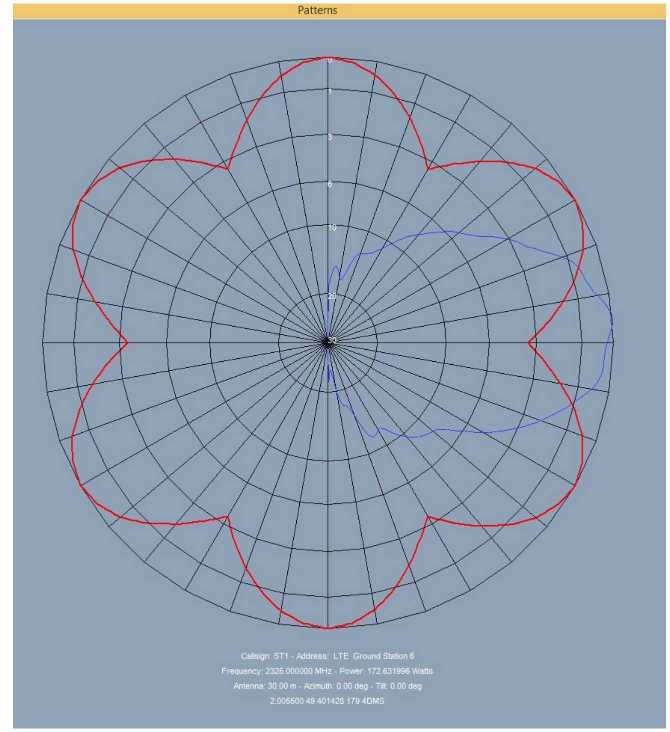
Throughput Target:

- DL/UL : 2Mbps
- Coverage probability: 87,5%

Aircraft Altitude: 8000 ft.







Antenna patterns (H/V)

3.3 – Broadband LTE A2G (use case)

E-Node B parameters:

Parameter	Value
Type	Tx/Rx A (0)
Signal	LTE TDD (57)
Tx/Rx	
Nominal power (W)	30
Dynamic (dB)	0
Tx ant gain (dBi)	9.60
Rx ant gain (dBi)	9.60
Losses (dB)	tx 0.50, rx 0.50
Tx add losses (dB)	1.50
E.I.R.P (W)	172.632
Frequency (MHz)	2325.000000
Antenna height (m)	30.00
Tx bandwidth (kHz)	5000.00
Rx bandwidth (kHz)	5000.00

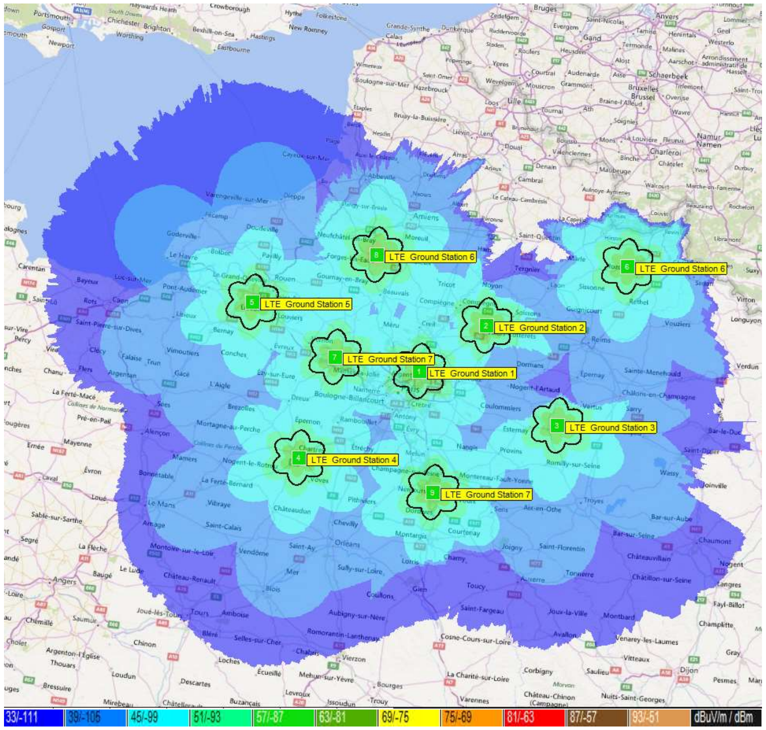


Fig 1: RSRP coverage
(Aircraft altitude: 8000 ft)

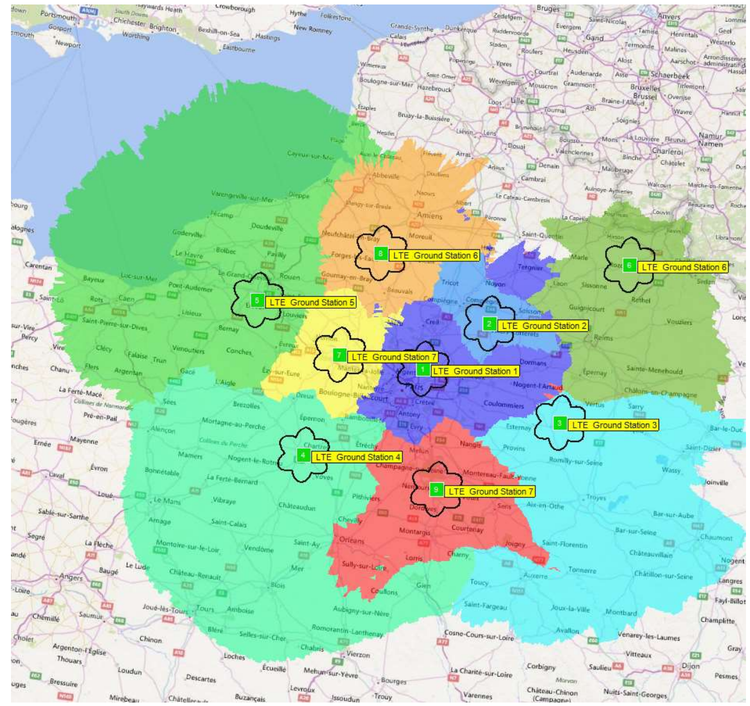


Fig 2: Best server RSRP map
(Aircraft altitude: 8000 ft)

3.3 – Broadband LTE A2G (use case)

E-Node B parameters:

Type	Signal
Tx/Rx A (0)	LTE TDD (57)

Tx/Rx

Parameter	Value
Nominal power (W)	30
Dynamic (dB)	0
Tx ant gain (dBi)	9.60
Rx ant gain (dBi)	9.60
Losses (dB)	tx 0.50 rx 0.50
Tx add losses (dB)	1.50
E.I.R.P (W)	172.632
Frequency (MHz)	2325.000000
Antenna height (m)	30.00
Tx bandwidth (kHz)	5000.00
Rx bandwidth (kHz)	5000.00

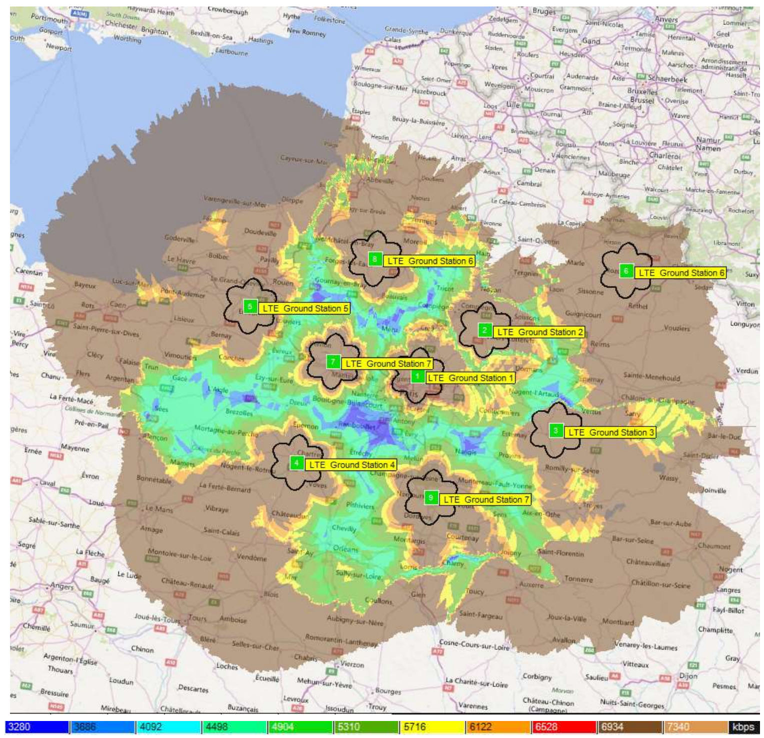


Fig 3: DL throughput map
(Aircraft altitude: 8000 ft)

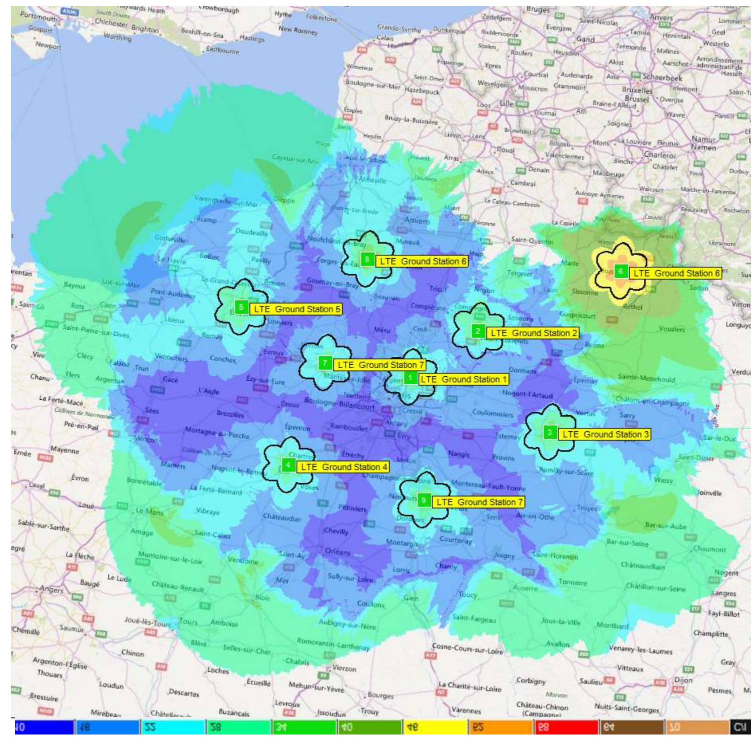


Fig 4: SNIR map
(Aircraft altitude: 8000 ft)

3.3 – Broadband LTE A2G (use case)

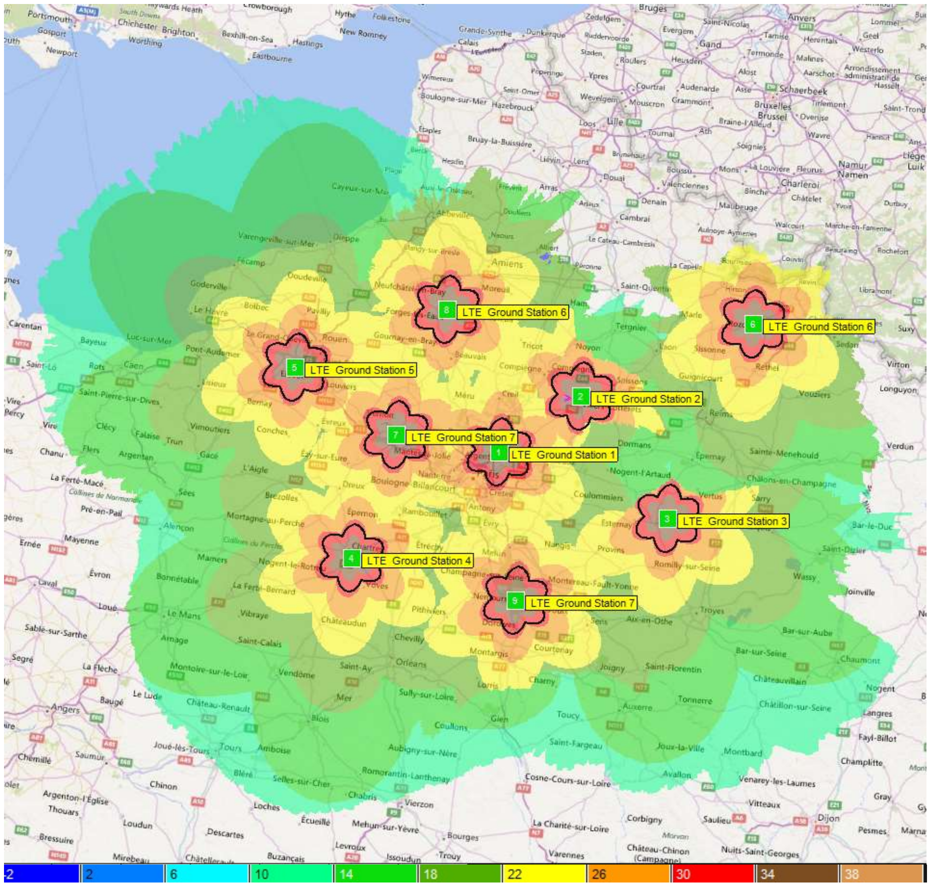
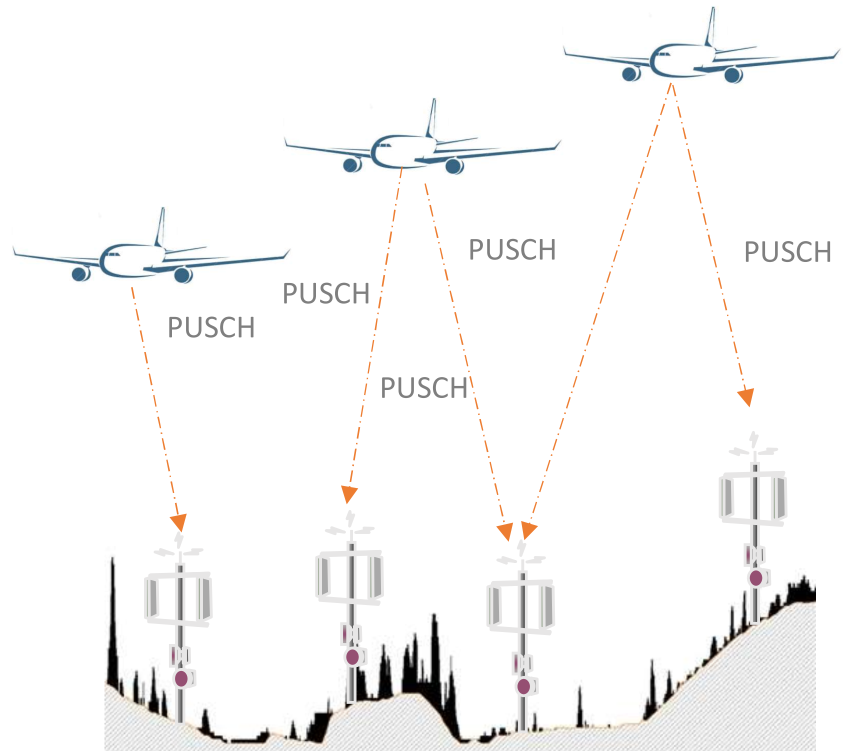
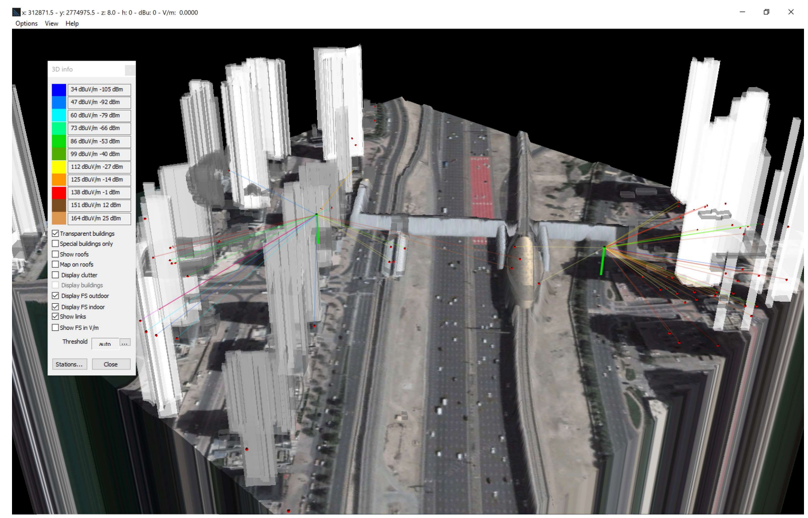


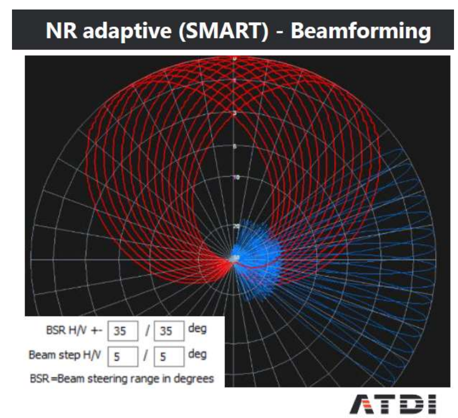
Fig 5: UL SNIR map (Aircraft altitude: 8000 ft)



3.3 – 5G Network configuration

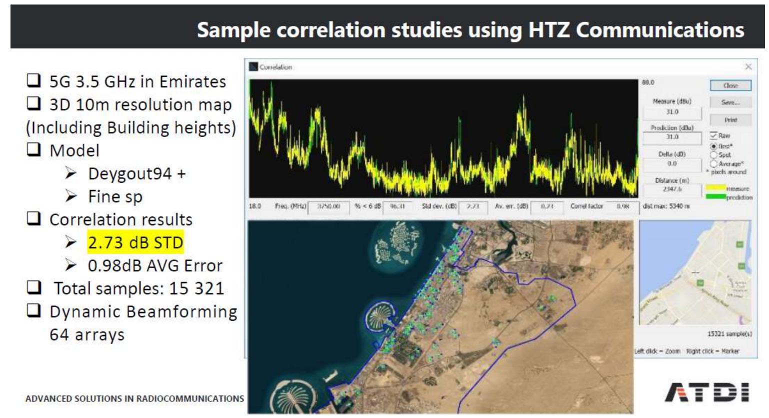
- Standalone (SA) and non-standalone (NSA) deployments ;
- All 5G-NR numerologies : 15,30, 60, 120, 240, 480 KHz;
- All 5G-NR Frequency bands (both below and above 6 GHz and bandwidths;
- Configuration of PDSCH, PSS, PBCH channels …;
- Multiport antenna system /Massive MIMO: SU-MIMO, MU-MIMO, and transmit/receive diversity;
- 2D/3D Dynamic beamforming (vertical and horizontal beams);
- DL/UL max throughput according to gNB configuration ;
- TDD/FDD/SUL, SDL duplex configuration;
- General technical parameters (feeder types, losses, power, antenna height, azimuths, …);
- PCI (Physical Cell ID)/ PHY_GRP_ID;
- HO margins;
- DL/UL load Traffic Factor;

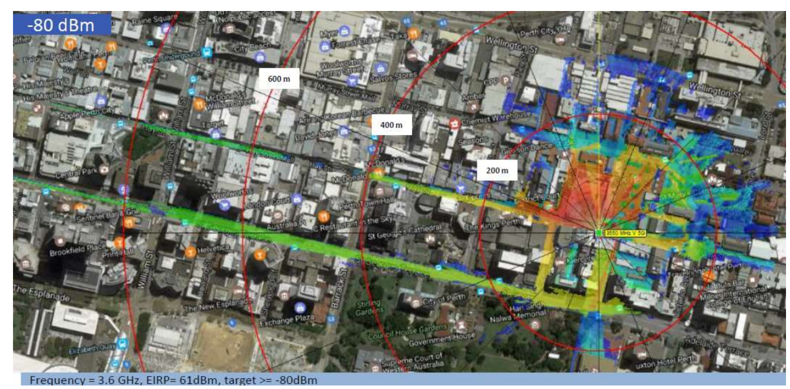




3.3 – 5G Network simulation and analysis

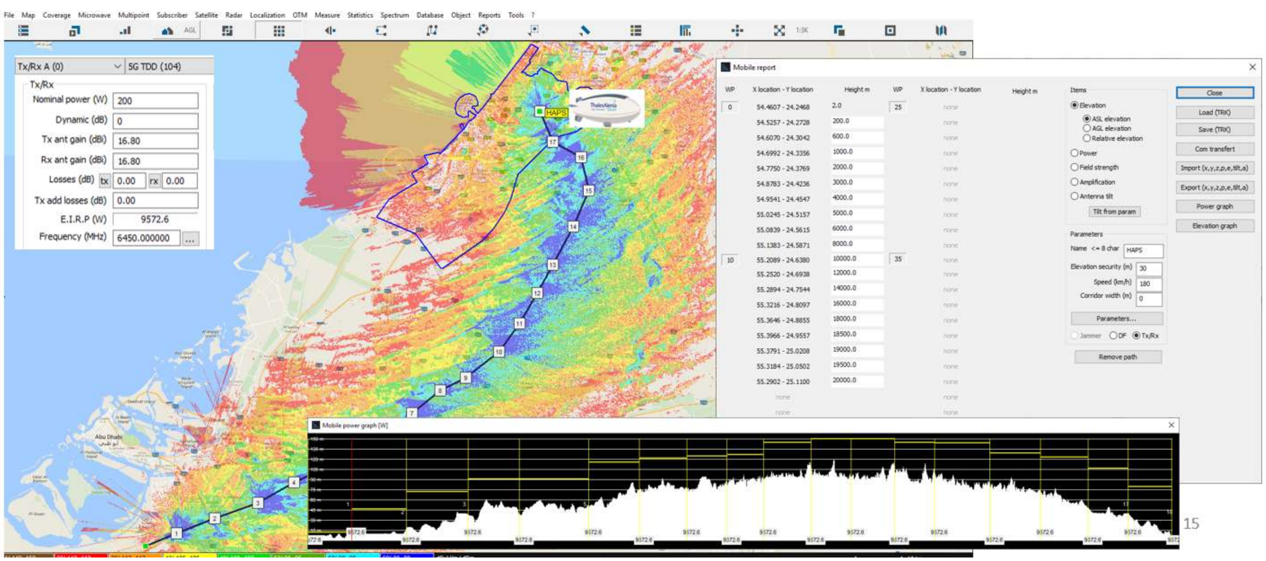
- Link budget calculator taking into account % reliability to achieve at the cell edge
- BRSRP plot , Probability of getting a given BRSRP value over a defined threshold, BRSRP overlapping, simultaneous BRSRP servers, 1st, 2nd and 3rd BRSRP server
- BRSRQ, best sever BRSRQ, BRSRQ with simultaneous servers, BRSRQ (normal std distribution)
- RSSI plot, best RSSI , overlapping, number of signal at a given pixel…
- Composite SNIR (PDSCH), best server SNIR, SNIR PBCH, SNIR PDCCH
- Uplink SNIR coverage map (Monte-Carlo and Noise rise methods
- Simultaneous display and analysis of network layers
- Link connections between 5G-NR UE's and gNB
- 5G traffic analysis, CQI
- 5G NR throughput plots according to Shannon method
- Automatic PCI (Physical Cell ID) planning, Automatic PRACH RSI planning
- Neighbor list (manual /automatic)
- Inter technology Handover calculation
- Automatic cell planning
- Automatic optimization of network coverage and capacity
- Automatic parameters optimization (height, azimuth & tilt)
- Automatic best site selection according to coverage and traffic targets
- Automated frequency planning, refarming frequency bands and inter-system coexistence
- Monte Carlos simulator



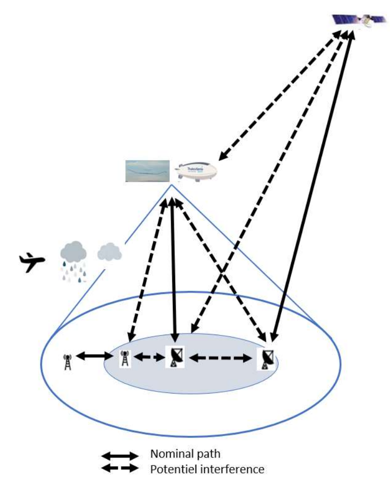


3.3 – DRONES AND HAPS (High Altitude Platform Station)

HTZ communications fully supports drones and HAPS (High Altitude Platform Station) systems for coverage (4G/5G broadband), coexistence analysis with other systems, interference (including ATPC) analysis.



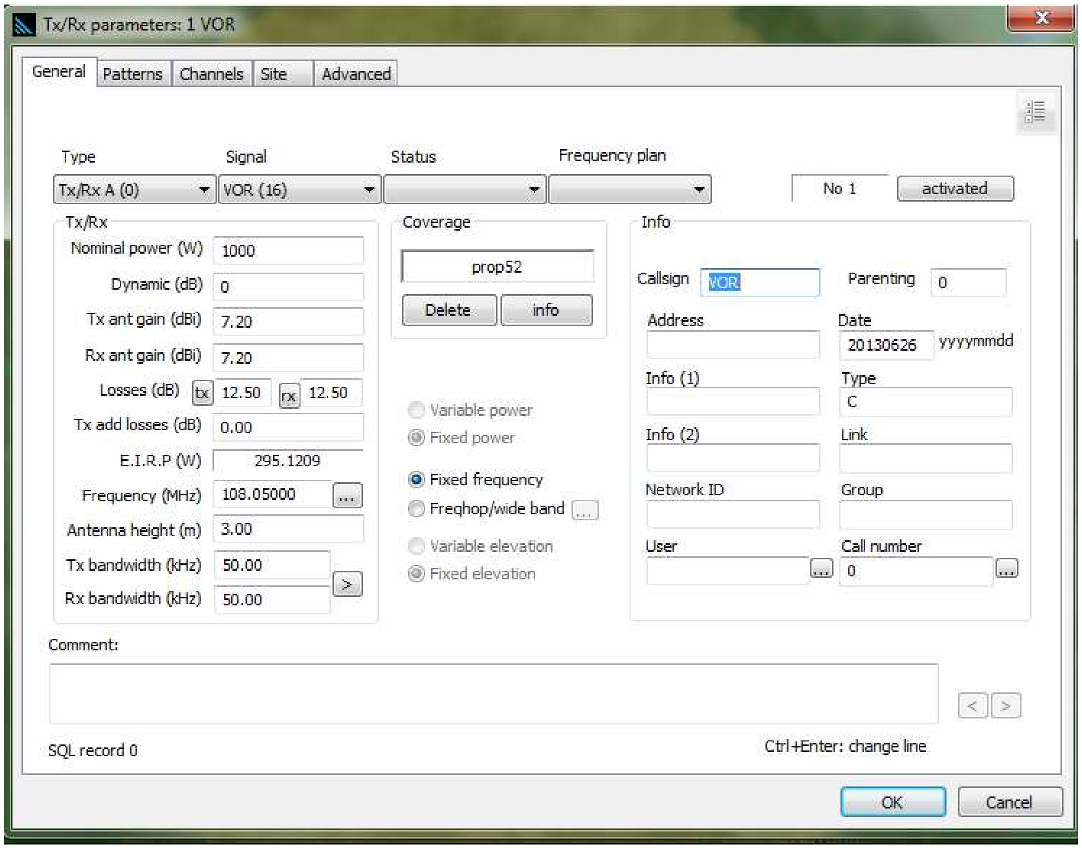
Frequency bands
6 440 – 6 520 MHz 6 560 – 6 640 MHz
27,9 – 28,2 GHz 31 – 31,3 GHz
47,2 – 47,5 GHz 47,9 – 48,2 GHz

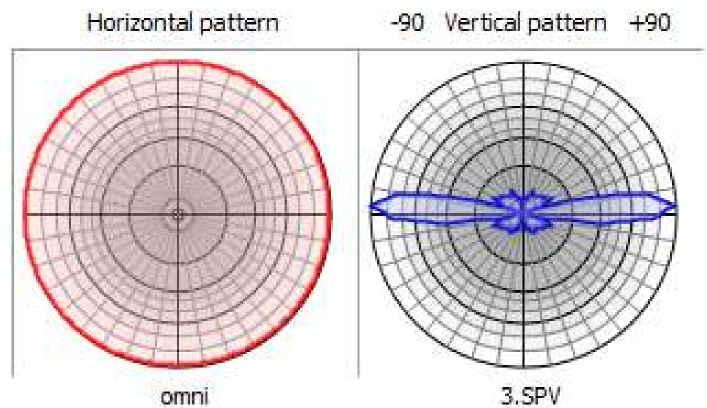


3.4 - RADIO NAVIGATION SYSTEMS

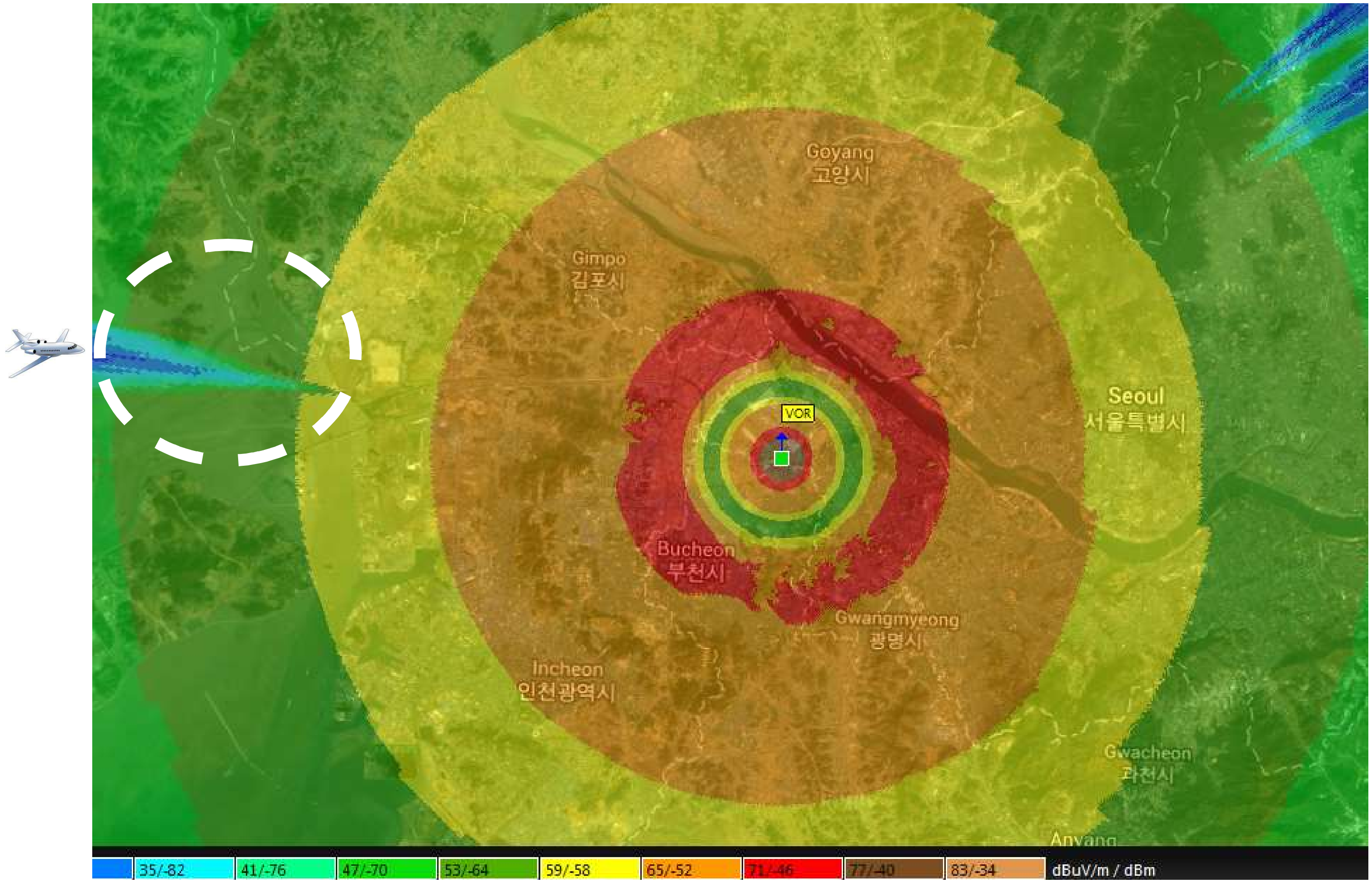
- Doppler VOR
- Instrument Landing System (ILS)
- Coordination with FM systems (SM 1009 recommendation)

3.4 - DOPPLER VOR

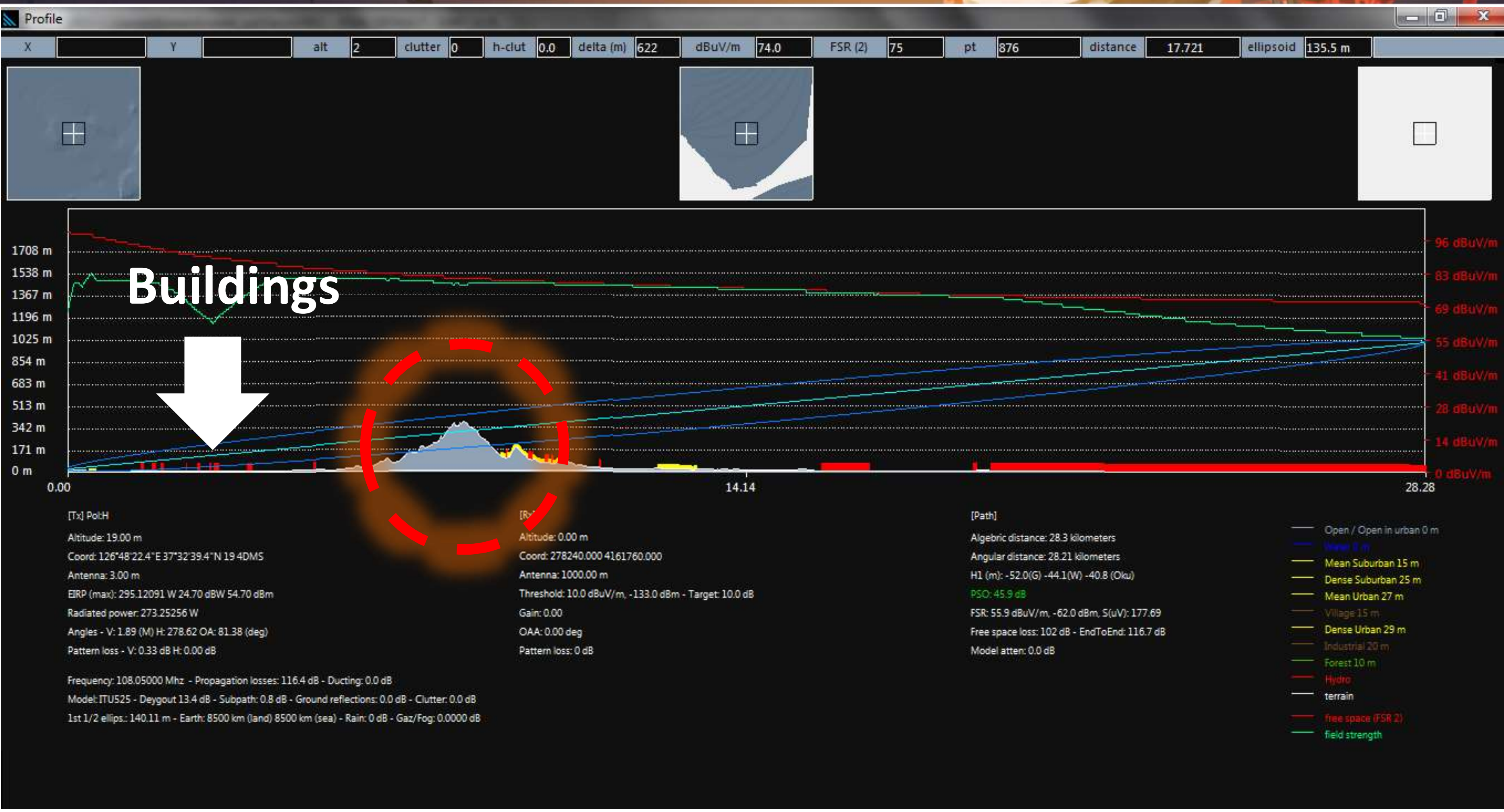




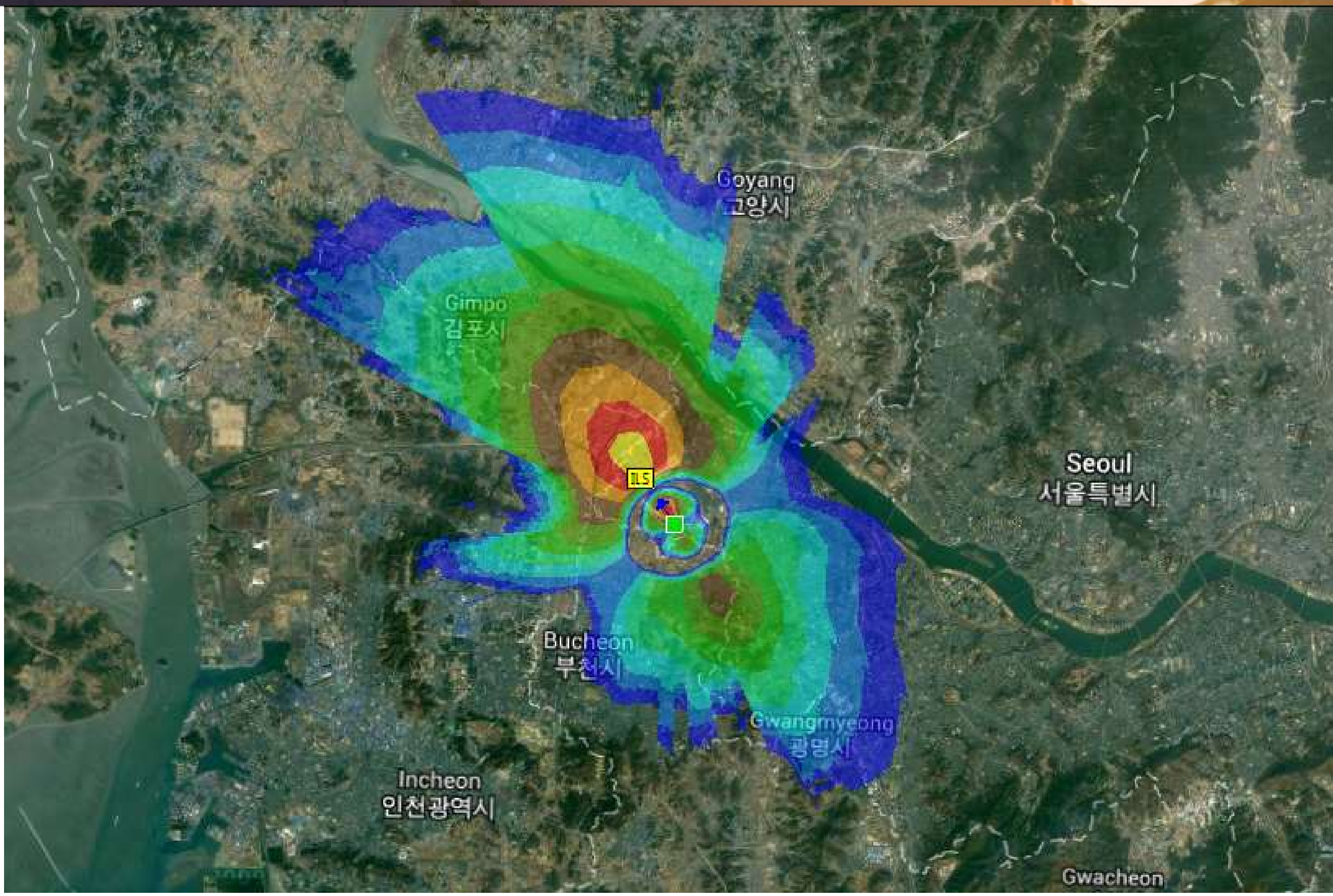
3.4 – DOPLER VOR

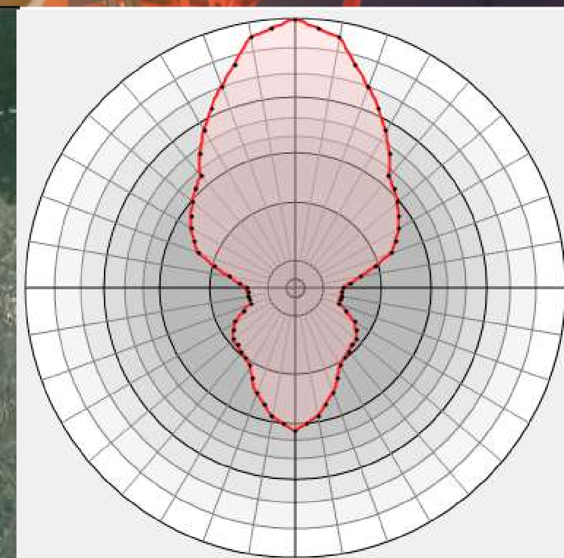


3.4 – DOPPLER VOR

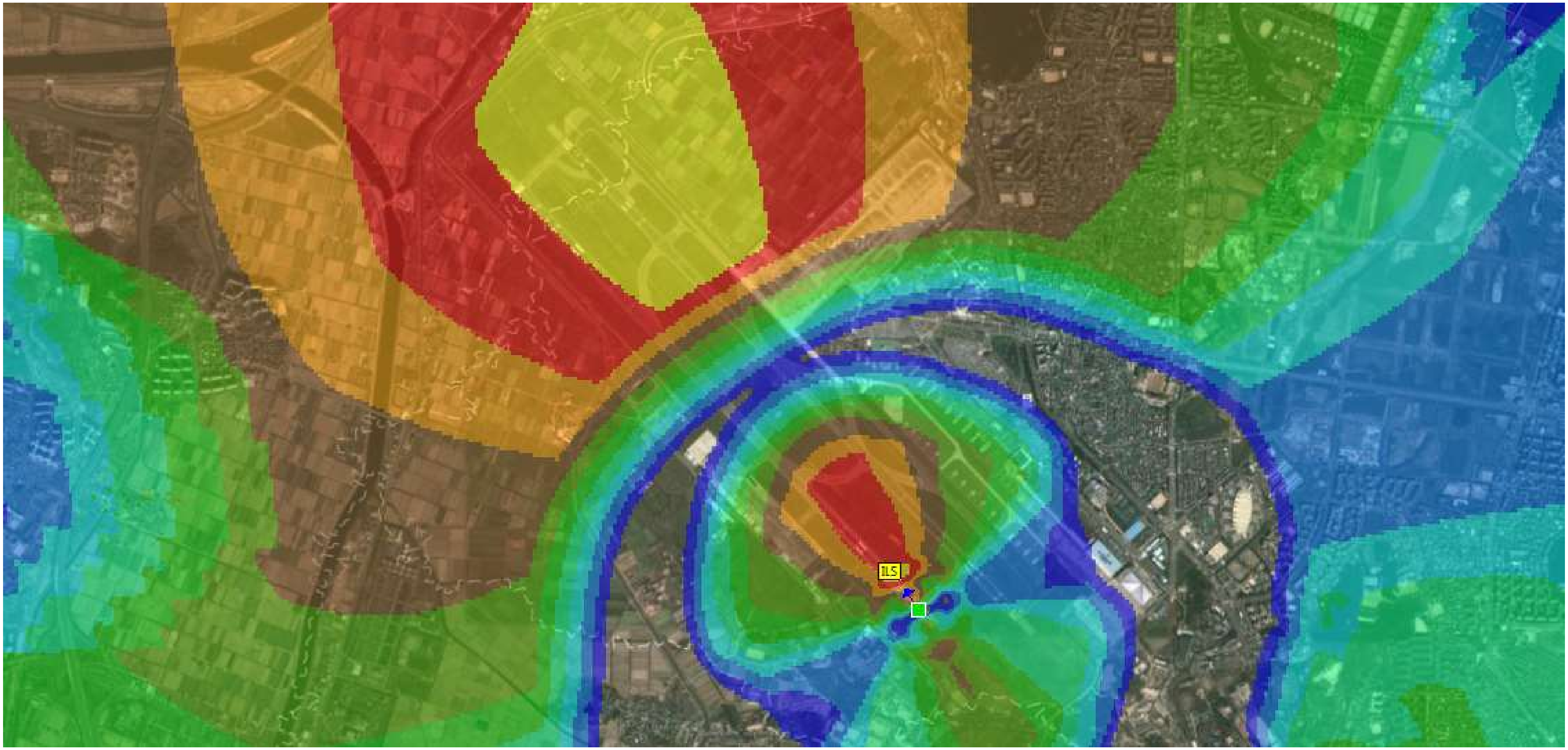


3.4. ILS


Goyang
고양시
Gimpo
김포시
ILS
Seoul
서울특별시
Bucheon
부천시
Gwangmyeong
광명시
Incheon
인천광역시
Gwacheon



3.4. ILS



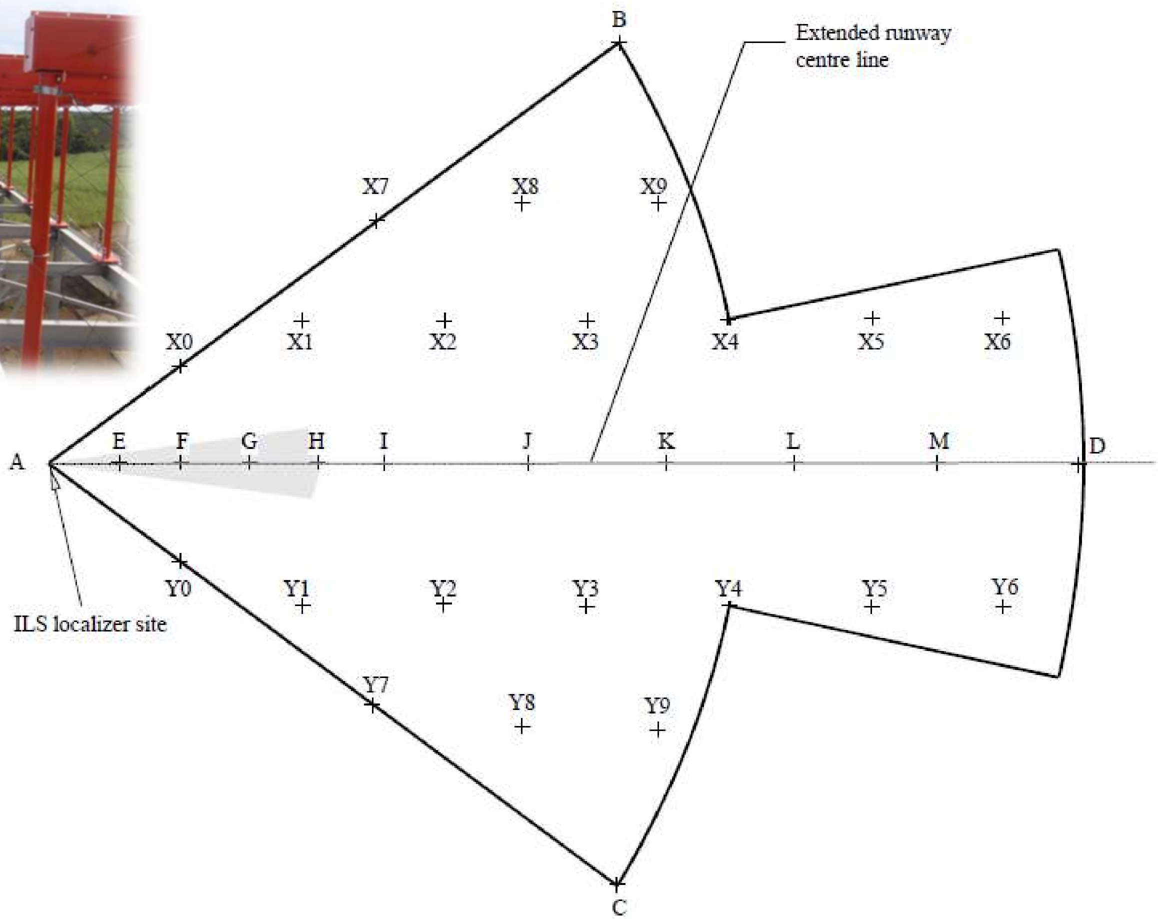
3.4. ILS/VOR COORDINATION

Implantation of ITU SM1009

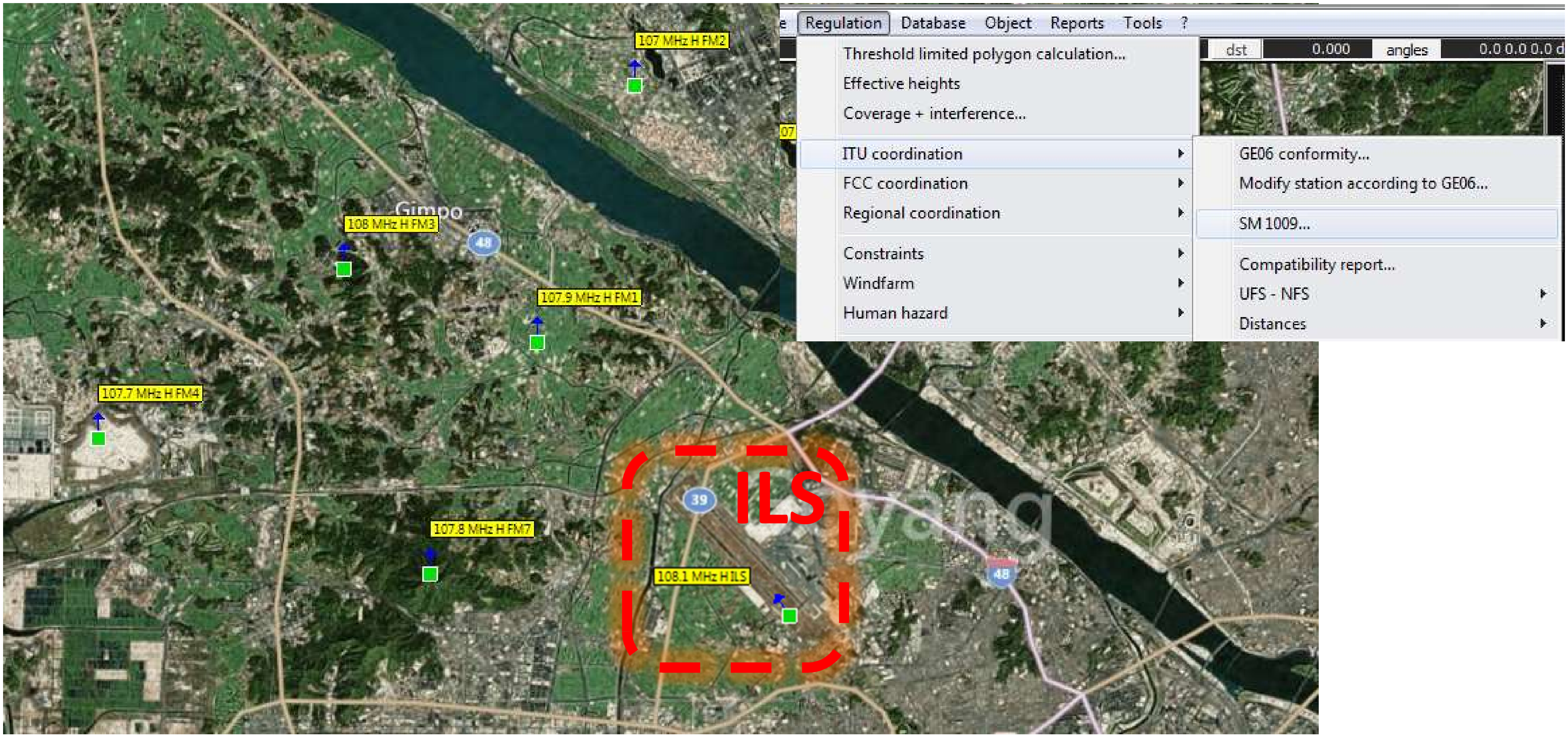
The aim of this recommendation is to check compatibility Between sound broadcasting service in 87-108 MHz and the aeronautical services in the 108-137MHz band

3.4. ILS/VOR COORDINATION

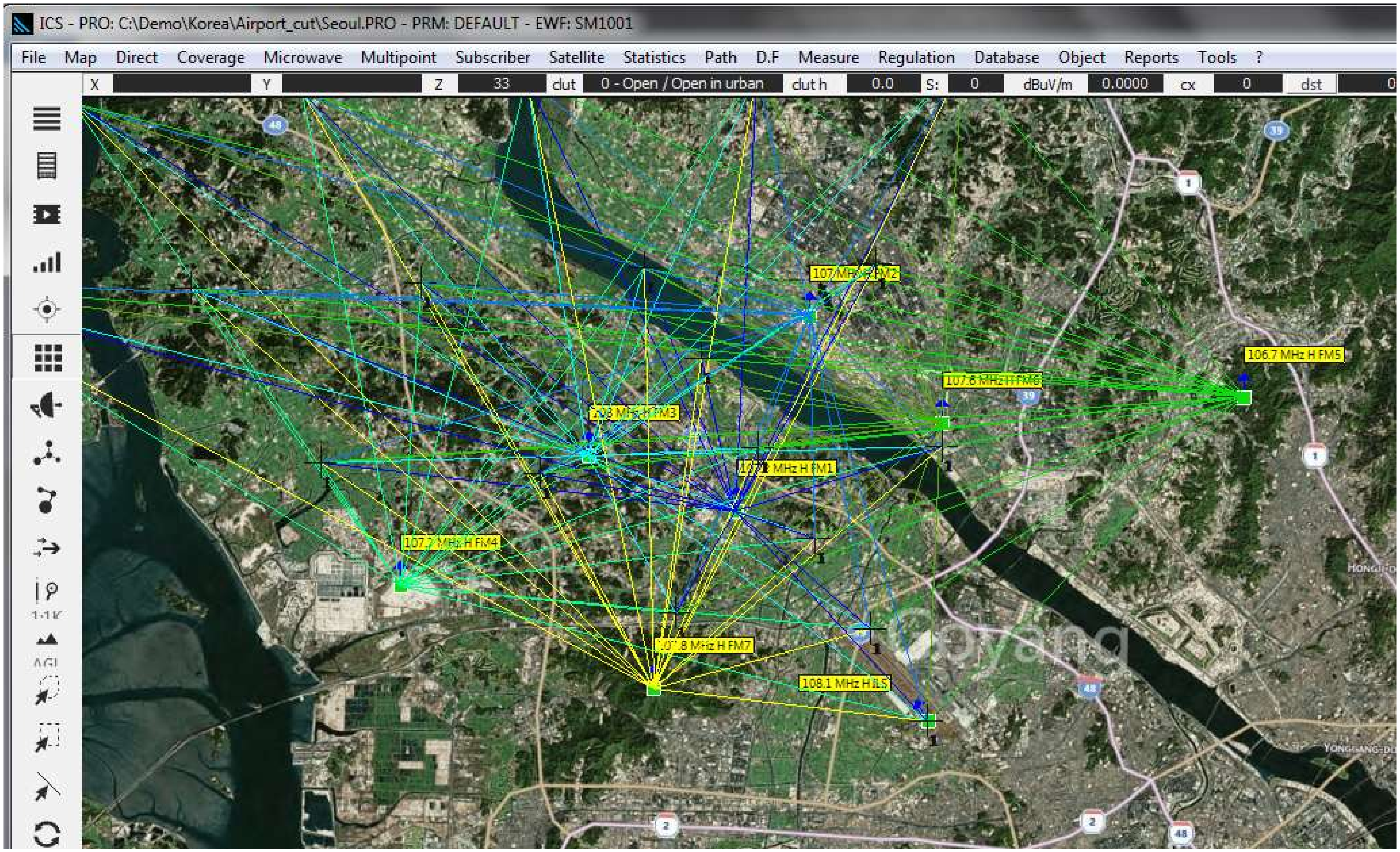
3.4. ILS/VOR COORDINATION



3.4 ILS/ VOR AND FM COORDINATION



3.4 ILS/ VOR AND FM COORDINATION



3.4 ILS/ VOR AND FM COORDINATION

Report listing

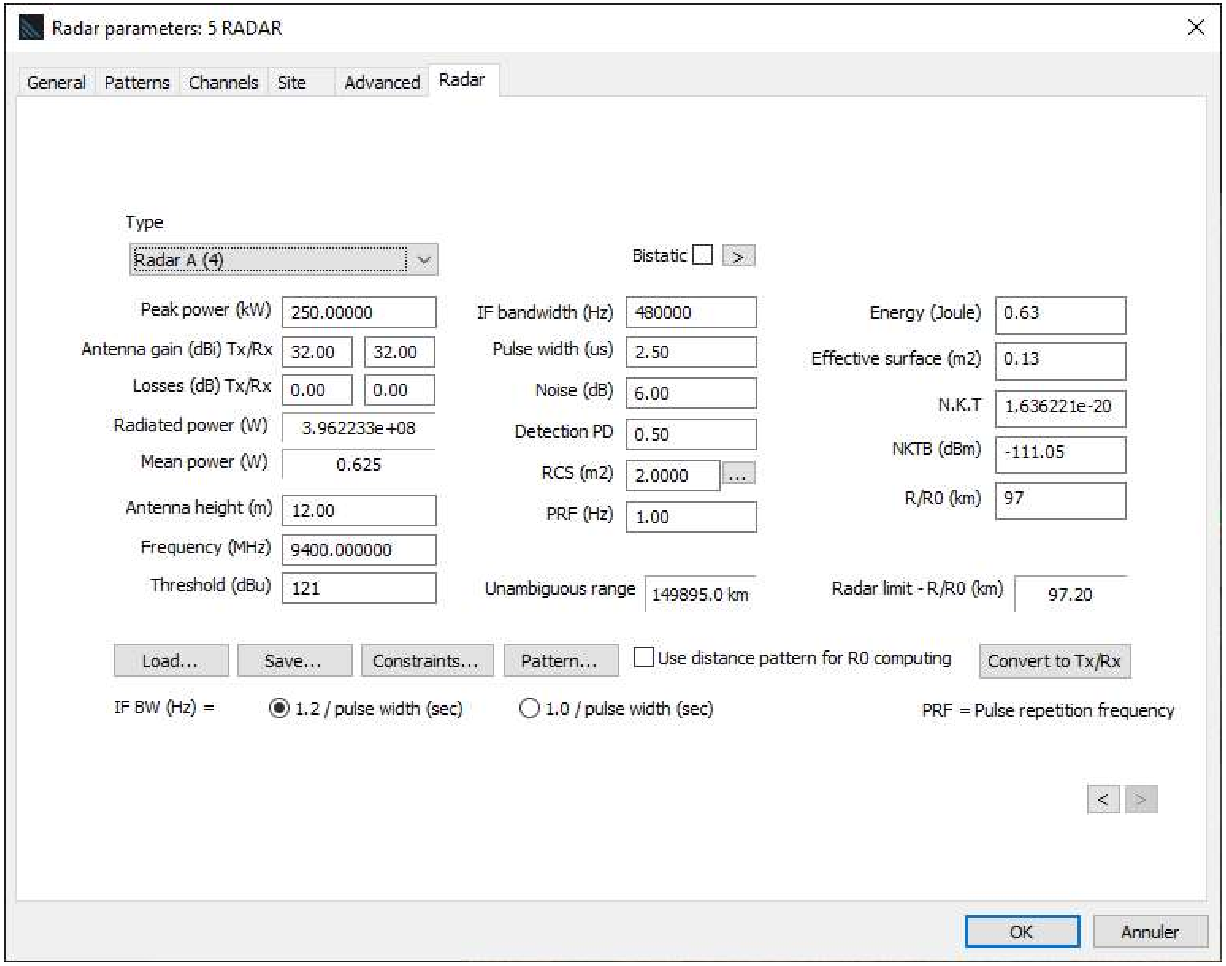
Record	Test point info	Wanted station #	Callsign	Wanted freq MHz	FTx 1 MHz	FTx 2 MHz	FTx 3 MHz	Fintermod MHz	Intermod product	Interference type	FS1+correct.(dBuV/m)	Co
8765	ILS y7	1	ILS	108.10000	108.00...	107.90...	107.80...	108.10000	1A+1B-1C	No interferenc...	81.1	5.
8766	ILS y7	1	ILS	108.10000	108.00...	107.90...	107.80...	108.10000	1A+1B-1C	No interferenc...	81.1	5.
8767	ILS x8	1	ILS	108.10000	108.00...	107.90...	107.80...	108.10000	1A+1B-1C	Interference A...	92.9	5.
8768	ILS x8	1	ILS	108.10000	108.00...	107.90...	107.80...	108.10000	1A+1B-1C	Interference A...	92.9	5.
8769	ILS x8	1	ILS	108.10000	108.00...	107.90...	107.80...	108.10000	1A+1B-1C	Interference B...	92.9	5.
8770	ILS x8	1	ILS	108.10000	108.00...	107.90...	107.80...	108.10000	1A+1B-1C	No interferenc...	92.9	5.
8771	ILS x8	1	ILS	108.10000	108.00...	107.90...	107.80...	108.10000	1A+1B-1C	No interferenc...	92.9	5.
8772	ILS x8	1	ILS	108.10000	108.00...	107.90...	107.80...	108.10000	1A+1B-1C	No interferenc...	92.9	5.
8773	ILS x9	1	ILS	108.10000	108.00...	107.90...	107.80...	108.10000	1A+1B-1C	Interference A...	92.5	7.
8774	ILS x9	1	ILS	108.10000	108.00...	107.90...	107.80...	108.10000	1A+1B-1C	Interference A...	92.5	7.
8775	ILS x9	1	ILS	108.10000	108.00...	107.90...	107.80...	108.10000	1A+1B-1C	No interferenc...	92.5	7.
8776	ILS x9	1	ILS	108.10000	108.00...	107.90...	107.80...	108.10000	1A+1B-1C	No interferenc...	92.5	7.
8777	ILS x9	1	ILS	108.10000	108.00...	107.90...	107.80...	108.10000	1A+1B-1C	No interferenc...	92.5	7.
8778	ILS x9	1	ILS	108.10000	108.00...	107.90...	107.80...	108.10000	1A+1B-1C	No interferenc...	92.5	7.
8779	ILS A	1	ILS	108.10000	108.00...	107.00...	107.90...	108.90000	1A+1B-1C	No interferenc...	-12.3	3.
8780	ILS A	1	ILS	108.10000	108.00...	107.00...	107.90...	108.90000	1A+1B-1C	No interferenc...	-12.3	3.
8781	ILS A	1	ILS	108.10000	108.00...	107.00...	107.90...	108.90000	1A+1B-1C	No interferenc...	-12.3	3.
8782	ILS A	1	ILS	108.10000	108.00...	107.00...	107.90...	108.90000	1A+1B-1C	No interferenc...	-12.3	3.
8783	ILS A	1	ILS	108.10000	108.00...	107.00...	107.90...	108.90000	1A+1B-1C	No interferenc...	-12.3	3.
8784	ILS A	1	ILS	108.10000	108.00...	107.00...	107.90...	108.90000	1A+1B-1C	No interferenc...	-12.3	3.
8785	ILS B	1	ILS	108.10000	108.00...	107.00...	107.90...	108.90000	1A+1B-1C	No interferenc...	-25.1	5.
8786	ILS B	1	ILS	108.10000	108.00...	107.00...	107.90...	108.90000	1A+1B-1C	No interferenc...	-25.1	5.
8787	ILS B	1	ILS	108.10000	108.00...	107.00...	107.90...	108.90000	1A+1B-1C	No interferenc...	-25.1	5.
8788	ILS B	1	ILS	108.10000	108.00...	107.00...	107.90...	108.90000	1A+1B-1C	No interferenc...	-25.1	5.
8789	ILS B	1	ILS	108.10000	108.00...	107.00...	107.90...	108.90000	1A+1B-1C	No interferenc...	-25.1	5.
8790	ILS B	1	ILS	108.10000	108.00...	107.00...	107.90...	108.90000	1A+1B-1C	No interferenc...	-25.1	5.

Listing... Close

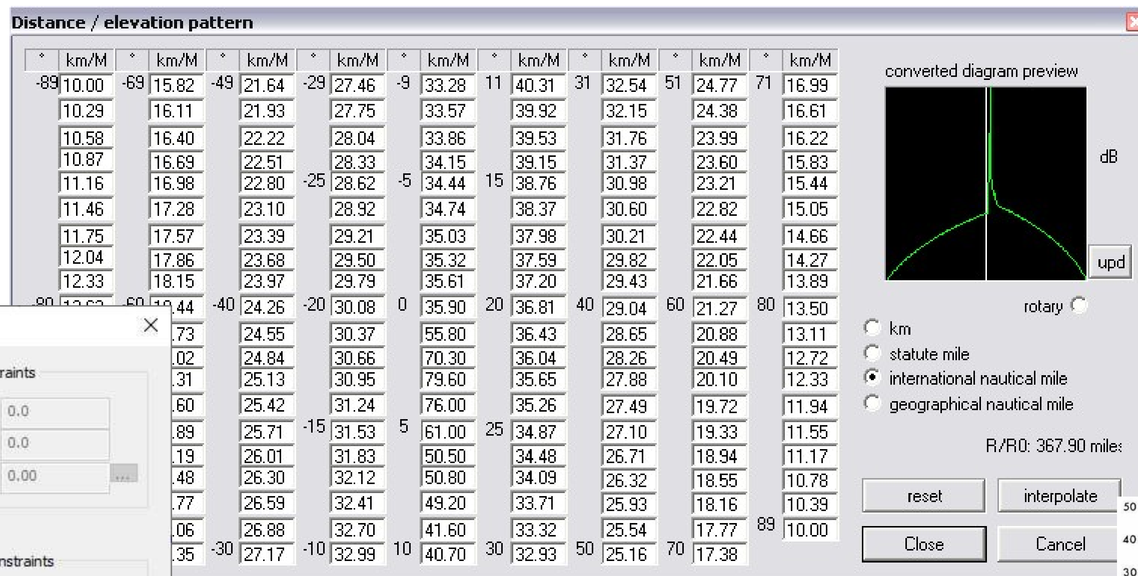
3.5 - RADARS AND MULTILATERATION SYSTEMS

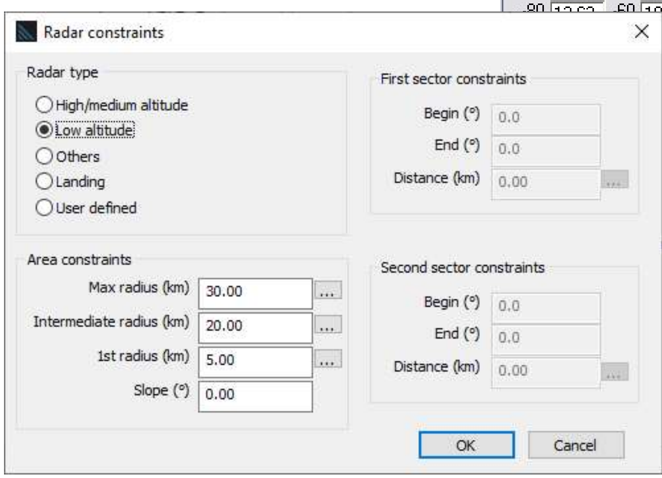
- Surveillance systems (Radar)
- Multilateration (MLAT)
- Coexistence between radars and other systems

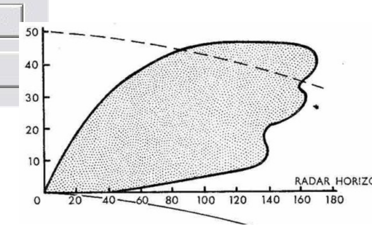
3.5. RADAR PARAMETERS



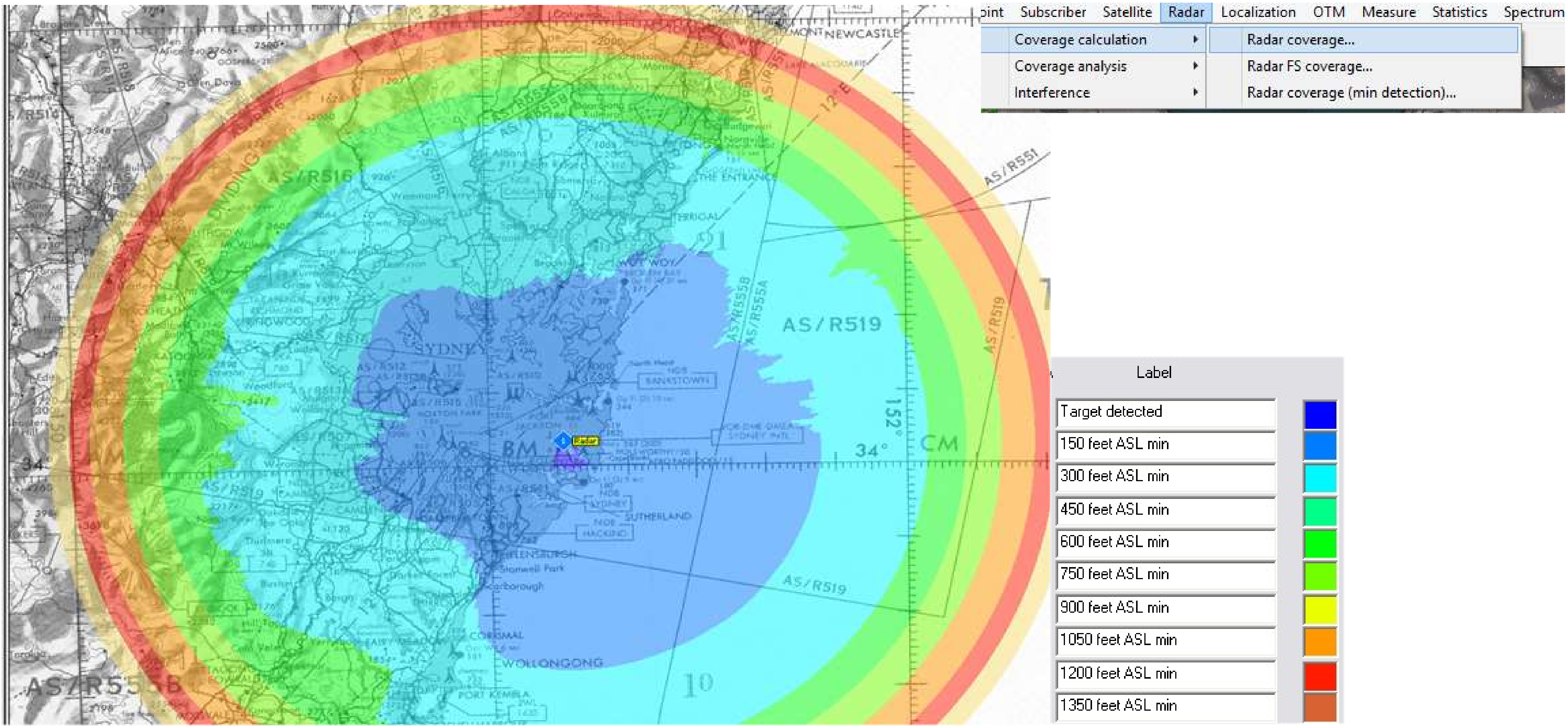
3.5. RADAR PARAMETERS



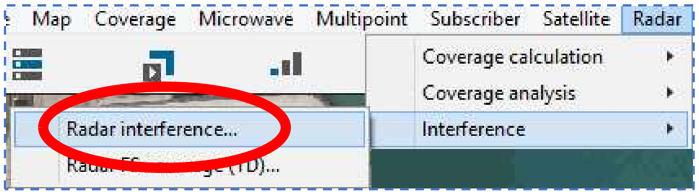


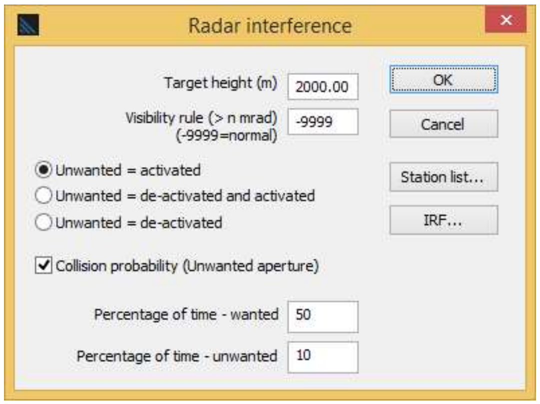


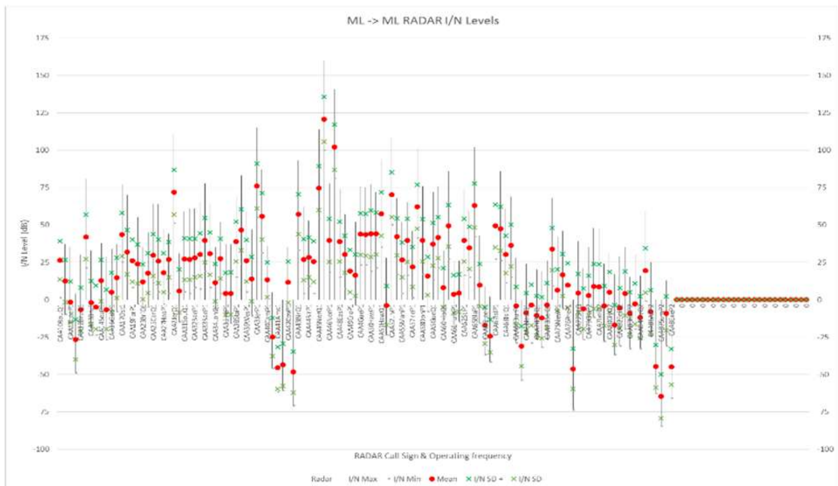
3.5. RADAR MIN DETECTION HEIGHT

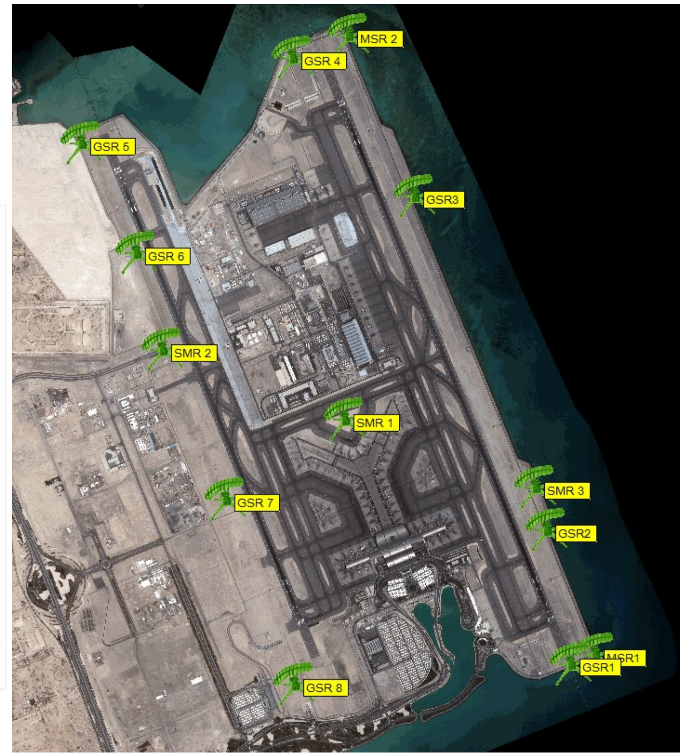


3.5 RADAR INTERFERENCE ANALYSIS





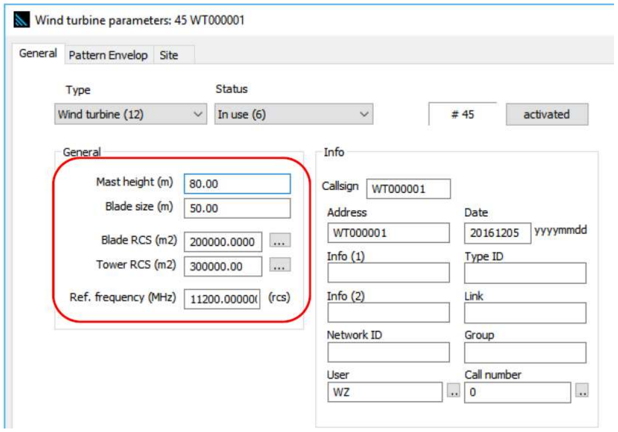


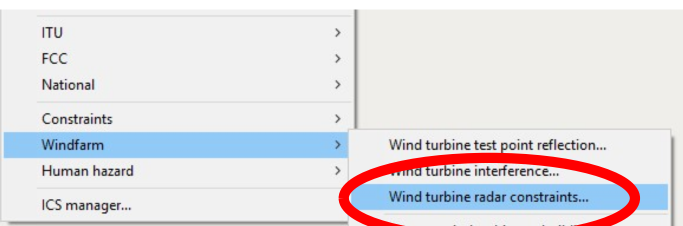


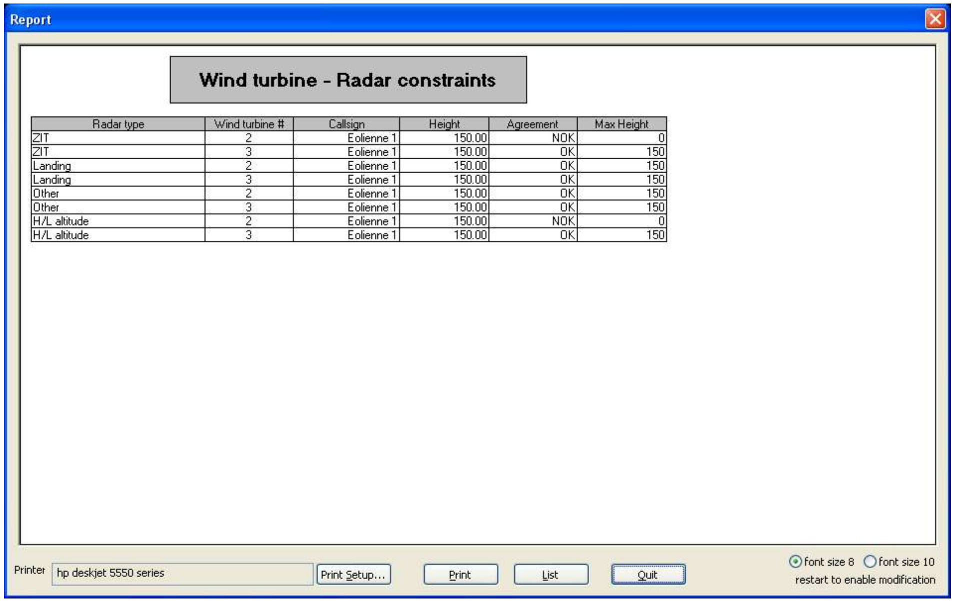
This functions rotates the radar horizontal antenna pattern in 1 degree intervals and calculates the I/N and Threshold degradation. The radar coverage is then calculated using the threshold degradation and then calculates the radar coverage for the given probability of detection and radar cross section.

3.5 COEXSISTANCE BETWEEN RADAR AND WIND FARMS

HTZ communications includes advanced features for the analysis and validation of the coexistence between radars and wind farms.






Report

Wind turbine - Radar constraints

Radar type	Wind turbine #	Callsign	Height	Agreement	Max Height
ZIT	2	Eolienne 1	150.00	NOK	0
ZIT	3	Eolienne 1	150.00	OK	150
Landing	2	Eolienne 1	150.00	OK	150
Landing	3	Eolienne 1	150.00	OK	150
Other	2	Eolienne 1	150.00	OK	150
Other	3	Eolienne 1	150.00	OK	150
H/L altitude	2	Eolienne 1	150.00	NOK	0
H/L altitude	3	Eolienne 1	150.00	OK	150

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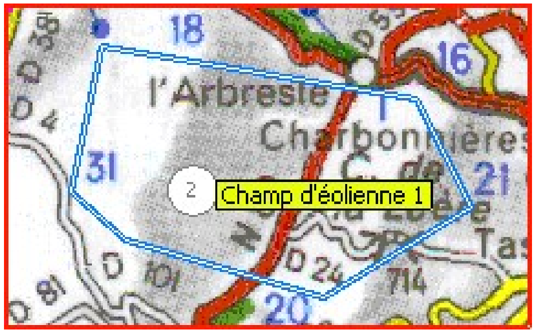
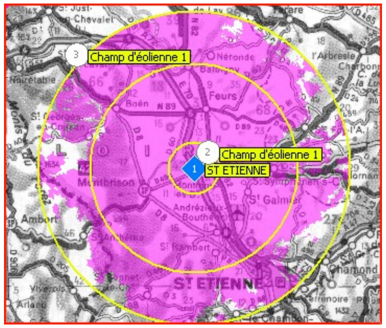
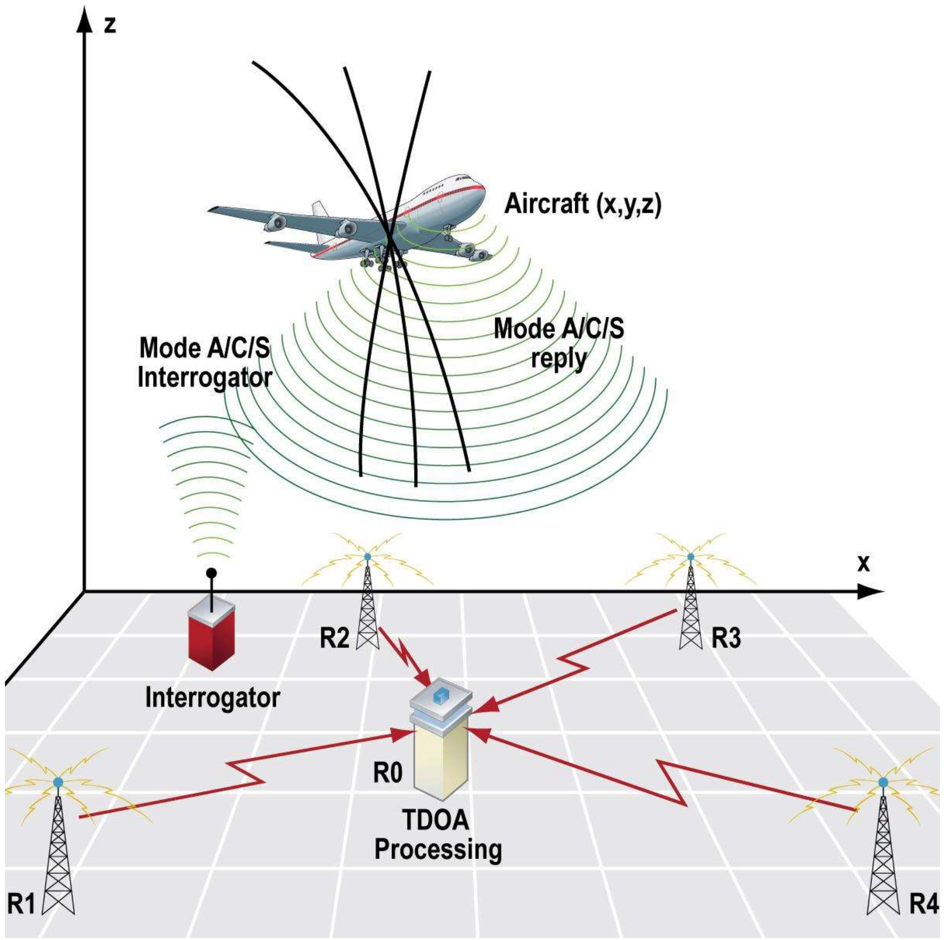


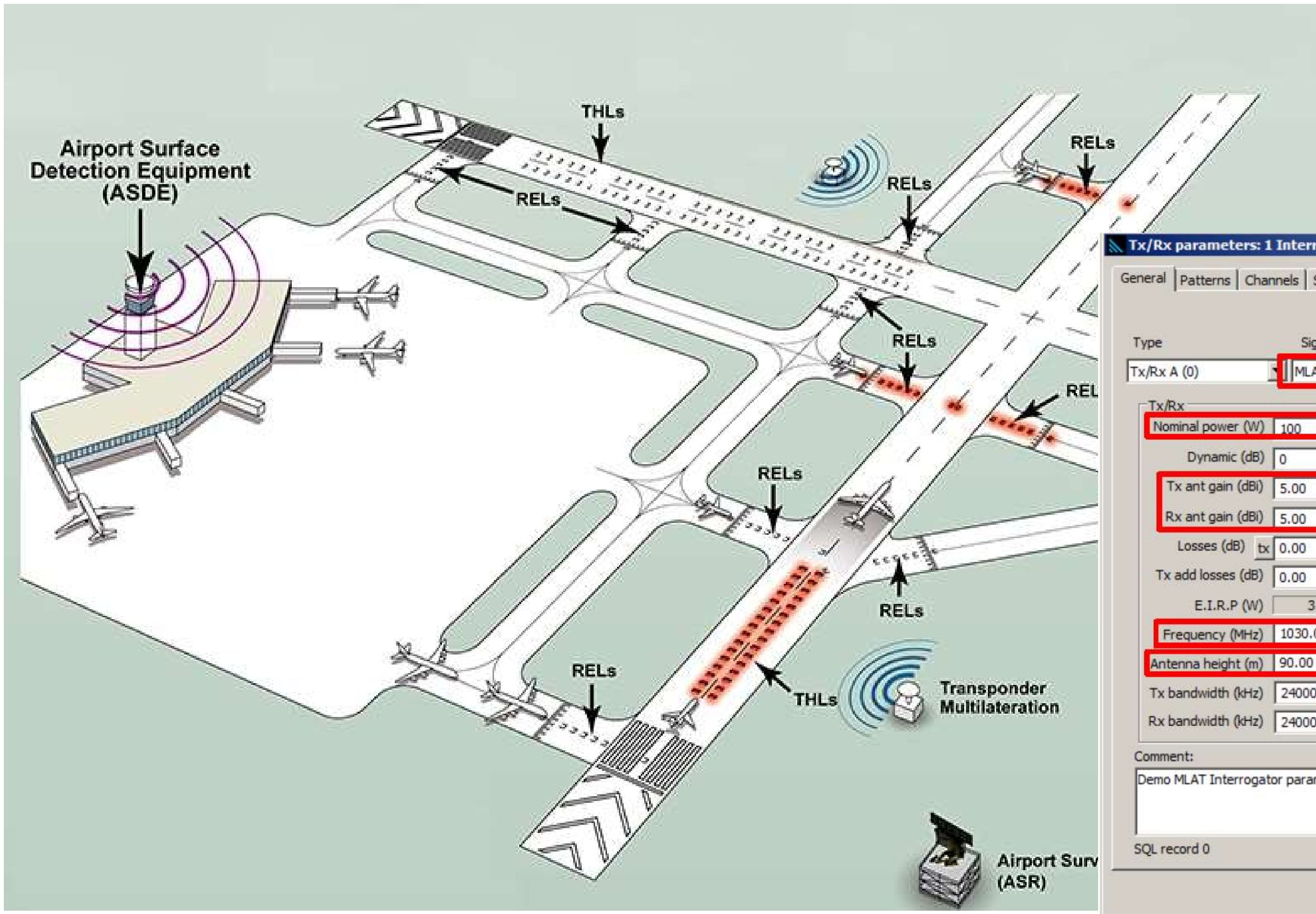


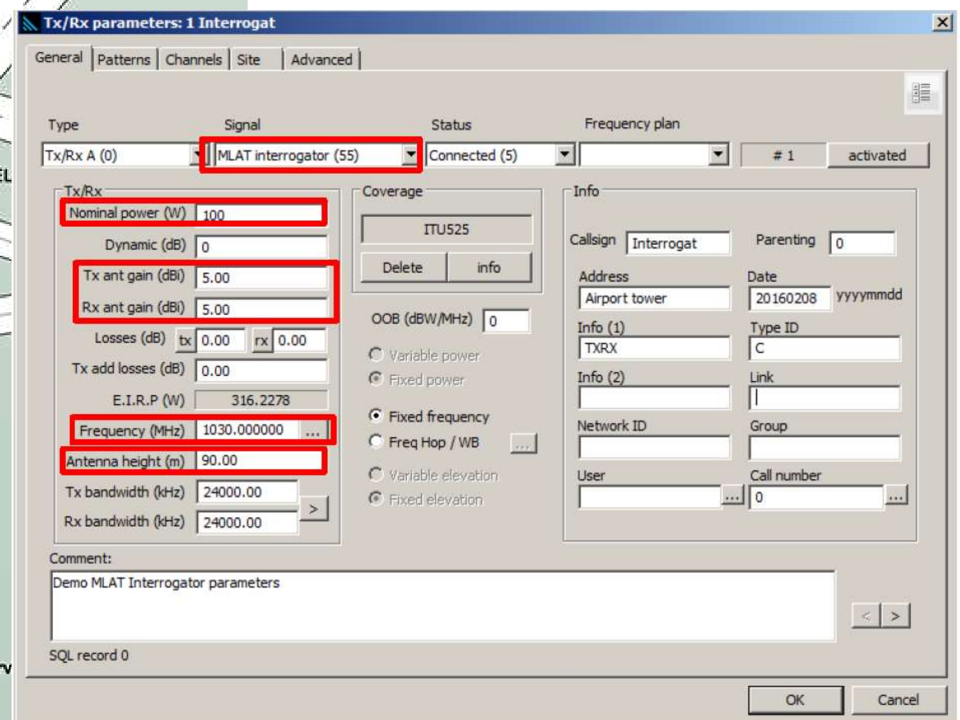
3.5. Multilateration –Sensor network



1. Interrogator ask airplane to identify itself
2. Airplane transmit signal
3. Sensors receive the signal
4. Base of ToA difference the location can be accurately evaluated

3.5. Multilateration – Airport surface

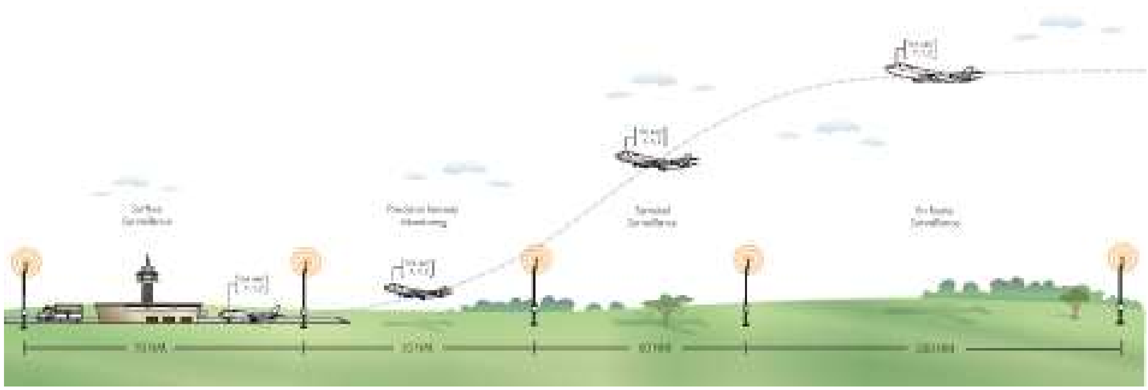




3.5. MULTILATERATION – Air Traffic Management

HTZ communications helps in

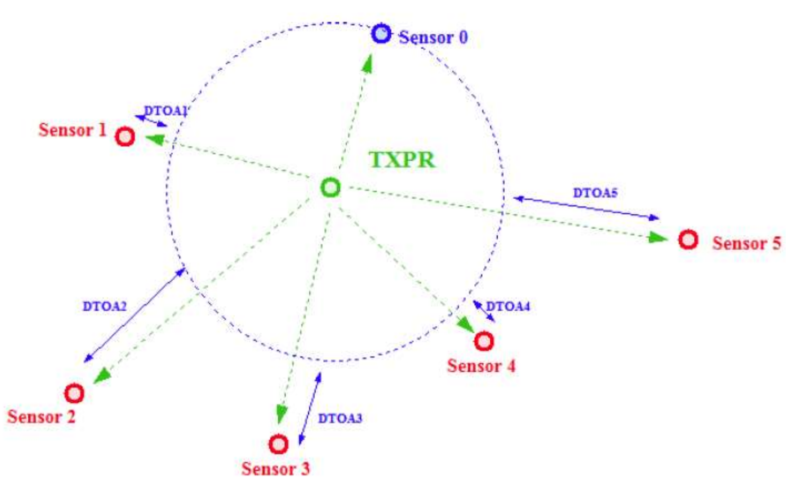
- Planning where to put the sensors
- Planning Best spot to put the interrogator
- Evaluate the accuracy/range of the sensor network

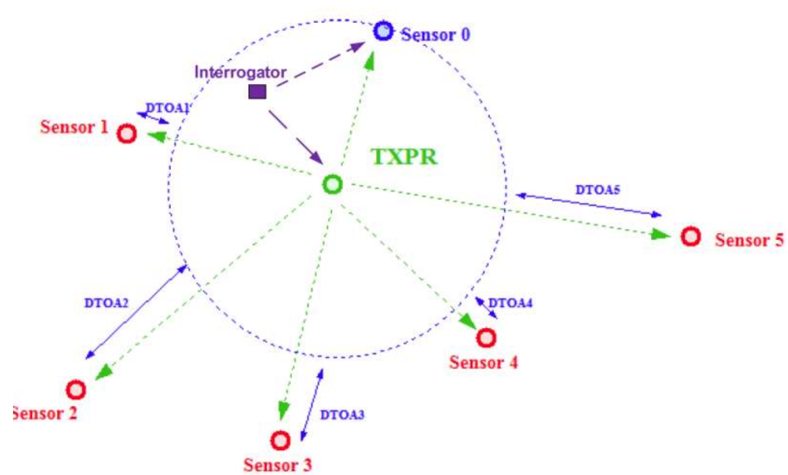


3.5. MULTILATERATION – Air Traffic Management

HTZ communications can asses the precision of a multilateration system

- Time Difference of arrival (TDOA)
- Time Sum of arrival (TSOA)

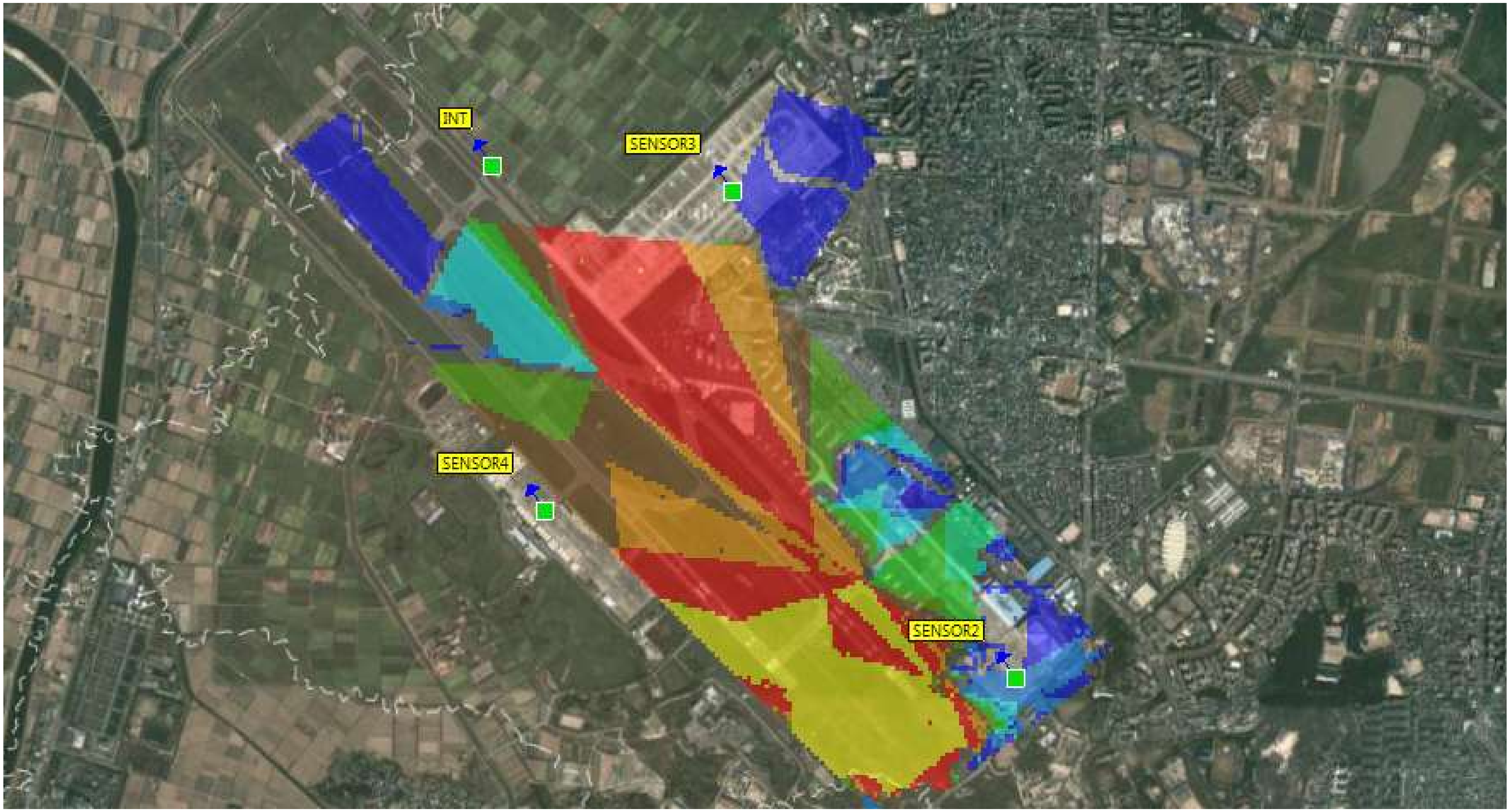




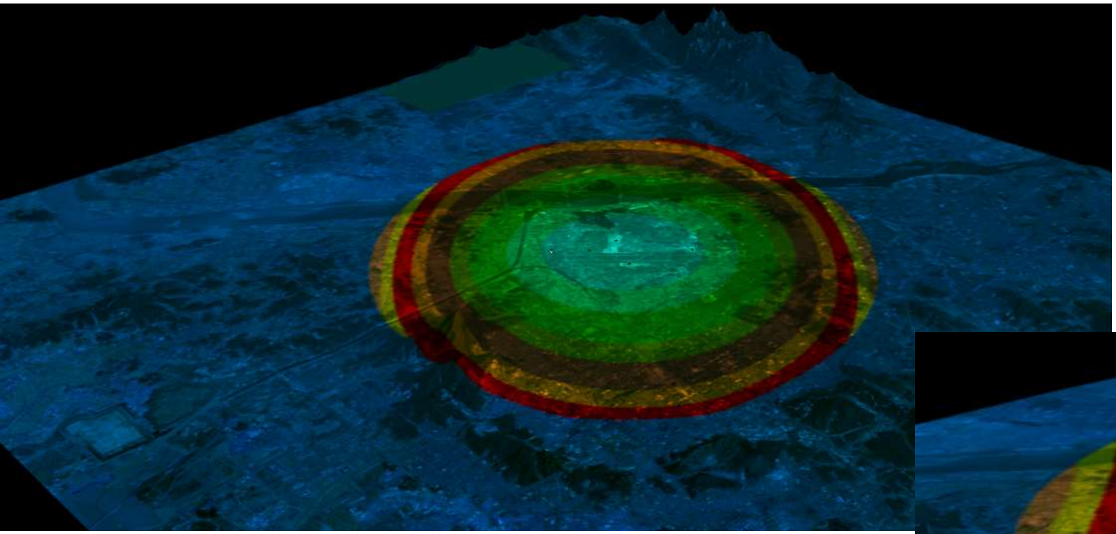
3.5. MULTILATERATION –SENSOR LOCATIONS

IoT 5G Lte

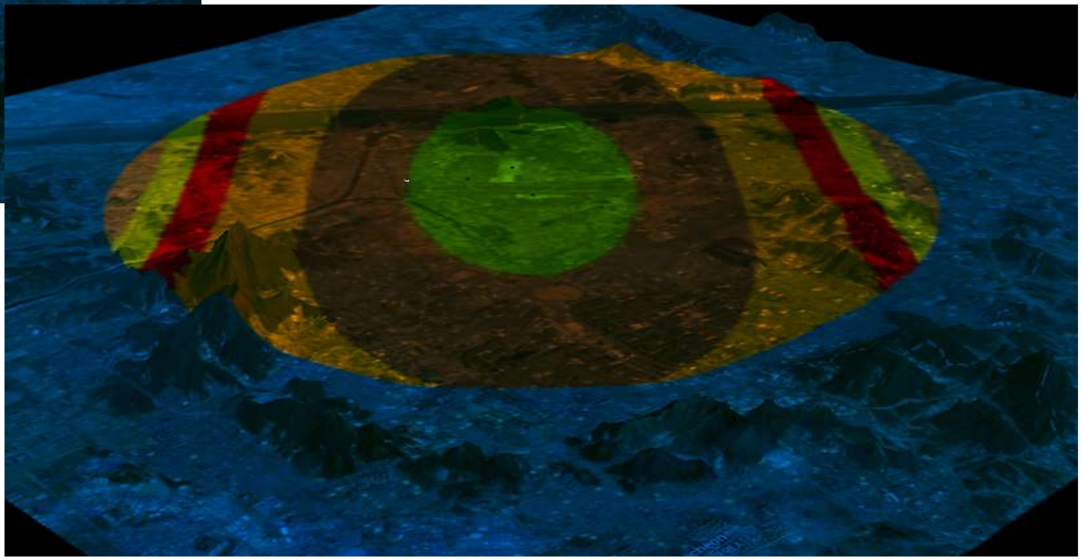
3.5. MULTILATERATION –SENSOR LOCATIONS



3.5 MULTILATERATION ACCURACY MAP



MLAT ACCURACY MAP (H)



MLAT ACCURACY MAP (V)

IoT 5G Lte

3.6 - HTZ communications – Harmful interference analysis

Interference & EMC

Interference calculation methods

- C/I (signal-to-interference ratio required for the receiver)
- TD (Threshold degradation)
- I/N (Interference to Noise ratio), C/N+I (Signal to Noise + Interference ratio), TIL, SNR
- IRF (Interference Rejection Factor) masks

Interference types

- Unwanted emissions: Spurious emissions and out-of-band emissions
- Intermodulation/ Harmonics
- Noise Desensitization
- Harmful interference
- DSM (Dynamic Spectrum Management)

Recommendations:

- ITU-R, ICAO CEPT, ETSI, 3GPP, FCC

Interference from non-aeronautical sources

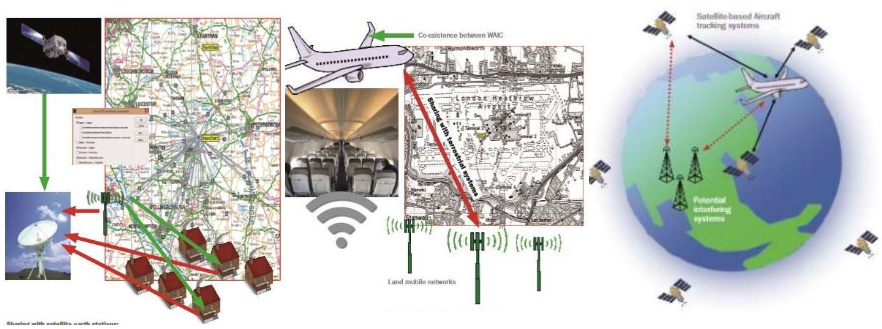
Basic functionality

- Radar vs. LTE
- Radar vs. Wind turbines
- ILS/VOR/GBAS vs FM
- VHF vs. VHF
- Jammers
- …

International coordination

International, bi-lateral and regional coordination

- Maximum Field strength limit
- Border coordination and border agreement
- UFS, NFS, UFS delta, SFN test report
- Compatibility report
- HCM



EUROCAE, RTCA, ETSI, CEPT ECC

Satellite

Global flight tracking for Civil Aviation Resolution 185 (Busan, 2014)

- Coexistence with other radio systems
- Interference/loss of tracking

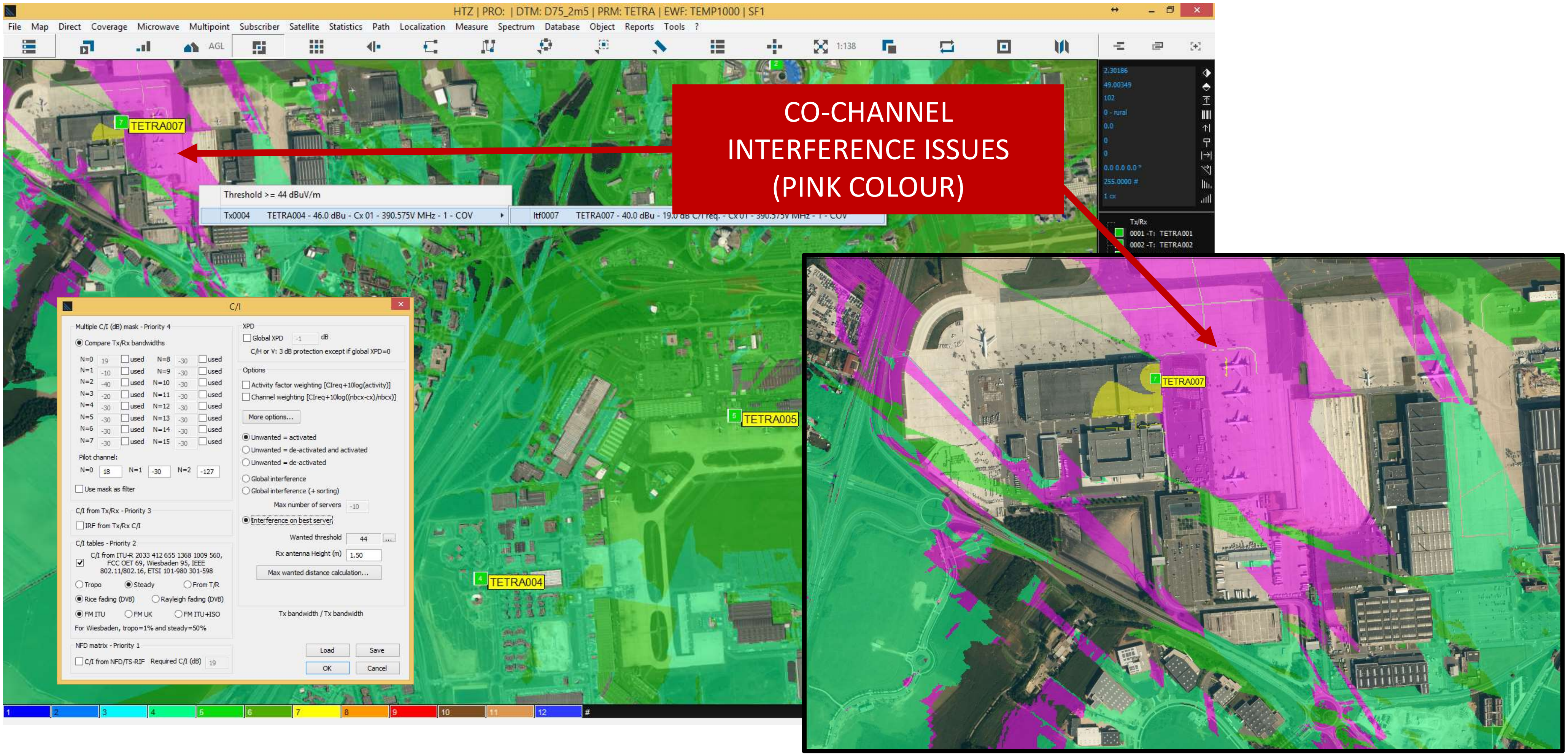
Wireless Avionics Intra-Communications (WAIC) – WRC 2015

- Parameters and Operational objectives for WAIC systems: Are systems in use when cabin doors are open?
- Fuselage attenuation and other surface attenuation above and below 15.7GHz.

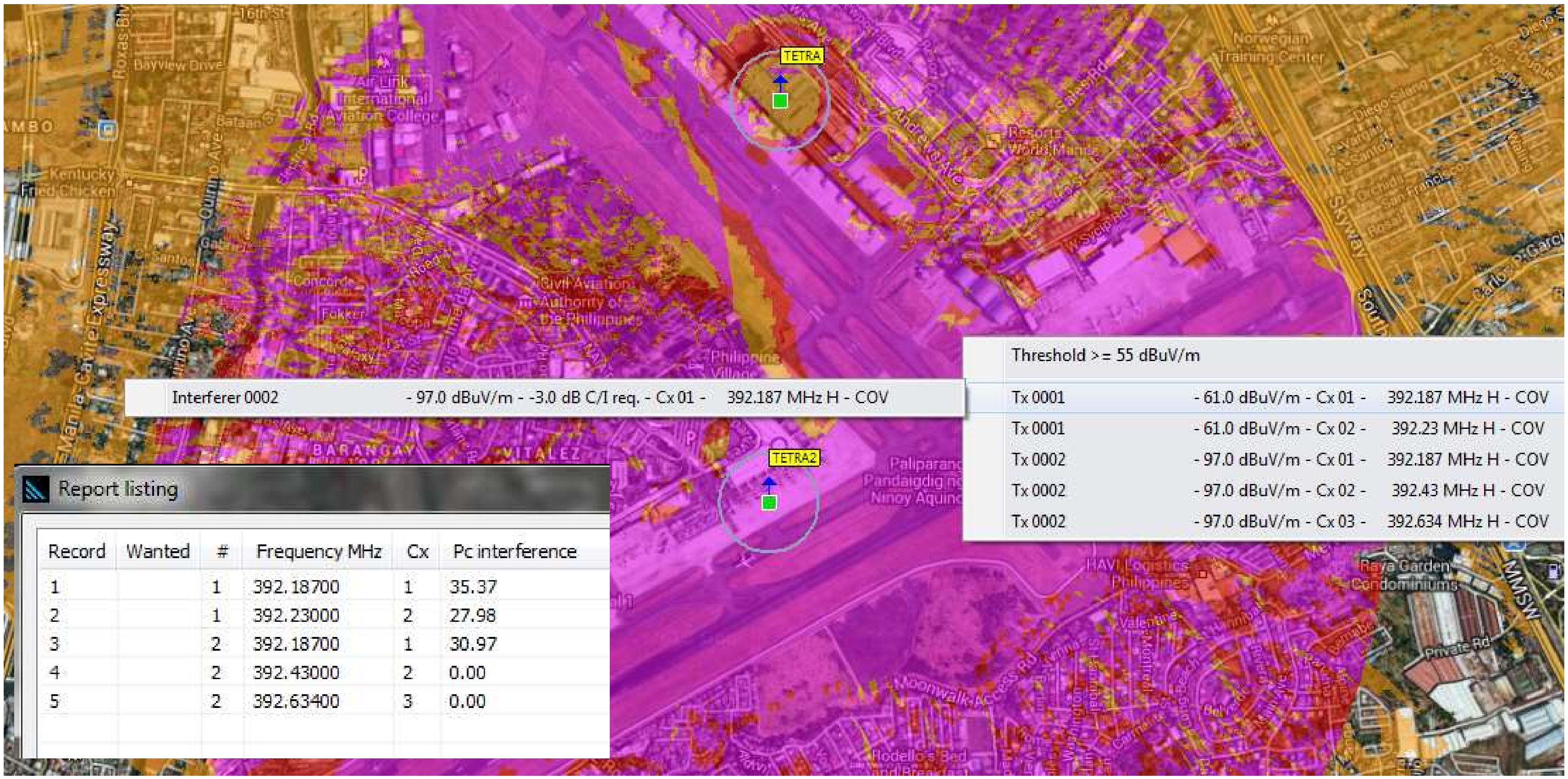
Interference into Earth station

- Earth station vs. microwave
- Earth station vs. satellite

3.7. INTERFERENCE ANALYSIS



3.7 INTERFERENCE ANALYSIS



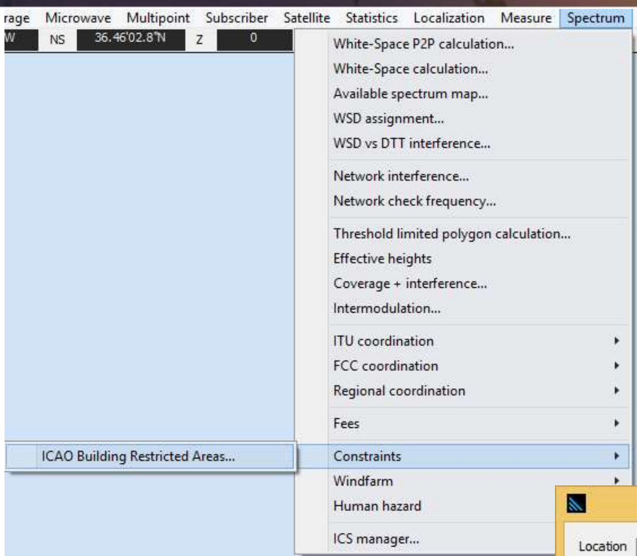
3.7. ICAO – Building Restricted Area

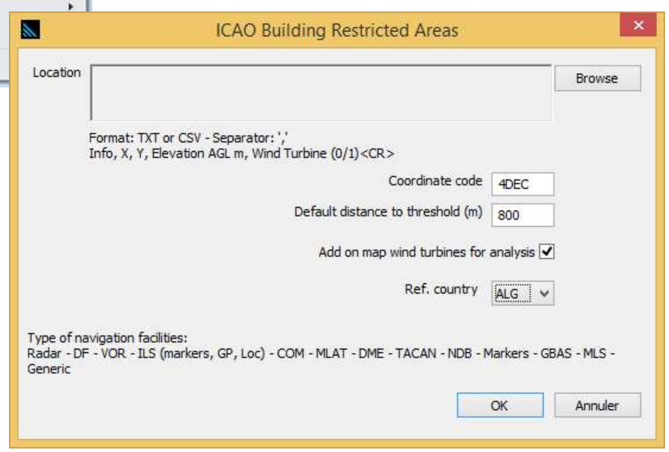
ATDI tool allows user to check compliance of an existing or new building structure in accordance with ICAO requirement within or around the airport. The ICAO recommendations test is based on European Guidance material on Managing Building restricted area, second edition published in 2009.

The compliance assessment calculations is valid for the following type of communication systems:

- DF
- VOR/DVOR
- ILS (markers, GP, Loc)
- COM
- MLAT
- TACAN
- NDB
- GBAS
- MLS
- Other

3.7. ICAO – Building Restricted Area





The ICAO building restricted area function requires area function requires a CSV File with following information of the building to be tested.

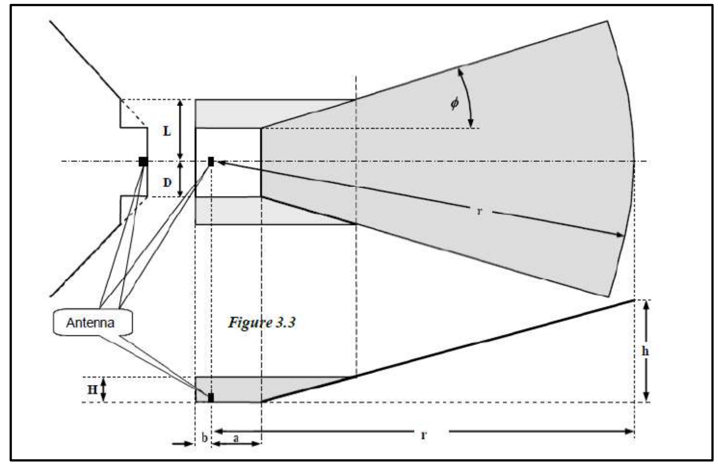


Figure: BRA shape for directional facilities (source: ICAO). The value of each dimension differs based on the technology at use.

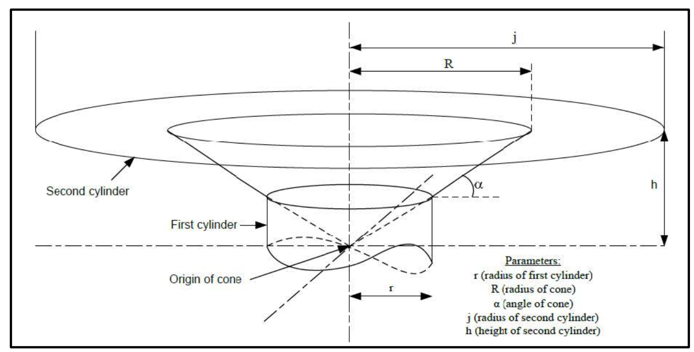
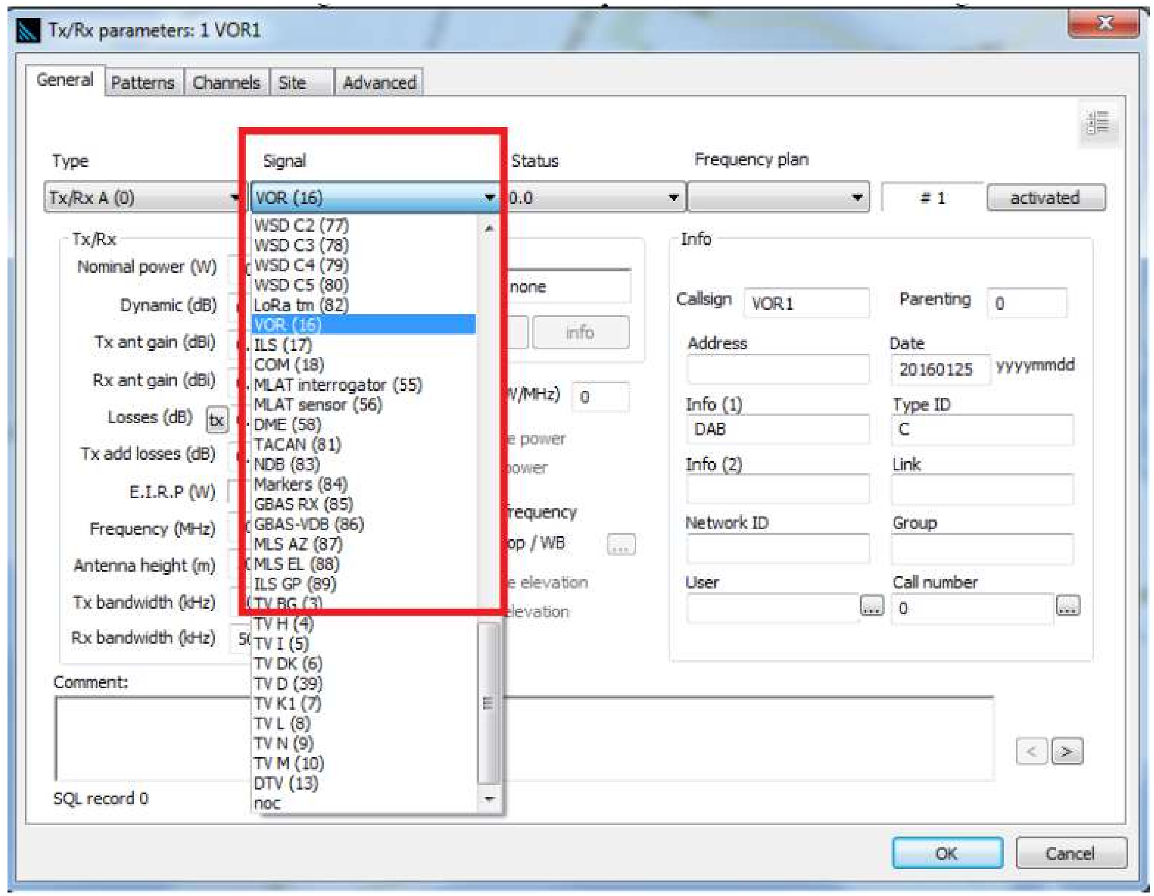


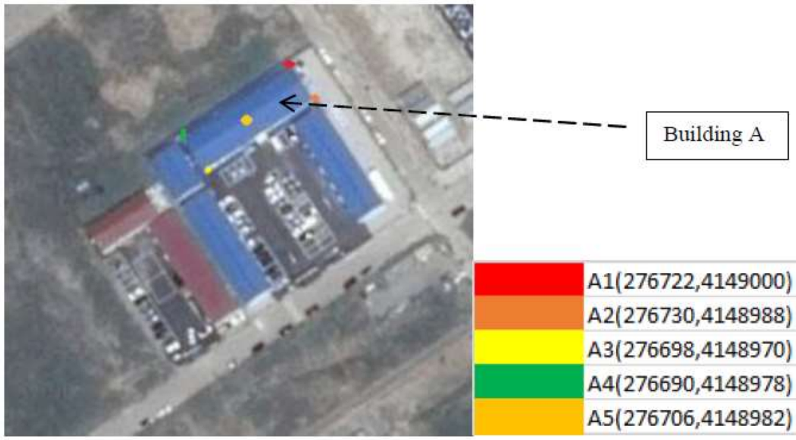
Figure: Omni-directional BRA shape 3D representation (source: ICAO)

3.7. ICAO – Building Restricted Area

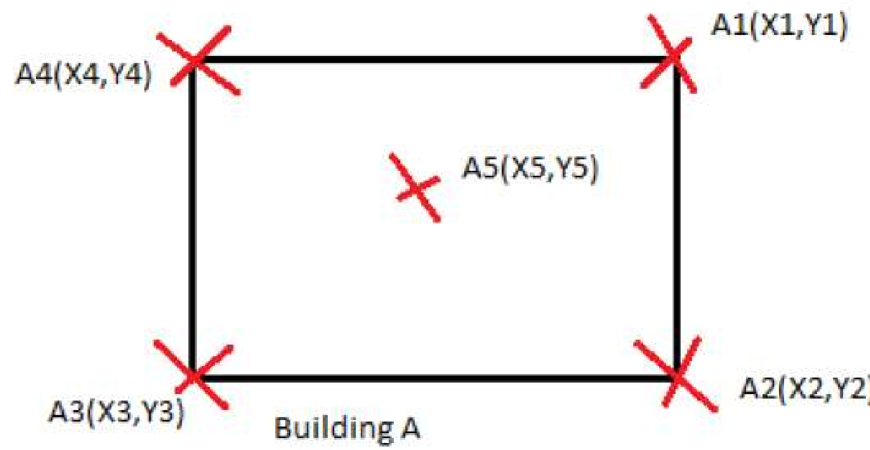
This function will be active only where there is an active station present in the project. The technology used by the station can be defined in the general tab of the station parameters.

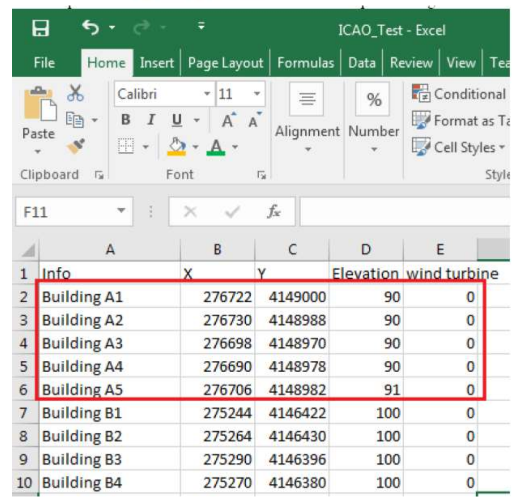


3.7. ICAO – Building Restricted Area



	A1(276722,4149000)
	A2(276730,4148988)
	A3(276698,4148970)
	A4(276690,4148978)
	A5(276706,4148982)





	A	B	C	D	E
1	Info	X	Y	Elevation	wind turbine
2	Building A1	276722	4149000	90	0
3	Building A2	276730	4148988	90	0
4	Building A3	276698	4148970	90	0
5	Building A4	276690	4148978	90	0
6	Building A5	276706	4148982	91	0
7	Building B1	275244	4146422	100	0
8	Building B2	275264	4146430	100	0
9	Building B3	275290	4146396	100	0
10	Building B4	275270	4146380	100	0

CSV file format:
Info: Building identifier
X: Longitude
Y: Latitude
Elevation AGL (m) : building height above ground level
Windmill (0/1) : 1 if building is windmill, 0 otherwise

3.7. ICAO – Building Restricted Area

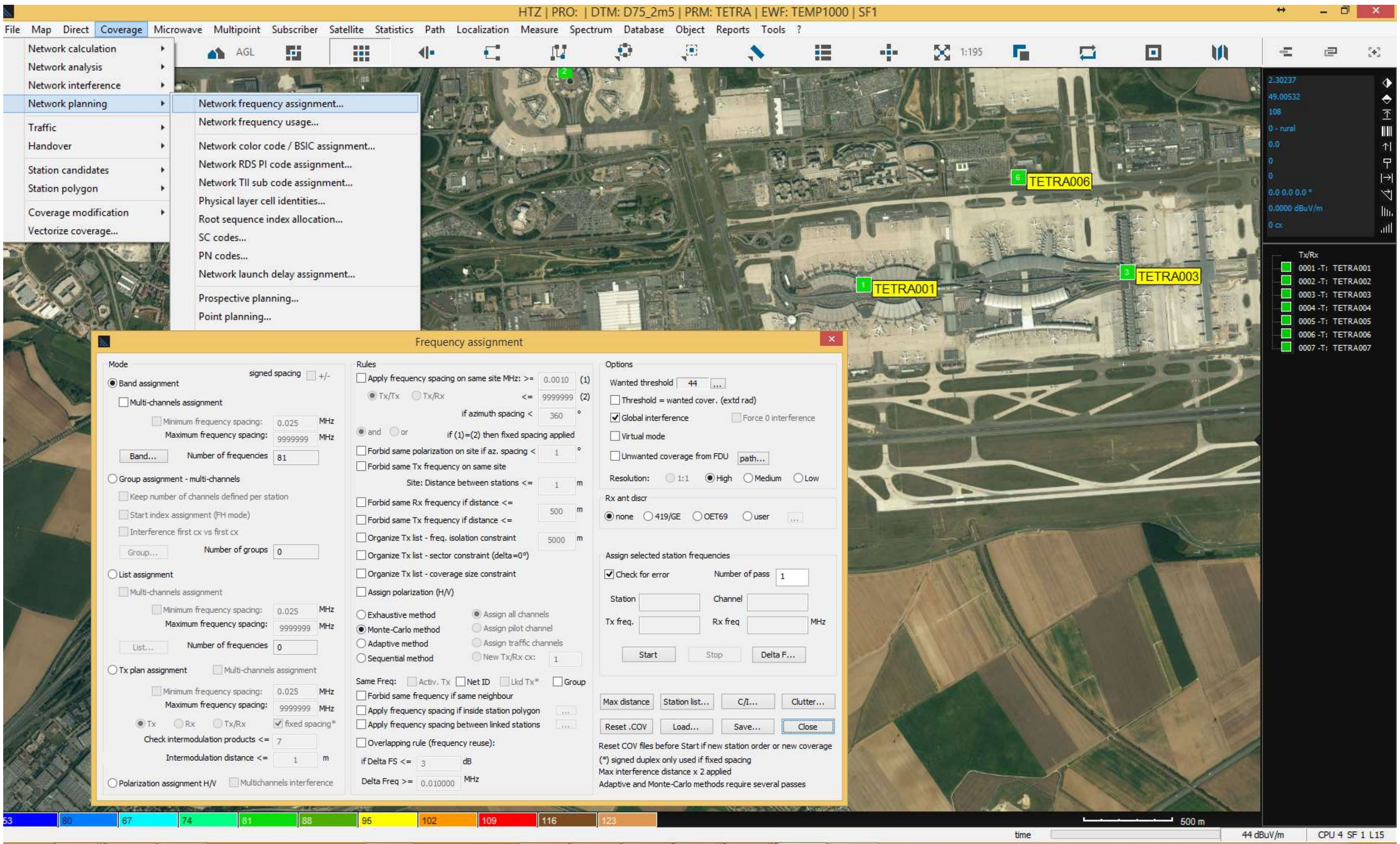
Report listing

Record	Shape	Compliance	Info	Building X coord	Building Y coord	Elevation m ASL	TypeNav	Callsign	X	Y	Z ASL	A
1	OMNI	YES	Building A1	276722.000...	4149000.00...	98.00	VOR	VOR1	273236.000000	4149362.00...	30...	
2	DIRECTIONAL	NO	Building A1	276722.000...	4149000.00...	98.00	ILS Single Freq	ILS	273076.000000	4151290.00...	8.00	
3	OMNI	YES	Building A2	276730.000...	4148988.00...	98.00	VOR	VOR1	273236.000000	4149362.00...	30...	
4	DIRECTIONAL	NO	Building A2	276730.000...	4148988.00...	98.00	ILS Single Freq	ILS	273076.000000	4151290.00...	8.00	
5	OMNI	YES	Building A3	276698.000...	4148970.00...	98.00	VOR	VOR1	273236.000000	4149362.00...	30...	
6	DIRECTIONAL	NO	Building A3	276698.000...	4148970.00...	98.00	ILS Single Freq	ILS	273076.000000	4151290.00...	8.00	
7	OMNI	YES	Building A4	276690.000...	4148978.00...	98.00	VOR	VOR1	273236.000000	4149362.00...	30...	
8	DIRECTIONAL	NO	Building A4	276690.000...	4148978.00...	98.00	ILS Single Freq	ILS	273076.000000	4151290.00...	8.00	
9	OMNI	YES	Building A5	276706.000...	4148982.00...	99.00	VOR	VOR1	273236.000000	4149362.00...	30...	
10	DIRECTIONAL	NO	Building A5	276706.000...	4148982.00...	99.00	ILS Single Freq	ILS	273076.000000	4151290.00...	8.00	
11	OMNI	YES	Building B1	275244.000...	4146422.00...	117.00	VOR	VOR1	273236.000000	4149362.00...	30...	
12	DIRECTIONAL	NO	Building B1	275244.000...	4146422.00...	117.00	ILS Single Freq	ILS	273076.000000	4151290.00...	17...	
13	OMNI	YES	Building B2	275264.000...	4146430.00...	115.00	VOR	VOR1	273236.000000	4149362.00...	30...	
14	DIRECTIONAL	NO	Building B2	275264.000...	4146430.00...	115.00	ILS Single Freq	ILS	273076.000000	4151290.00...	15...	
15	OMNI	YES	Building B3	275290.000...	4146396.00...	115.00	VOR	VOR1	273236.000000	4149362.00...	30...	
16	DIRECTIONAL	NO	Building B3	275290.000...	4146396.00...	115.00	ILS Single Freq	ILS	273076.000000	4151290.00...	15...	
17	OMNI	YES	Building B4	275270.000...	4146380.00...	115.00	VOR	VOR1	273236.000000	4149362.00...	30...	
18	DIRECTIONAL	NO	Building B4	275270.000...	4146380.00...	115.00	ILS Single Freq	ILS	273076.000000	4151290.00...	15...	

Listing... Close

Final report generated by the "ICAO Building restricted area" function

3.8. AUTOMATIC FREQUENCY ASSIGNMENT



Thank you!