








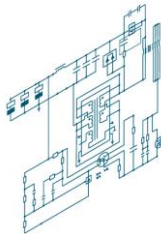

INTRODUCTION TO WRAP AND EMC

Stefan Fors, Lead Software Developer

ALTAIR SOLUTION

Altair Solution for Electronic System Design

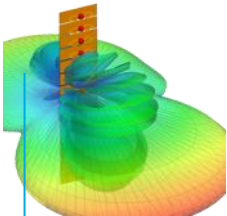
Altair enables the team of specialized engineers required to deliver today's smart, connected devices to collaborate on all aspects of physical, logical, thermal, electrical, and mechanical design

Electronics	Electrical	Mechanical	Thermal	Mechatronics	Circuit	Code
	 <p data-bbox="378 721 558 811">Simulate and optimize wireless connectivity, EMC and radar electronics.</p> <p data-bbox="388 860 529 885">Altair Feko</p>	 <p data-bbox="625 721 817 784">Automate structural stress, vibration, & drop test performance.</p>	 <p data-bbox="875 721 1039 805">Thermal analysis of electronics without advanced CFD knowledge.</p>	 <p data-bbox="1122 721 1290 827">Accelerate the design of motors, power electronics, sensors & actuators with simulation.</p>	 <p data-bbox="1373 721 1530 805">Circuit simulation with an enhanced proprietary version of SPICE.</p>	 <p data-bbox="1620 721 1823 805">Visual firmware development supporting many common microcontroller families.</p>

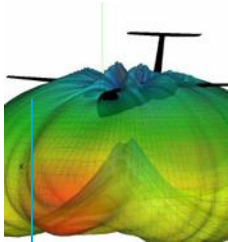
Efficient HPC Scheduling & Cloud Accessibility

Wireless Connectivity, EMC and Radar

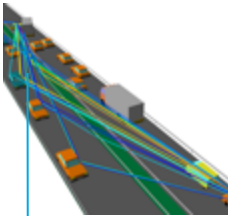
Main Electrical Applications with Altair Feko



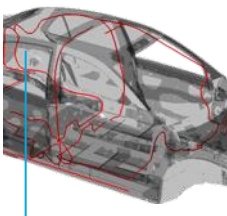
Antenna Design



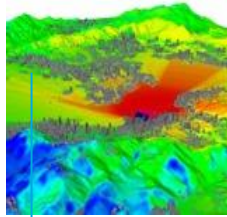
Antenna Placement & Coupling



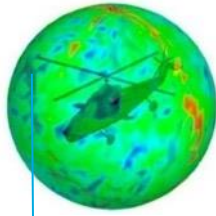
Virtual Drive & Flight Tests for Platform Connectivity & ADAS



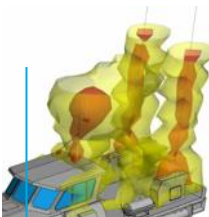
Electromagnetic Compatibility



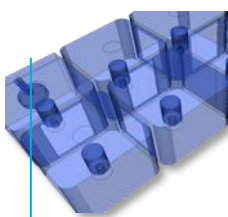
Radio & Radar Coverage & Planning



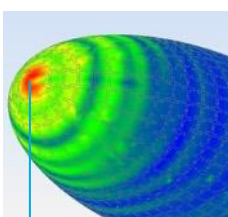
Scattering & RCS



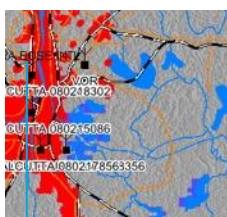
RADHAZ & Bio-Electromagnetics



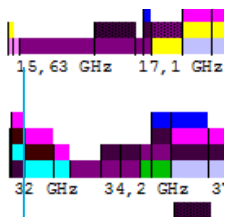
RF Devices



Radomes, including FSS



Radio Frequency Interference



Spectrum Management

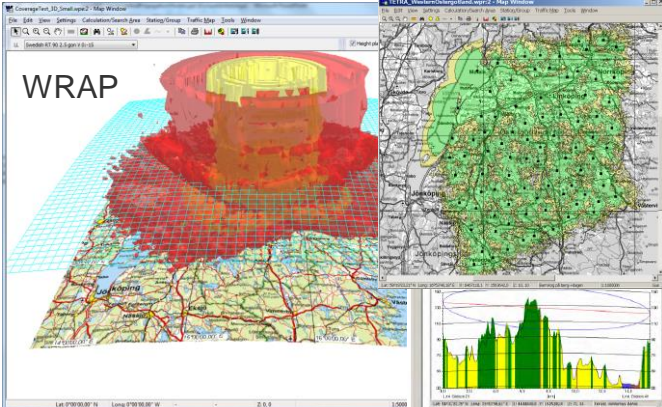
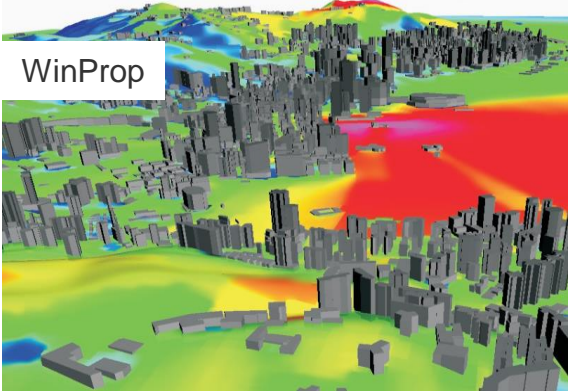
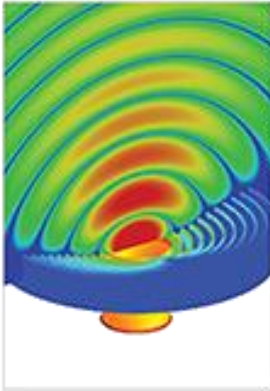
Altair Electromagnetic Simulation Solutions

Altair Feko

Antenna Design and Antenna Placement

Wave Propagation & Radio Planning

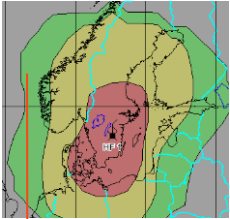
Radar Coverage & Spectrum Management



Advanced Simulation Tools for Wireless Networks

Main Radio Coverage & Planning Applications

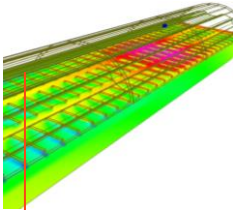
Wide Range of Scenarios



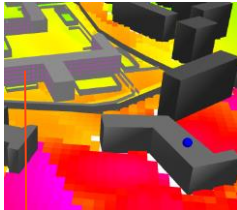
Radio Planning over Large Areas including HF



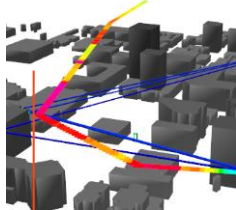
Radio Planning in Built-up Scenarios



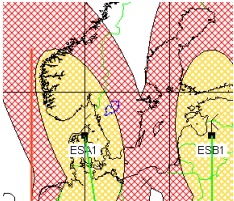
In-Vehicle Radio Coverage



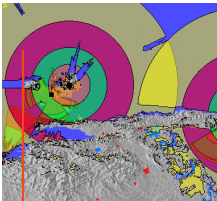
Jamming of Cellular & Satellite Signals



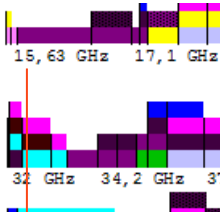
Virtual Drive & Flight Tests



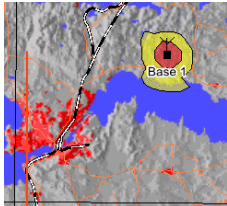
Satellite Radio Coverage



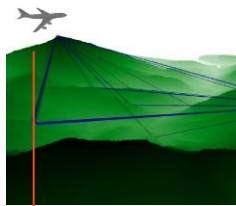
Radar Coverage



Spectrum Management



Cost & Coverage Optimization

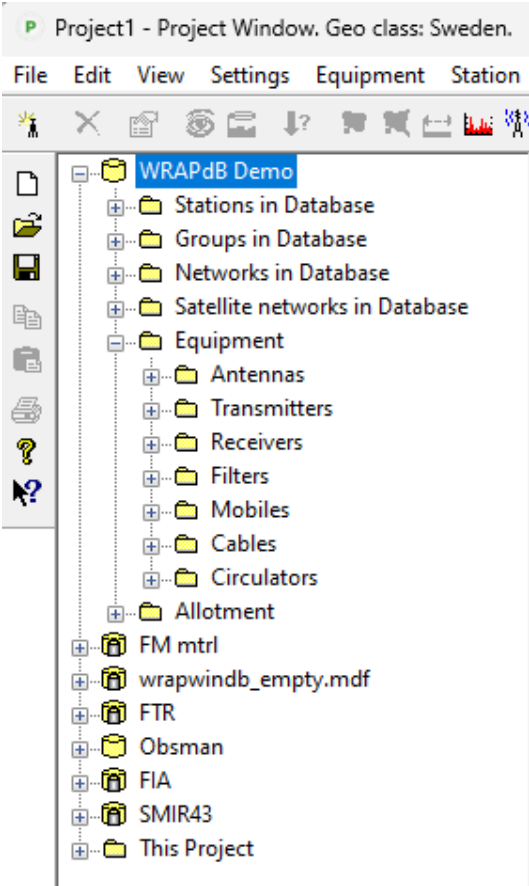


Multipath Impairments for Navigation Systems

WRAP

WRAP – a Frequency Management System

- Create and store
 - stations
 - transmitters
 - receivers
 - antennas
 - filters
- Connect reference database
 - National Master registry
 - BRIFIC



Radio Stations

The image displays four overlapping windows from a software application used for configuring radio stations. Each window is titled "Edit Station: Base Station 01".

- Leftmost window:** Shows general station information. Fields include Name (Base Station 01), Class (FB - Base station), Type (Tx, Rx, TxRx), Symbol Type (Standard, User defined), Position (Lat: 58°34'40,52" N, Long: 15°25'06,66" E, X: 524338,2, Y: 6493130,7), Ground height ASL [m] (97), and Owner (WRAP User).
- Second window:** Shows a table of frequencies. The table has columns for Calc. Fq, Tx [MHz], Rx [MHz], Channel, and Us. One row is populated with Tx [MHz] 935,00000 and Rx [MHz] 890,00000.
- Third window:** Shows transmitter settings. Transmitter: WSTD GSM Base, Mode: 200KG7W 10DBW, Designation of emission: 200KG7W, Power [dBW]: 10. Below is a table for Antenna with columns for Wrap ND, 9 / Vert, Mode, VER 9 dBi, and EIRP [dBW] (19). Other fields include Beamwidth [deg] (0) and Gain [dBi].
- Rightmost window:** Shows receiver settings. Receiver: WSTD GSM Base, Mode: 200KG7W -105DBM, Designation of emission: 200KG7W, Sensitivity [dBm]: -105. Below is a table for Antenna with columns for Wrap ND, 9 / Vert, Mode, VER 9 dBi, Height AGL [m] (20), Azimuth [deg] (0), and Tilt [deg] (0). Other fields include Beamwidth [deg] (0), Gain [dBi] (9), and Polarisation (Vertical linear).

Equipment: Transmitter

The image displays four overlapping windows from the Altair software interface, all titled "Edit Transmitter: WSTD GSM Base - 200KG7W 10DBW".

- Leftmost window (Main):** Contains general transmitter information:
 - Name: WSTD GSM Base
 - Status: [Dropdown]
 - Comment: Standard GSM
 - Mode: 200KG7W 10DBW
 - Description: [Text field]
 - Frequency: 800 To 96
 - Modulation type: Digital, Analog
 - Occupied bandwidth [kHz]: 200
 - Necessary bandwidth [kHz]: 200
 - Class of emission: G7W
- Middle-left window (Frequency Characteristics):** Shows a graph of Frequency [kHz] vs. dB. A table lists the data points for the curve:

[kHz]	[dB]
-40000,00	-150,00
-20000,00	-140,00
-2000,00	-120,00
-542,00	-80,00
-254,00	-38,00
-237,00	-36,00
-220,00	-37,00
-203,00	-40,00
-135,00	-16,00
-68,00	-6,00

Other parameters: FQ Diff [kHz]: 0, Gain [dB]: 0, Symmetric. Buttons: Add, Delete, Generate...
- Middle-right window (Collocation):** Shows harmonic attenuation values:
 - 2nd order IM attenuation [dB]: 60
 - Harmonic Attenuation [dB]:
 - 2nd order: 80
 - 3rd order: 84,6
 - 4th order: 92,1
 - 5th order: 97,9Buttons: Calculate
- Rightmost window (Modulation):** Shows modulation parameters:
 - Modulation: GMSK
 - Modulation factor: 2
 - Data rate [kbit/s]: 271
 - OFDMButtons: OK, Avbryt, Verkställ, Hjälp

Equipment: Receiver

Edit Receiver: WSTD GSM Base - 200KG7W -105DBM

Main | Frequency Characteristics | Miscellaneous | Digital Modulation | Calculations

Name: WSTD GSM Base
Status: [dropdown]
Comment: Standard GSM base station receiver
Mode: 200KG7W -105DBM
Description: [text area]
Frequency [MHz]: 876 To 915
Class of emission: G7W
Necessary bandwidth [kHz]: 200
Impedance [ohm]: 50
Sensitivity [dBm]: -105
Processing gain [dB]: 0

Curve: 0 | Add curve

[kHz]	[dB]
-4000,00	-150,00
-20000,00	-140,00
-2000,00	-120,00
-500,00	-90,00
-200,00	-70,00
-100,00	-50,00
-95,00	-35,00
-90,00	-15,00
-85,00	-3,00
0,00	0,00

FQ Diff [kHz]: 0
Gain [dB]: 0
 Symmetric
Add Delete

Collocation
IF attenuation [dB]: 70
2nd order IM attenuation [dB]: 85
3rd order IM attenuation [dB]: 70
Blocking level [dBm]: -10
Image frequency attenuation [dB]: 70
Radar
Pulse width [µs]: 5

Modulation: GMSK
Modulation factor: 2
Data rate [kbit/s]: 271
 OFDM

Fade margin characteristics | Signature parameters | Normalized system parameters

T/I	BER	Threshold
10	1e-06	-105

T/I [dB]: 0
BER: 0
Threshold [dBm]: 0
-> Threshold [dBm] 0
<-

OK Avbryt Verkställ Hjälp

Equipment: Antenna

Edit Antenna: FV45-12-00_A - HOR 14,4 dBi

Main | Antenna Diagram | Calculations

Name: Owner:

Status:

Comment: OptiFill 12dBd Vertical Polar Array Rev. # 0

Mode:

Description:

Frequency: To MHz

Polarisation:

Cross polarisation isolation: dB

Max gain: dBi

Edit Antenna: FV45-12-00_A - HOR 14,4 dBi

Main | Antenna Diagram | Calculations

Hor	Ver	[dB]
-179,00	0,00	26,10
-178,00	0,00	27,40
-177,00	0,00	27,90
-176,00	0,00	29,10
-175,00	0,00	28,10
-174,00	0,00	28,50
-173,00	0,00	29,20
-172,00	0,00	28,10
-171,00	0,00	29,50

Horizontal Vertical

Angle [deg]:

Attenuation [dB]:

Symmetric

Show horizontal vertical plane

Ver. angle [deg]:

Edit Antenna: FV45-12-00_A - HOR 14,4 dBi

Main | Antenna Diagram | Calculations

Antenna gain

Maximum gain [dBi]:

Lobe width [°]:

Diameter [m]:

Frequency [MHz]:

HCM antenna

Horizontal diagram code:

Vertical diagram code:

Gain conversion

[dB]:

[dBd]:

[dBv]:

Equipment: Filter

Edit Filter

Main Frequency Characteristics

Name

Status

Frequency To MHz

Owner WRAP User

Comment

Edit Filter

Main Frequency Characteristics

[kHz]	[dB]
-4000,00	-60,00
-2000,00	-40,00
-1000,00	-25,00
-500,00	-15,00
-300,00	-8,00
-200,00	-5,00
0,00	-2,00
200,00	-5,00
300,00	-8,00
500,00	-15,00

FQ Diff [kHz]

Gain [dB]

Symmetric

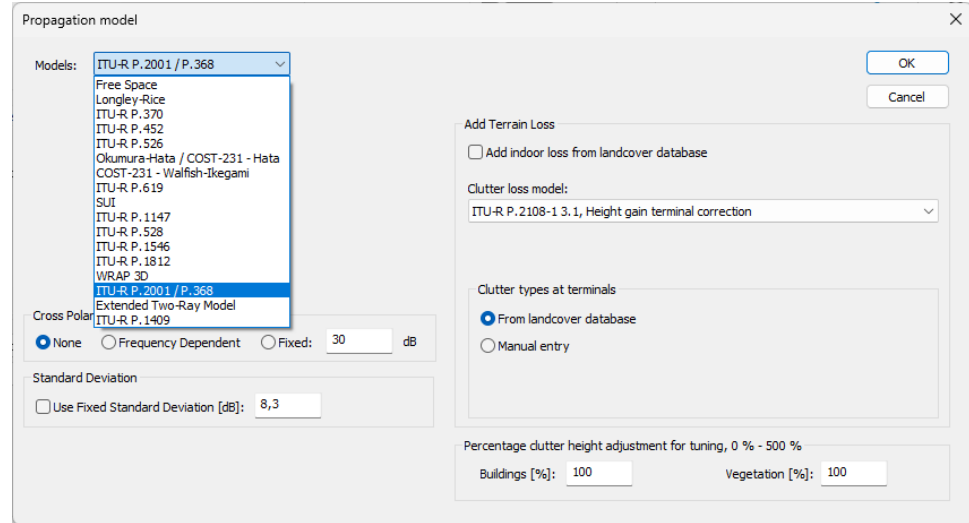
Reference Frequency

Main functions

- Coverage
- Radar Coverage
- Interference
- Collocation Interference
- Radio Link Performance
- Spectrum View
- Frequency Assignment
- Traffic Capacity
- Earth Station Coordination
- Satellite Network Coordination
- Dynamic Satellite calculations
- Coverage Comparison
- Broadcast
- Radio Network Management
- Point-to-Multipoint
- HF Planning
- Cost and Coverage Optimiser
- Aeronautical Interference
- Obstruction Manager
- Spectrum Allocation Manager
- Licensing and Coordination Manager
- Application Programming Interfaces
- Calculators

Supported Propagation Models

- Many Propagation Models are supported
 - Detailed terrain
 - Statistical
 - Troposcatter
- Attenuation due to atmospheric gases can be included
- Clutter loss (incl. ITU-R P.2108-0) and building penetration loss can be added
- HF Planning with ITS HF software:
 - VOACAP/ICEPAC/REC533 (point-to-point)
 - VOAAREA/ICEAREA/RECAREA (point-to-area)
- Possibility to connect user-defined propagation models through a CDII interface

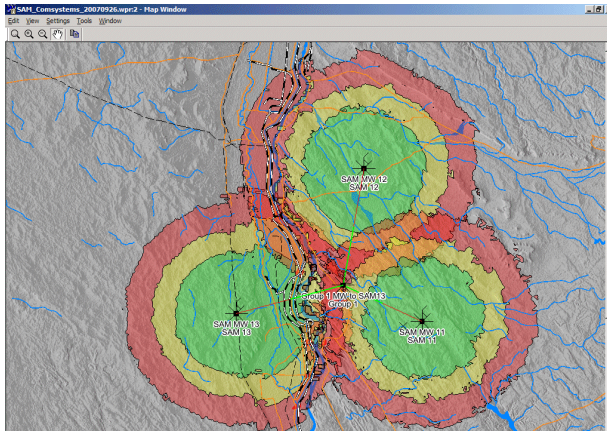


RADAR PLANNING & RADIO COVERAGE

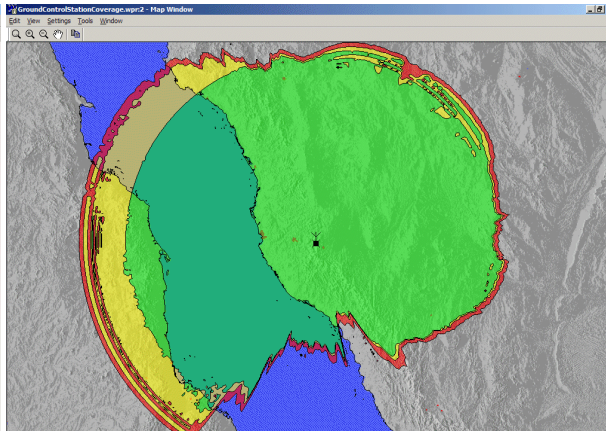
Radar & Radio Coverage

Propagation Models, Air Interfaces and Some Relevant Scenarios

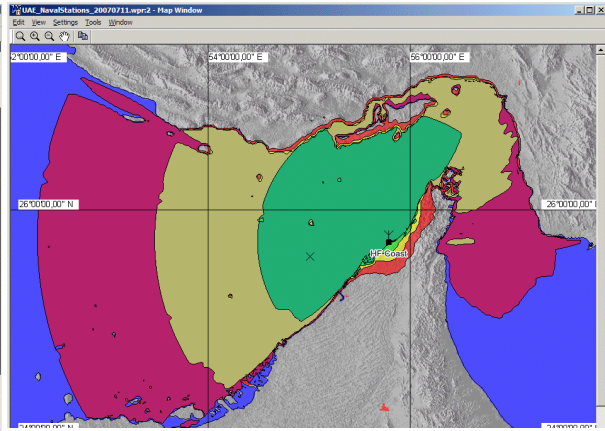
- Comprehensive set of propagation models (empirical, semi-empirical and deterministic ones) (including a wide collection of ITU-based models) for nation-wide, rural, urban and indoor scenarios
- Air interfaces available for all major military and civilian radio systems, from HF through 5G to radar and microwave links



Ground-to-ground coverage of combat net radios



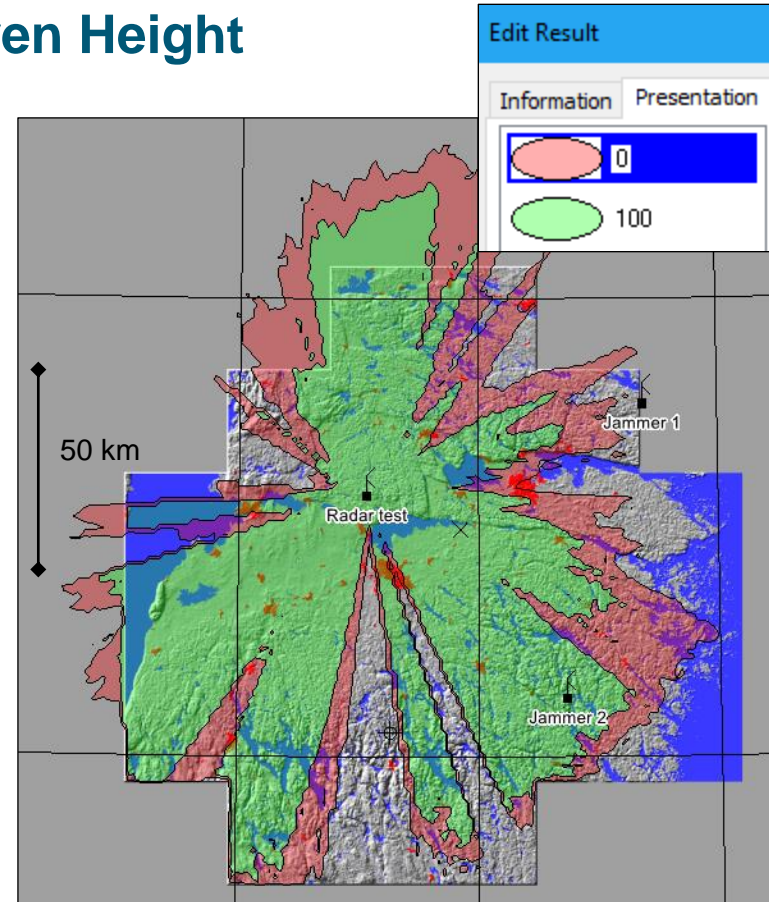
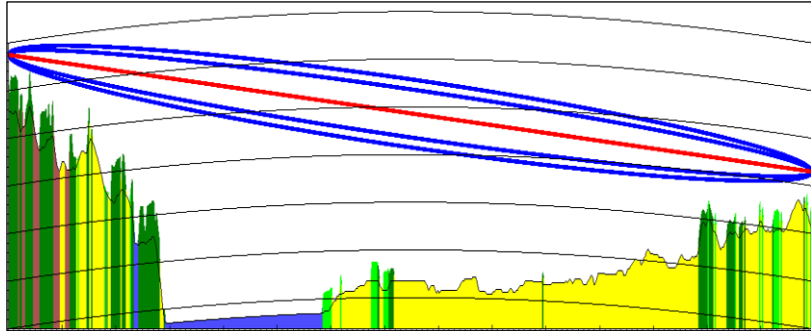
Ground control station coverage to aircraft



Coast station ground wave coverage

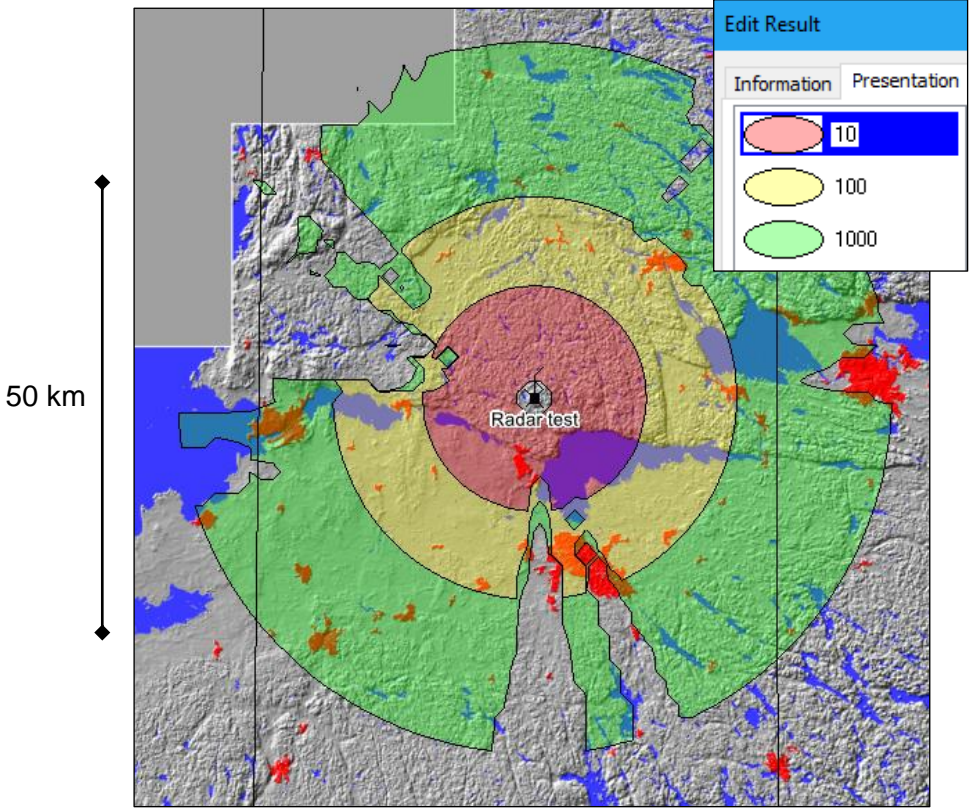
Radar Coverage: Target Visibility at Given Height

- *Radio Coverage* analysis calculates received signal.
- For *Radar Coverage* you're interested in detection.
- Example: Radar station in hilly landscape. *Three types of calculations* are possible.
- Type 1: target visibility, regardless of RCS.



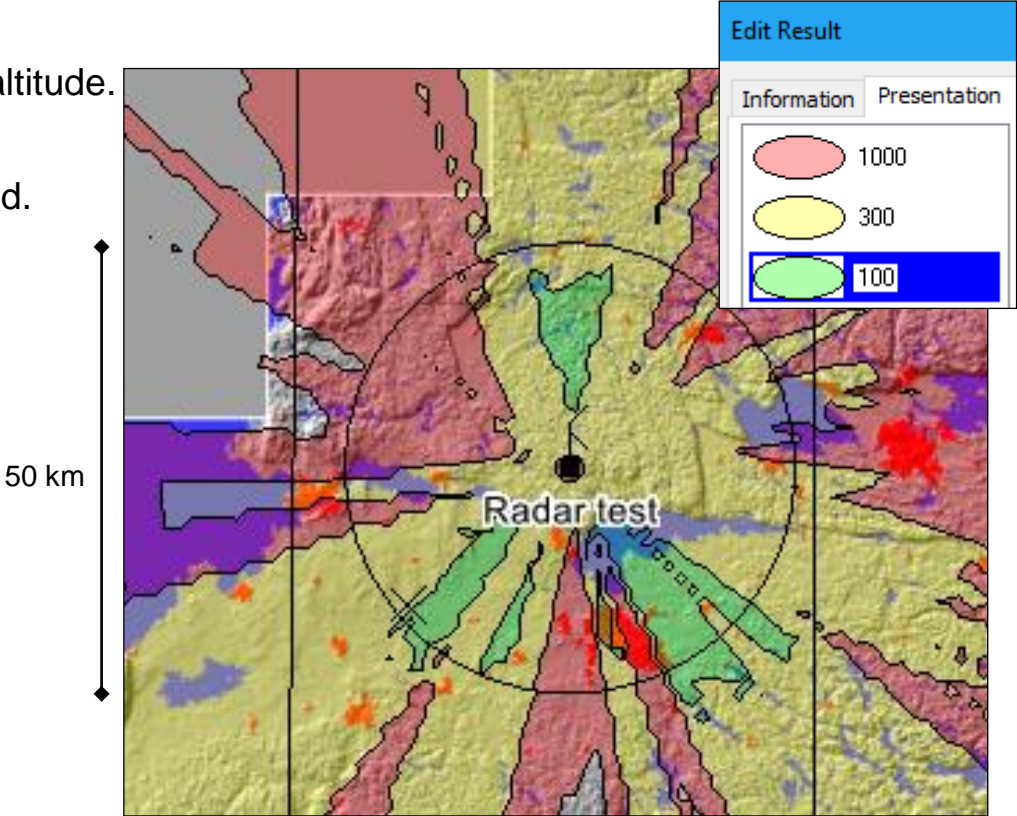
Radar Coverage: Target Detection at Given Height

- Type 2: Target detection depending on RCS.
- Plot shows for a given flight altitude (300 m) the minimum RCS that can be detected.



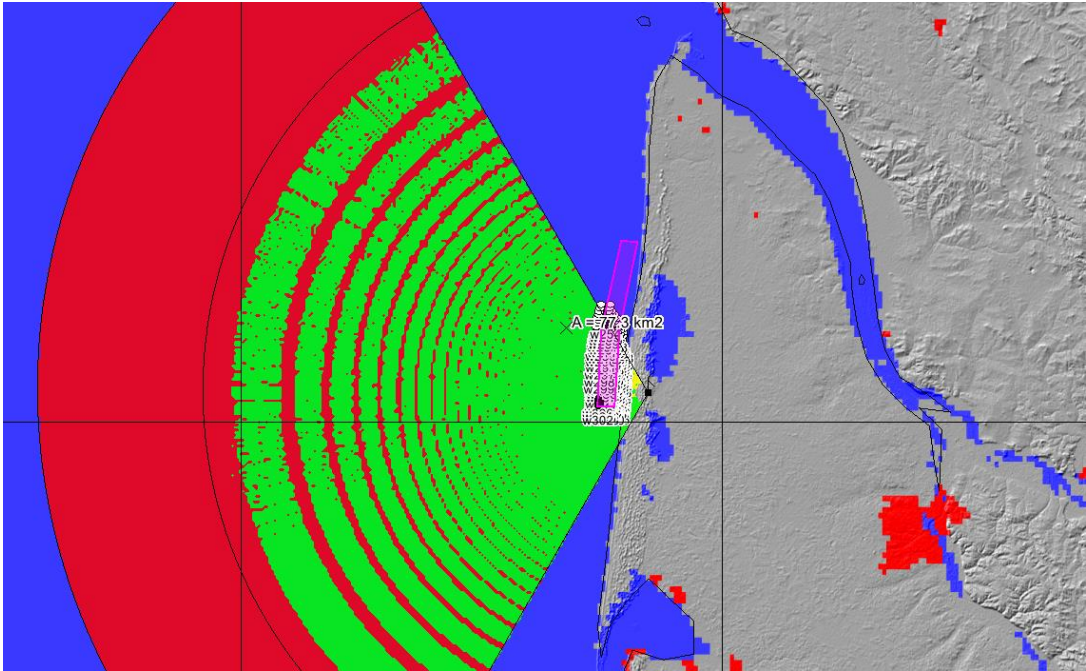
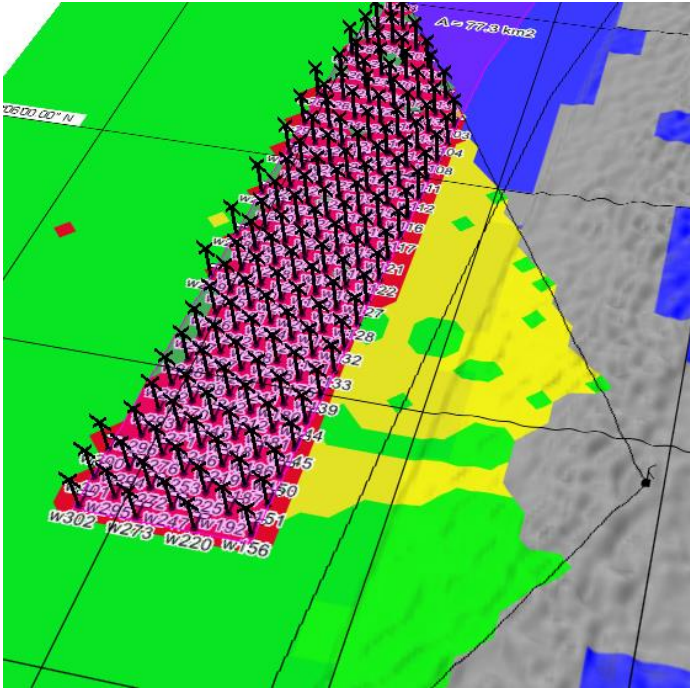
Radar Coverage: Target Detection of Given RCS

- Type 3: Target detection depending on altitude.
- Plot shows for a given target (100 m²) the minimum flight altitude to be detected.



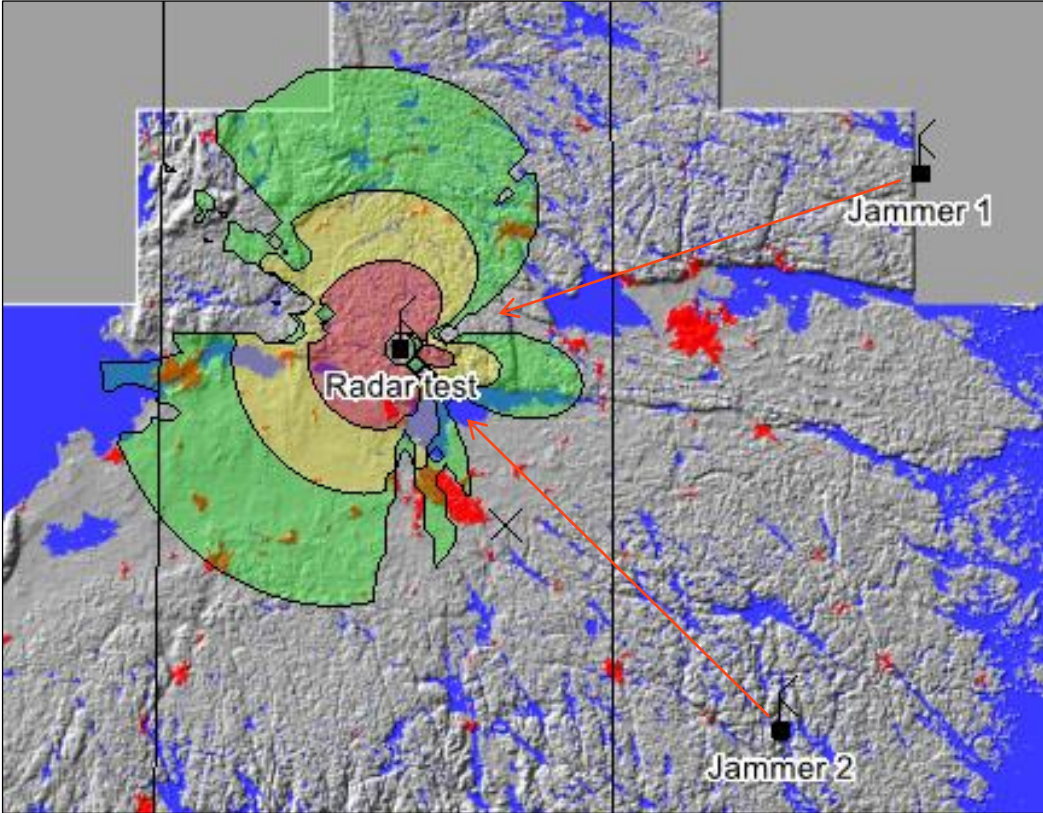
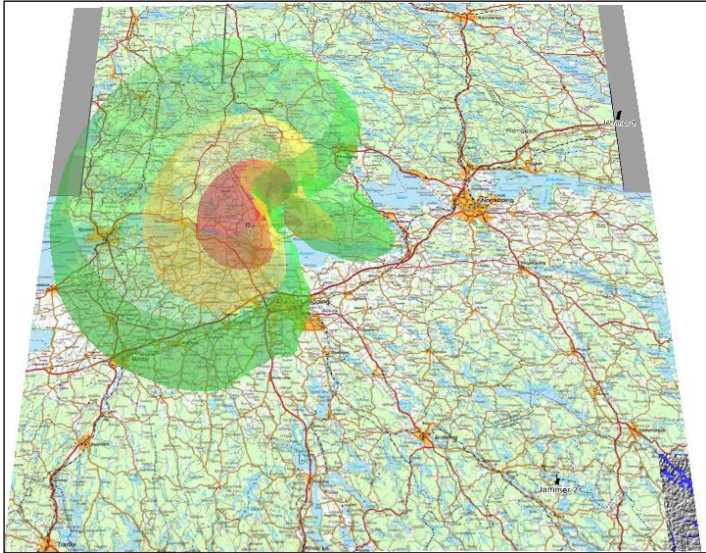
Impact of Windmills on Radar Coverage

- Windmills can be included.
- The wind farm has a visible effect on detection and produces ghost targets.



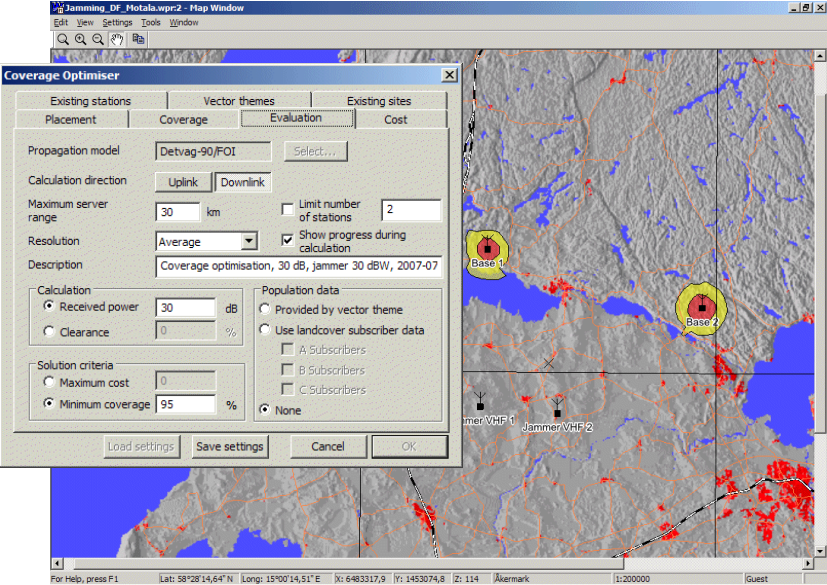
Impact of Jammers on Radar Coverage

- Jammers have a disproportionate impact:
Jammer power $\sim 1/R^2$
Radar detection $\sim 1/R^4$

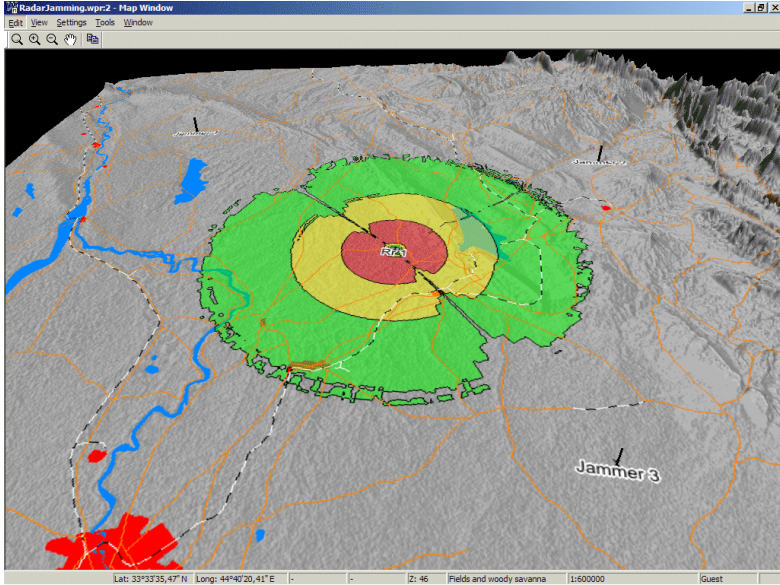


Radar & Radio Coverage

Coverage Optimizer and Jamming



Use of Coverage Optimiser for Radar Planning



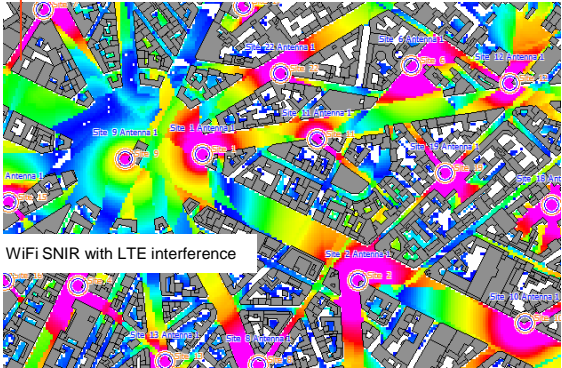
Air Surveillance Radar Coverage with Jammers

RADIO FREQUENCY INTERFERENCE AND SPECTRUM MANAGEMENT

Predicting Radio Frequency Interference

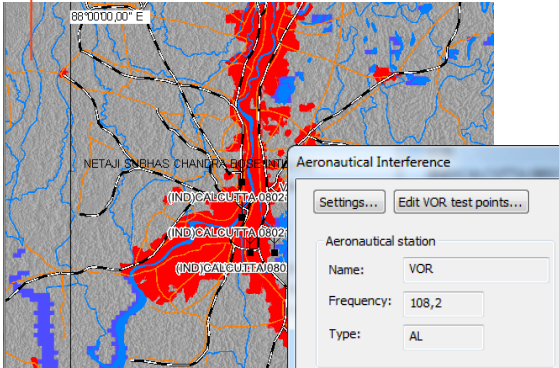
Scenarios

Wireless Networks Co-Existence



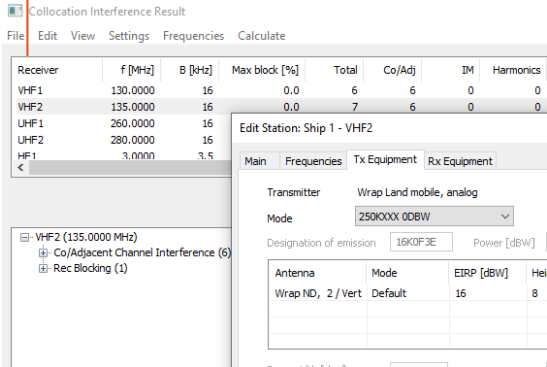
Analysis of interferences between radio technologies in multiple scenarios (including indoor, urban and nation-wide)

Aeronautical Interference



Calculates interferences between sound broadcasting stations (87 – 108 MHz) and the ILS localizer, VOR and the VHF communications equipment in the 108 – 137 MHz frequency band

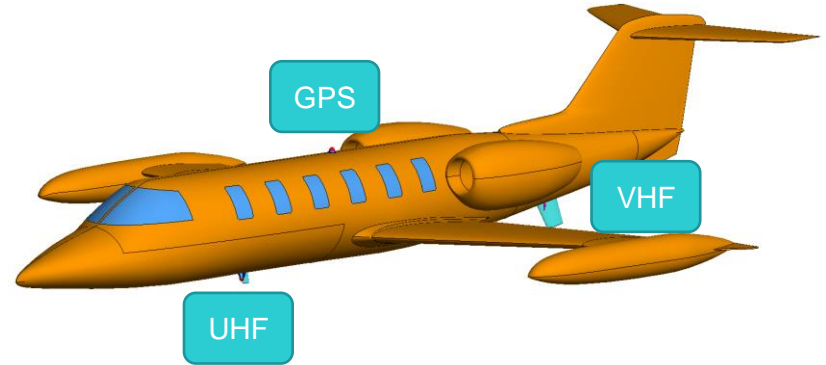
Collocation Interference



Analysis and mitigation of interferences in site with multiple transmitters and receivers

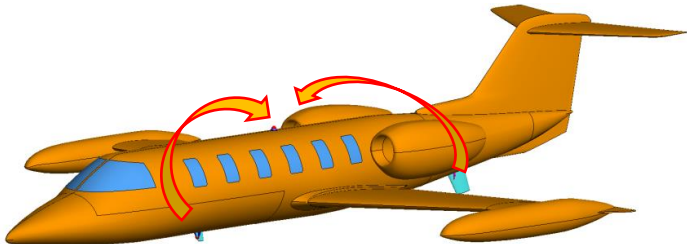
Collocation Interference Example

- Antennas not far apart: different services on the same site/mast, multiple systems on an aircraft, ship or vehicle.
- Many more effects need to be included:
 - Intermodulation
 - IF breakthrough
 - Image frequency
 - Harmonics
 - Transmitter spectrum
 - Receiver selectivity
 - Receiver blocking
- WRAP calculates all dangerous frequencies.
- WRAP reports interference levels and their reasons.
- Spread-spectrum (frequency hopping and direct sequence spreading) is supported.



Collocation Interference Result Reporting

- Very detailed report makes obvious what the reasons for the problems are.
- To solve the problems add filters on the equipment in WRAP or move stations or adjust frequencies.



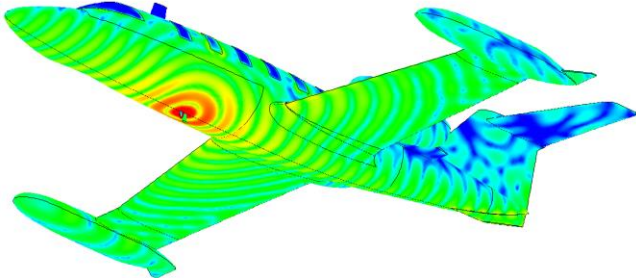
Collocation Interference Result					
File Edit View Settings Frequencies Calculate					
Receiver	f [MHz]	B [kHz]	Max block [%]	Total	Co/Adj
Blade_VHF	131.2850	250	0.0	1	1
Blade_UHF	315.0840	500	0.0	1	1
GPS_L1_Receiver	1575.4200	500	0.0	4	2

GPS_L1_Receiver (1575.4200 MHz)	Transmitter	f [MHz]	B [kHz]	EIRP [dBW]	Margin [dB]
Co/Adjacent Channel Interference (2)	Blade_VHF	131.2850	250	15.0	-18.4
Harmonic Interference (2)	Blade_UHF	315.0840	500	15.0	-2.4

GPS_L1_Receiver (1575.4200 MHz)	Transmitter	f [MHz]	B [kHz]	EIRP [dBW]	Margin [dB]
Co/Adjacent Channel Interference (2)	Blade_UHF	315.0840	500	15.0	-19.9
Harmonic Interference (2)	Blade_VHF	131.2850	250	15.0	-4.2

Isolation between Stations

- Interfering signal level
 - $I = P_{TX} - L_b + G_{RX} - L_{cable} - L_{add} - L_{spectrum}$
- Isolation between stations
 - Coupling loss matrix



A\B	Frequency	Test TX1	Test TX2	Test TX3
Test TX1	100,0000 MHz	---	32,3 *	35,3 *
Test TX2	100,1000 MHz	32,3 *	---	32,3 *
Test TX3	10,7000 MHz	16,8 *	13,8 *	---
Test RX4	100,2000 MHz	40,0	35,3 *	32,3 *
Test RX5	200,0000 MHz	45,0	38,3 *	41,3 *
Test RX6	300,0000 MHz	50,0	49,0 *	45,0 *
Test RX7	78,6000 MHz	39,2 *	37,2 *	33,2 *
Test RX8	200,1000 MHz	45,5 *	41,3 *	38,3 *
Test RX9	700,0000 MHz	56,3 *	55,4 *	49,4 *
XB	1,0000 kHz	---	---	---

Important: default values from propagation calculation can be replaced by results from measurements, Feko or other tools.

Coupling loss [dB] A to B at A-frequency. *Denotes an automatically calculated system loss (Ls).

Spectrum Management via WRAP

Main Applications

- Coordination between national/international civilian and national/international military frequency utilisation
- Central management and coordination distribution of frequency allocations, allotments and assignments
- Long-term planning of the frequency utilisation within the region/service
- Short-term planning of the frequency utilisation for missions, manoeuvres and large exercises

Levels of Implementation

- Central telecom or defence spectrum management agency
- Regional and service level (e.g. Army, Air Force, Navy)
- Local unit level
- Single-user and client-server configurations with the possibility to handle several station databases

Radio Network Design

- Planning and design of radio communication and radar systems to achieve required capabilities for coverage, performance and electromagnetic protection.

The screenshot displays the WRAP software interface. On the left, the 'Edit Allotment' window is open, showing the allotment name 'GSM', owner 'WRAP User', and a table of frequency bands. On the right, the 'Edit Group' window is open, showing a table of radio network components. The central map shows a terrain view with several radio stations marked: 'Vehicle 1.1', 'Vehicle 2.2', 'Portable 1', and 'Battalion station'. A red area on the map indicates a specific region of interest.

f [MHz]	f' [MHz]	Tx [MHz]	Rx [MHz]
890	935	935	890
890.2	935.2	935.2	890.2
890.4	935.4	935.4	890.4
890.6	935.6	935.6	890.6
890.8	935.8	935.8	890.8
891	936	936	891
891.2	936.2	936.2	891.2

Group/Network	Bat Net	1st Comp Net	2nd Comp Net
Battalion	Battalion st...		
1st Company			
Vehicle 1	Vehicle 1.1		
Vehicle 2		Vehicle 2.1	
Soldier		Portable 1	
2nd Company			
Vehicle 1	Vehicle 1.1		

LIVE DEMONSTRATION



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