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WattGuard – a high accurate, easy to use software for 3D calculation of the exposition of amateur radio stations

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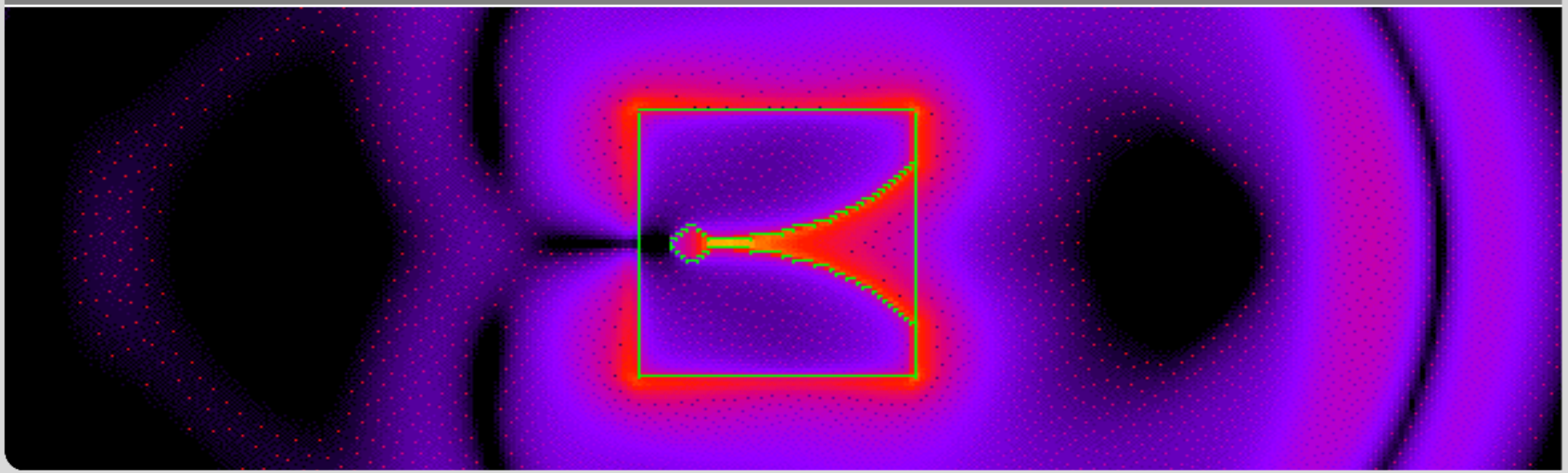


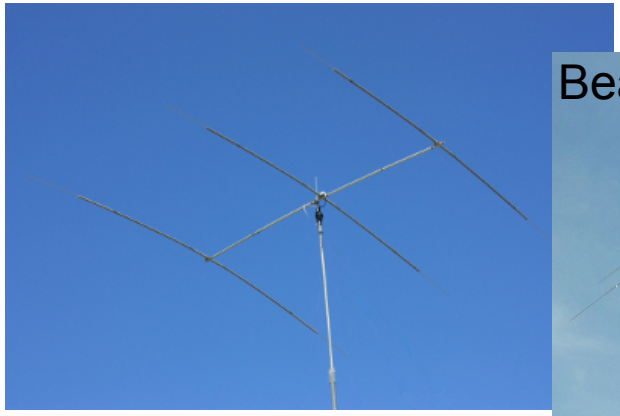
Amateur Radio in Germany and World Wide

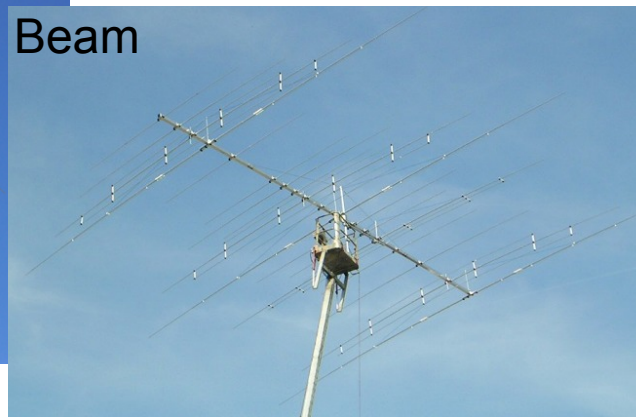
- Approx. 80 000 radio amateurs in Germany, approx. 2.8 millions worldwide
- Hobby and communication in emergency cases
- License necessary
- Frequency from 135 kHz to 250 GHz
  Transmit power up to 750 W PEP

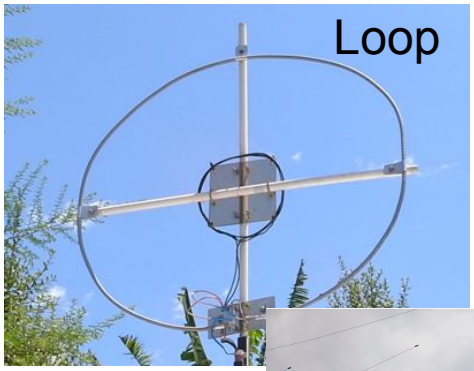
Important Frequency Bands

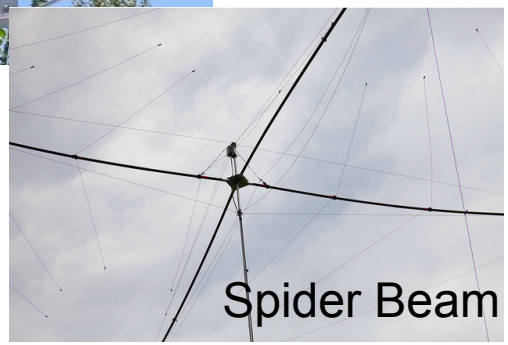
frequency in MHz	wavelength in m
1.81 – 1.85	160
3.5 – 3.8	80
7.1 – 7.2	40
14 – 14.35	20
18.068 – 18.168	17
21 – 21.45	15
24.89 – 24.99	12
28 – 29.7	10
50.08 – 51	6
144 – 146	2

Typical Amateur Radio Antennas



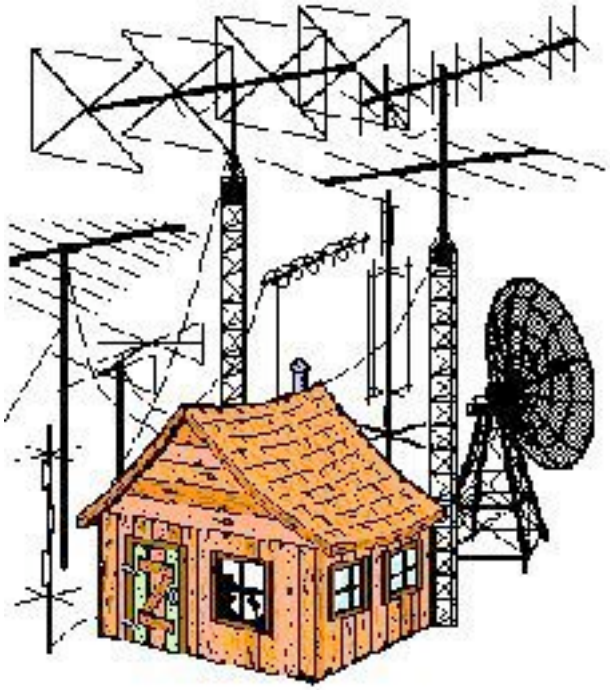






Problem and Solution

- Stationary amateur radio station must be safe
- It has to be assured that the EM exposition is not exceeding the limits for the public areas
- Nearfield and farfield data has to be taken into account as well as ground reflections
- Calculation should be possible for almost all antenna configurations



Software for the calculation of safety distances

- easy to use, fast and accurate
- provides nearfield calculations, ground reflections, superposition of several stations

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Basics for EM Field Calculations

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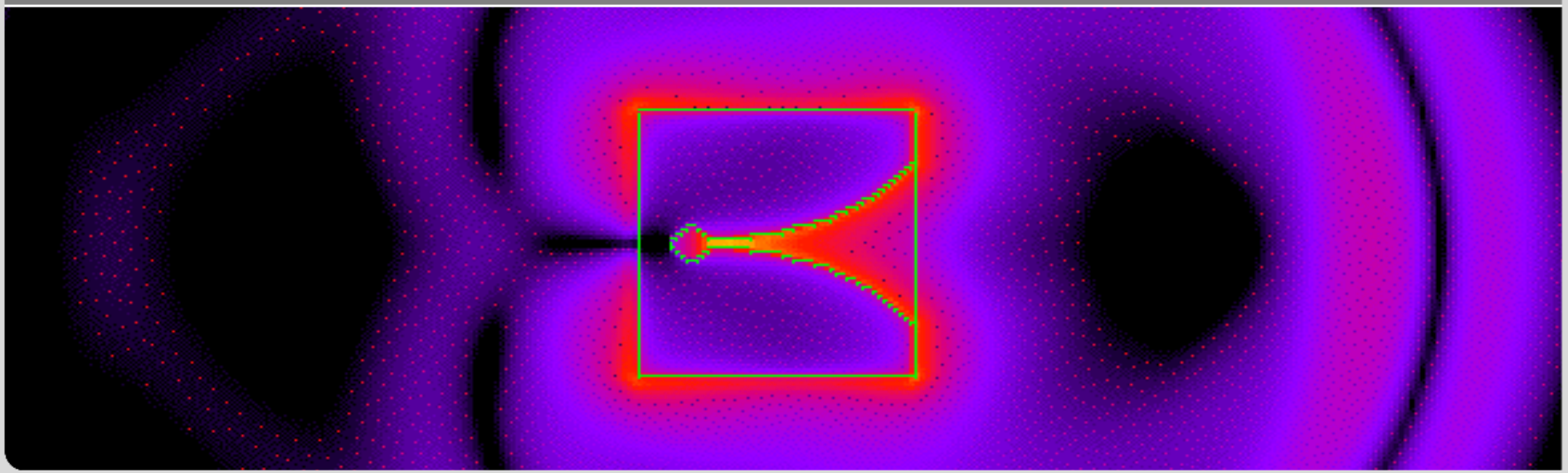


Elementary Radiator: Fields of the Hertz'ian Dipol

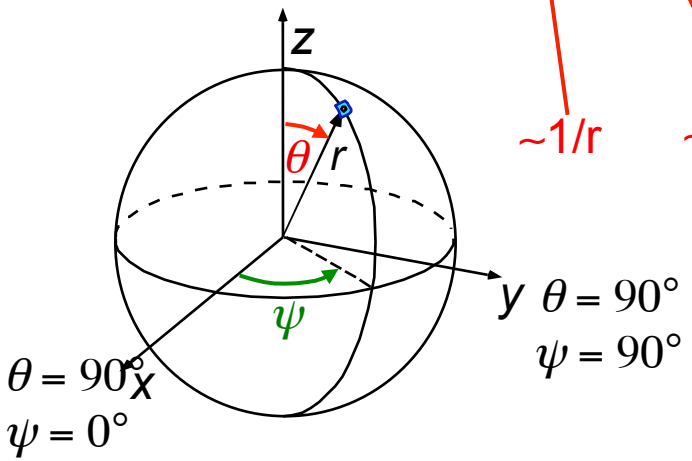
E-Feld

$$\underline{\vec{E}}_r = -\underline{I}\Delta z \frac{\mu}{4\pi}\frac{e^{-j\beta r}}{r} j\omega\left(\frac{2j}{\beta r} + \frac{2}{(\beta r)^2}\right)\cos\theta$$

$$\underline{\vec{E}}_\theta = \underline{I}\Delta z \frac{\mu}{4\pi}\frac{e^{-j\beta r}}{r} j\omega\left(1 - \frac{j}{\beta r} - \frac{2}{(\beta r)^2}\right)\sin\theta$$

$$\underline{\vec{E}}_\psi = 0$$

~1/r ~1/r² ~1/r³



H-Feld

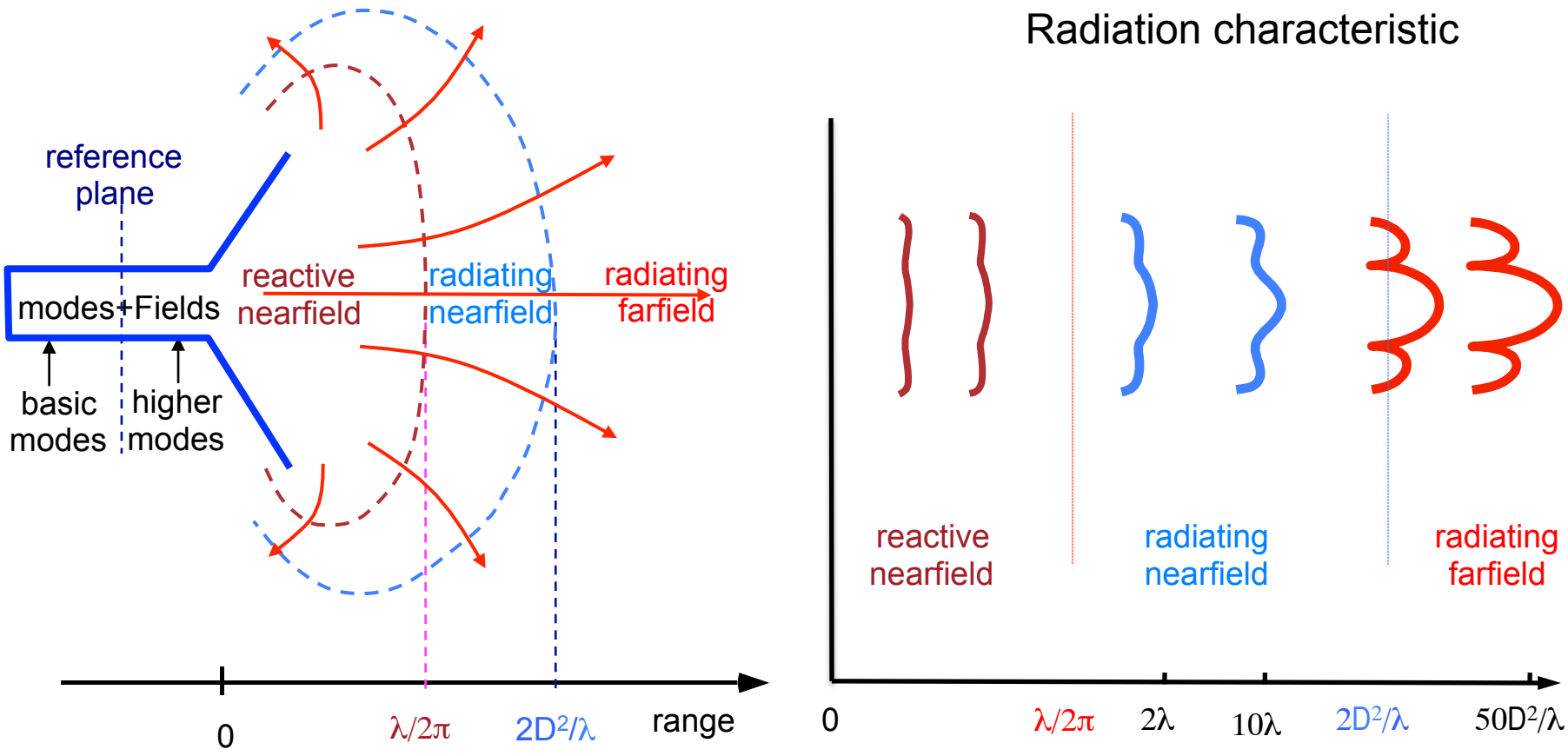
$$\underline{\vec{H}}_r = 0$$

$$\underline{\vec{H}}_\theta = 0$$

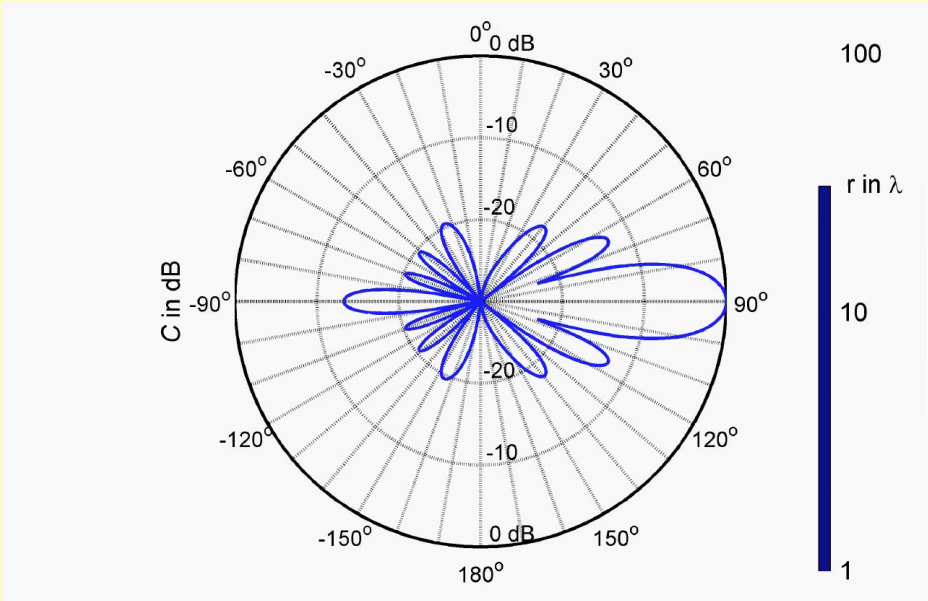
$$\underline{\vec{H}}_\psi = \underline{I}\Delta z \frac{1}{4\pi}\frac{e^{-j\beta r}}{r} j\beta\left(1 - \frac{j}{\beta r}\right)\sin\theta$$

~1/r ~1/r²

Antenna Near Field to Far Field Transition



Transition Near Field – Far Field Fitting $C_{fit}(r,\theta,\psi)$



- Antenna pattern depends on distance

- Separate fitting für near field and far field

$C(\theta,\psi)$ Far field

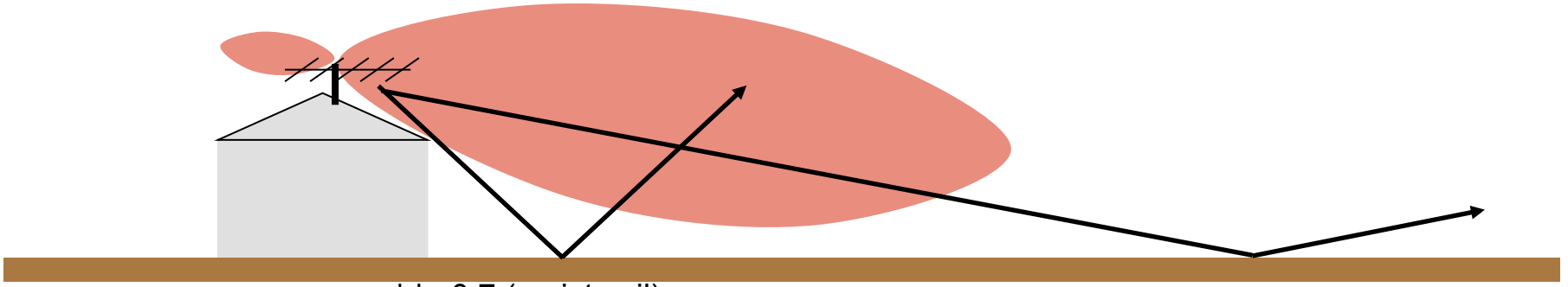
$C_E(r,\theta,\psi)$, $C_H(r,\theta,\psi)$ Near field

$C_{fit}(r,\theta,\psi)$ describes angle dependancy of far field und near fields

with numerical available data C_{fit} can be calculated directly

- else: approximation by similar antennas
- approximation of near field pattern by far field in certain distances
- in close vicinity isotropic approximation (worst-case)

Determination of the Reflected Field



Reflection factor: $|r|$ =0.7 (moist soil)
$|r|$ =0.25 (dry soil)

$|r|$ =1 (grazing incidence)

subsurface	permittivity ε
dry soil	2 ... 10
moist soil	30
grass	10 ... 15
concrete	6.4 ... 7

$$E_{total} = \left|\underline{E}_{direct}\right| + \left|\underline{E}_{reflect}\right|$$

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- reflected field is calculated by mirroring method
- worst-case approximation: total reflection, but can be varied in a certain range (0.3 – 1)
- ground reflection can also be considered using NEC data

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Calculation of the Safety Area with WattGuard

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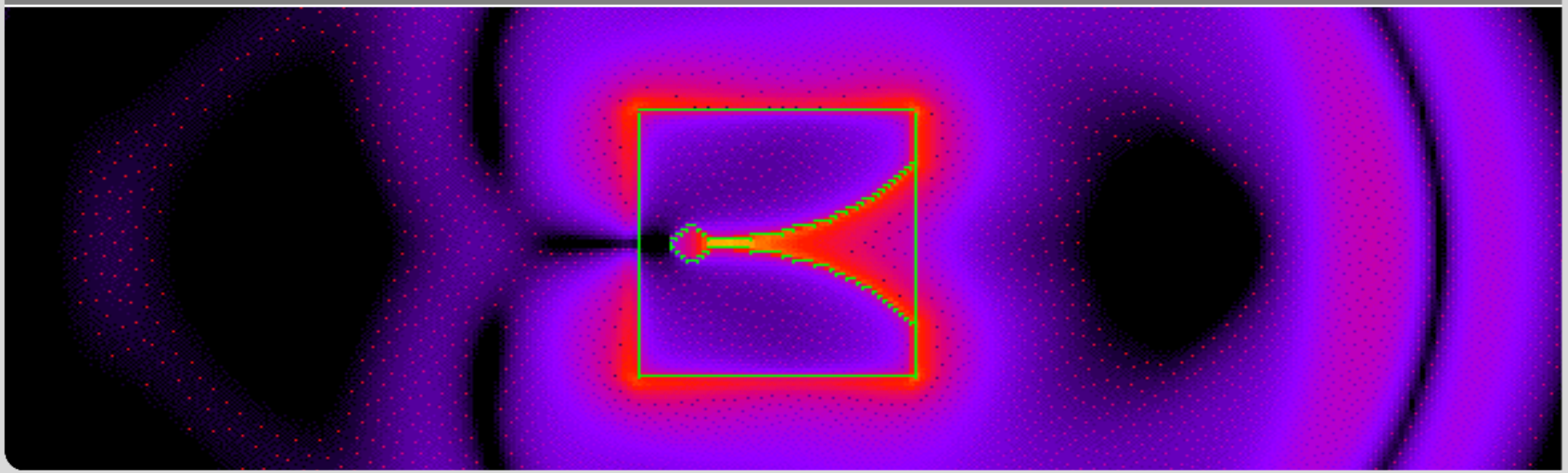
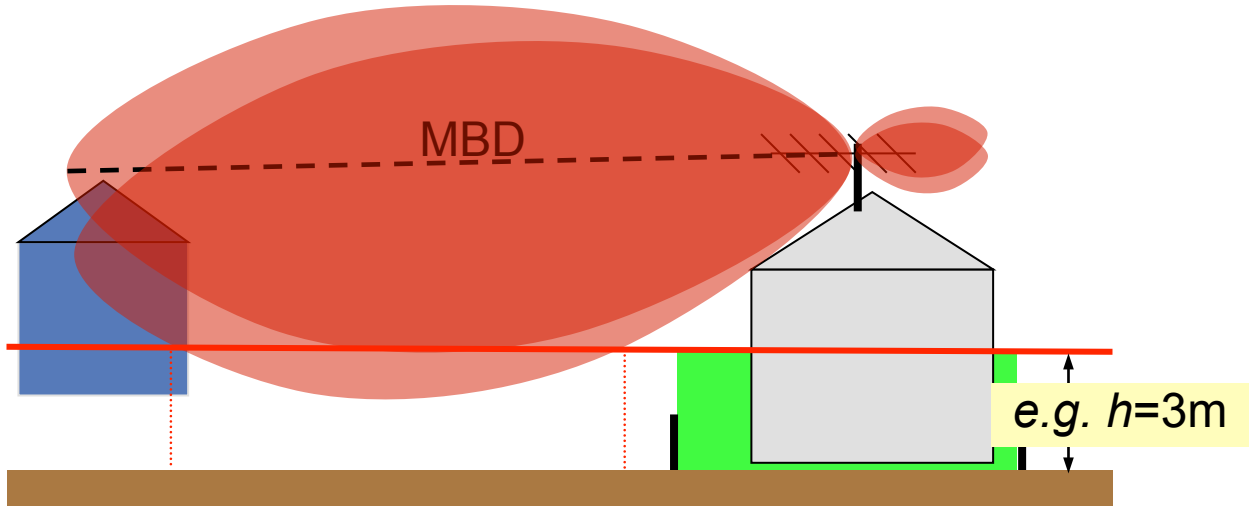


KIT – University of the State of Baden-Wuerttemberg and
National Research Center of the Helmholtz Association

Safety Area



- Region between ground surface and height of e.g. 3m is considered
- Orthogonal projection to ground surface

- Safety distance is a function of the elevation angle

Calculation of the maximum of the safety area in Main Beam Direction (MBD)

→ Is there a building in this area ?

→ Are there any persons in this area ?

WattGuard Software

Definition in cooperation with the German Federal Network Agency in clearance with the Radio Amateur Association (RTA)

Input Data

- Antenna Data
- Frequency
- Position/Height
- Orientation
- Transmit Power
- Cable Attenuation
- Modulation

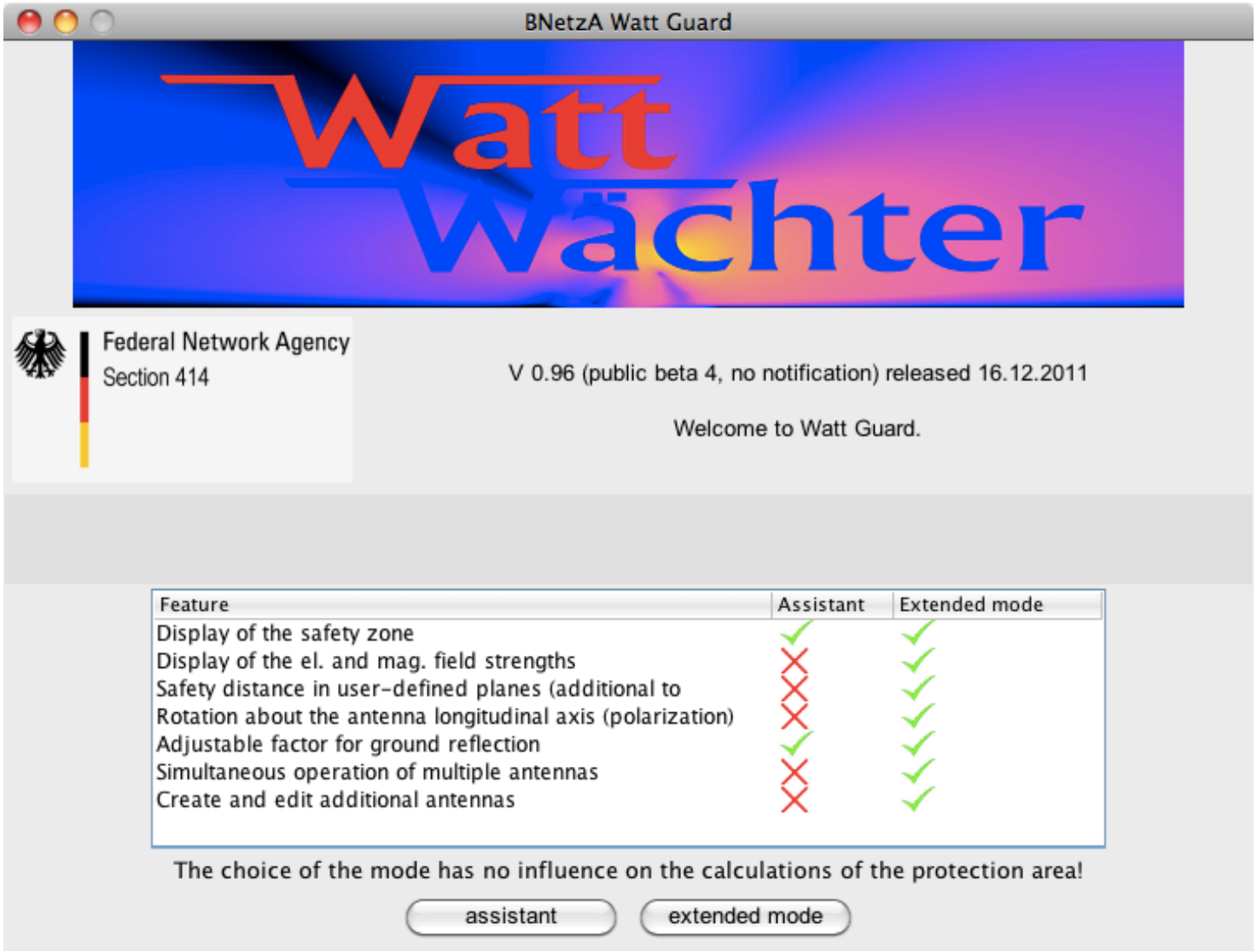
Exposure Limits

Calculation

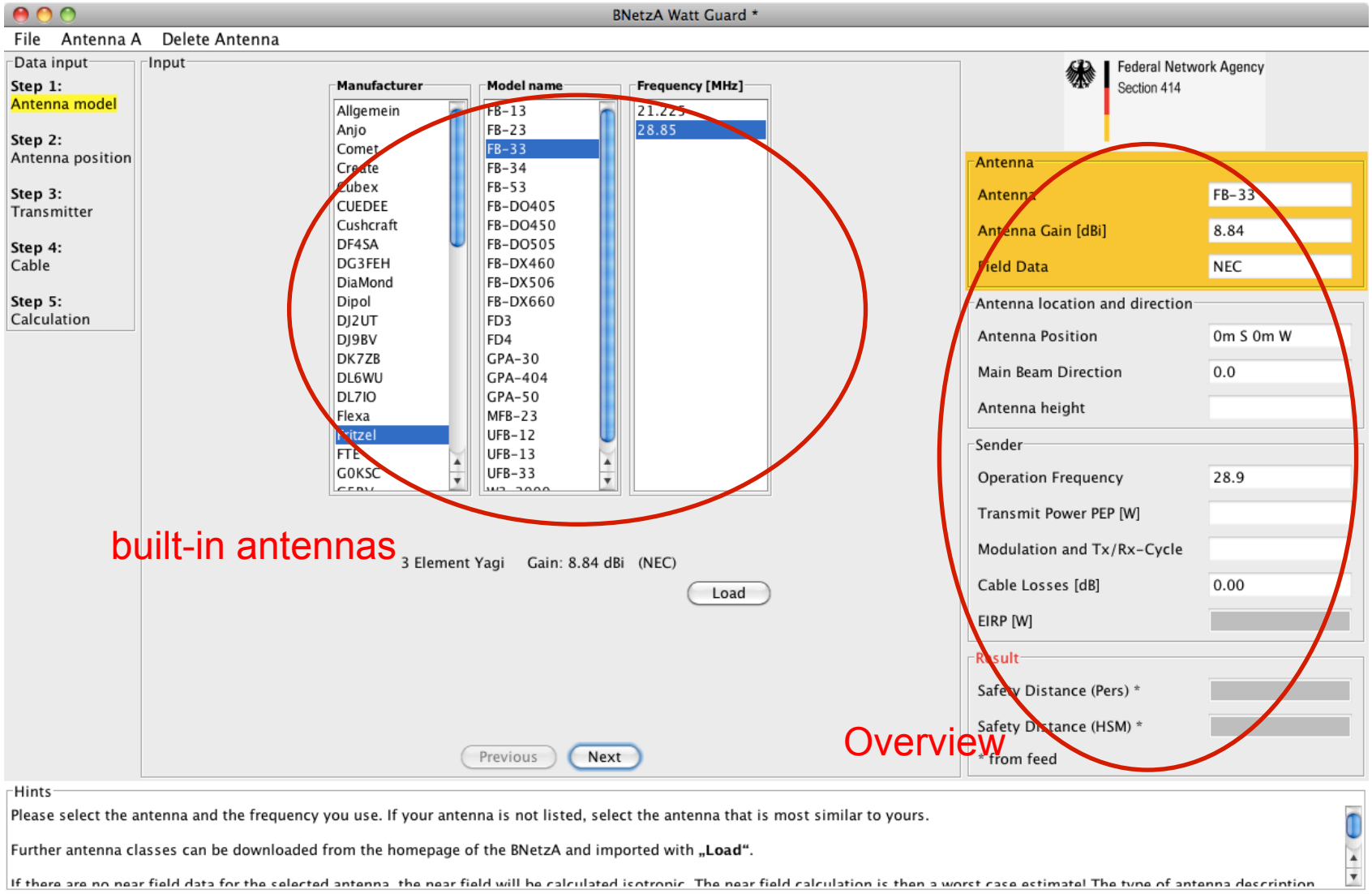
- exact 3D field calculation (E, H) if data available
- else: fitted distance function $F(r)$ and fitted antenna pattern $C(r,\theta,\psi)$
- Far field, near field, ground reflections

Safety Area (3D)

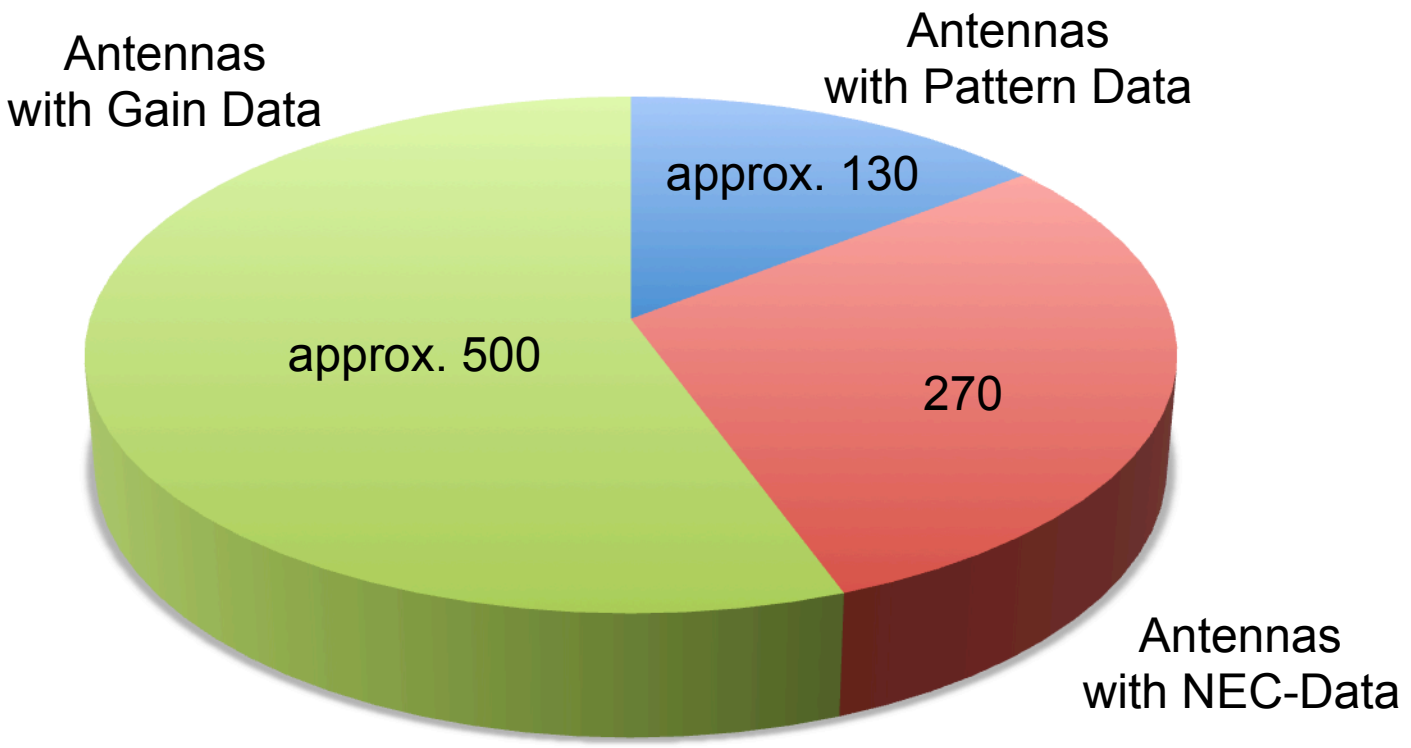
Program Start



Program Step 1/5: Antenna Data

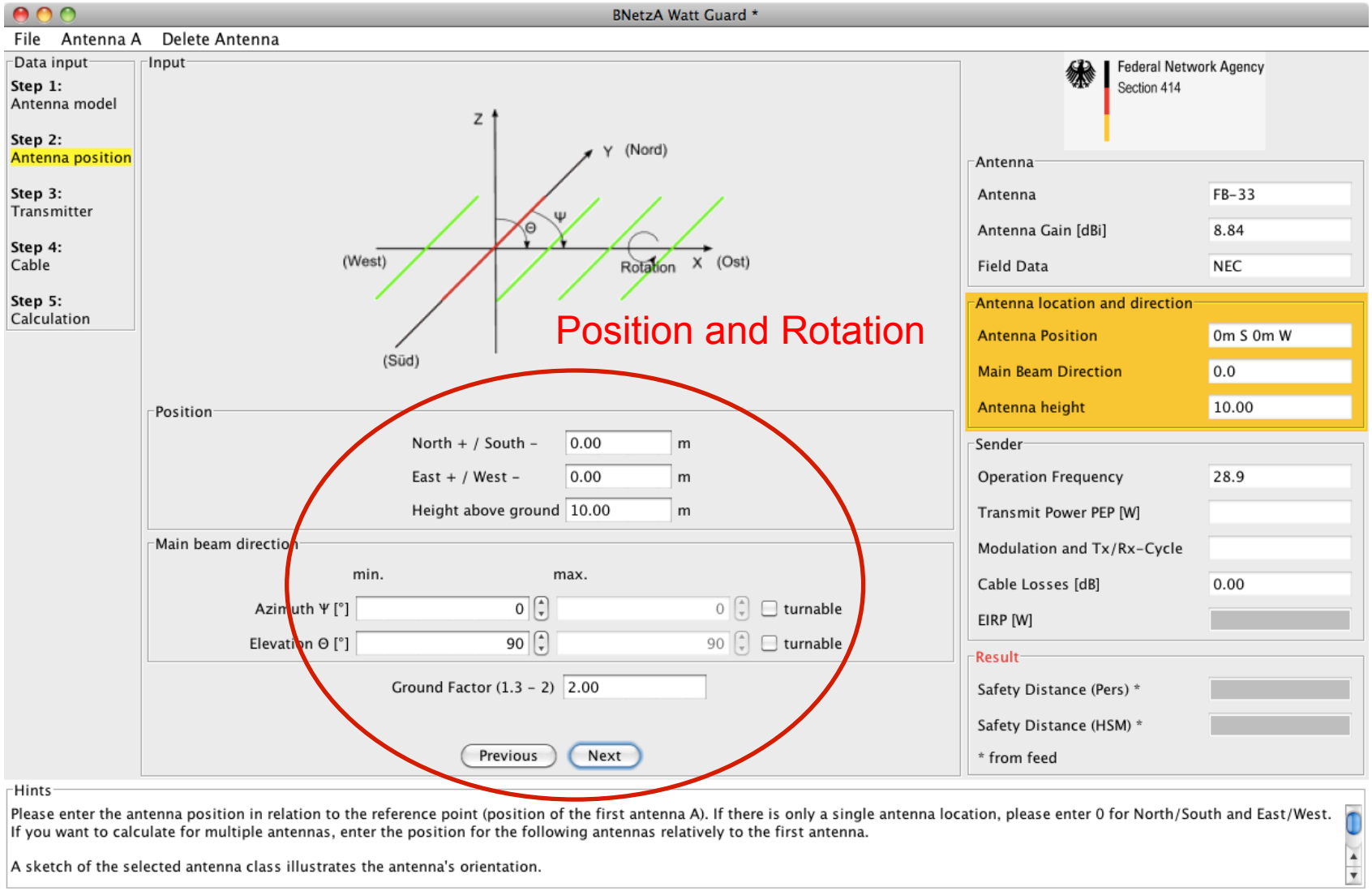


Integrated Antennas

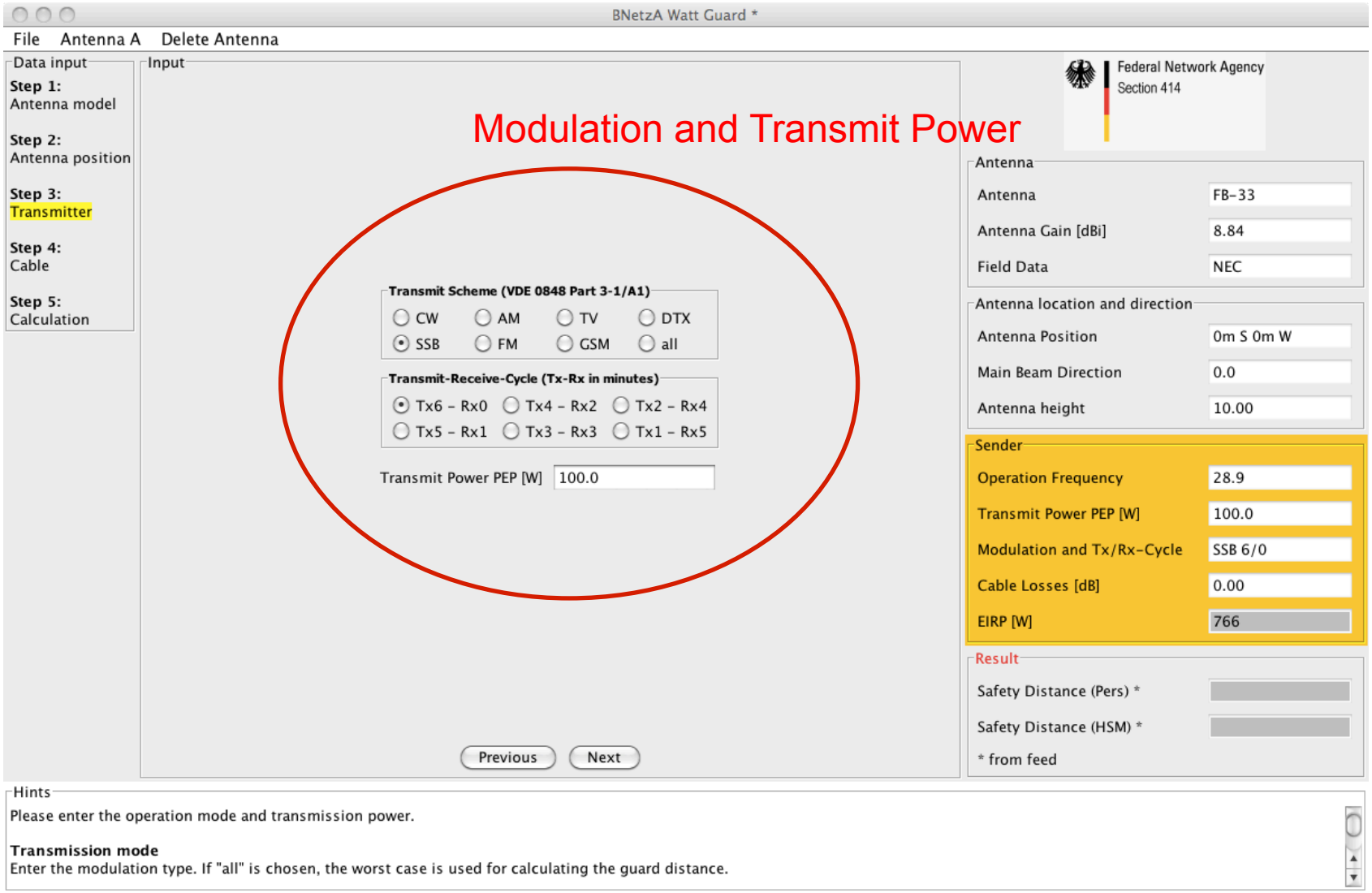


- Pattern- or NEC-Data: Exact Calculation of Safety Area
- Gain Data: Isotropic Approximation-> worst-case-consideration
- Antenna Base in Coordination with Radio Amateurs and Fed. Network Agency

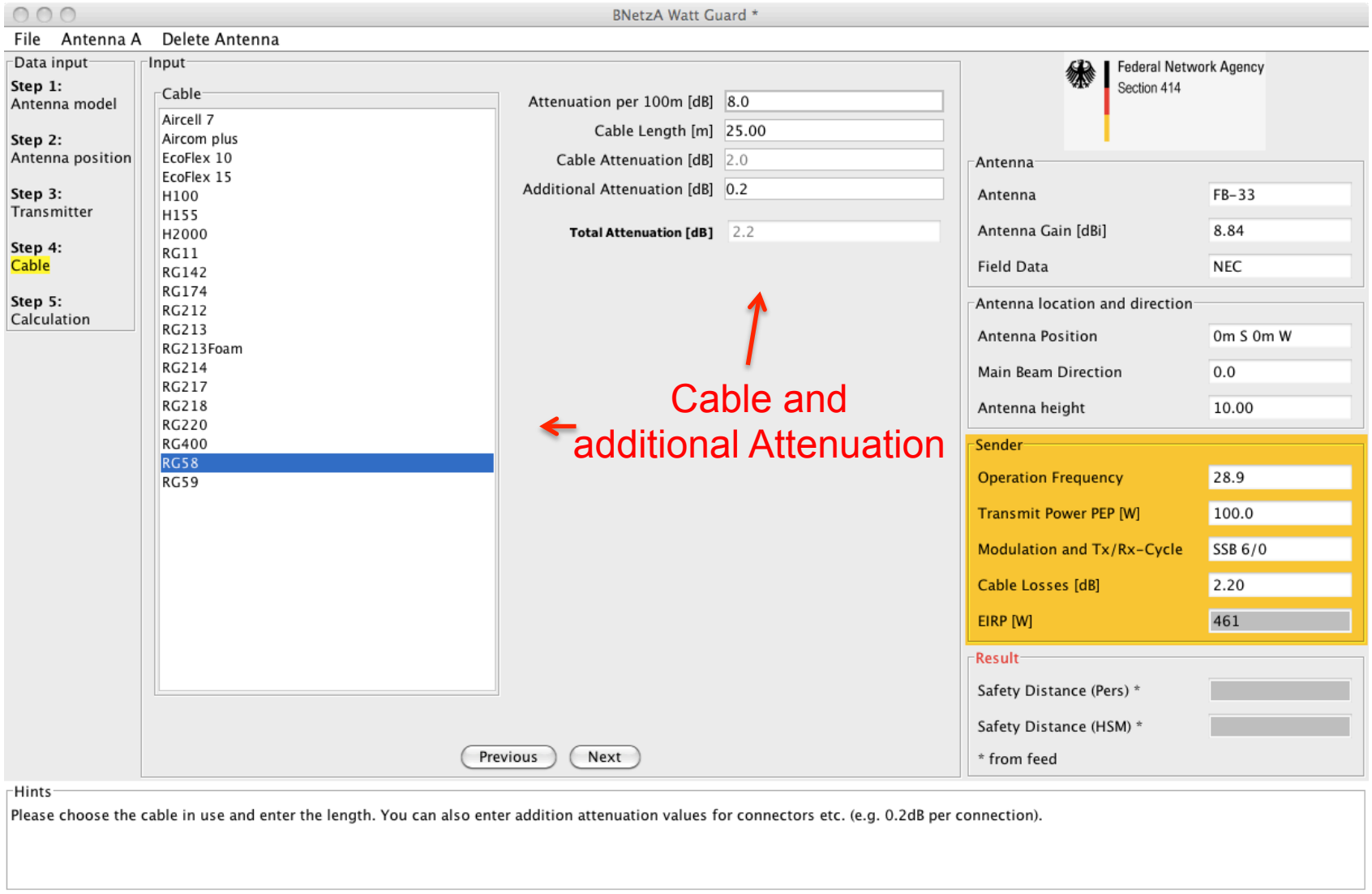
Program Step 2/5: Position Data



Program Step 3/5: Modulation, Transmit Power

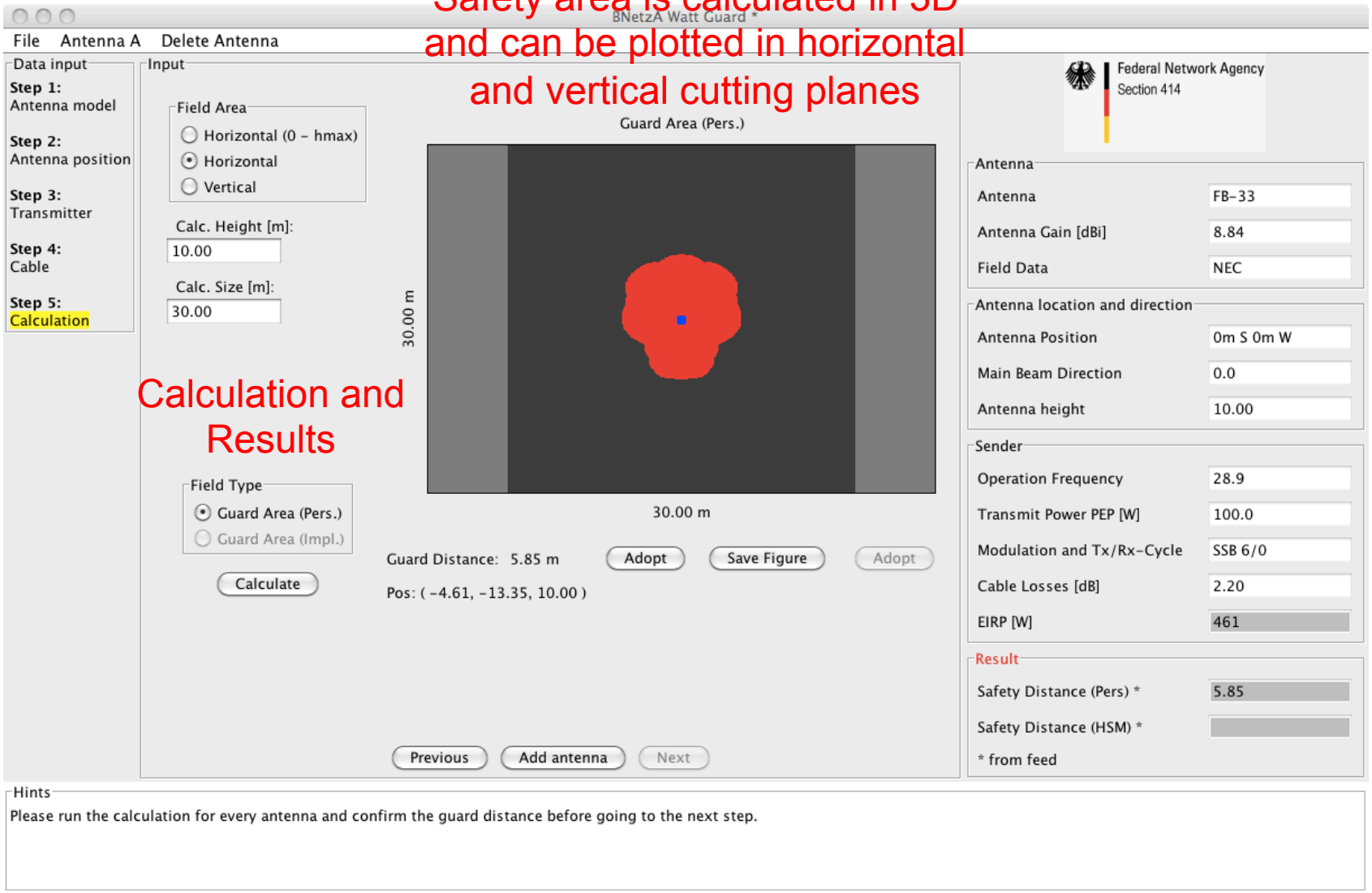


Program Step 4/5: Cable Attenuation



Program Step 5/5: Safety Area

Safety area is calculated in 3D and can be plotted in horizontal and vertical cutting planes



Summary Assisted Mode

- totally free of charge
- license free
- can be downloaded from BNetzA server (and ITU – if possible)
- no special equipment required
- runs on nearly every PC
- large antenna base, can be extended

  approx. 95% of the typically used amateur radio antennas are covered
- small program, no complicated installation needed
- easy to handle without special knowledge about electromagnetics or special training
- fast and accurate

Why WattGuard ?

- Approved and accepted calculation method
- Easy to use with user guidance in Assisted Mode
- Enhanced Mode for experienced users
- Large antenna base
- Modular: further antennas, different exposure limits and additional propagation models are easy to integrate
- Fast 3D calculation of the safety area with near field consideration
- NEC data can be imported for taking into account the environment
- Export function for graphical display of safety area
- Display of field strengths possible
- Simultaneous operation of multiple antennas or stations
- System/platform independent software