Radio Interference Calculations

ITU Workshop on cross border Radio Frequency Management in Arab States

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International Telecommunication Union

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What to expect in these slides

- Basic Concepts of Measurements
- How radio interference prediction helps
- Filed strength measurements
- Relevant ITU reports and Recommendations

Basic Concept of Measurement

The measurement is the process of assigning a value to an attribute or phenomenon.

The result is, in principle, independent of the procedure used.

Nevertheless, the accuracy of the measurement process is essential to obtain a reliable value.

Basic Concept of Measurement

The measurement process should define

- **Attribute or phenomenon to measure**
  Measurement of electromagnetic fields which could be characterized as either a value of E or H fields or as characteristics of a signal (frequency, amplitude, phase, bandwidth, etc.)

- **Conditions of operations**
  Details of all conditions including influences caused by surrounding infrastructure, weather, limitation with measuring equipment (size of antenna, embedded equipment) have to be known to ensure the measurement is reproducible

- **The measurement system and parameters to use**
  All devices involved in the measurement should be specified to take into account all parameters in the measurement result (type of equipment, characteristics and uncertainties)

Basic Concept of Measurement

The measurement process should define:

- **Sequence of technical operations to apply.**

  A general description of how to perform the measurements is provided below:
  - *The description of the measurement chain set up, including identification of equipment used.*
  - *The description of preliminary measurements to carry out (e.g. measurements to ensure that there's no strong emitter at the measurement location which could lead to a wrong result).*
  - *Measuring device settings to be used (e.g. frequency band, resolution bandwidth (RBW), span, etc.)*
  - *Tasks to be achieved to carry out the measurement*
  - *Consistency of the result (e.g. checking of the result by comparison with theoretical reckoning, uncertainty calculation, etc.)*

- **Result reckoning and uncertainties**

  To provide a reliable value of the measurement, post-processing is necessary to take into account uncertainties of the measurement chain to assess the uncertainty of the final result.

  The final step could be, if necessary, to specify the form of publication of the results.

Radio Interference Prediction

Helps in

- Planning and co-ordinating a station
- Determine if special protection required?
- Determine if Co-ordination required?
- Having reference values for calculation of interfering field strength at specified height on border
- Having reference values for calculation of cross-border interference range according to prediction method, band, etc.

Need to consider

- Station's technical characteristics
- Frequency offset and bandwidth of stations affected
- Use of specific propagation curves

Radio Interference Prediction - Example

Interference field strength based on ITU-R P.1546

*(Method for **point-to-area predictions** for terrestrial services in the frequency range 30 MHz to 3 000 MHz)*

- **Determine Type of Propagation path**
- **Determine Nominal Time percentages and Nominal frequencies**
- **Estimate field strength while factoring in:**
  - *Terrain clearance angle*
  - *Tropospheric scattering*
  - *Receiving antenna height*
  - *Clutter around the transmitting/base terminal*
  - *Slope-path correction*
  - *Adjustment for different climatic regions etc.*

Field Strength Measurements - Ways

Basic two ways of measurements

- **At a monitoring station;**
- **Along a route (Mobile)**

Time durations can vary and the measurements can be more complex involving coordinated use of mutiple measurements equipments at different geographical sites

Field Strength Measurements - Categories

The term "measurement of field strength" is intended to apply to four general categories of measurement:

- Measurements performed with portable or mobile facilities, to obtain relatively instantaneous or **short-term data at one or several locations**;
- Measurements performed with mobile facilities to obtain **statistical parameters** of coverage in the field of mobile radio;
- **Short-term measurements at a fixed location**, generally in support of other monitoring operations;
- **Long-term measurements** involving field strength recordings and analysis of chart records, respectively storage and analysis of measured data using computers.

Field Strength Measurements - Types

Two types of measurements:

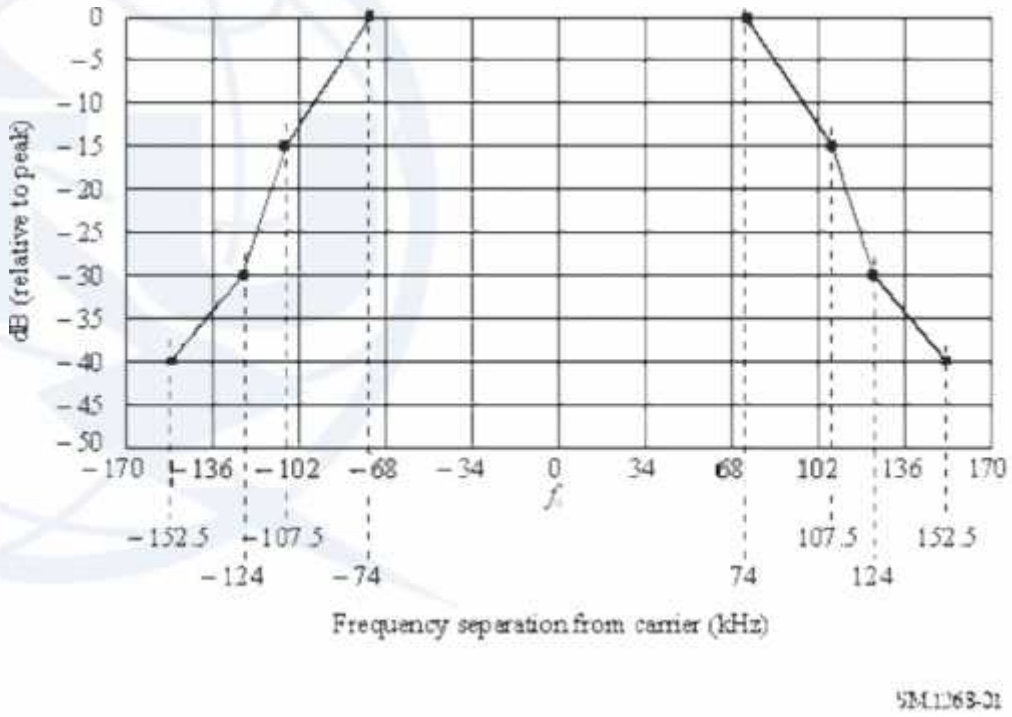
- Simple “go-no go” test based on a spectrum mask
- Method used when the values of the deviation and modulation power are required

Field Strength Measurements - Deviation

Mask method

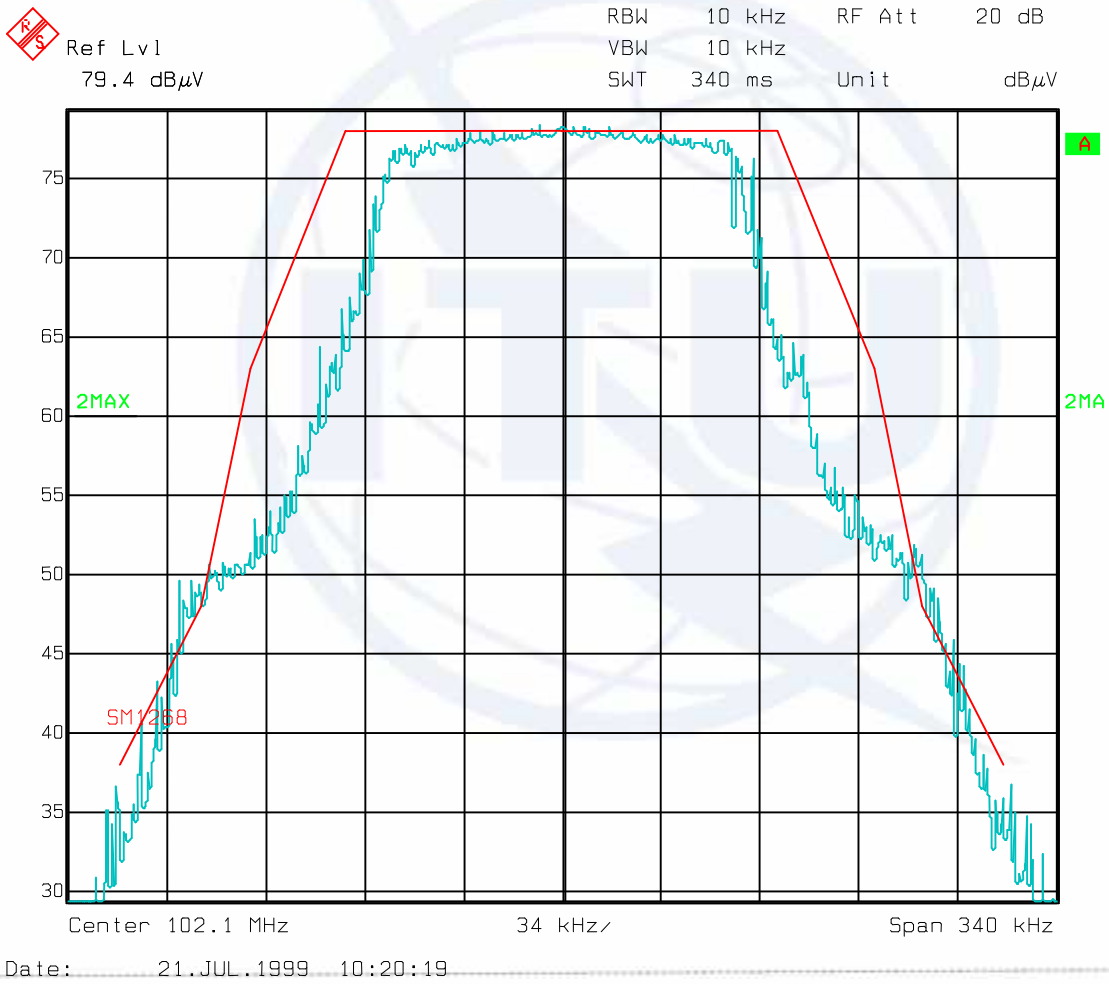
- May be used as a verification to indicate whether the frequency deviation of an FM broadcasting station exceeds the limits;

- Cannot be applied on transmissions with 50 kHz peak deviation due to the fact that no appropriate spectrum mask is available;



Field Strength Measurements - Deviation

Example Spectrum Mask measurement



Field Strength Measurements - Deviation

Method when the values of the deviation and modulation power are required.

Example

The protection ratios specified in Recommendation ITU-R BS.412 for the planning of FM sound broadcasting transmitters ***apply on the condition that*** *a peak deviation of ±75 kHz is not exceeded and that the average modulation power over any interval of 60 s does not exceed that of a single sinusoidal tone which causes a peak deviation of ±19 kHz.*

Field Strength Measurements - Frequency

Conventional methods are :

- Beat Frequency (BF) method
- Offset Frequency (OF) method
- Direct Lissajous (DL) method
- Frequency Counter (FC) method
- Frequency Discriminator (FD) method
- Phase Recording (PR) method
- Swept Spectrum Analyser (SSA) method.

At monitoring stations most of the time the methods DL, FC and SSA are used as these methods cover all types of frequency measurements. The other methods are included for completeness but are in practice not used anymore and not available due to the introduction of Digital signal processing (e.g. FFT, IFM…), which is now generalized in measuring equipment.

Field Strength Measurements - Frequency

Digital Signal Processing (DSP) based methods are :

- Instantaneous Frequency Measurement (IFM) method
- FFT method.

DSP methods should be preferable on Monitoring Stations.

ITU Reports and Recomm. on Measurements

Category	Report/Recommendation Details
General	• Recommendation ITU-R SM.1050 • Recommendation ITU-R SM.1723 • Recommendation ITU-R SM.1794 • ITU Spectrum Monitoring Handbook, 2011, Chapter 1
Direction finding measurement and location determination	• Recommendation ITU-R SM.854 • Recommendation ITU-R SM.1598 • ITU Spectrum Monitoring Handbook, 2011, Section 4.7
Spectrum and channel Occupancy measurement	• Recommendation ITU-R SM.1880 • Report ITU-R SM.2256 • ITU Spectrum Monitoring Handbook, 2011, Section 4.10
Unwanted emissions	• Recommendation ITU-R SM.328 • Recommendation ITU-R SM.329 • Recommendation ITU-R SM.1752 • Recommendation ITU-R SM.1792 • ITU Spectrum Monitoring Handbook, 2011, Section 4.12
Measurement on digital broadcasting systems	• Recommendation ITU-R SM.1682 • Recommendation ITU-R SM.1792 • ITU Spectrum Monitoring Handbook, 2011,Sections 4.11 and 5.2
Mobile monitoring	• Recommendation ITU-R SM.1708 • Recommendation ITU-R SM.1723 • ITU Spectrum Monitoring Handbook, 2011,Section 2.4.2
Standard data exchange format at monitoring stations	• Recommendation ITU-R SM.1809

ITU Reports and Recomm. on Measurements

Category	Report/Recommendation Details
Frequency	• Recommendation ITU-R SM.377 • ITU Spectrum Monitoring Handbook, 2011, Section 4.2
Field strength (see also Radio Regulations Art. 21)	• Recommendation ITU-R P.845 • Recommendation ITU-R SM.378 • Recommendation ITU-R SM.1447 • Recommendation ITU-R SM.1708 • ITU Spectrum Monitoring Handbook, 2011, Section 4.10
Modulation	• Recommendation ITU-R SM. 1268 • ITU Spectrum Monitoring Handbook, 2011, Sections 4.6 and 4.8
Bandwidth	• Recommendation ITU-R SM.443 • ITU Spectrum Monitoring Handbook, 2011, Section 4.5
Identification	• Recommendation ITU-R SM.1052 • Recommendation ITU-R SM.1600 • ITU Spectrum Monitoring Handbook, 2011, Section 4.8
Signal analysis	• ITU Spectrum Monitoring Handbook, 2011, Section 4.8
Measurements related to inspection of radio installations	• Report ITU-R SM.2130

ITU Reports and Recomm. on Measurements

Category	Report/Recommendation Details
Selectivity of monitoring receivers	• Recommendation ITU-R SM.1836 • Report ITU-R SM.2125
IP3 of monitoring receivers	• Recommendation ITU-R SM.1837 • Report ITU-R SM.2125
Noise figure of monitoring receivers	• Recommendation ITU-R SM.1838 • Report ITU-R SM.2125
Scanning speed of monitoring receivers	• Recommendation ITU-R SM.1839 • Report ITU-R SM.2125
Sensitivity of monitoring receivers	• Recommendation ITU-R SM.1840 • Report ITU-R SM.2125
Other parameters	• Report ITU-R SM.2125
Selectivity of monitoring receivers	• Recommendation ITU-R SM.1836 • Report ITU-R SM.2125

Calculation of Interference : Example FX and MS (Germany)

Calculation of Interference : Fixed, Mobile

Based on previous introduction of IT-supported frequency co-ordination following examples shall illustrate evaluation of co-ordination obligation and interference calculations in fixed and mobile service:

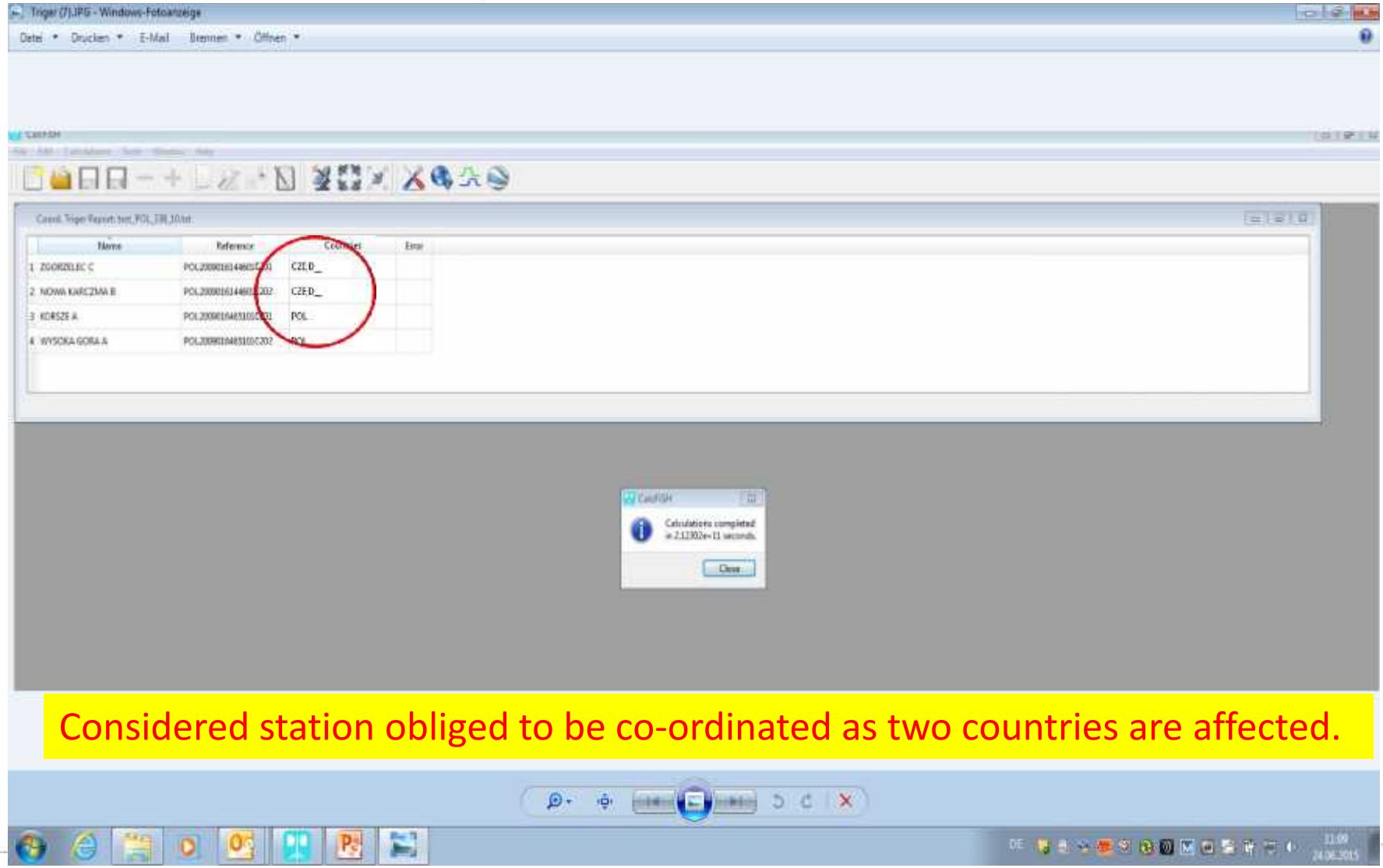
Fixed Service (CalcFiSH):

- Co-ordination Distance (determination of affected country)
- Threshold Degradation (stations: point-to-point)

Mobile Service (HCM-MS and GREKO/FLAP):

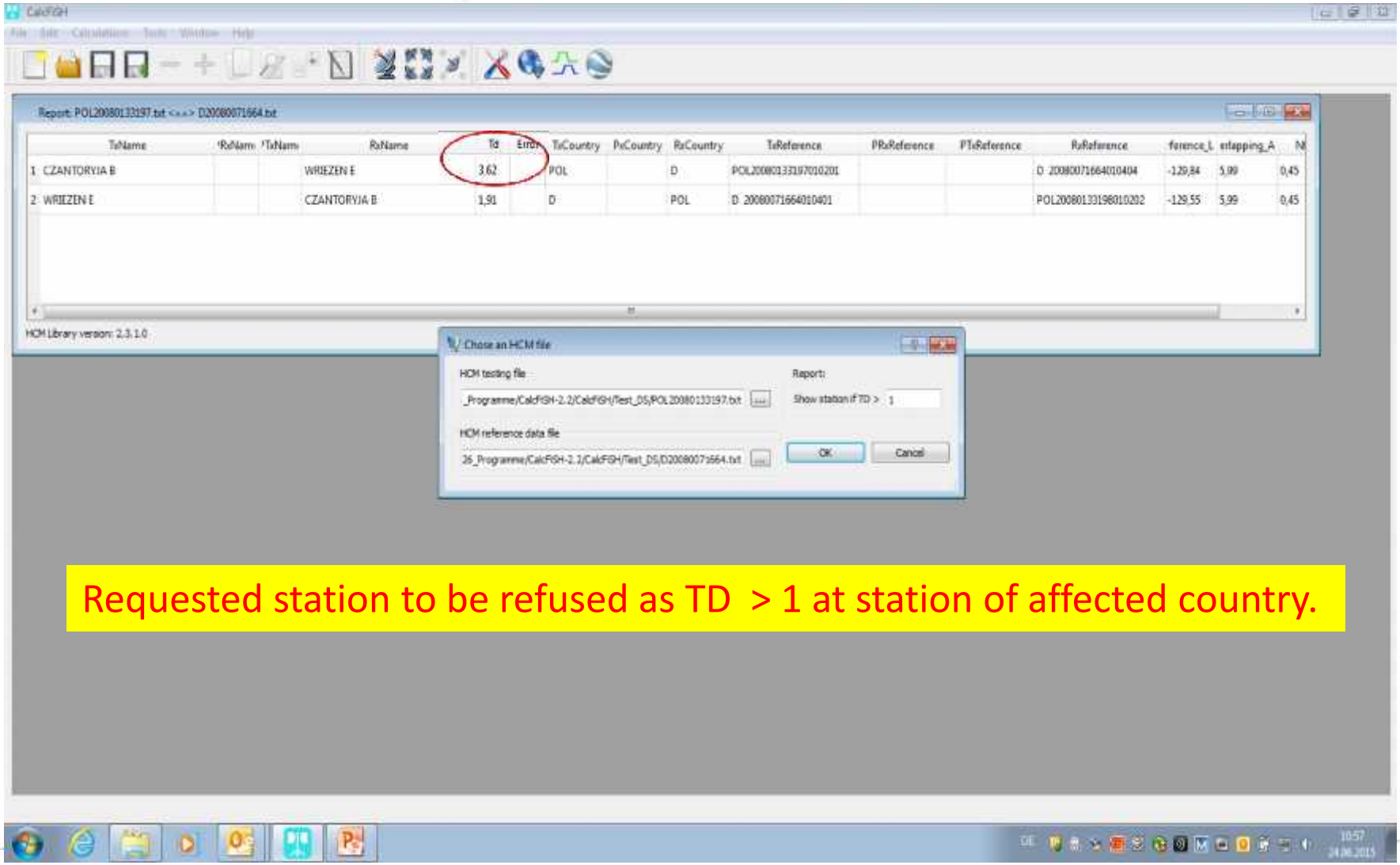
- Co-ordination Trigger (determination of PM on border-line)
- Cross Border Range (determination of PM on CBR-line)
- Preferential Condition (determination of PM on x-km-line)
- Stations: Point-to-Point (determination of PM at counter-stations)
- Point-to-Area prediction (propagation from a station to an area)

Calculation of Interference : Fixed, Mobile



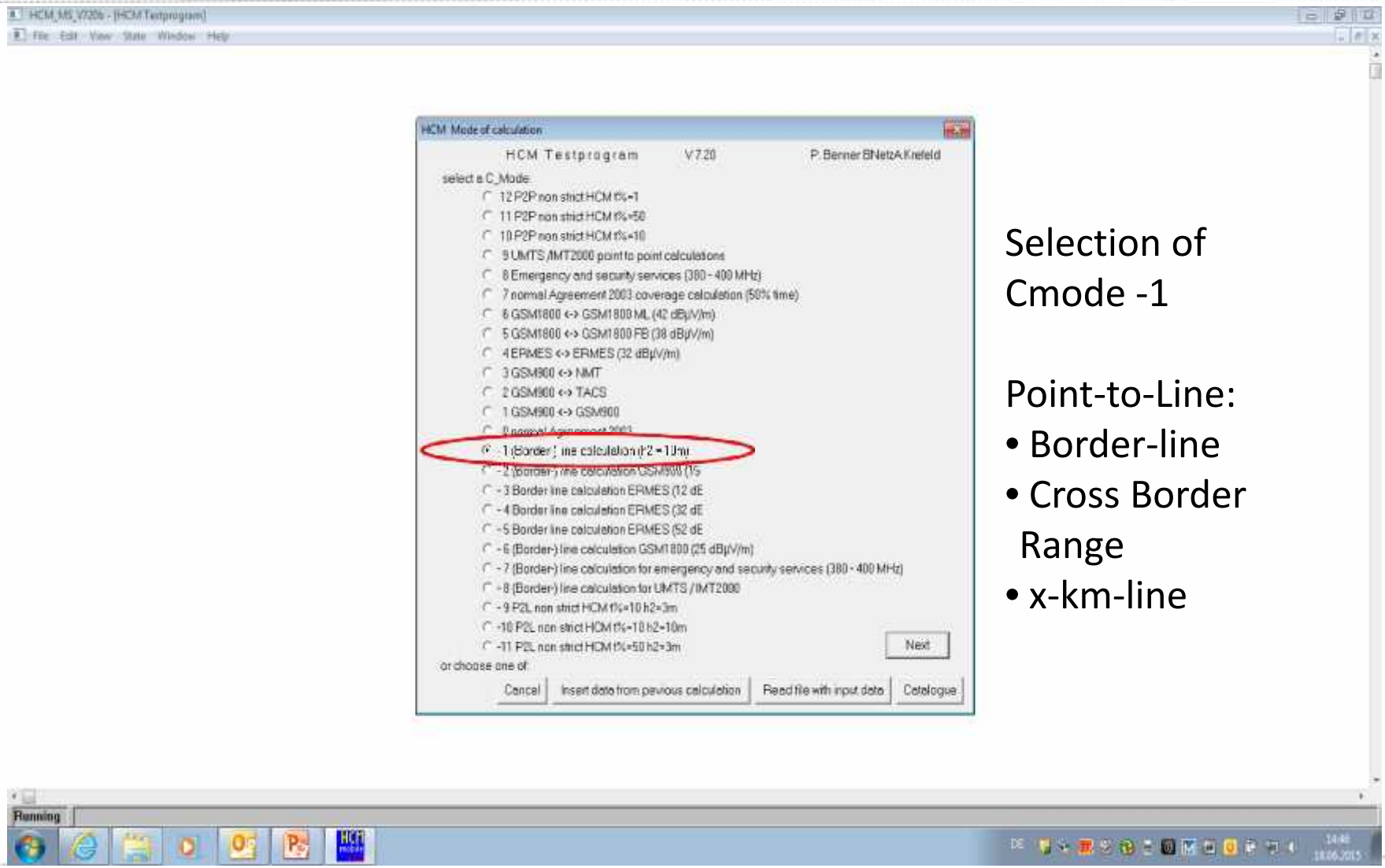
Considered station obliged to be co-ordinated as two countries are affected.

Calculation of Interference : Fixed, Mobile



Requested station to be refused as TD > 1 at station of affected country.

Calculation of Interference : Fixed, Mobile

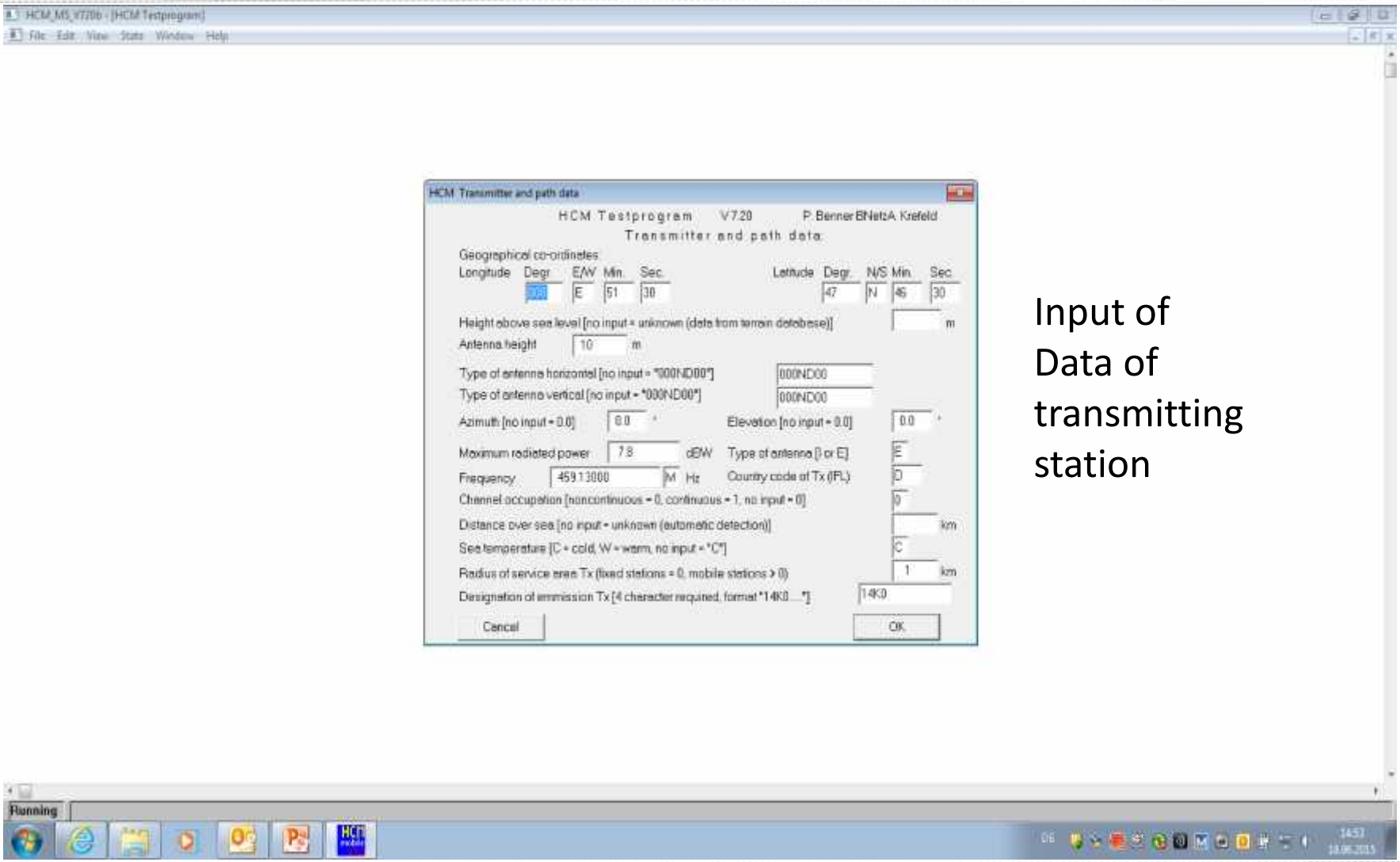


Selection of Cmode -1

Point-to-Line:

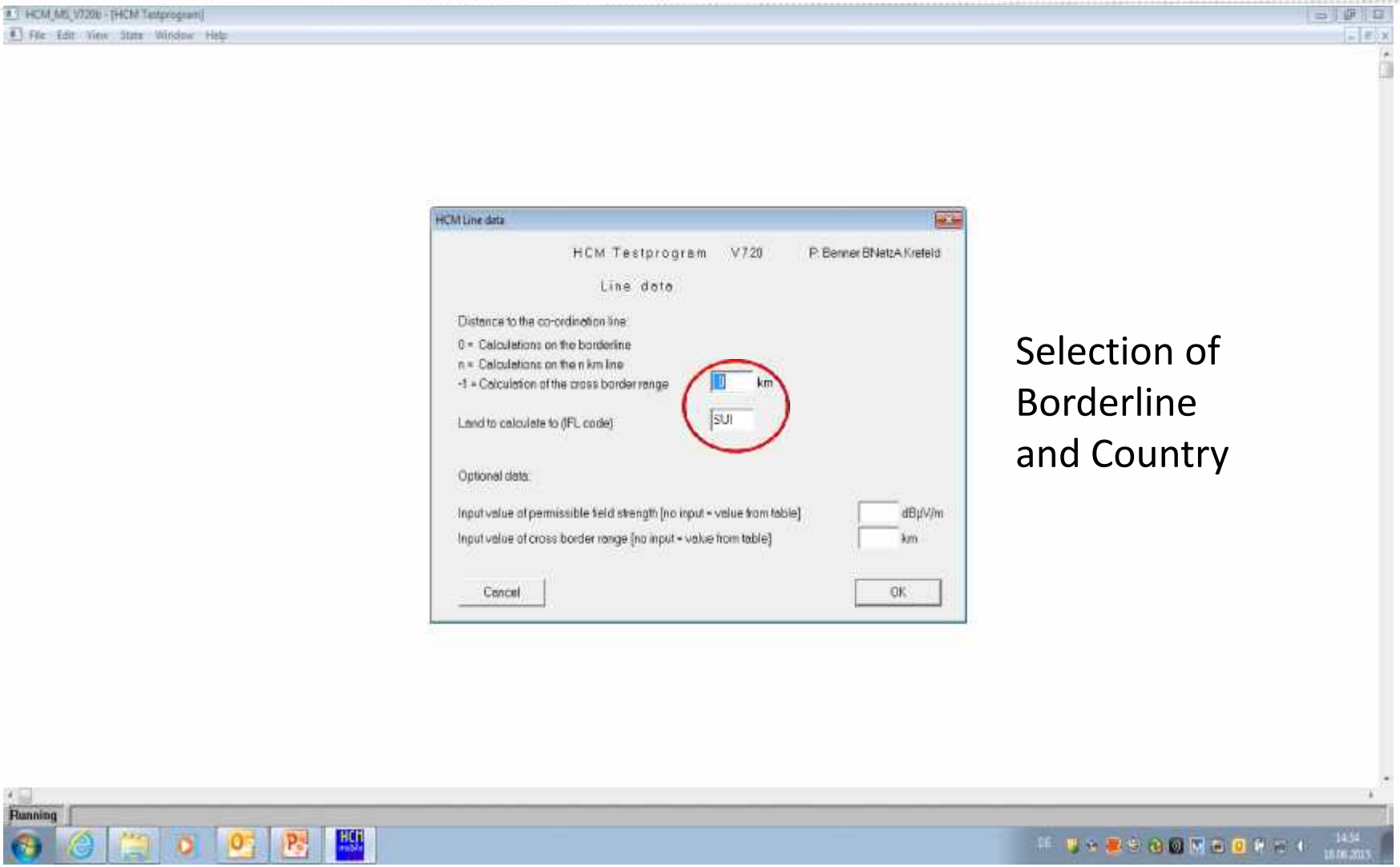
- Border-line
- Cross Border Range
- x-km-line

Calculation of Interference : Fixed, Mobile



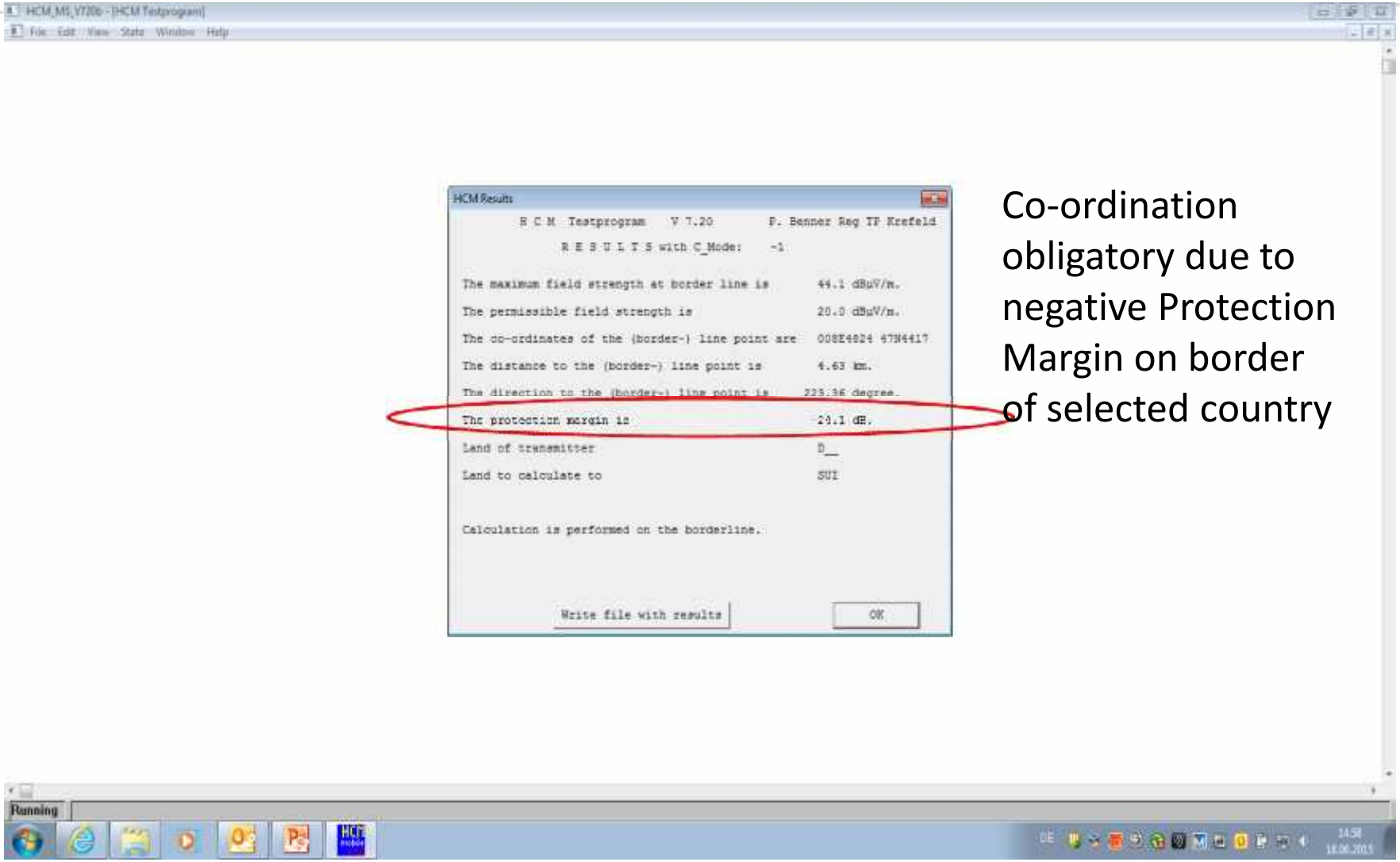
Input of Data of transmitting station

Calculation of Interference : Fixed, Mobile



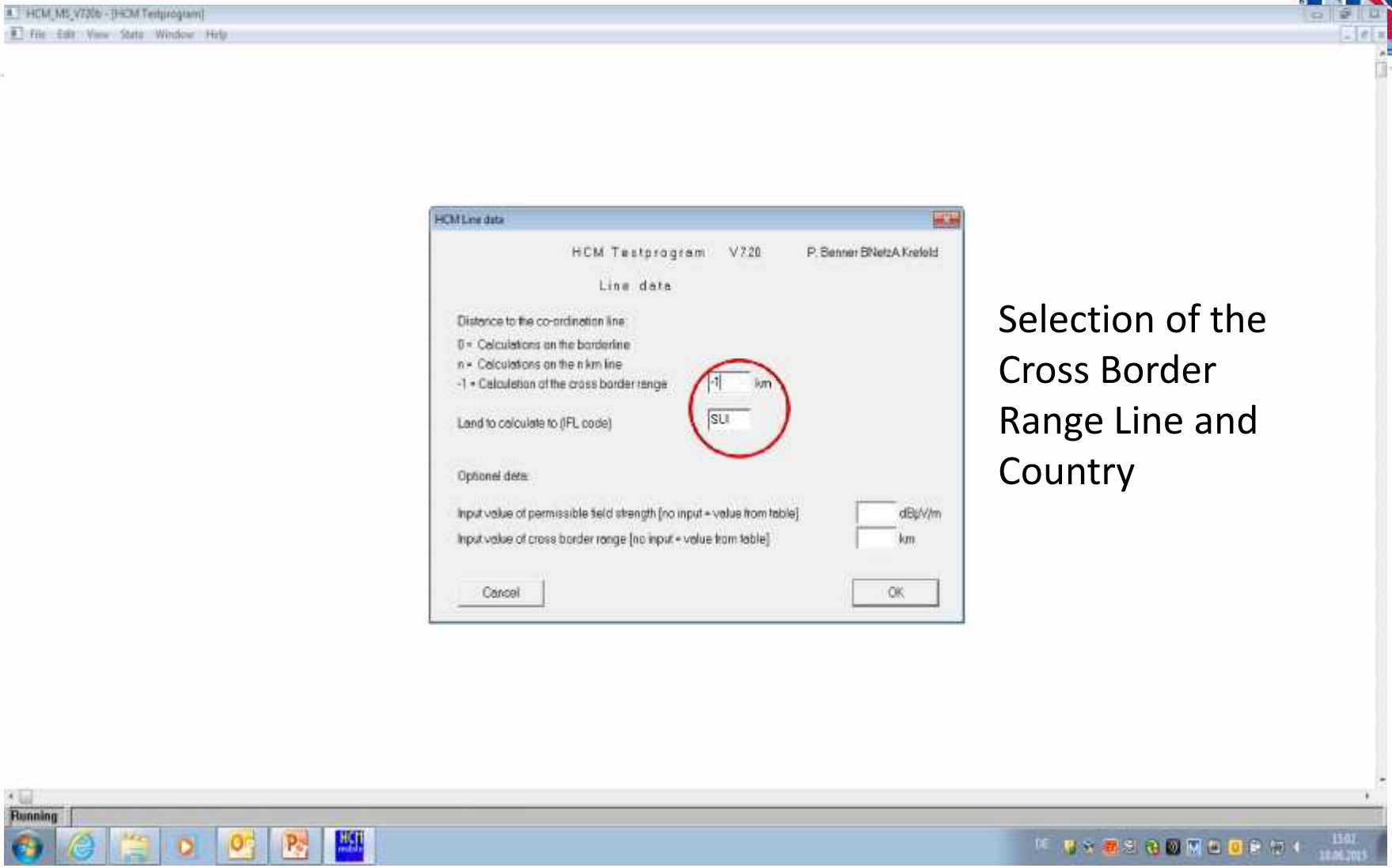
Selection of Borderline and Country

Calculation of Interference : Fixed, Mobile



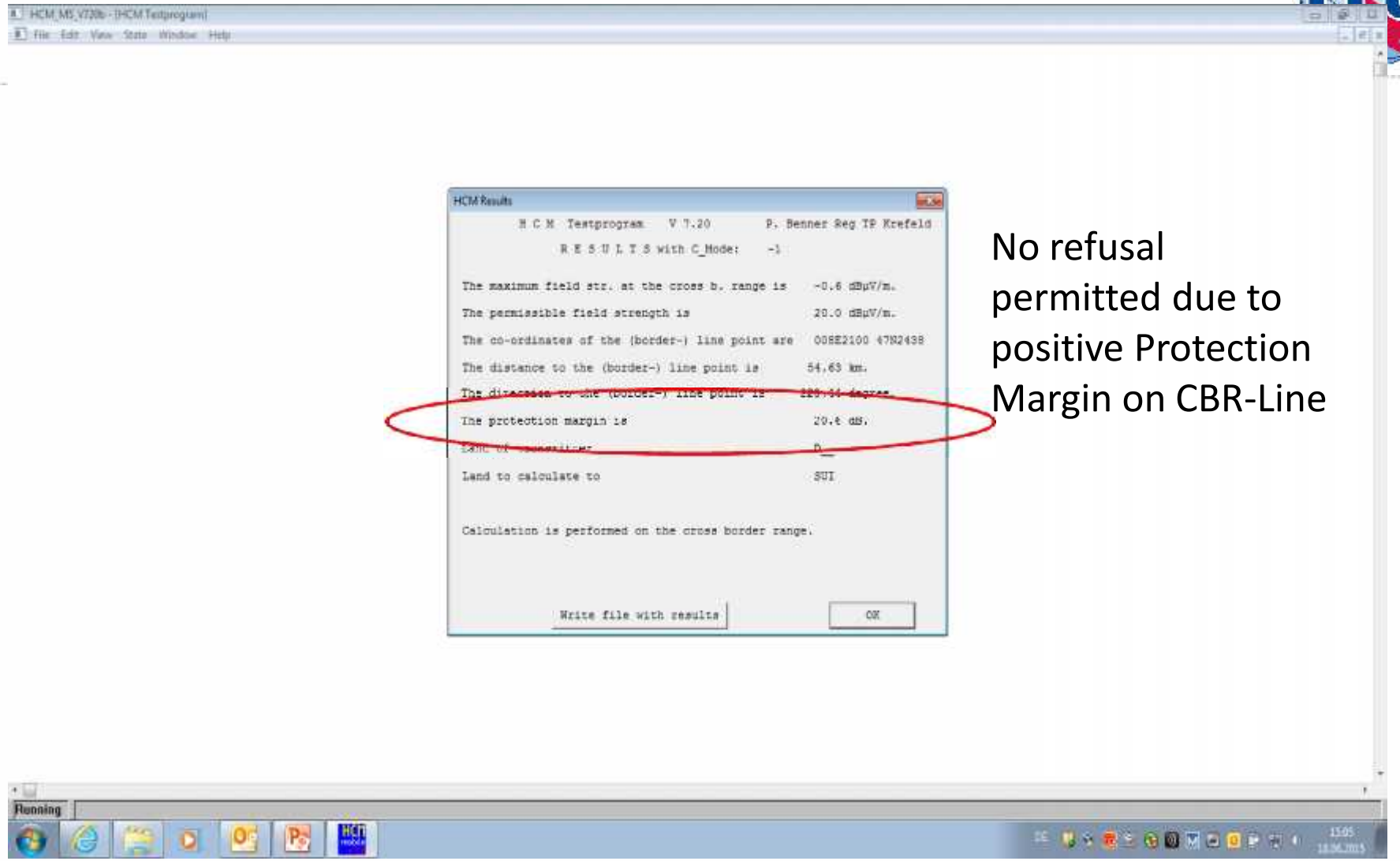
Co-ordination obligatory due to negative Protection Margin on border of selected country

Calculation of Interference : Fixed, Mobile



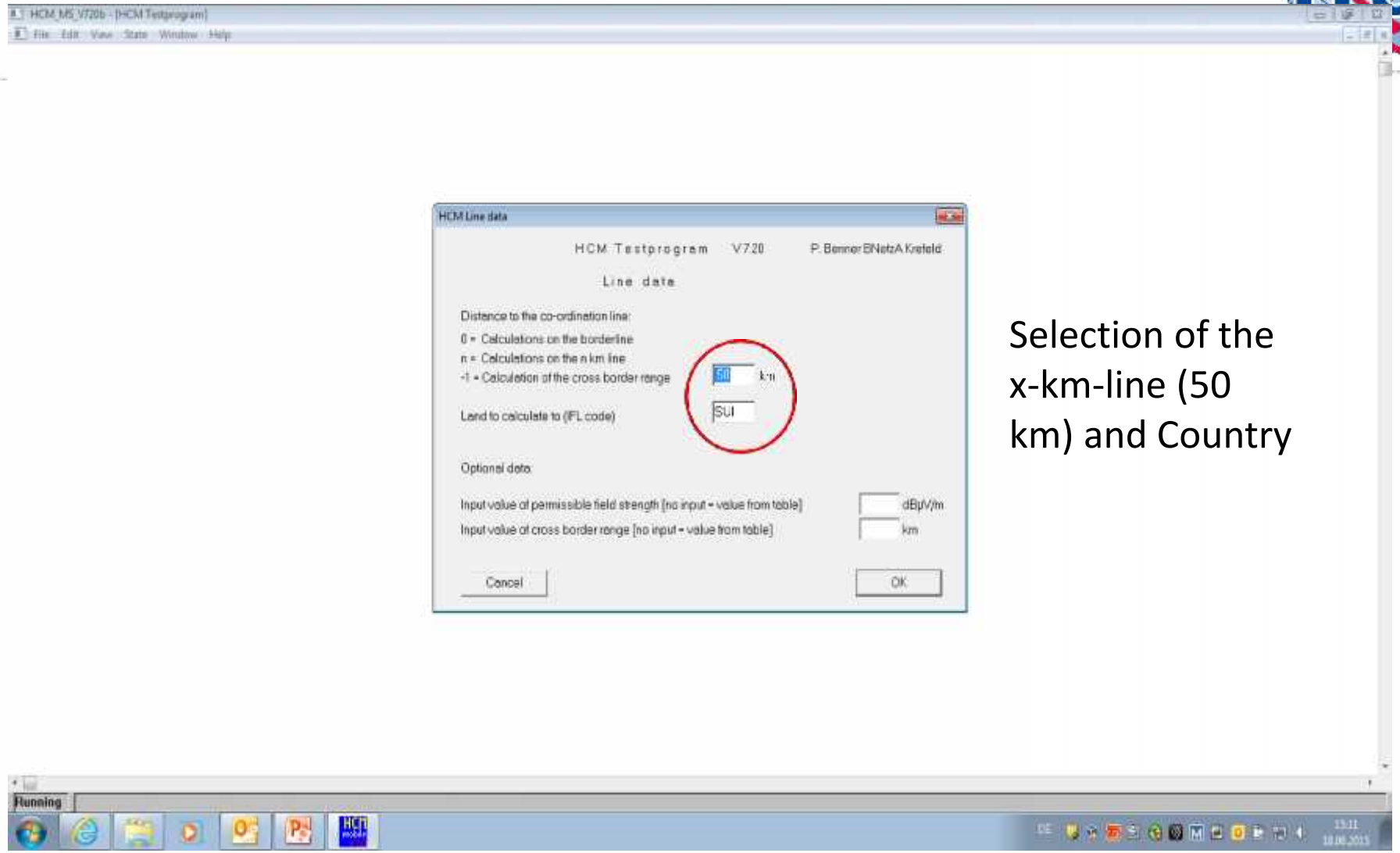
Selection of the Cross Border Range Line and Country

Calculation of Interference: Fixed, Mobile



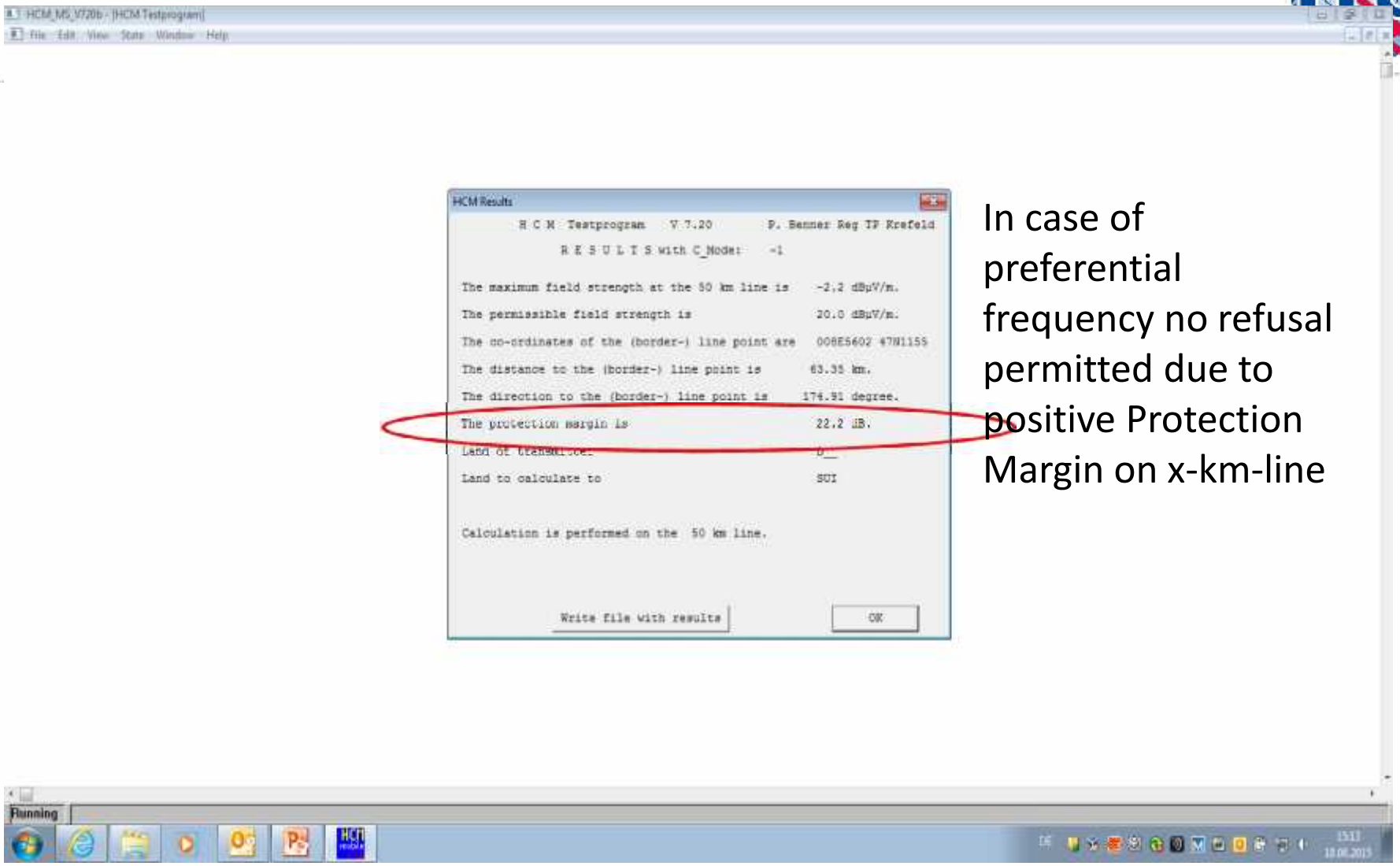
No refusal permitted due to positive Protection Margin on CBR-Line

Calculation of Interference : Fixed, Mobile



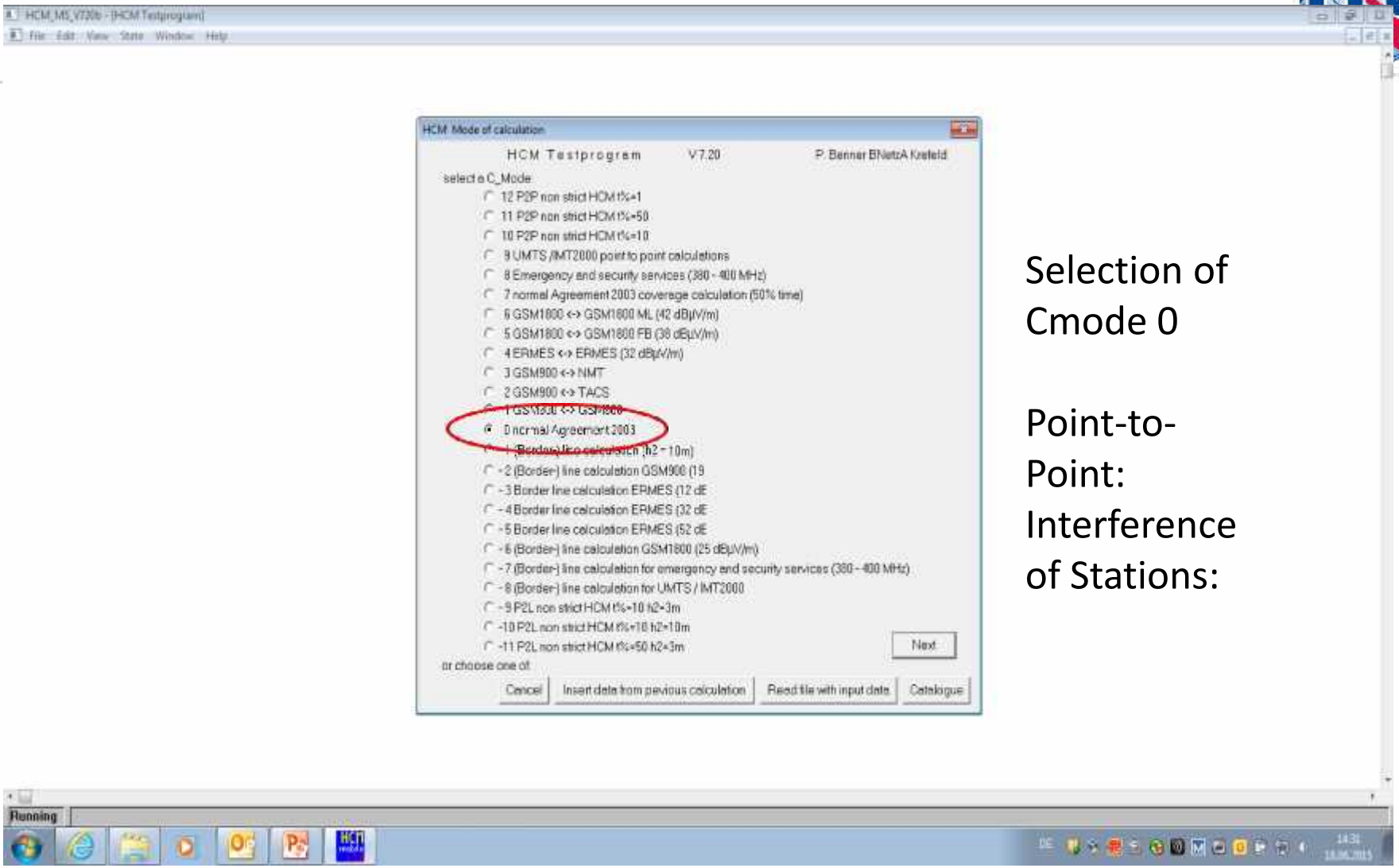
Selection of the x-km-line (50 km) and Country

Calculation of Interference : Fixed, Mobile



In case of preferential frequency no refusal permitted due to positive Protection Margin on x-km-line

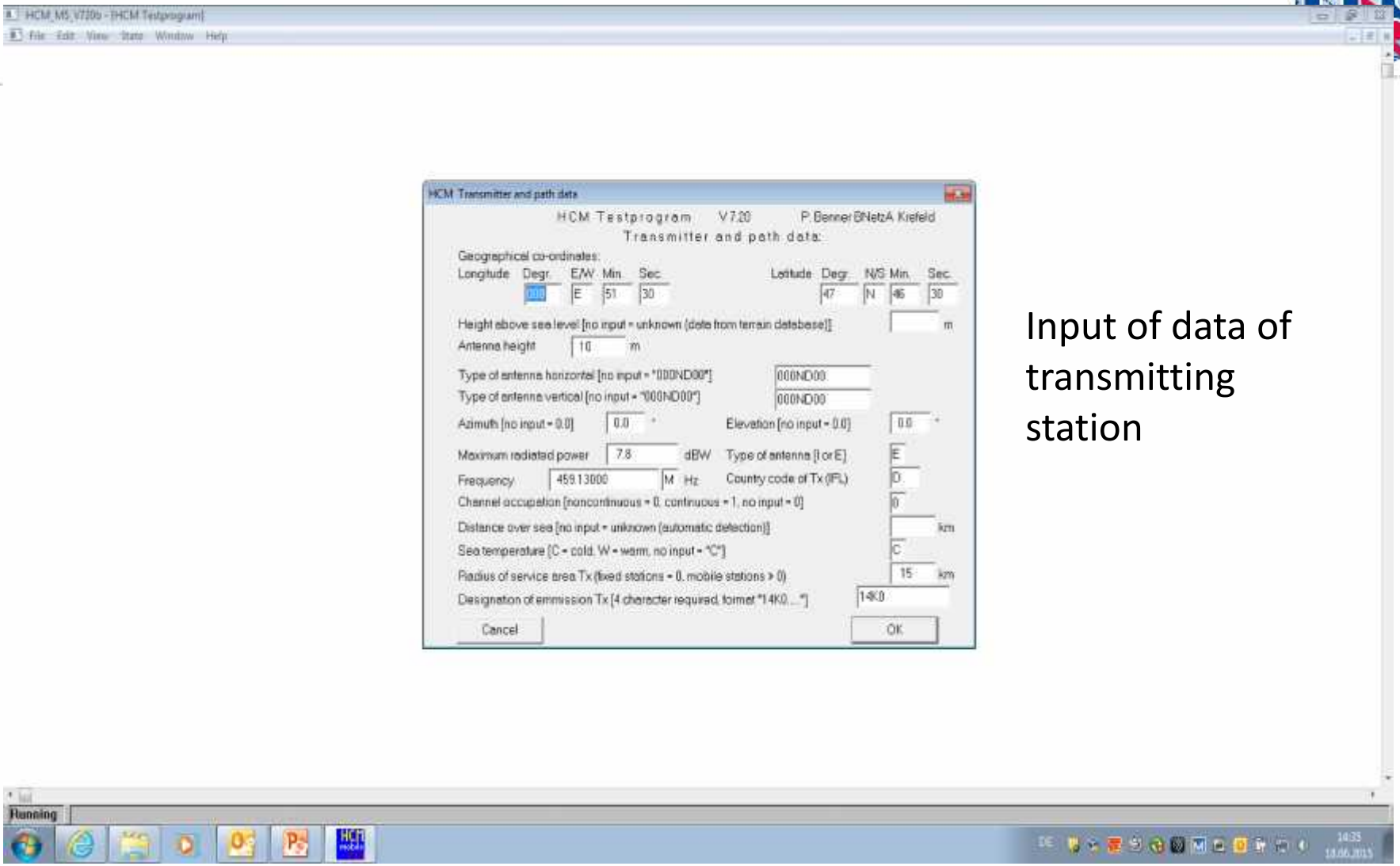
Calculation of Interference : Fixed, Mobile



Selection of Cmode 0

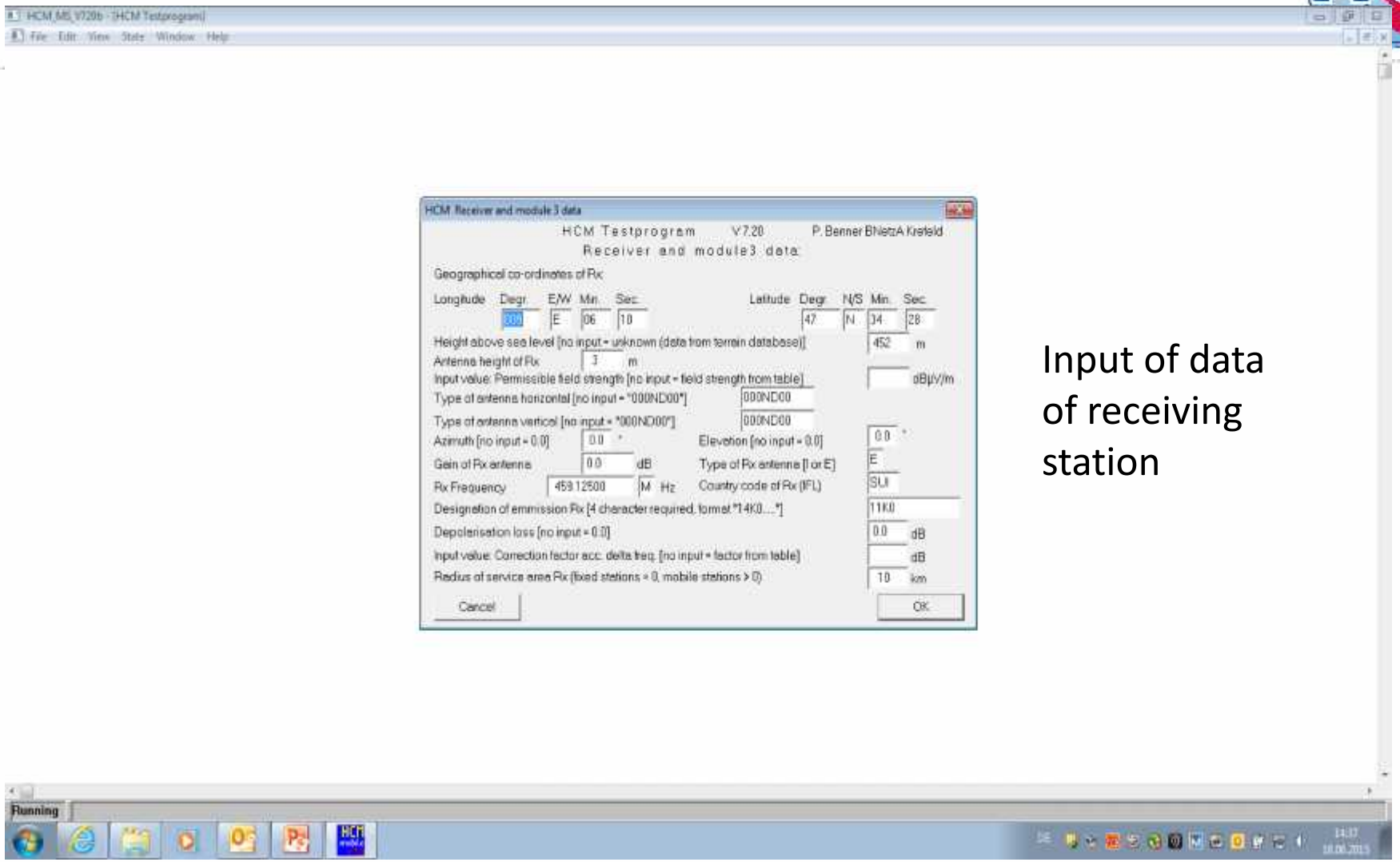
Point-to-Point: Interference of Stations:

Calculation of Interference: Fixed, Mobile



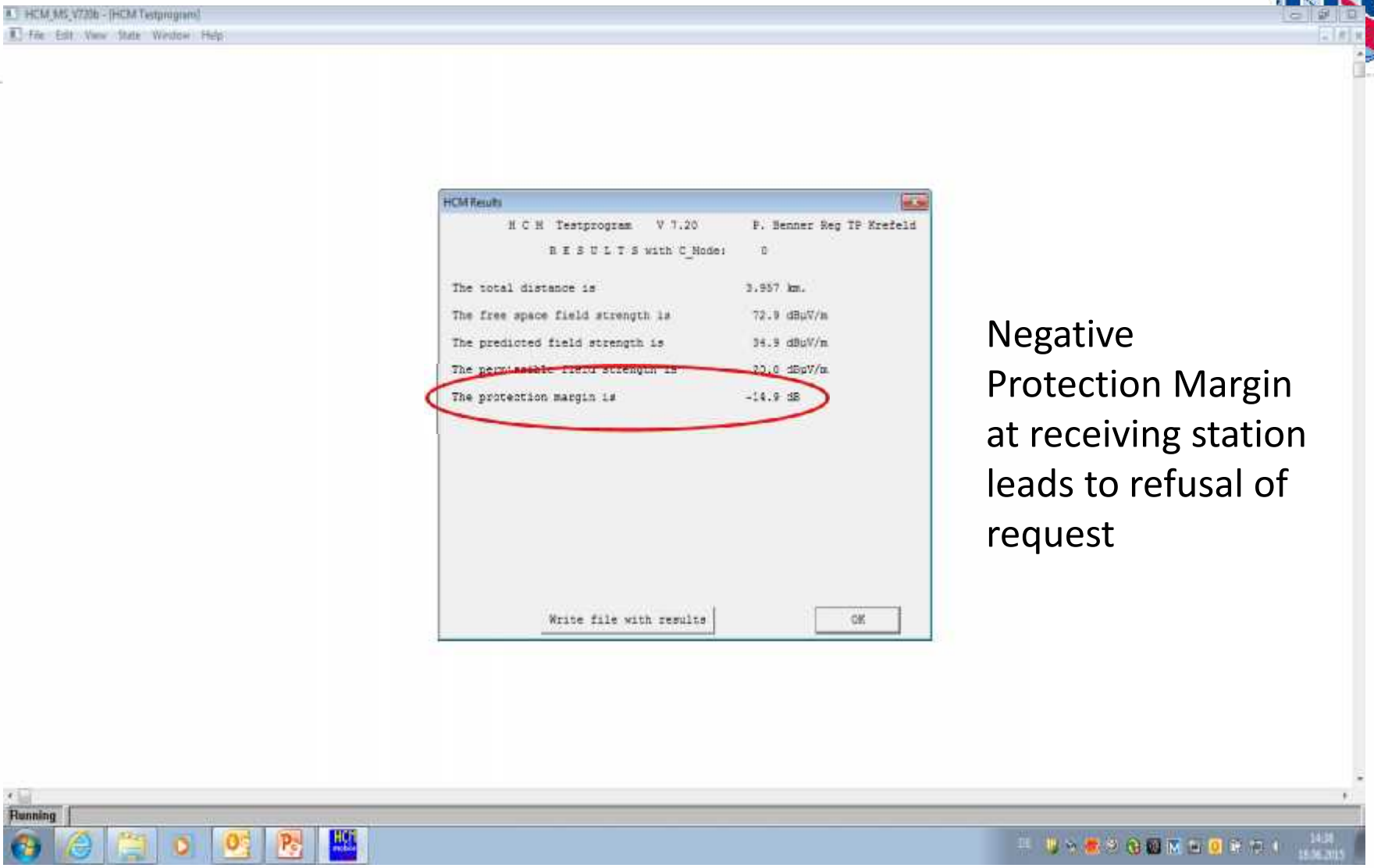
Input of data of transmitting station

Calculation of Interference: Fixed, Mobile



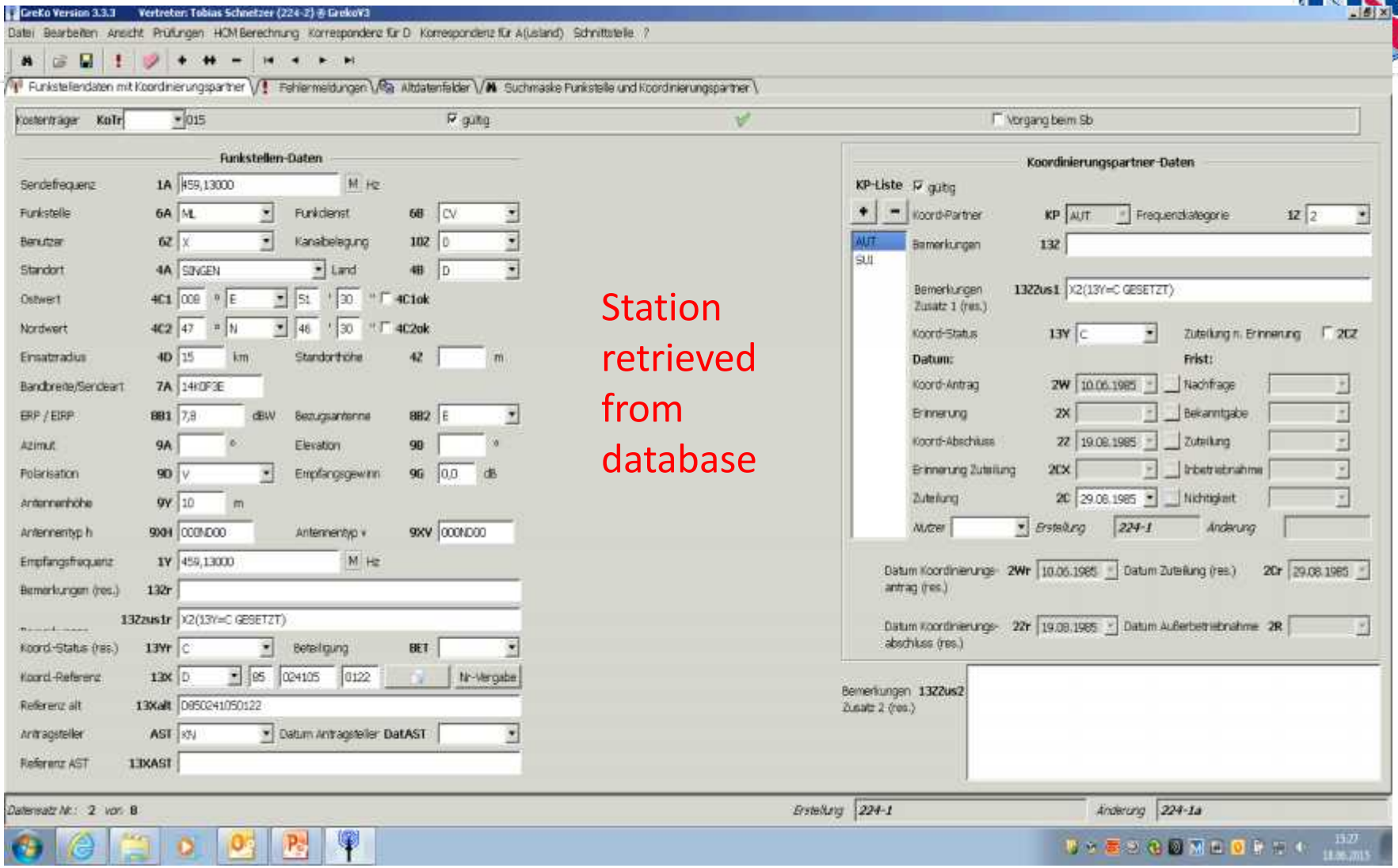
Input of data of receiving station

Calculation of Interference: Fixed, Mobile

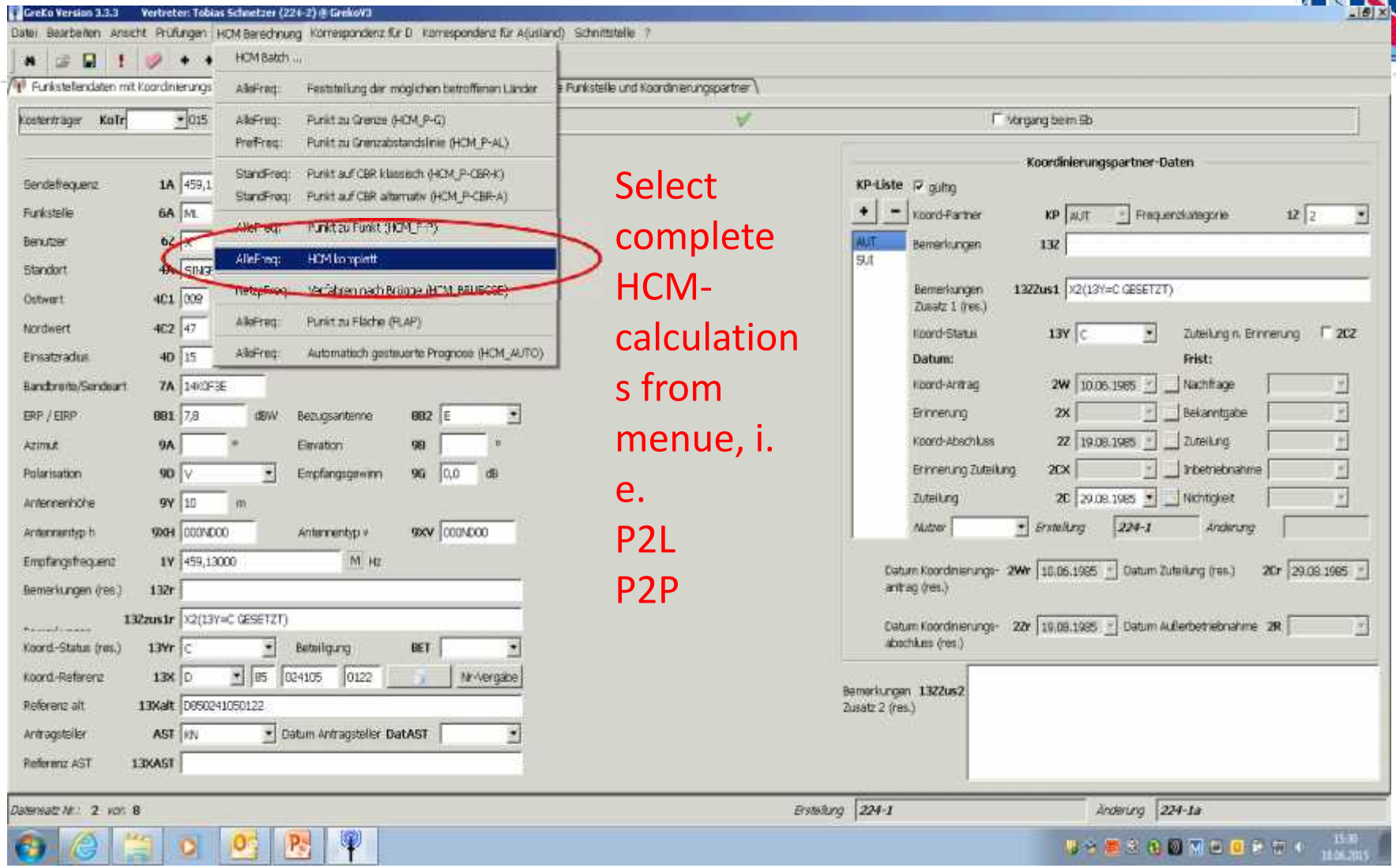


Negative Protection Margin at receiving station leads to refusal of request

Calculation of Interference: Fixed, Mobile

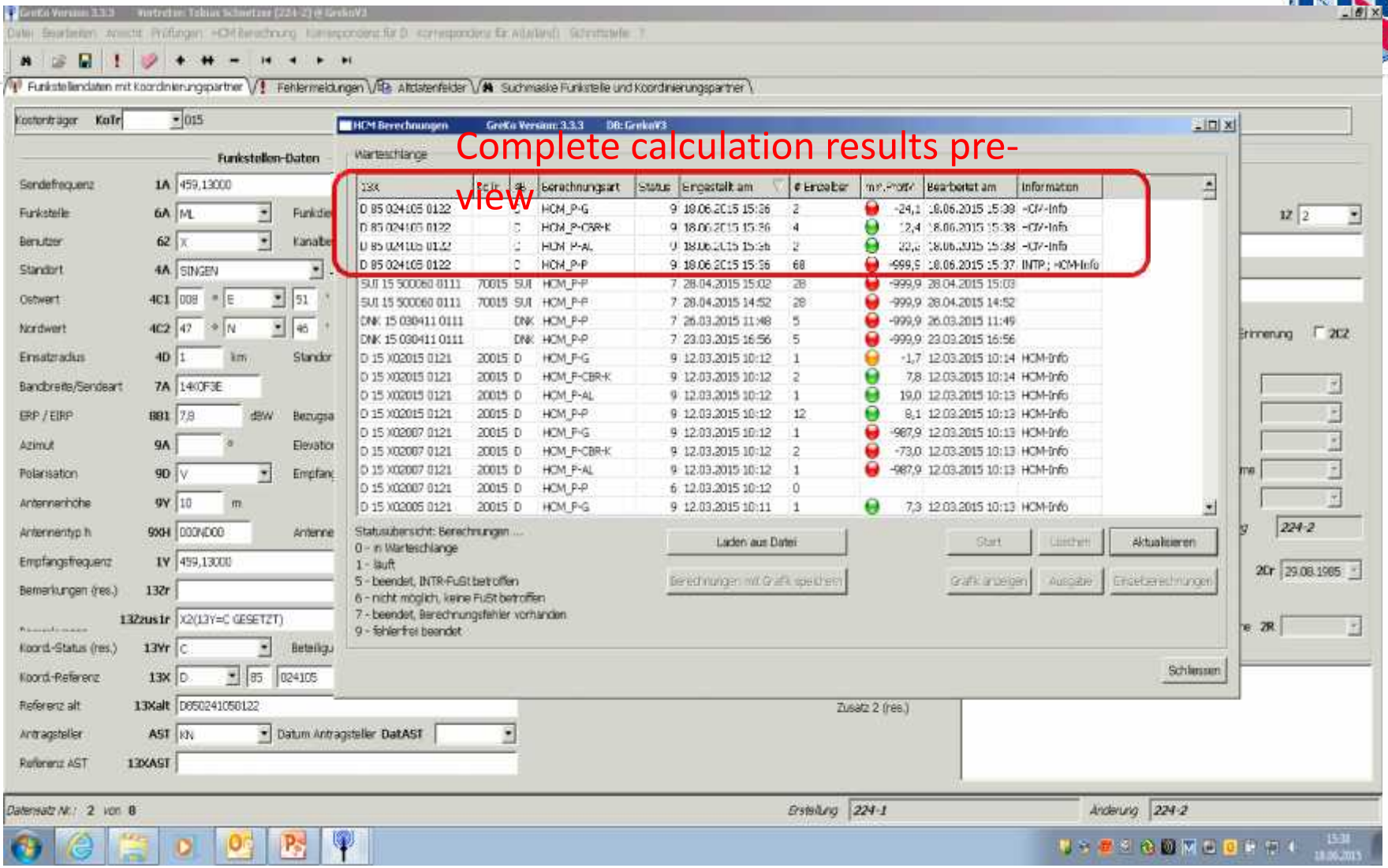


Calculation of Interference: Fixed, Mobile

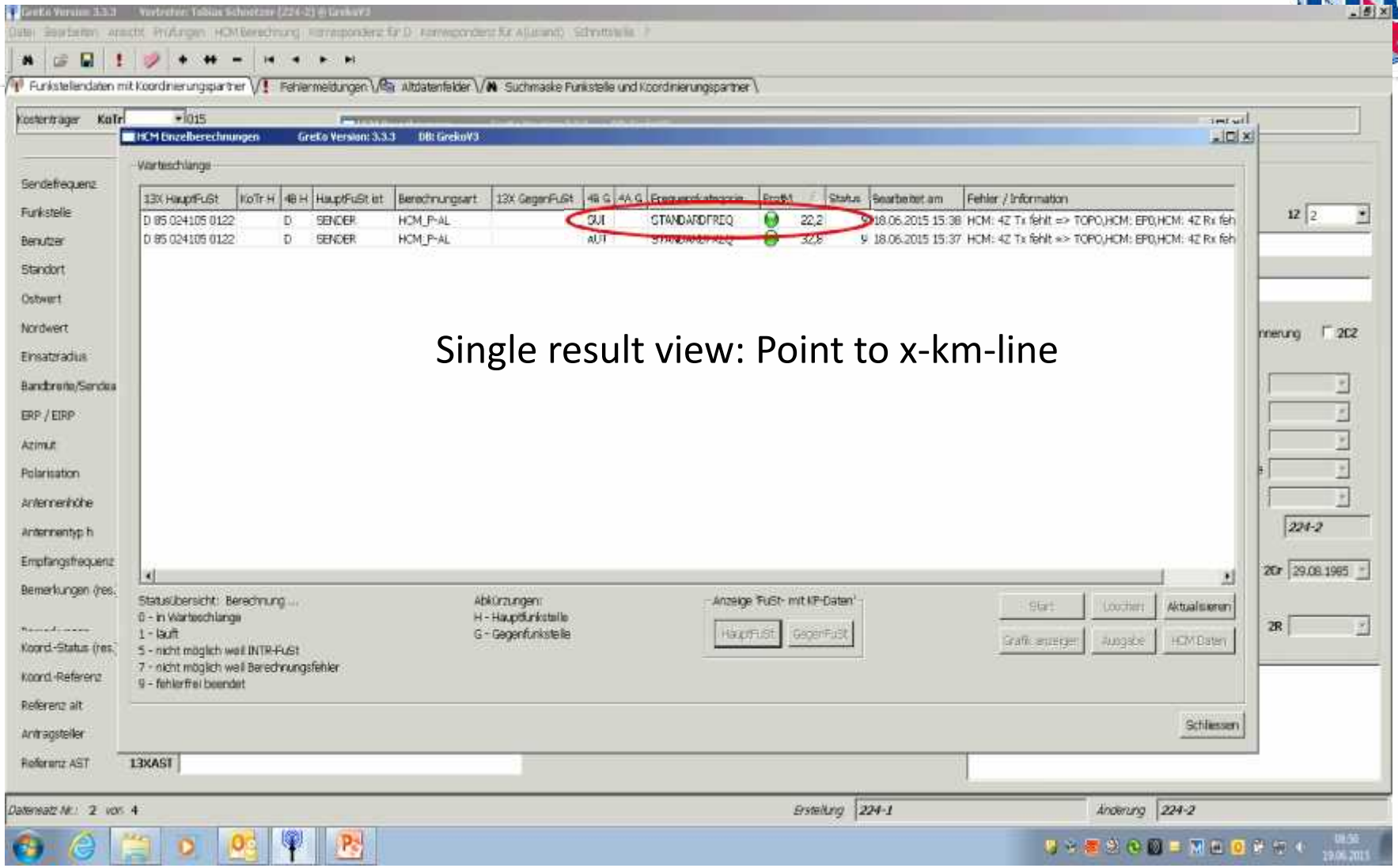


Select complete HCM-calculations from menue, i.e.
P2L
P2P

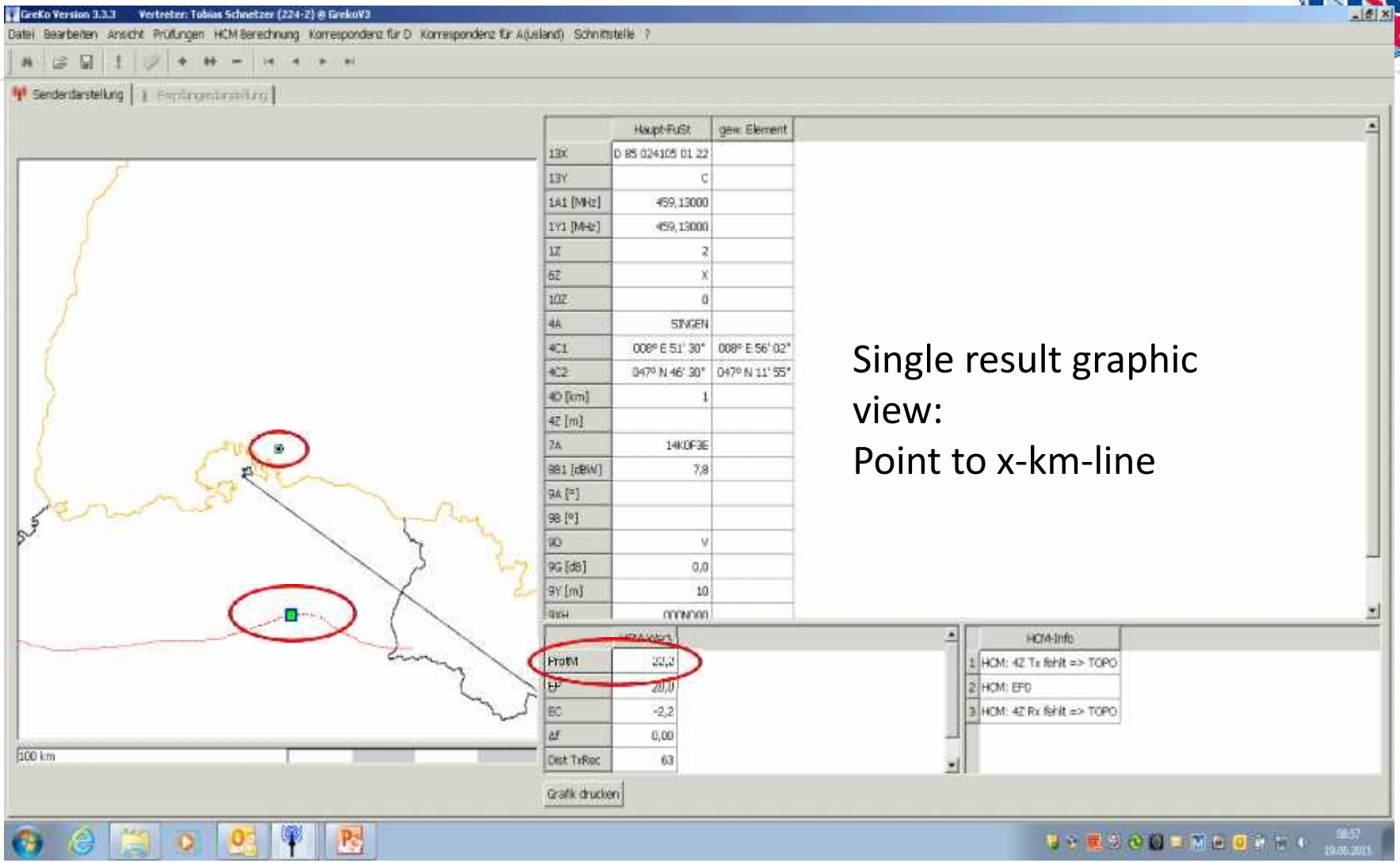
Calculation of Interference: Fixed, Mobile



Calculation of Interference: Fixed, Mobile

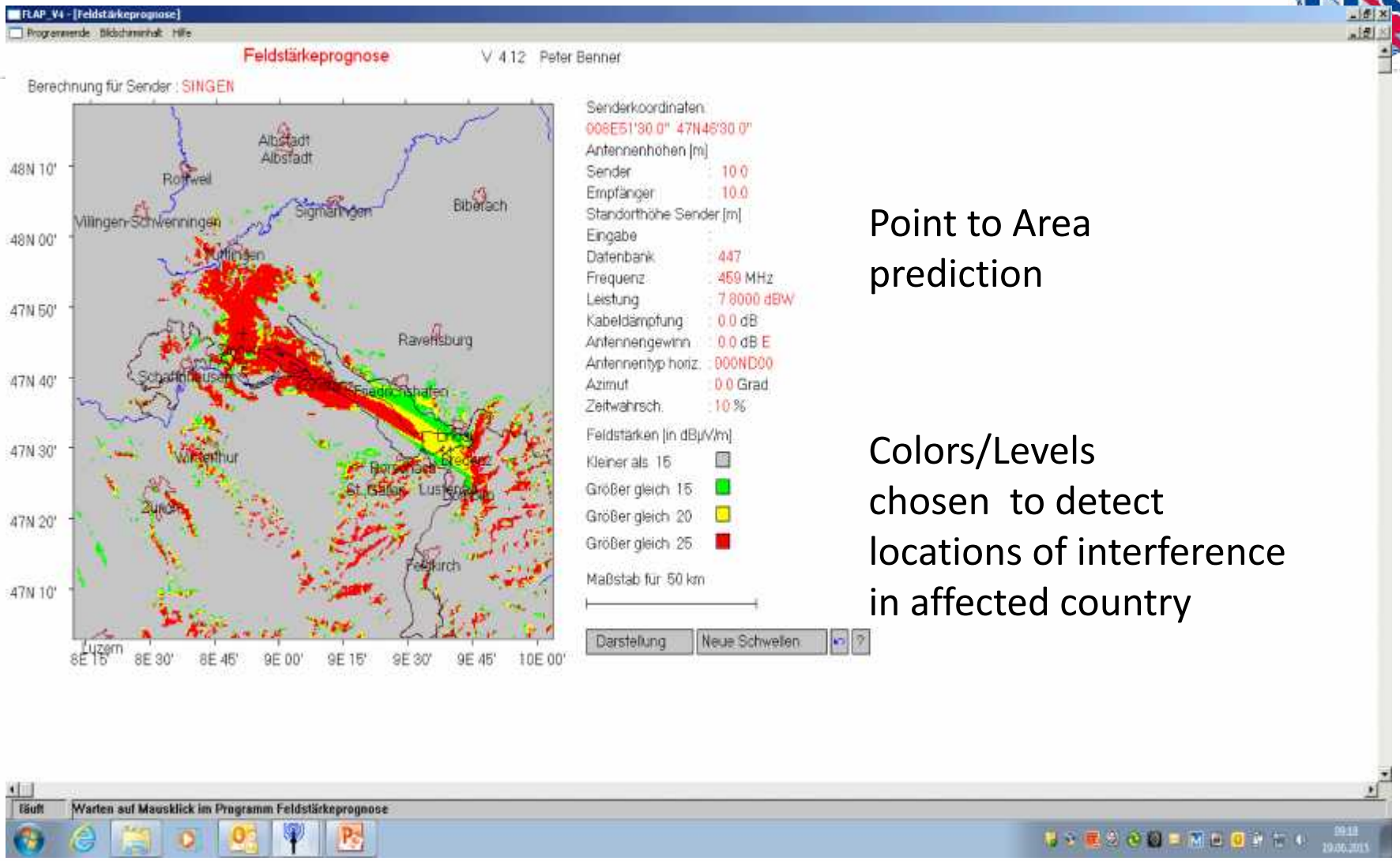


Calculation of Interference: Fixed, Mobile



Single result graphic view:
Point to x-km-line

Calculation of Interference: Fixed, Mobile



Point to Area prediction

Colors/Levels chosen to detect locations of interference in affected country

I Thank U

"Committed to connecting the WORLD"

Major ITU-ASP SM Events in 2017

ITU COE online training on Spectrum Management (Legal and wireless innovation Issues)
13 - 24 February 2017

ITU COE training on Spectrum Engineering and Cross border Coordination
Xian, China, May 2017

ITU-Forum Global regional workshop on Spectrum Management
Bangkok-Thailand, Q2/3 2017

ITU Study Group Meetings
ITU-D (Res. 9) and ITU-R SG1

Your active participation in and contribution to these events is most welcome!