Workshop on Network Planning Strategy for Evolving Network Architectures ror Asia Pacific Region

(ITU, Bangkok, Thailand, 11-15 November 2002)

Session 5.7

Supporting Network Planning Tools I

by

Roland Götz

Spectrocan / LS telcom AG

Dipl.-Ing. Roland Götz,
member of the board of management of LS telcom AG, studied electrical engineering and received his Dipl.-Ing. (M.S.E.E.) degree from the Technical University Karlsruhe/Germany.

From 1993 to 1998 he was with L&S Hochfrequenztechnik GmbH in various positions including that of head of Radio Network Planning Department. During this period he worked on the specification of radio network planning software, technical trainings, costumer support and RF planning projects.

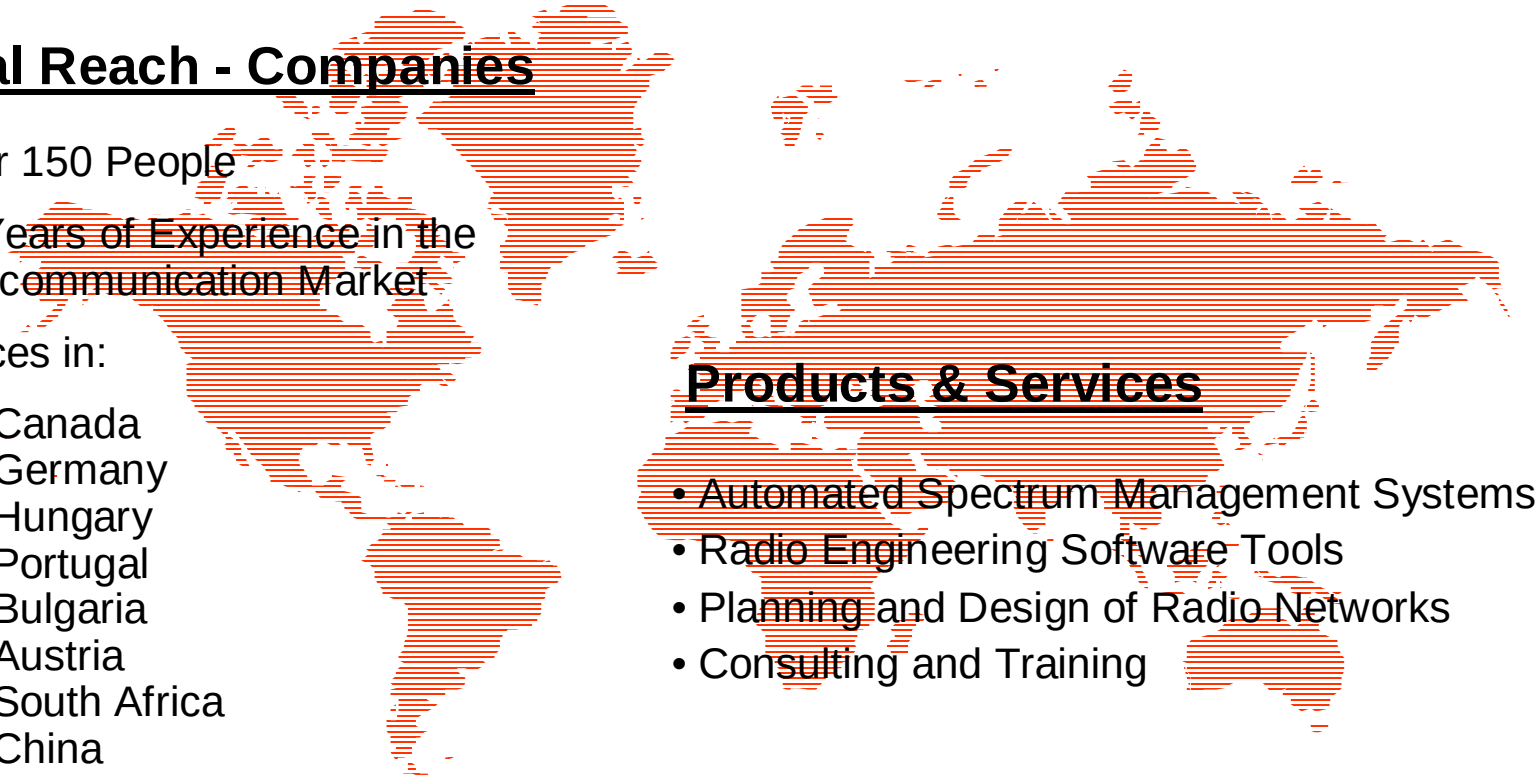
From 1998 to 2000 he was managing director of the new founded L&S Radio Communications GmbH performing radio network planning and consultancy services in the field of wireless communications.

Since 2000 he has been a member of the board of management of the LS telcom AG, responsible for the divisions consulting & engineering services as well as the strategic business development.

LS telcom Spectrocan

Global Reach - Companies

- Over 150 People
- 17 Years of Experience in the Telecommunication Market
- Offices in:
  - Canada
  - Germany
  - Hungary
  - Portugal
  - Bulgaria
  - Austria
  - South Africa
  - China



Products & Services

- Automated Spectrum Management Systems
- Radio Engineering Software Tools
- Planning and Design of Radio Networks
- Consulting and Training

Software for Regulatory Authorities:

License Issuance and Monitoring of Licensing Conditions to Guarantee Interference-Free Frequency Bands for all Services and Operators

Software for Network Operators

By use of LS telcom‘s comprehensive software solutions, clients can perform all essential planning and management tasks, which there are:

- Network calculations, dimensioning and analysis
- Coverage, frequency and traffic planning as well as market opportunity simulations
- Site planning for base stations; database for existing radio sites
- Management of sites and network elements
- Acquisition and maintenance of geo-data
- Terrain and field-strength profiles

Lines of Business – Consulting Services

Our Consulting Team includes Spectrum Managers and RF Specialists, who have managed Spectrum of various countries and assisted regulators worldwide.

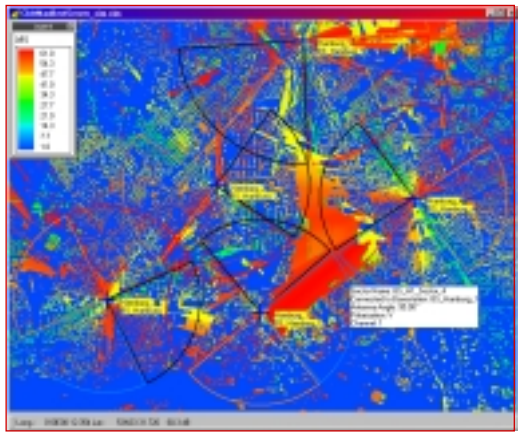
Several hundred person years of experience and capability in:

- Radio Policy
- Frequency Planning
- Spectrum Operations
- Automated Tools
- Radio Monitoring

- Preparation of Tender Documents
- Feasibility Studies / Expert Surveys
- Process / Workflow Development
- Technical Concepts

This comprises all sorts of planning services relevant to network operators, regulatory organisations and system suppliers, including:

- coverage analysis
- license application support
- network planning and design
- network implementation and radio site qualification
- network optimisation: interferences analysis and frequency plan optimisation
- geo data: consulting, generation, conversion and acquisition



Planning services are offered for all types of wireless communication systems.

Mobile networks (GSM900, UMTS), Trunking networks (Tetra, analog), Microwave links, PMP, Air traffic control, Maritime services, Analogue broadcast (FM), Digital audio broadcast (T-DAB), Digital video broadcast(DVB-T)

Trainings and Seminars

This comprises a wide variety of trainings in the whole field of telecommunications, including:

- Basic- and Expert-seminars for our Software Solutions
- Expert trainings for Radio Network Planning (mobile, microwave and broadcast services)
- Expert Trainings on Spectrum Management Tasks
- Seminars on radio site qualification and EMC
- Seminars on „New technologies“

ITU Centres of Excellence

AIBD - Asia-Pacific Institute for Broadcasting Development, Malaysia

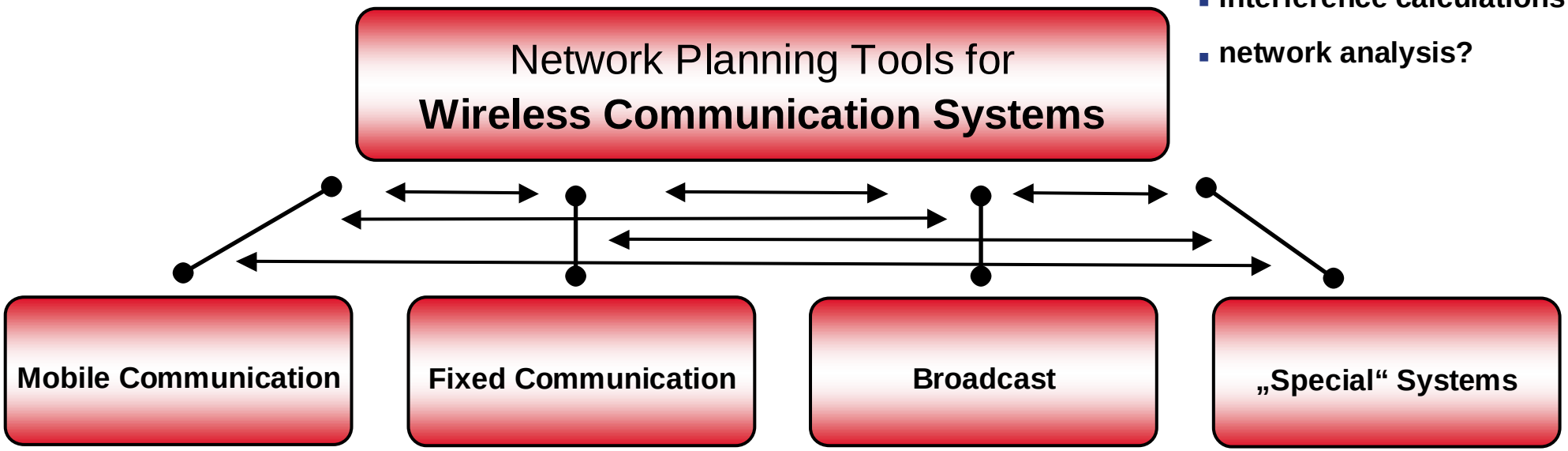
LS Training Center, Germany

Supporting Network Planning Tools

One fits All?

for:

- **basic coverage maps?**
- **interference calculations?**
- **network analysis?**



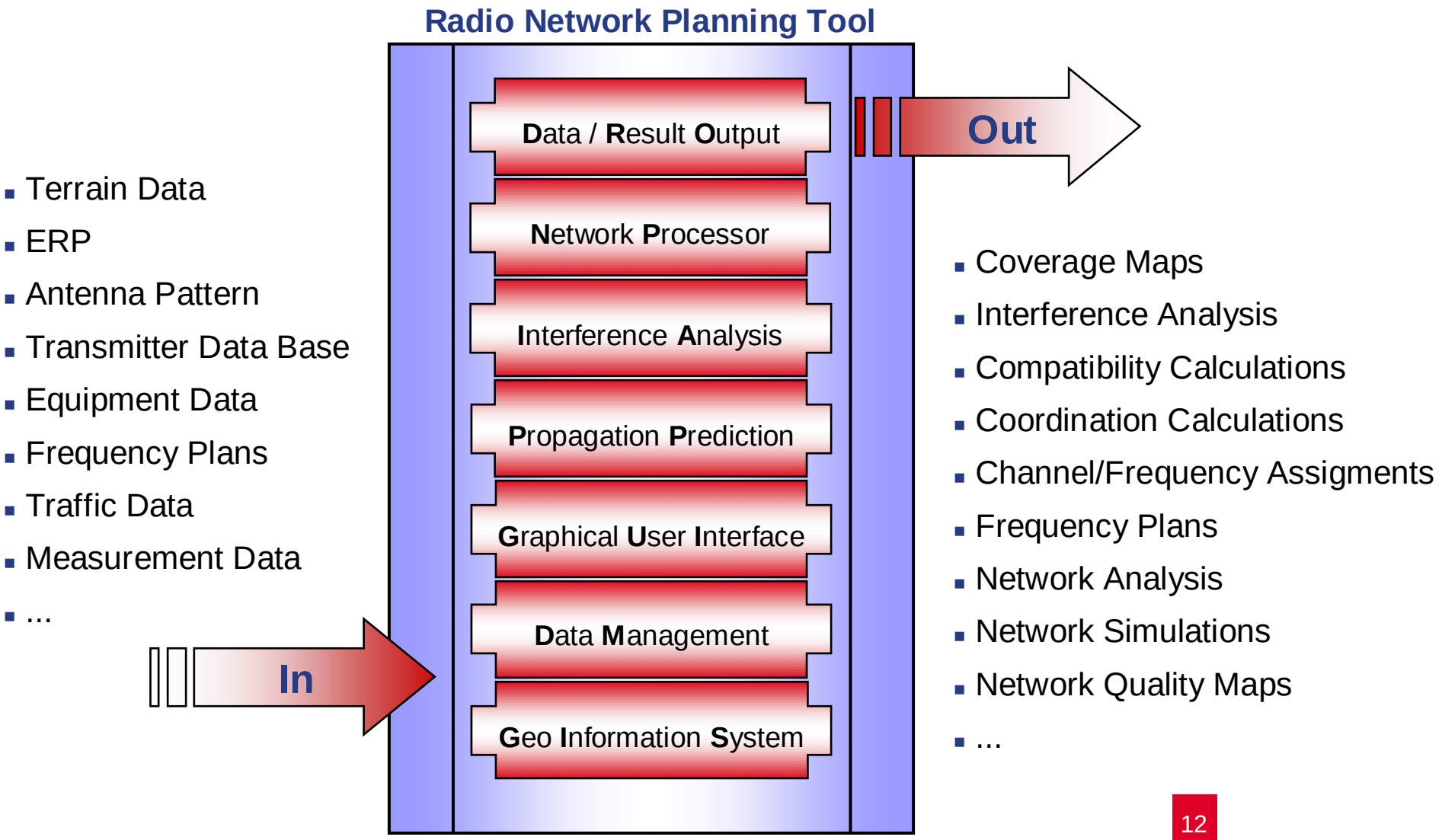
- analog
- GSM
- 3G / UMTS
- Trunking
- TETRA
- Land Mobile Systems

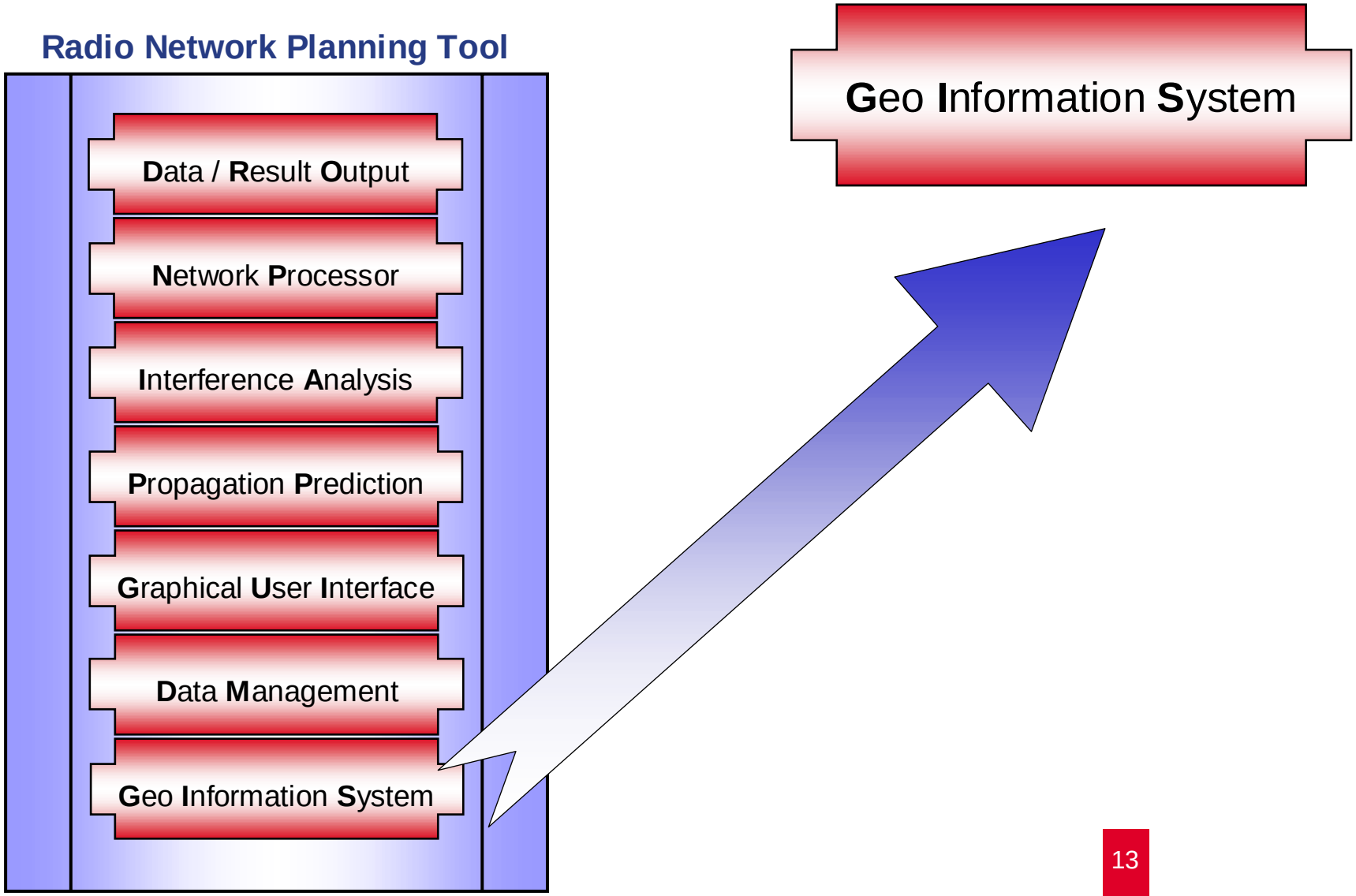
- Microwave (PtP)
- Point to Multipoint (PMP)
- Wireless Local Loop

- FM
- TV
- T-DAB
- DVB-T

- Satellite
- Air Traffic Control
- Maritime Services

Modern Radio Network Planning Tools





Modern Planning Tools typically use two basic Data Formats

Geo Information System

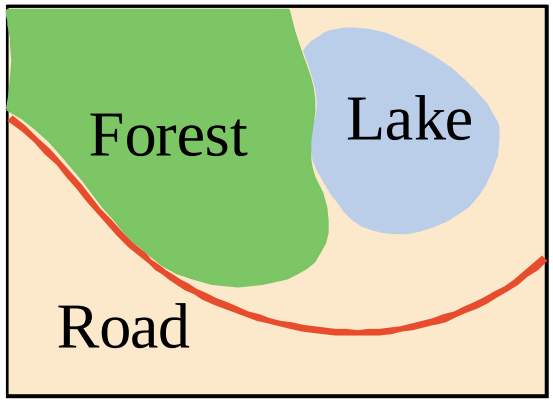
Vector Format

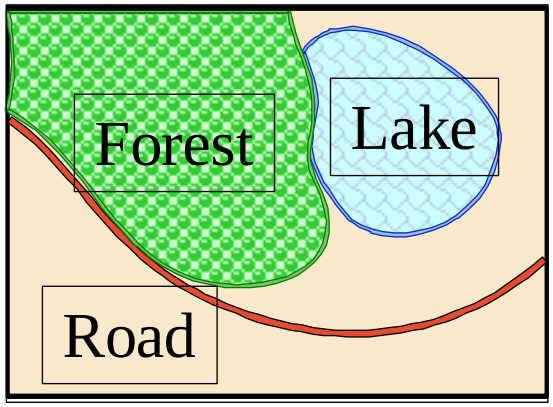
Geographical features described as:

- Points
- Lines
- Polylines

e.g.

- Names
- Contours
- Borders
- Roads



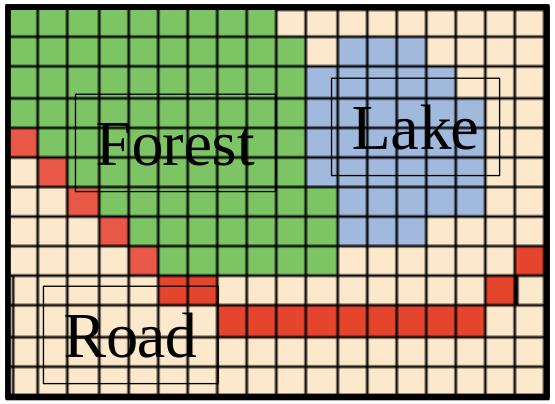


Raster Format

Geographical region divided in equally spaced areas (pixel)

Only **1** valued information for each pixel

- Elevation
- Clutter



Data Types

Modern Radio Network Planning Tools are using Digital Terrain and Mapping Data for:

- Display, Visualisation and Overlay Functionalities
- Comprehensive Calculations and Analysis (Coverage, Availability…)

Only used for Display, Visualisation and Overlay Functionalities

Geo Information System

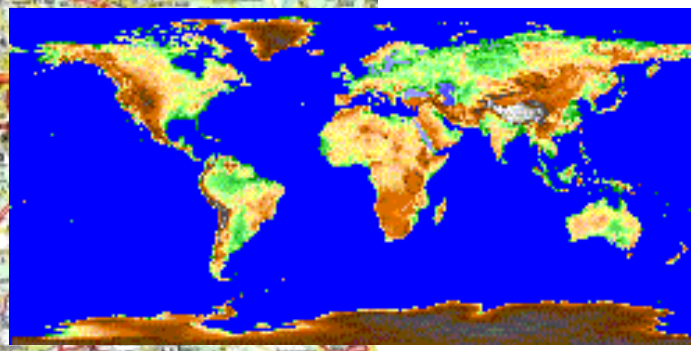
Overview Maps, Road Maps

Sources

- National Ordnance Survey
- Local Map Suppliers
- International Flight Maps

Scales

- 1:10,000
- 1:50,000
- 1:200,000 / 1:250,000
- 1:500,000
- ≥ 1: 1,000,000



...only used for Display, Visualisation and Overlay Functionalities

Geo Information System

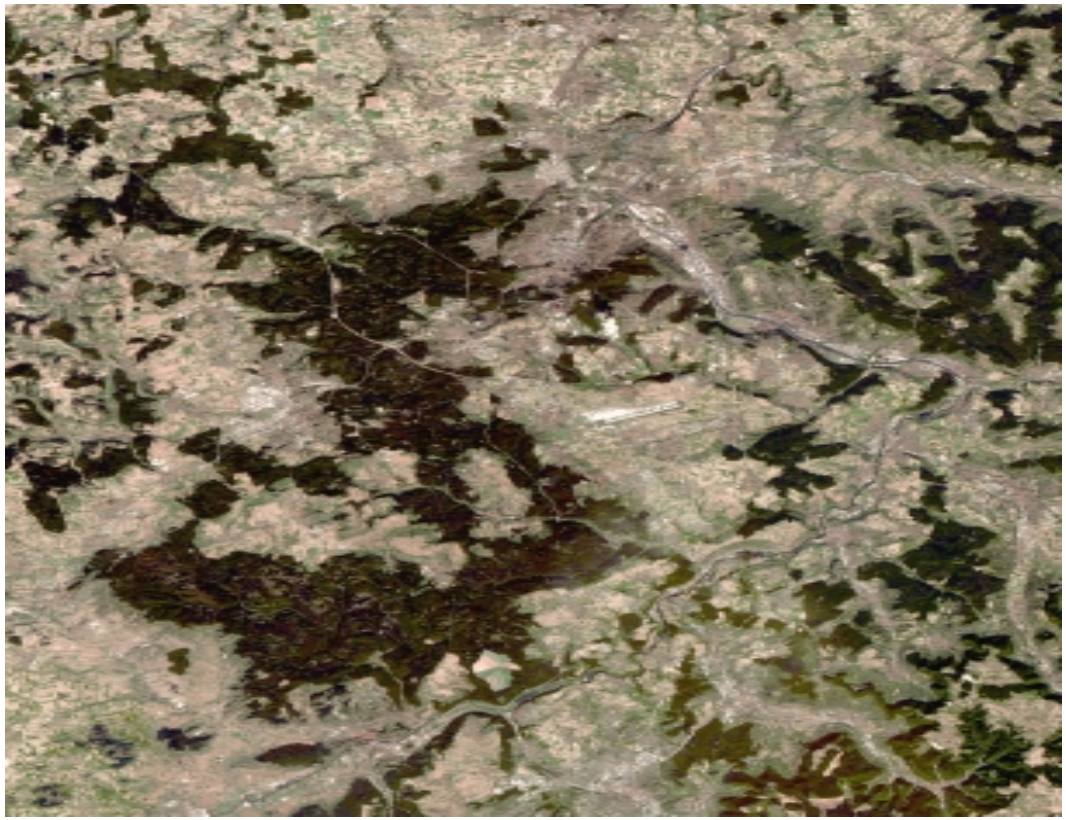
Satellite Images

Sources:

- SAR – Satellite Airborne Radar
- Optical Satellite Images
- Aerial Photography

Resolutions:

- 0.2 m
- 1 m
- 10 m
- 35 m
- 100 m



Data Types

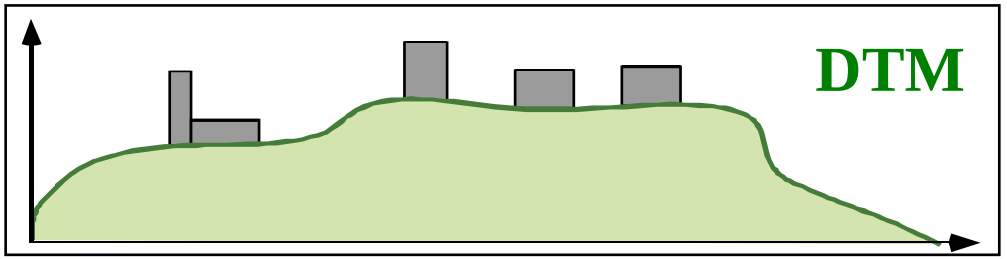
... also used for Calculations and Analysis

Geo Information System

Topographical Data ⇔ Elevation Data

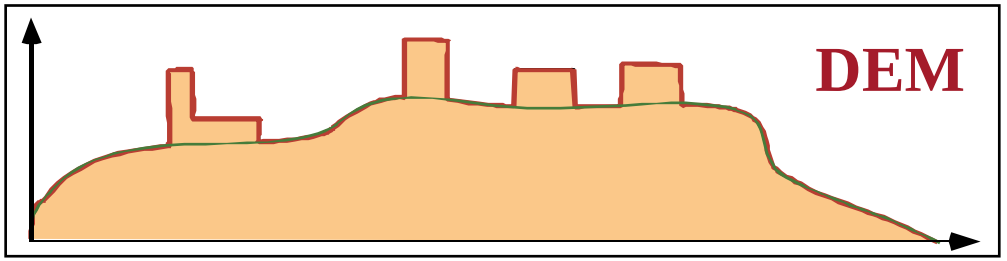
DTM – Digital Terrain Model

Elevation of earth surface



DEM – Digital Elevation Model

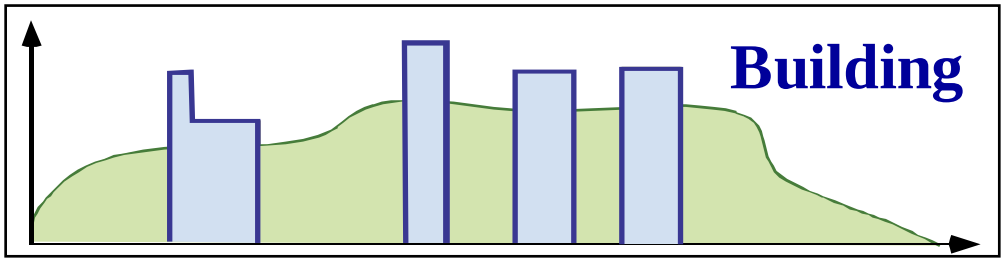
Elevation of earth surface
+ building height



Building

Elevation of earth surface
+ building height

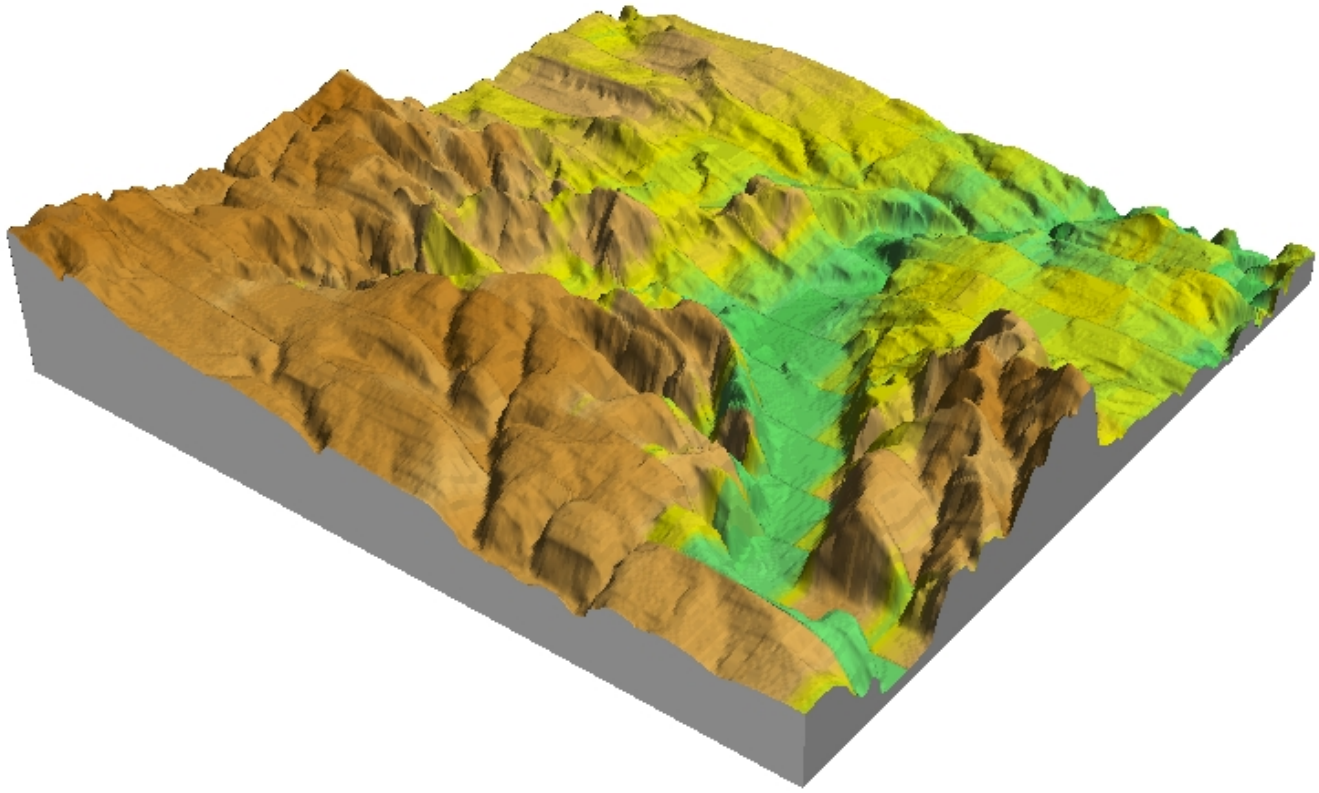
Only at building areas



DTM – Digital Terrain Model

Geo Information System

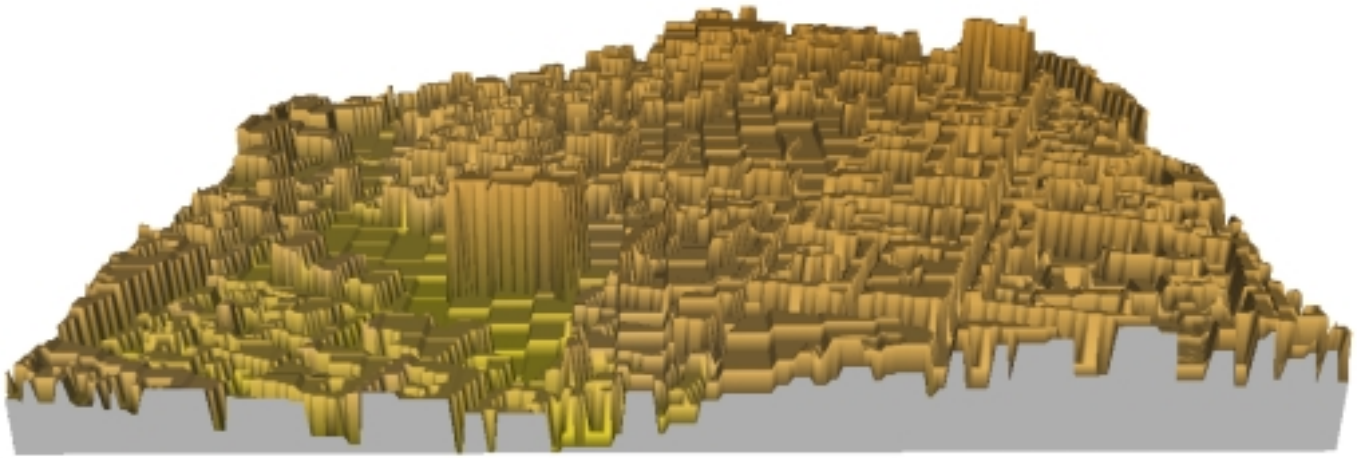
Resolution	Source: Paper Maps	SAR Satellite Data	Satellite Images	Aerial Photography	Laser Scanning
1000m	x				
500m	x				
200m	x				
100m	x	x			
50m	x	x			
25m	x	x	x		
10m	x		x	x	
5m	x			x	x
1m	x			x	x



DEM – Digital Elevation Model

Geo Information System

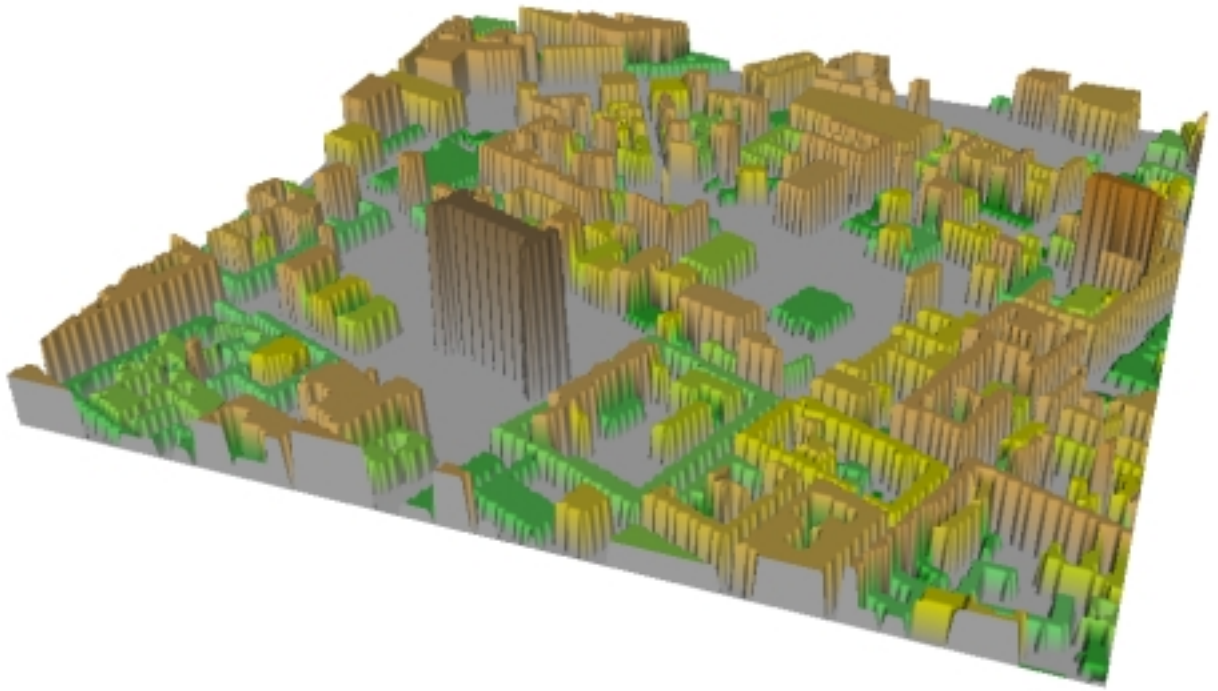
Resolution	Source: SAR Satellite Data	Satellite Images	Aerial Photography	Laser Scanning
1000m				
500m				
200m				
100m				
50m				
25m	x	x		
10m		x	x	
5m			x	x
1m			x	x



Building Data

Geo Information System

Resolution	Source: SAR Satellite Data	Satellite Images	Aerial Photography	Laser Scanning
1000m				
500m				
200m				
100m				
50m				
25m	x	x		
10m		x	x	
5m			x	x
1m			x	x



... also used for Calculations and Analysis

Geo Information System

Clutter Data

Also called:

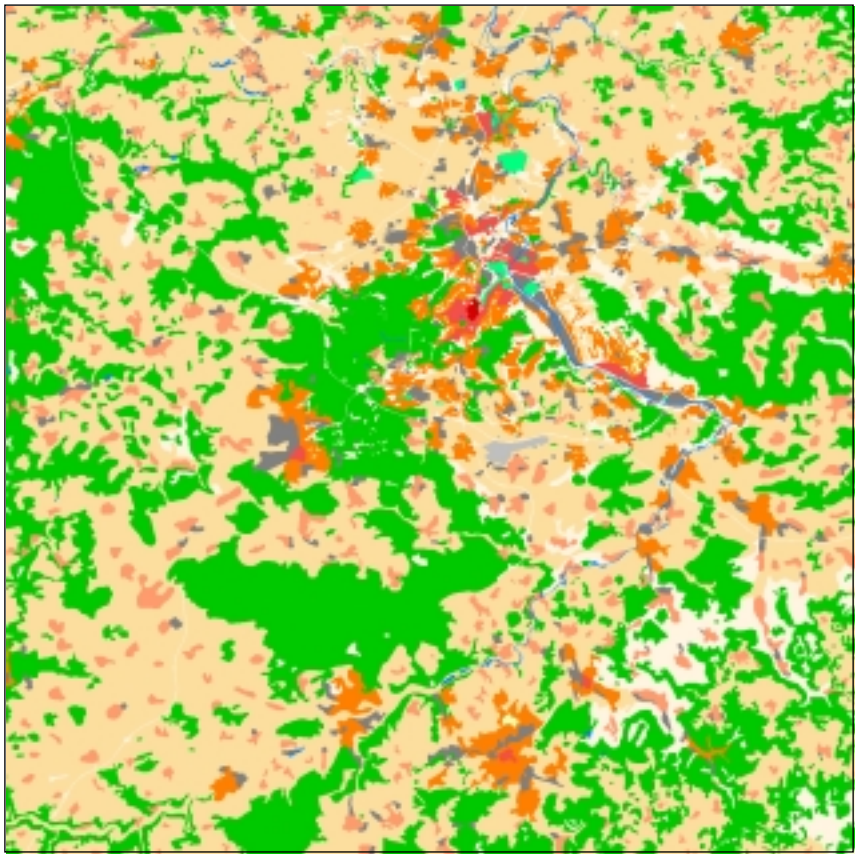
Morpho

Land-Use

Land-Coverage

Stores information about the coverage of the earths surface, like:

- Water
- Agricultural land
- Forest
- Village
- Industrial
- Urban

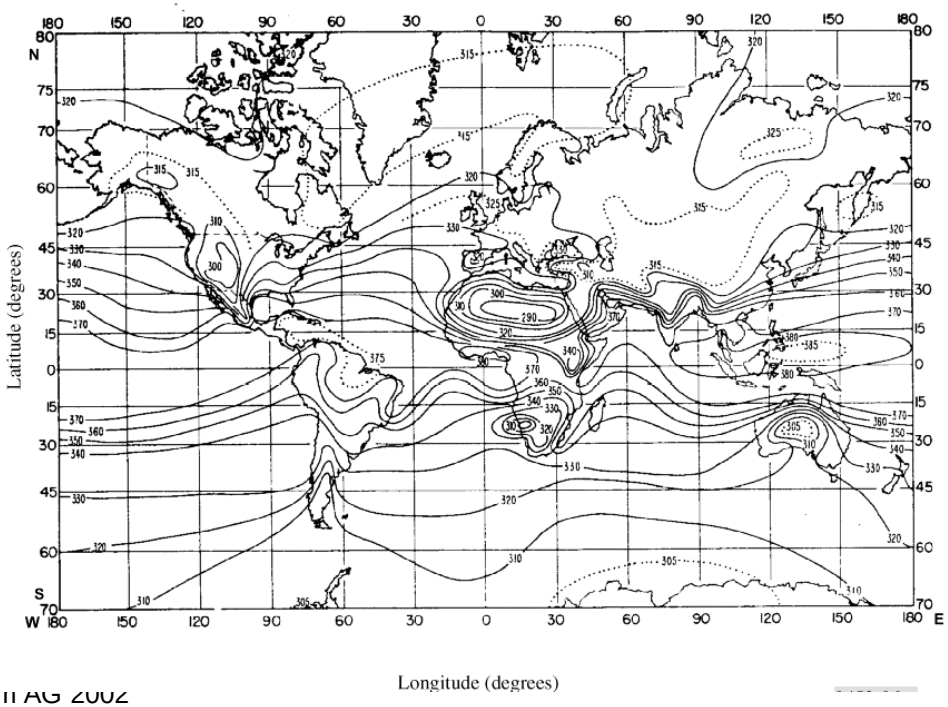


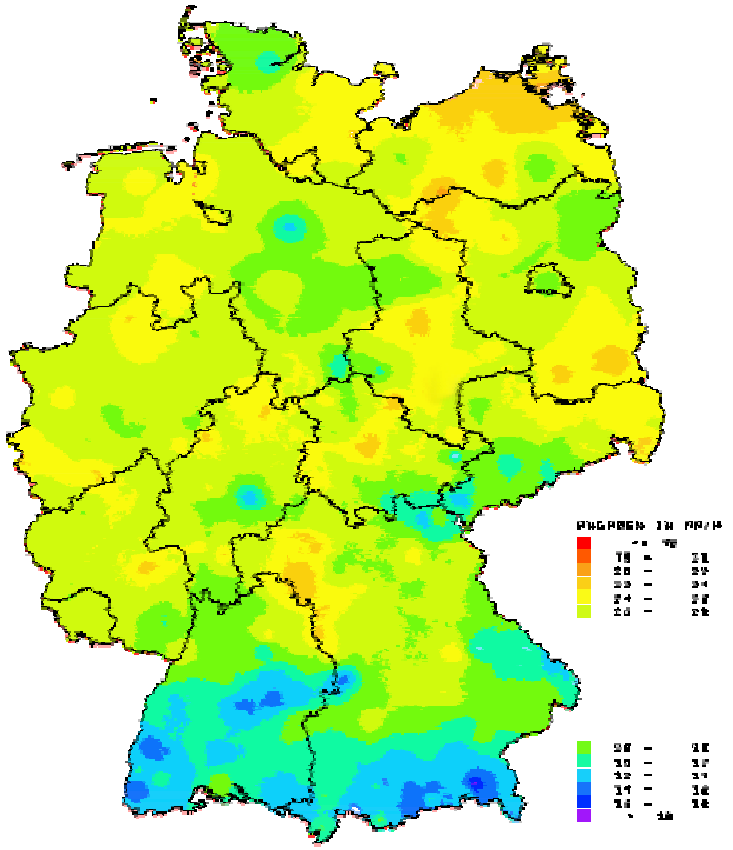
Resolution	Source: Paper Maps	SAR Satellite Data	Satellite Images	Aerial Photography	Laser Scanning
1000m	x				
500m	x				
200m	x				
100m	x	x			
50m	x	x			
25m	x	x	x		
10m	x		x	x	
5m	x			x	x
1m	x			x	x

... for special Calculations and Analysis

Geo Information System

- Radio Climatic Zones
- Rain Rates
- Sea Level Surface Refractivity N0
- Electrical ground Conductivity
- Population Density





Live
Planning Tool Demonstration

„CHIRplus_M“
Design Tool for Planning & Optimizing Mobile Networks

Turn Key Data Services

- **The Quality of the Planning results are strongly dependend on the the type and quality of the used data.**
- **The best data for the planning job have to be found considering the costs.**

Turn Key Data Services

Generation of Digital Terrain Data

DTM, Clutter,Population, Traffic, Conductivity

Conversion of Customer Data

Conversion between different file formats

Transformation between different Coordinate Systems

Integration into LS telcom tools

Terrain data

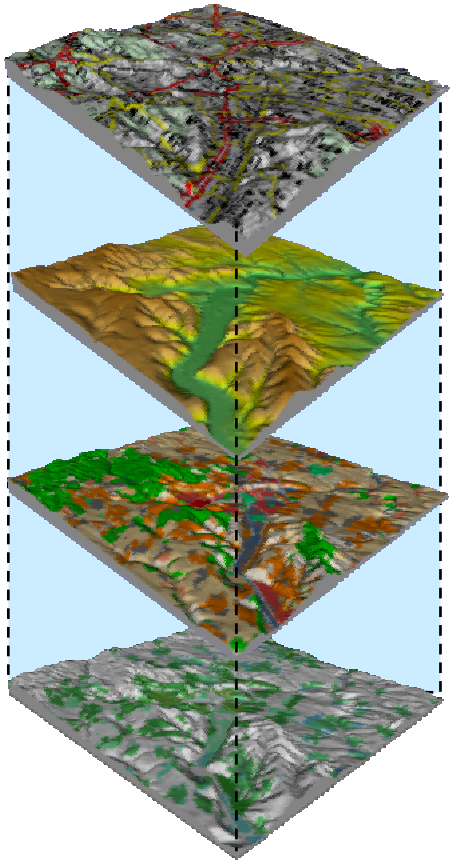
Local Coordinate Systems

Independent Evaluation of

Available data on the market

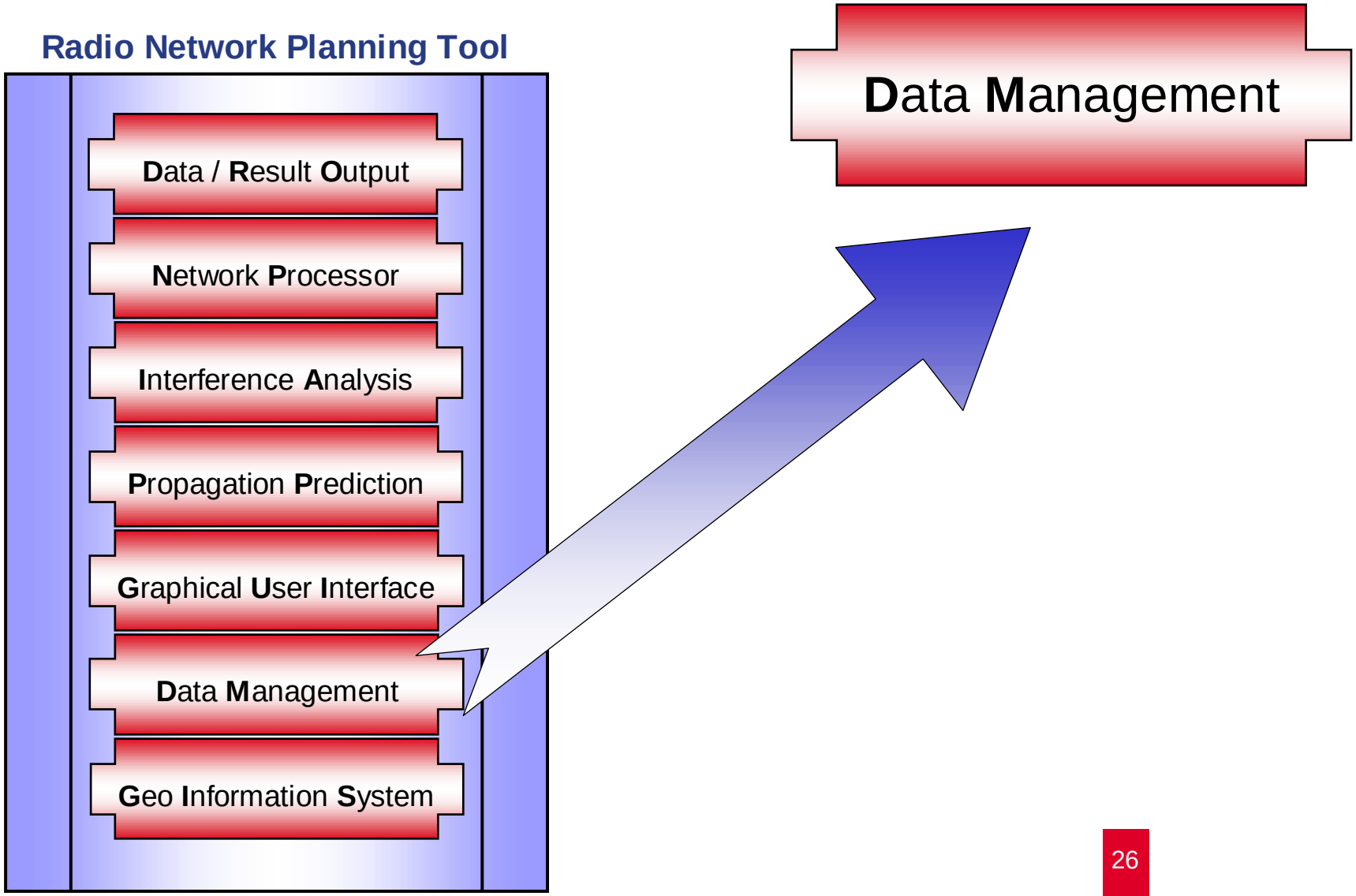
Best quality ⇔ price relation

Consulting



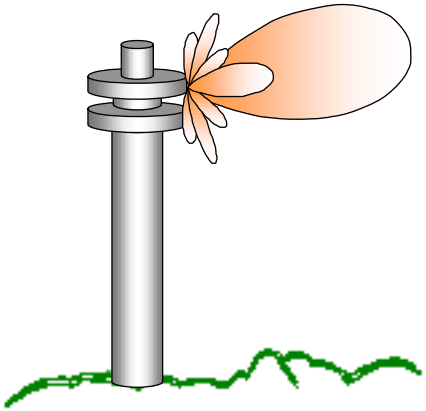
Software Tool

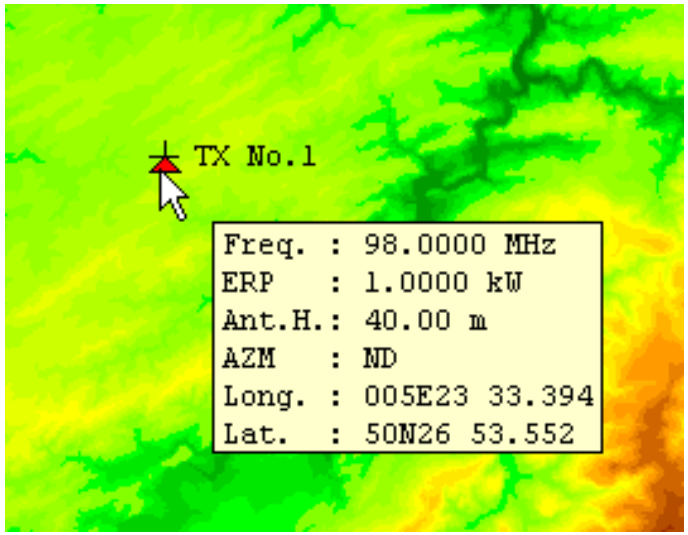
CATCHit



What is the Minimum Set of Data you need to perform a Basic Coverage Prediction?

- Coordinates of the Transmitter
- Radiated Power
- Frequency
- Antenna Pattern





What other kind of Data have to be managed and Why?

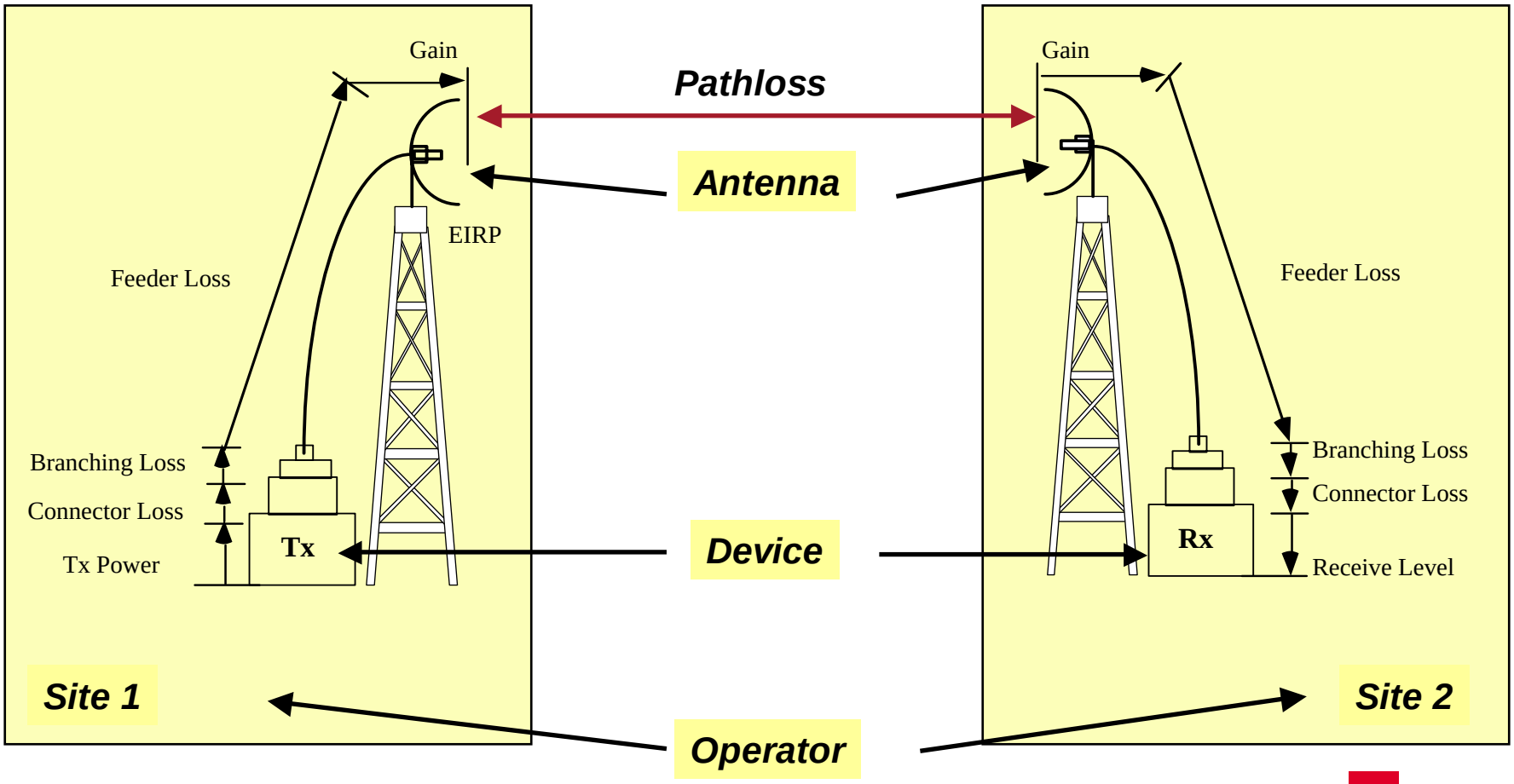
- **Data describing the Transmitter**
  - Antenna
  - all technical parameters (power range, frequency range, sensitivity...)
- **Data describing the Network**
  - Sites
  - Cells, Sectors, links
  - neighbouring relations
  - frequency plans, frequency rasters
- **Data describing Interfering Networks**
  - same service other operators
  - other services
  - in other countries

What other kind of Data have to be managed and Why?

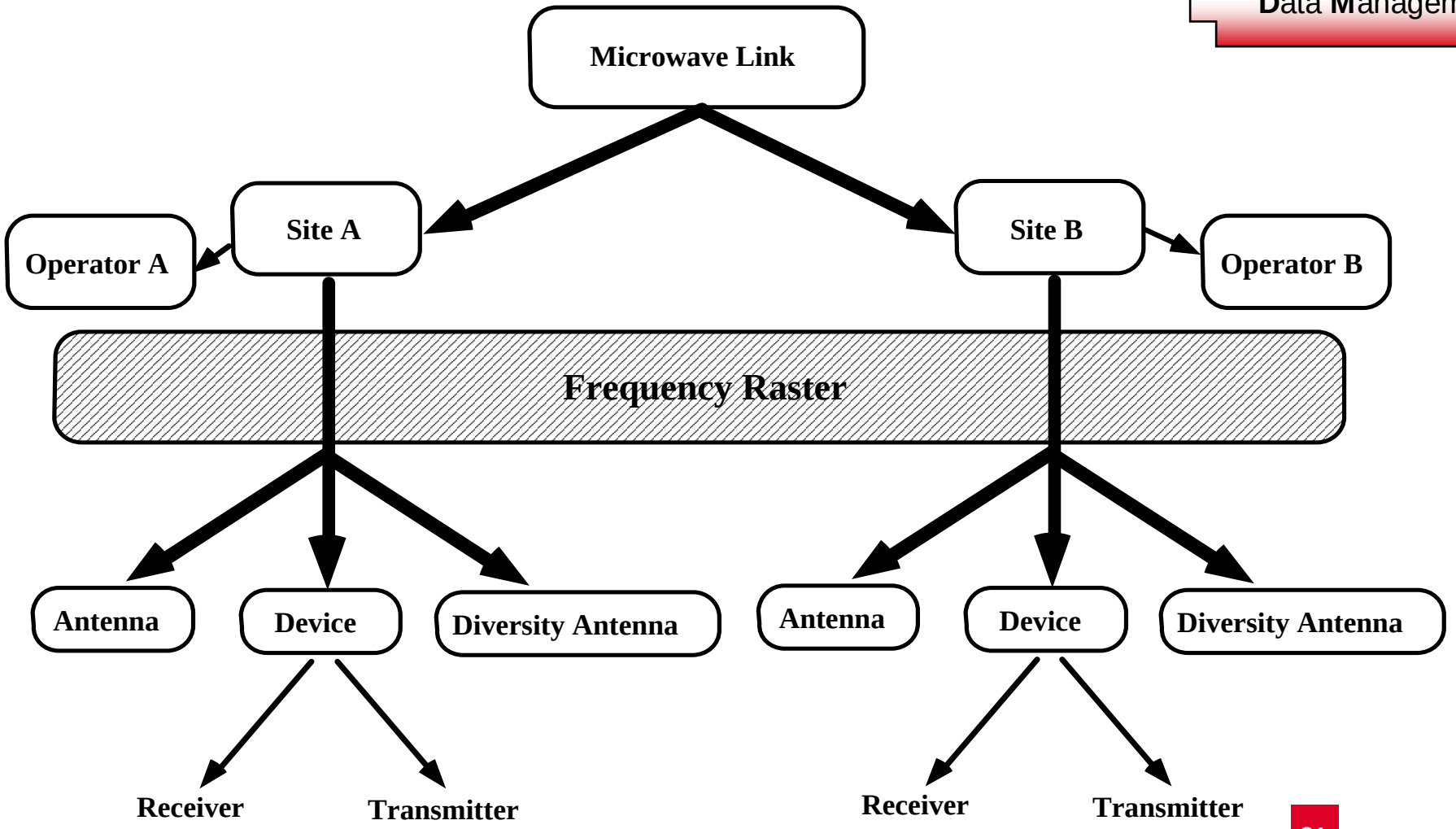
- **for Tool Administration**
  - User / Role
  - Password
  - System Layout
- **Result Data Base**
  - Coverage Maps
  - Interference Relations
  - Network Analysis

  which have been performed in the past
- **Libaries**
  - Antenna Equipment
  - Transmitter Equipment
  - Receiver Equipment
  - ...

Example: Microwave Link



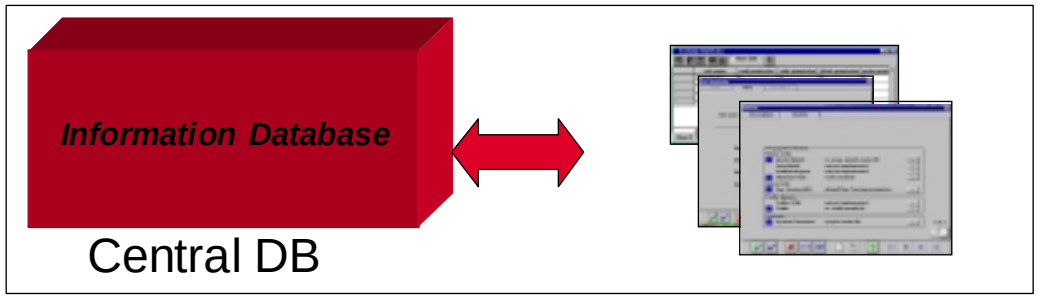
Example: Microwave Link

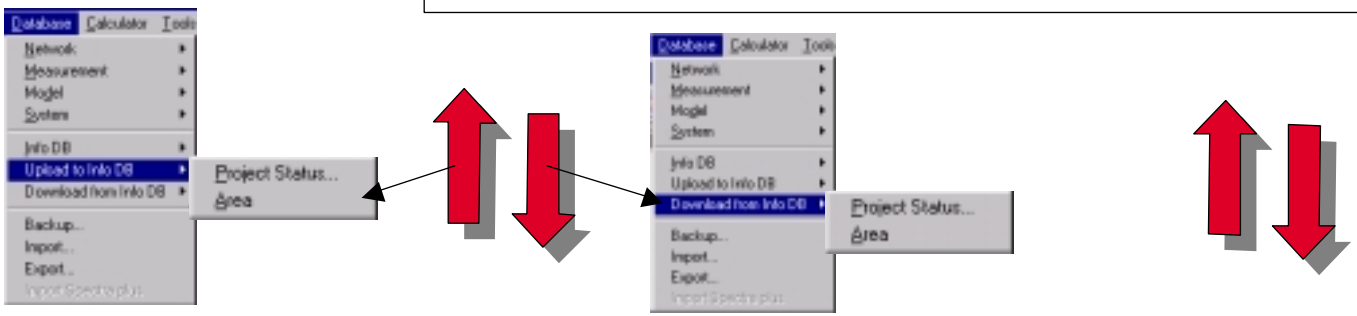


Database Concepts

Data Management

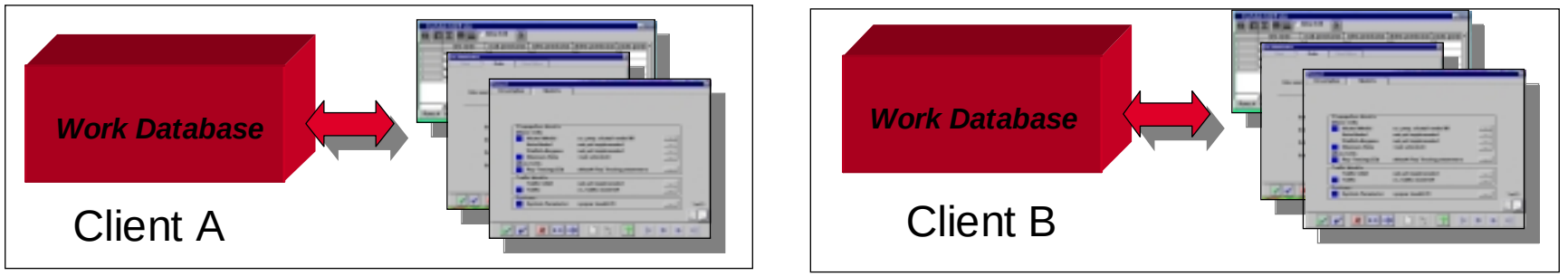
Information Database





Update IDB (area or project status)

Update your WDB (area or project status)



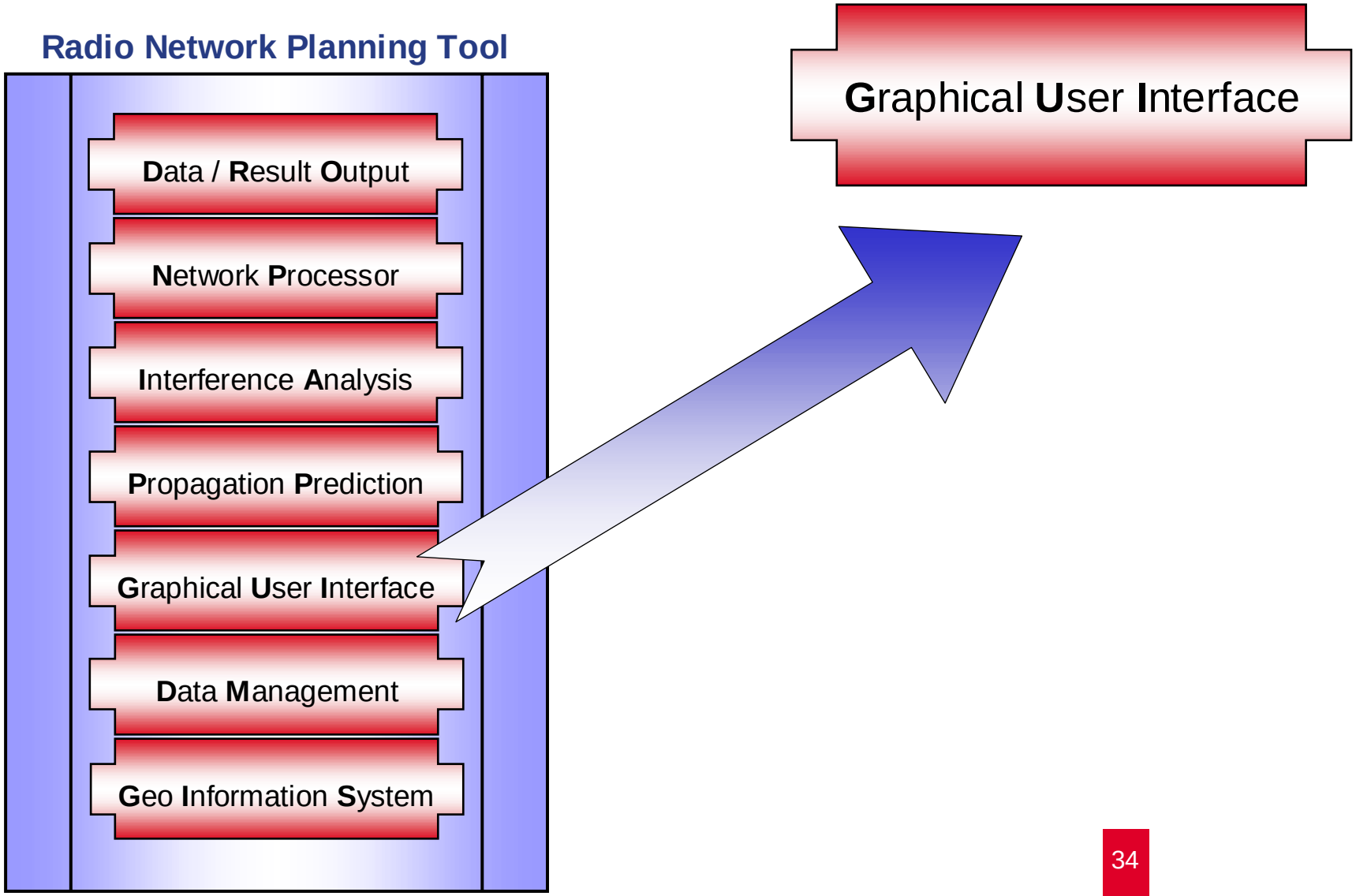
Working Database

Detailed Data Information

- **are necessary to perform comprehensive network analysis / optimisations**

An comprehensive Data Management

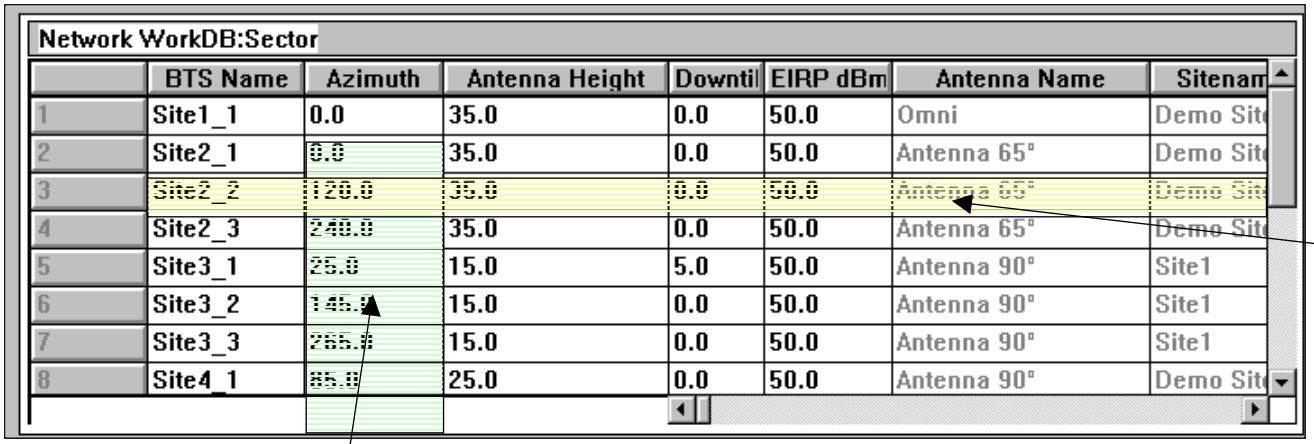
- **allows keeping all network data in one central data base**
- **makes daily work easier (Libraries)**



Graphical User Interface

Spreadsheets offer a view on database tables.

All records of the related database table (e.g all sectors) can be edited:



Each row contains information for one object e.g Antenna type, antenna height, azimuth etc. for a specific sector

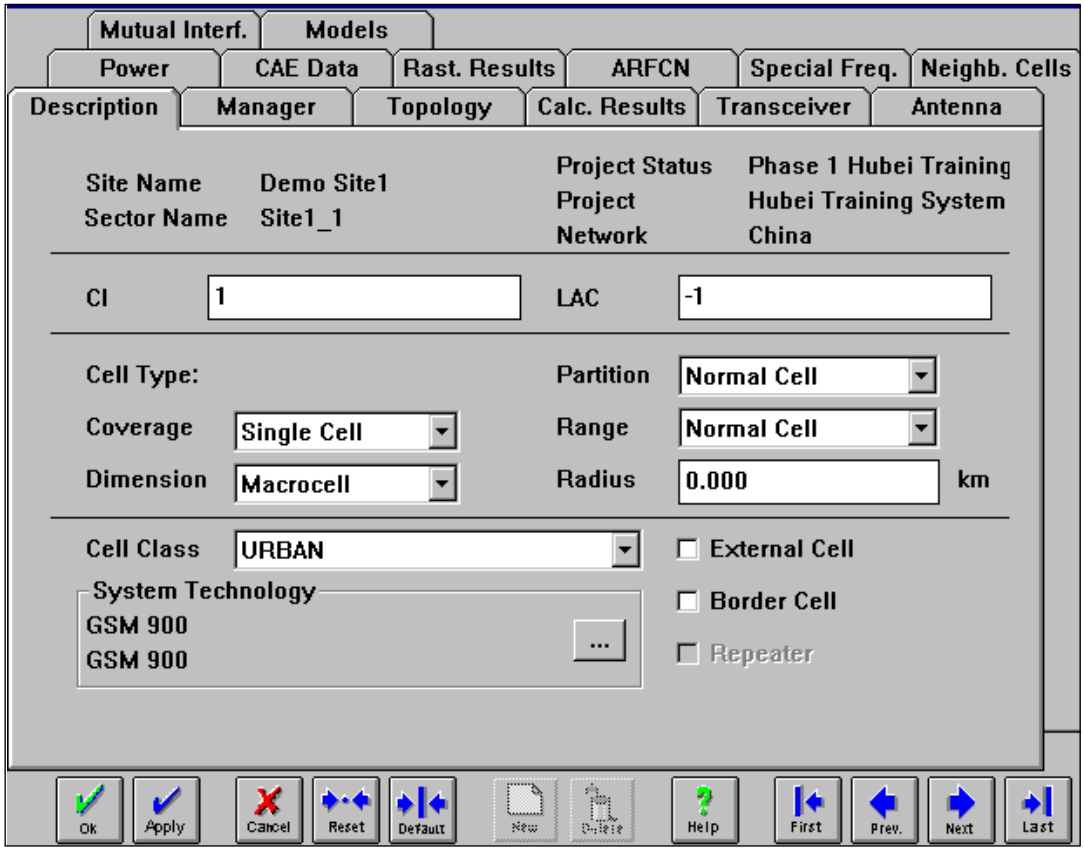
Each column stands for one specific database field e.g Antenna Height

The following options are available to work with spreadsheets

- Edit functions
- Query Functions
- Functions to change the layout of the spreadsheet
- Functions for graphical display of the spreadsheet data
- Import / Export Functions

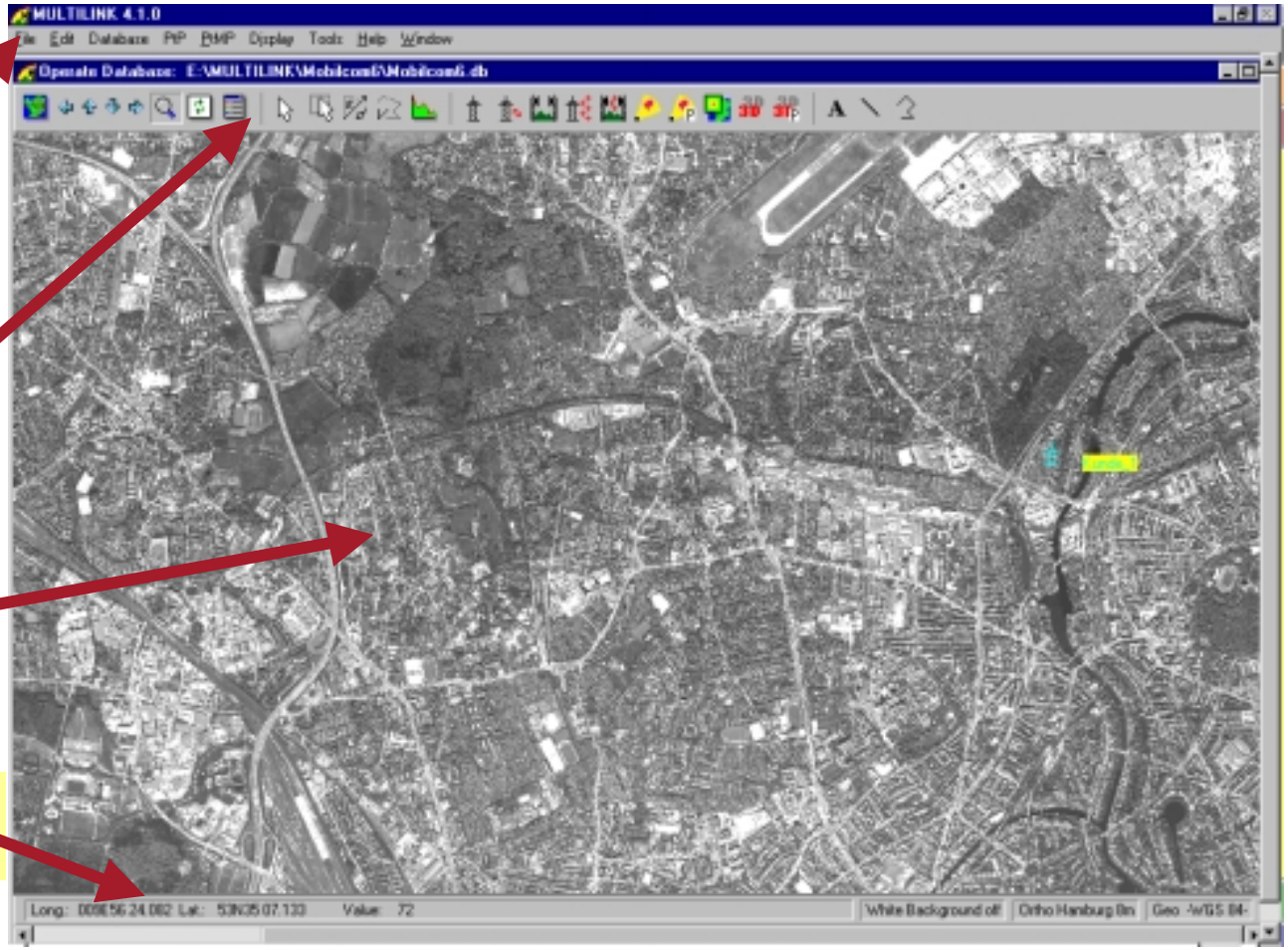
Graphical User Interface

Editor views allow to edit all data related to a specific object



Working Window

Graphical **U**ser **I**nterface



Menu

Toolbar

Working map

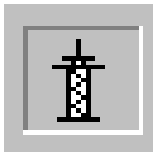
Value display (status bar)

Task: Creating new Sites

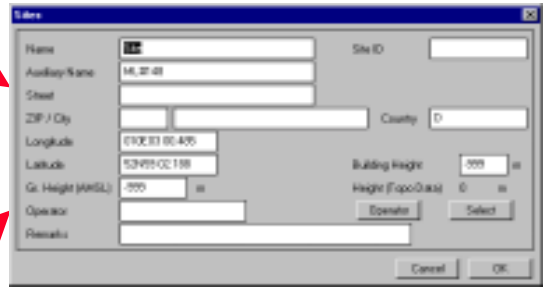
Graphical User Interface

1. Graphically on a map:

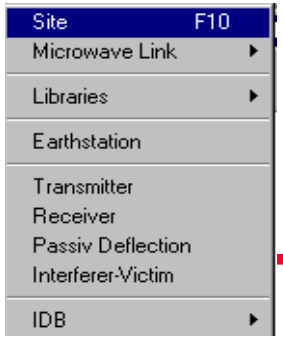
- *Activate the site tool*
- *Click on a pixel on the map*

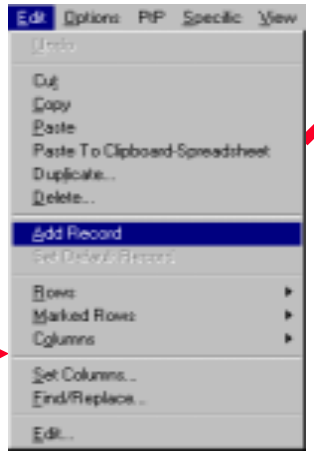


Co-ordinates from selected position on map



2. In the site table:

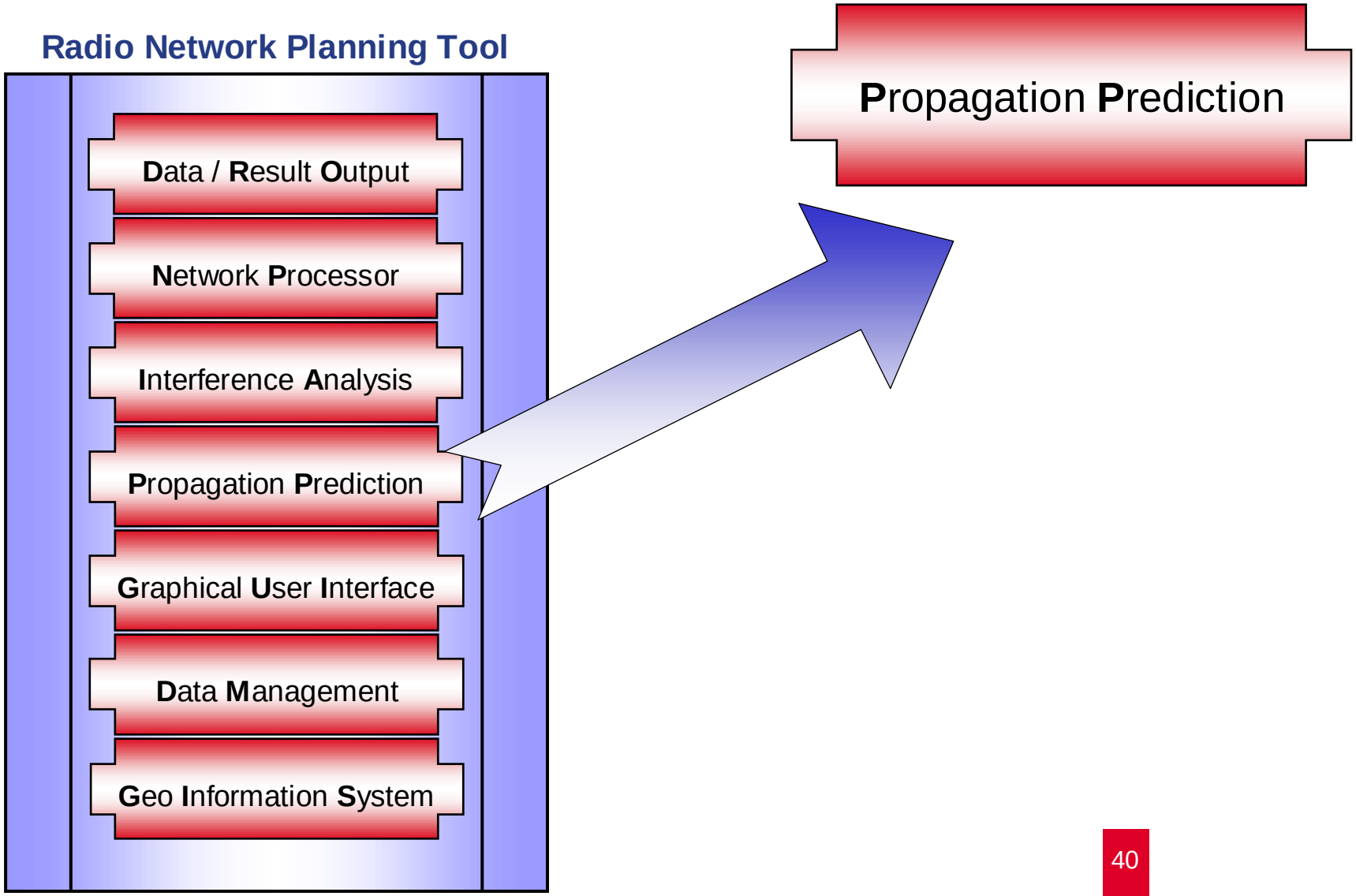




Enter co-ordinates manually

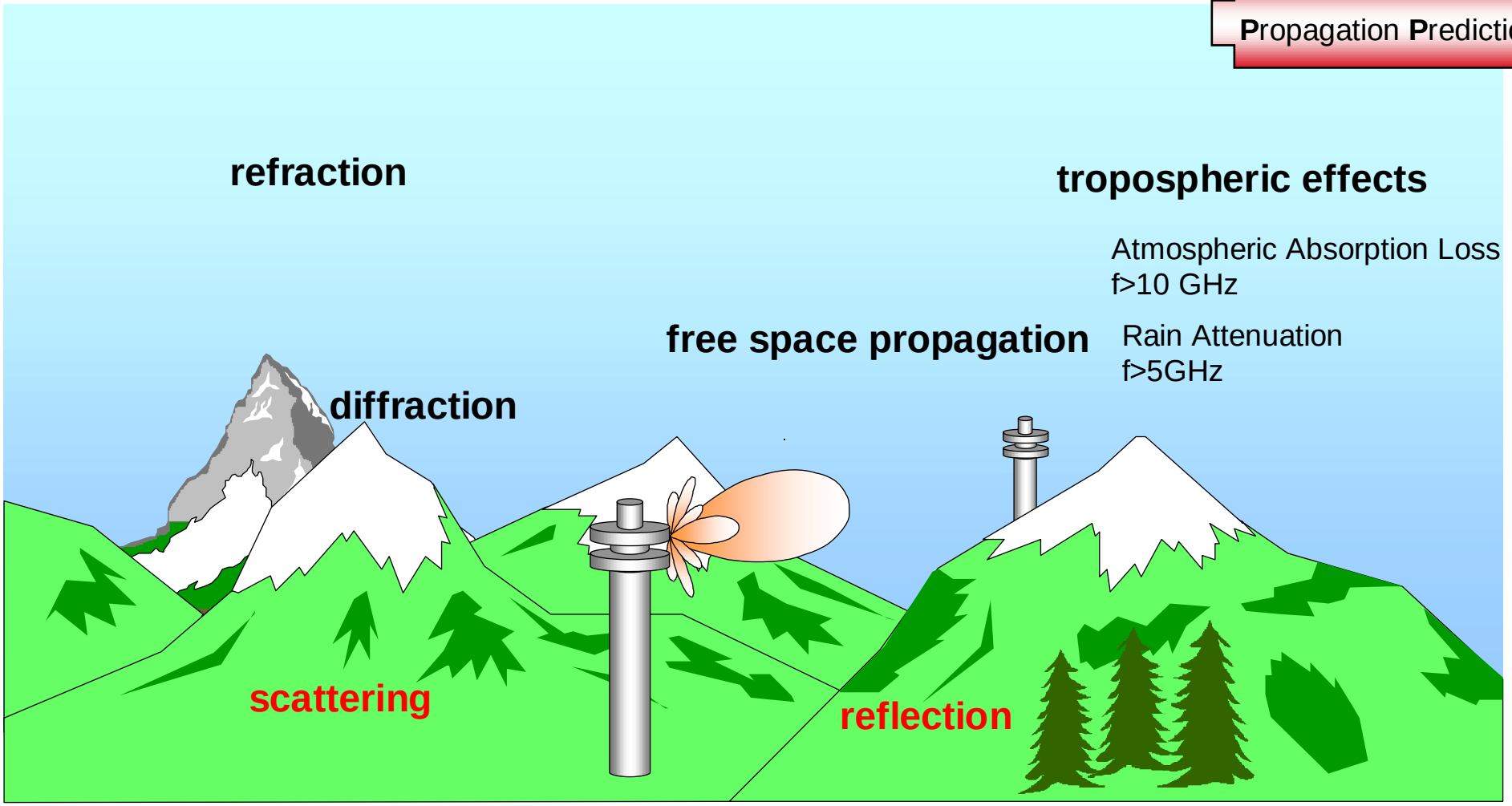
Live
Planning Tool Demonstration

„MULTIlink“
Design Tool for Engineering Microwave Links and PMP / WLL / LMDS Planning



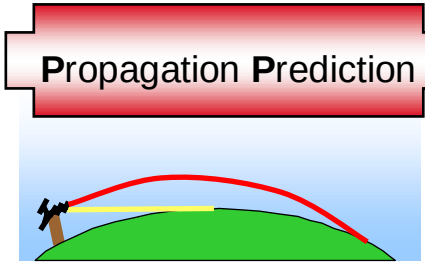
Wave Propagation Effects

Propagation Prediction

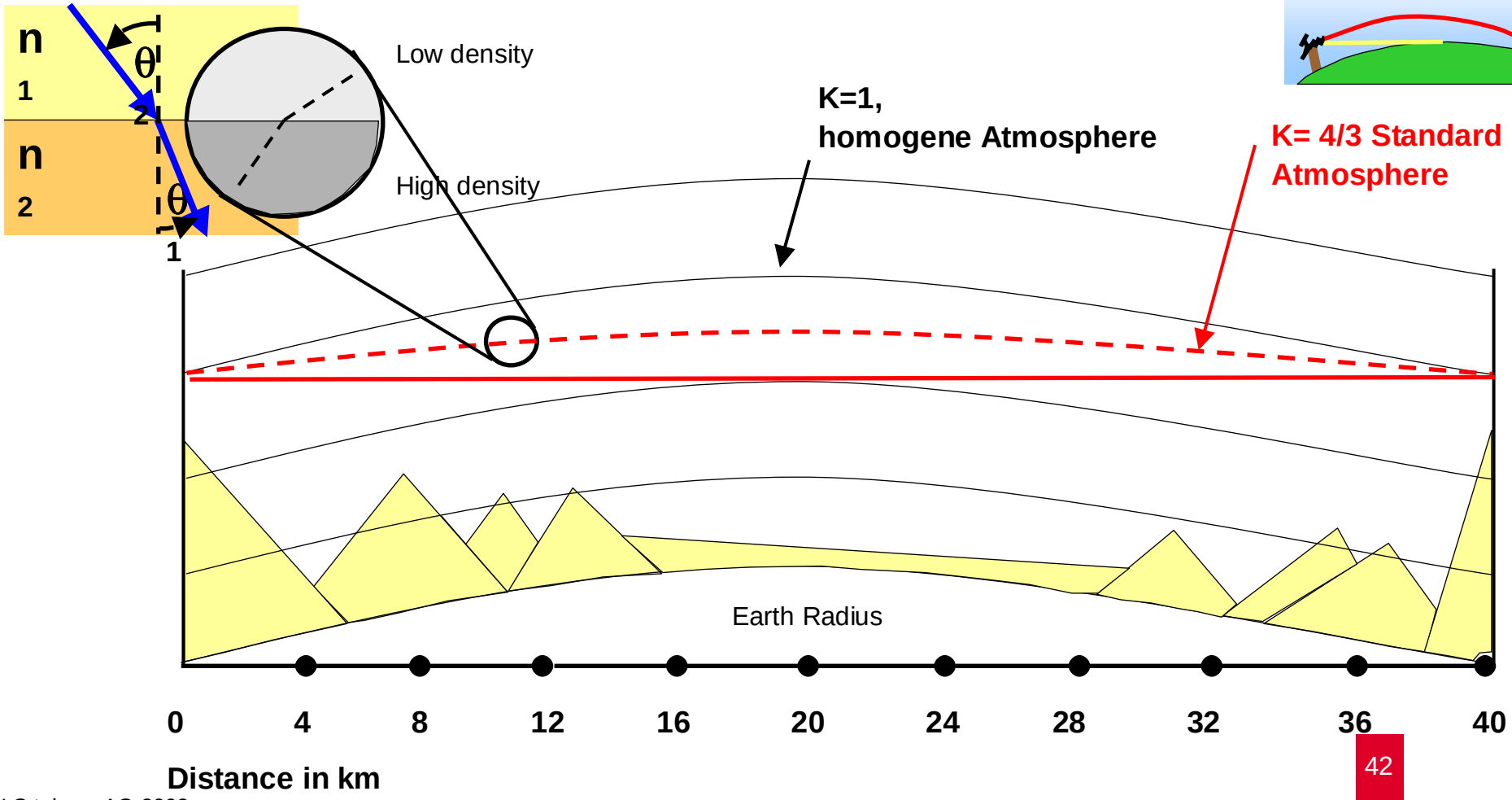


Refraction

Propagation Prediction

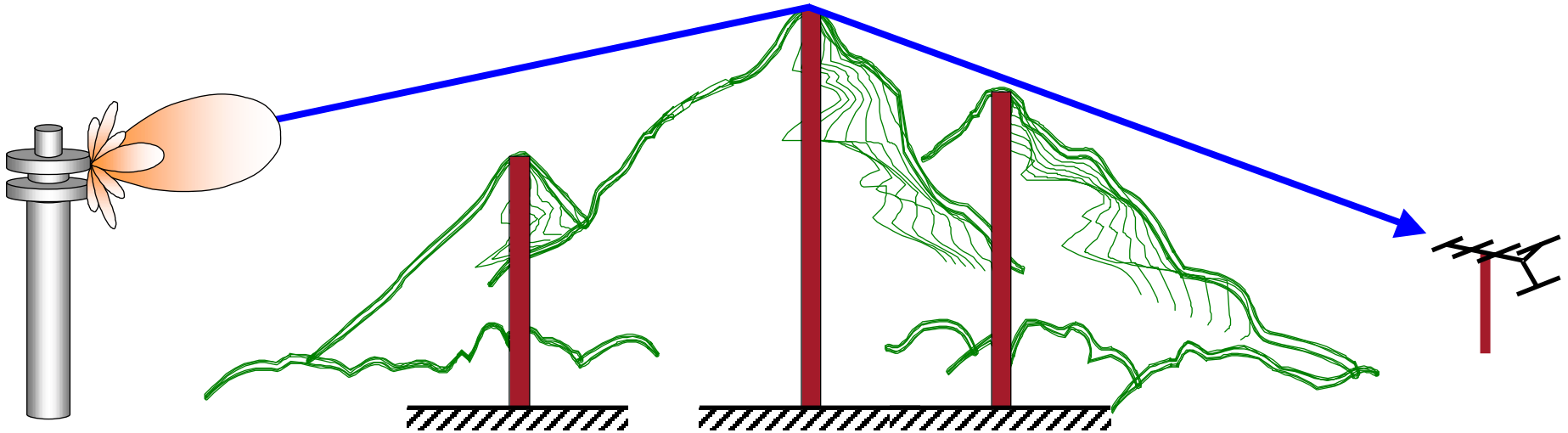


The refraction of the VHF/UHF signal in the troposphere causes an enhancement of the radio horizon compared to the geometric horizon



Diffraction:

- a signal could be received even if there is no line of sight
- diffraction means also an attenuation of the wave.
- higher frequency -> higher diffraction attenuation.



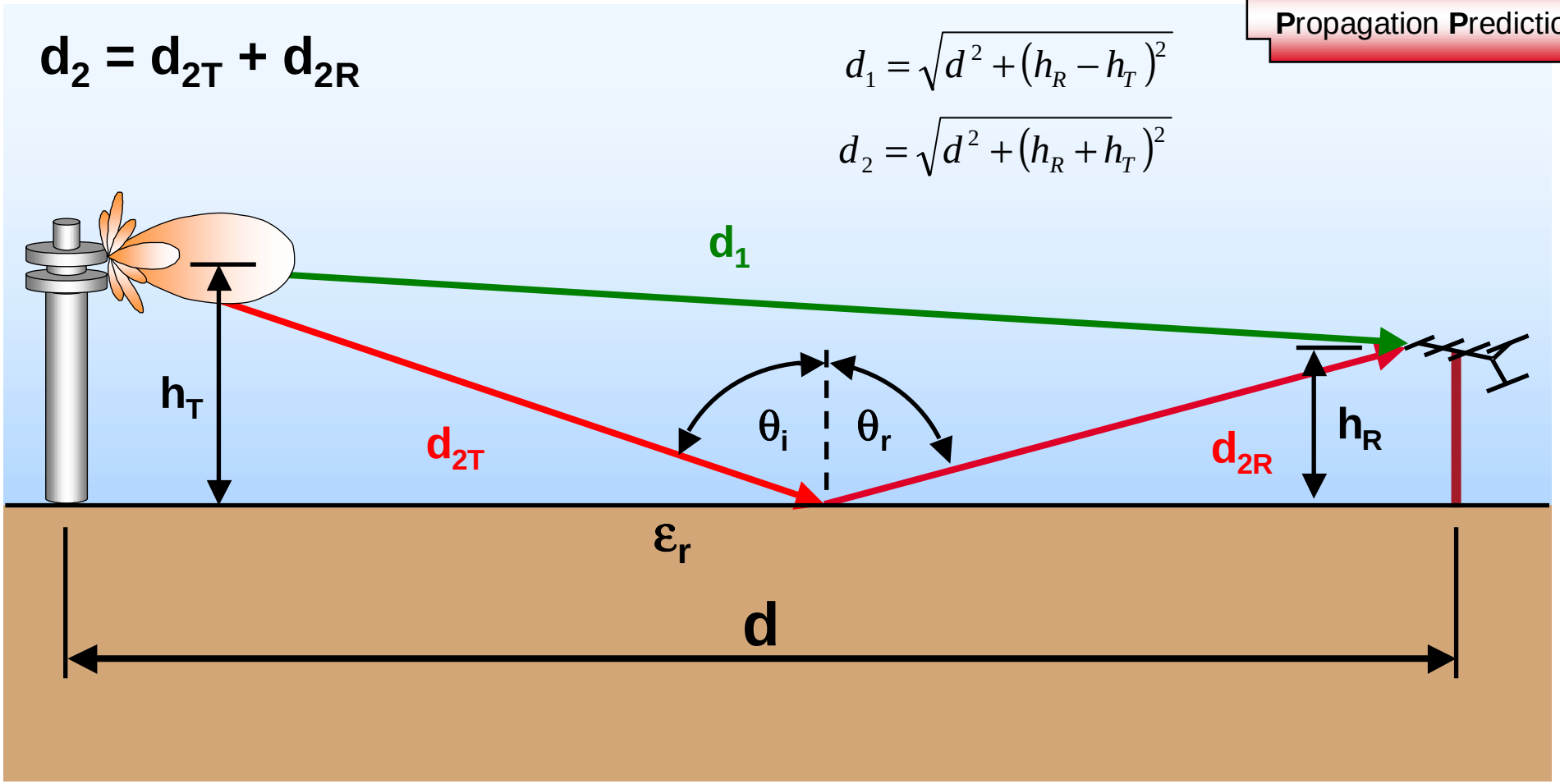
- replace obstacles by Knife-edges

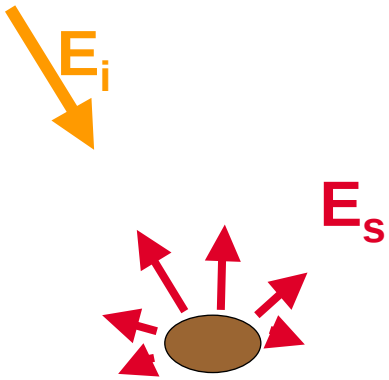
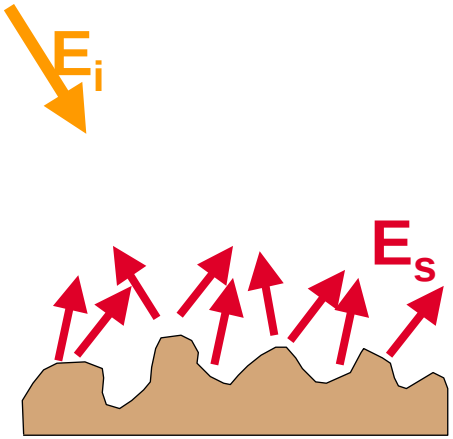
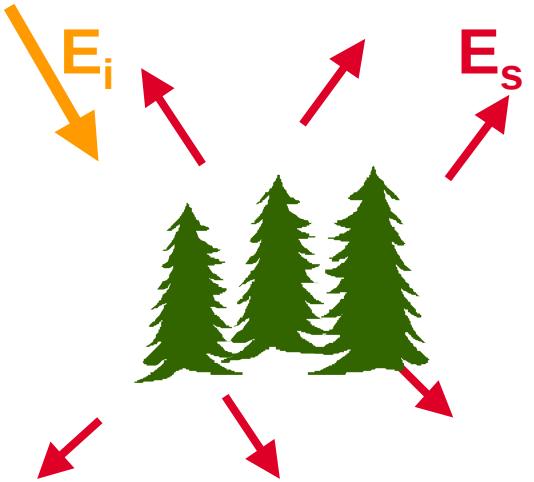
Propagation Prediction

$d_2 = d_{2T} + d_{2R}$

$$d_1 = \sqrt{d^2 + (h_R - h_T)^2}$$

$$d_2 = \sqrt{d^2 + (h_R + h_T)^2}$$



from point	from rough surface	from volume
		
analytical model for sphere numerical techniques	modified reflection coefficient	radiative transfer theory statistical models

Wave Propagation Models VHF/UHF

Modern Radio Network Planning Tools offer a wide range of Propagation Models

Propagation Prediction

Information models

- Sight Check
- Sight Check (Fresnel)

Physical models

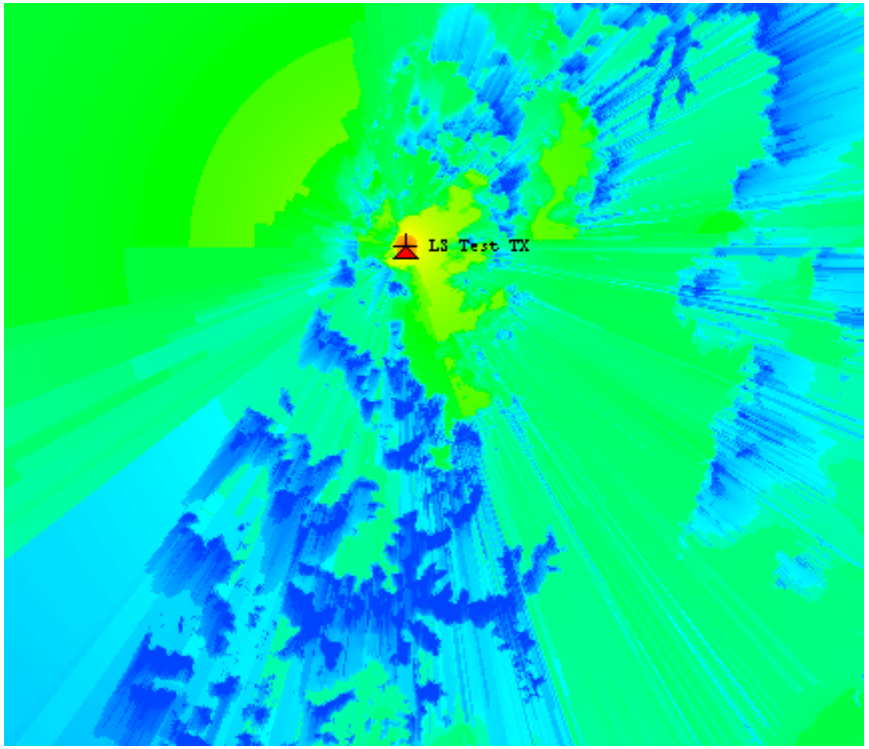
- Free space
- Epstein-Peterson

Empirical models

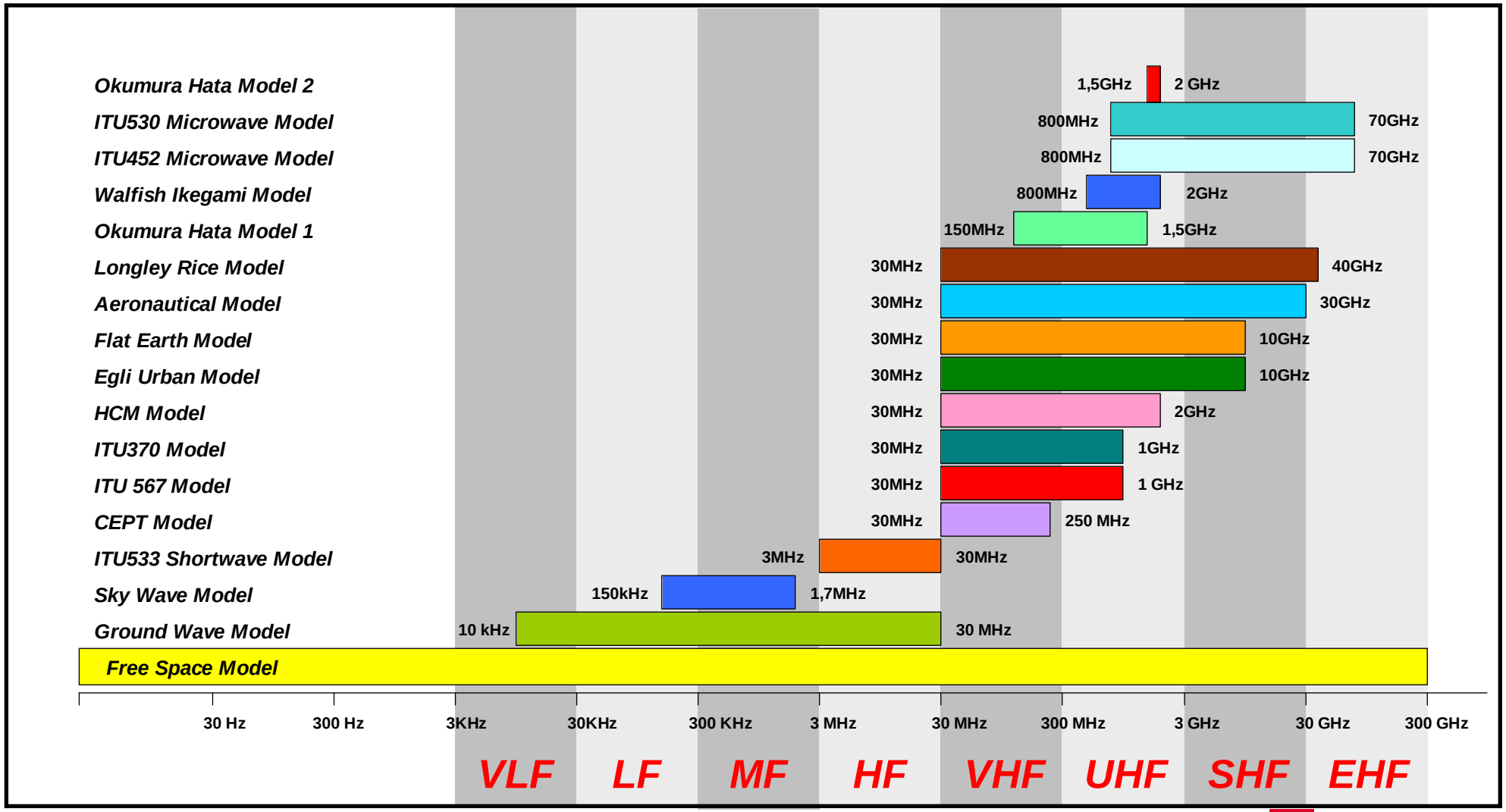
- Okumura-Hata

Mixed models

- Longley-Rice
- ITU-R P.370
- ITU-R P.1546
- GEG
- L&S VHF/UHF



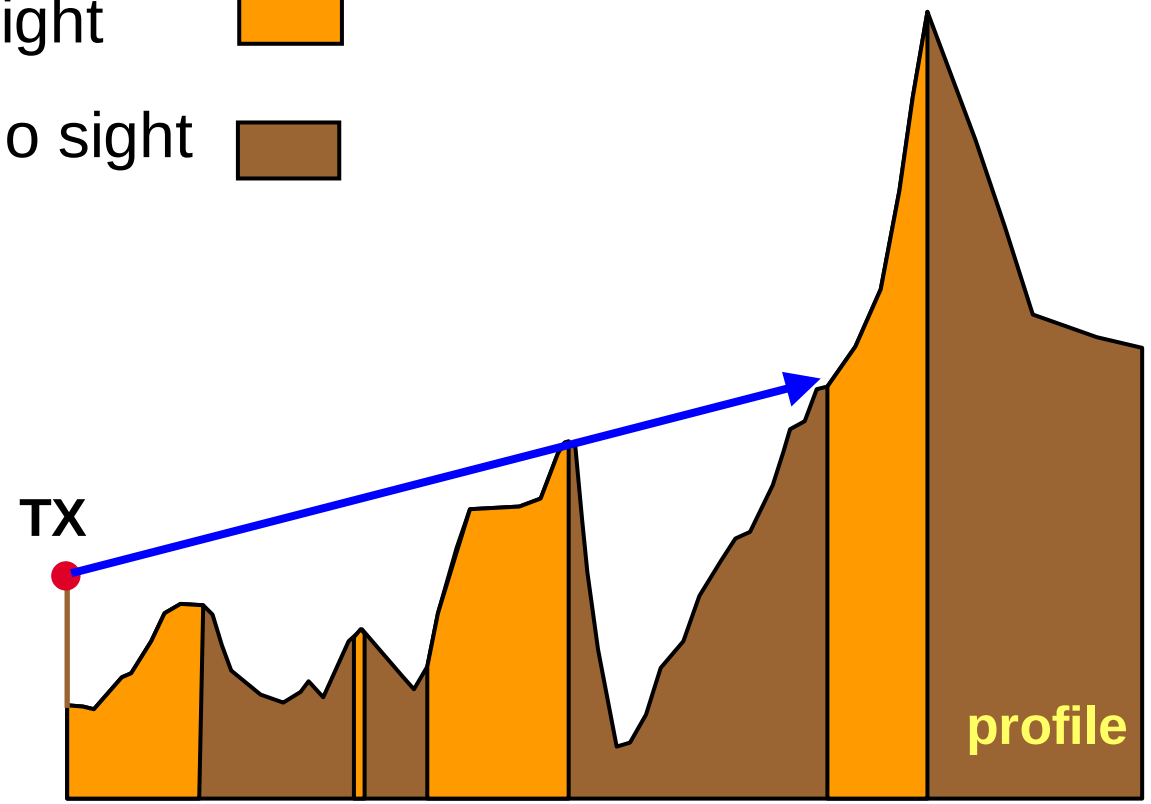
Models and Frequency Ranges



performs line of sight (LOS) check

result

- sight
- no sight



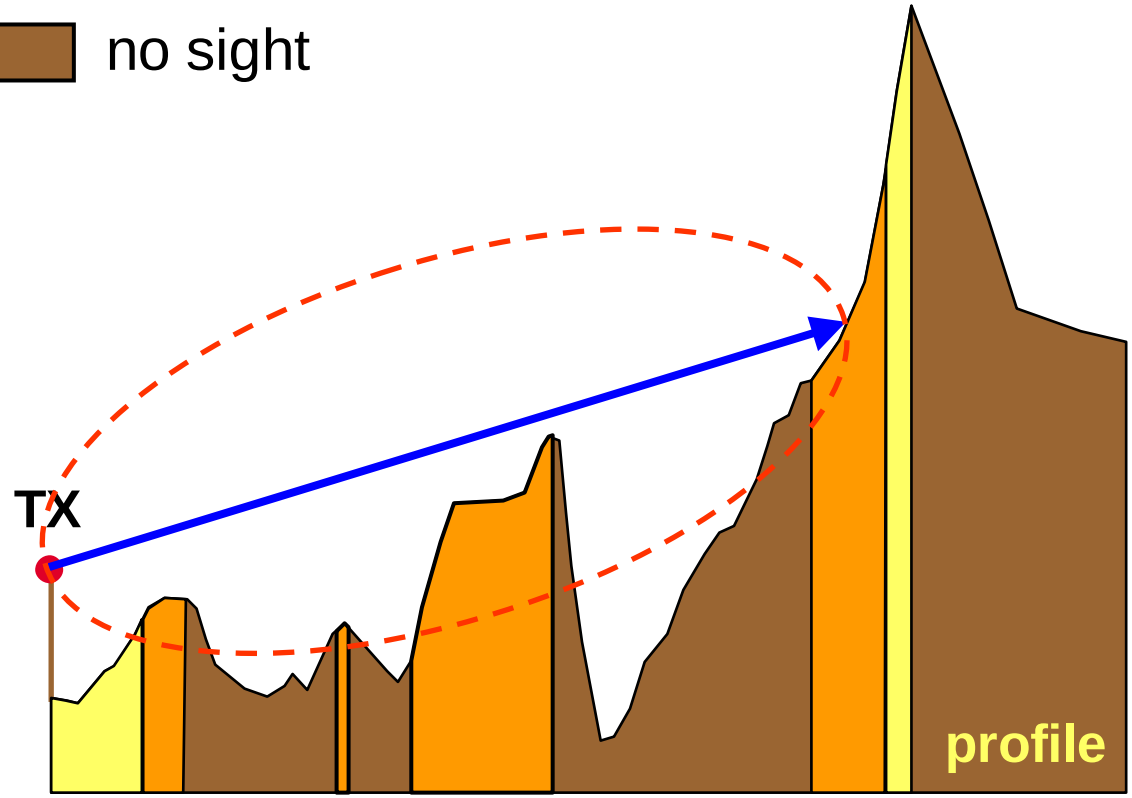
Sight Check (Fresnel)

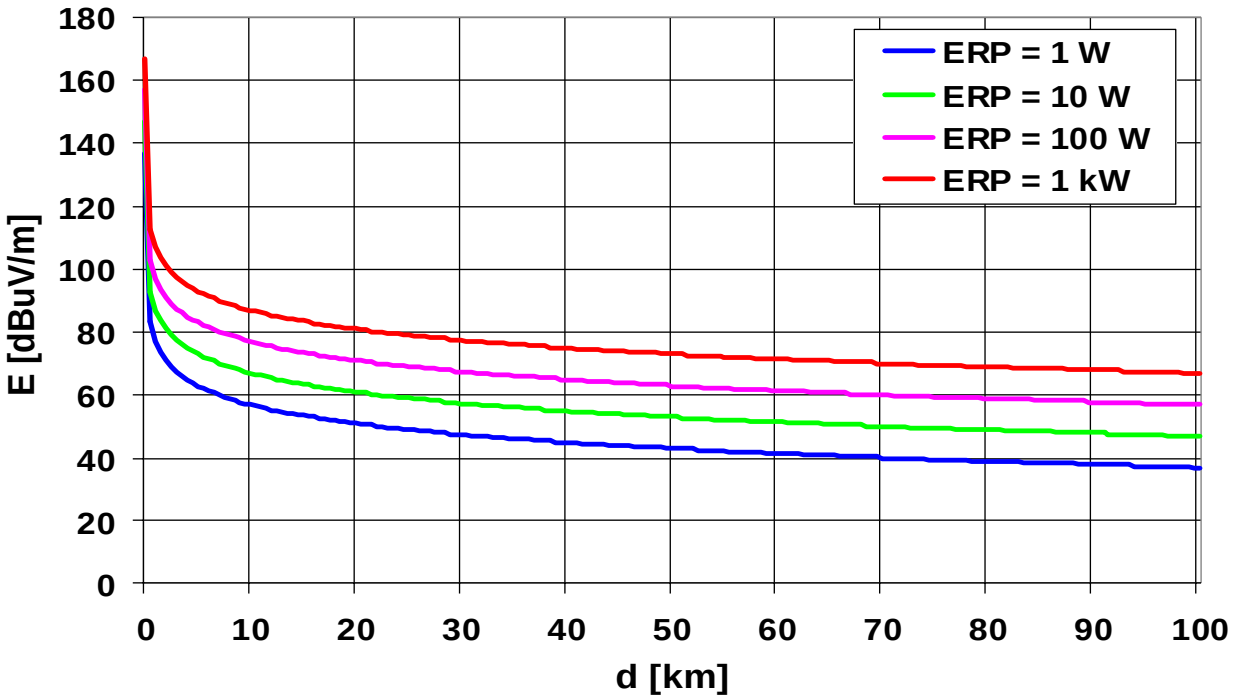
Propagation Prediction

performs extended line of sight (LOS) check

result

- sight, no obstacles within 1st Fresnel zone
- sight, but obstacle within 1st Fresnel zone
- no sight





propagation over a flat earth

- Determines the field strength value purely on the basis of the loss due to the distance d from the transmitter
- Selected calculation mode affects the k-factor for the calculation (see sight check)
- Additionally the consideration of morphological classes is possible if available; the clutter heights of the urban and rural morphologic classes are added to the topological heights

Propagation Model ITU-R 370

Propagation Prediction

- latest version 1995
- coordination model ⇒ tends to overestimate fieldstrength
- basis:

  measured data from North America, Europe, North Sea (cold) and Mediterranean Sea (warm)

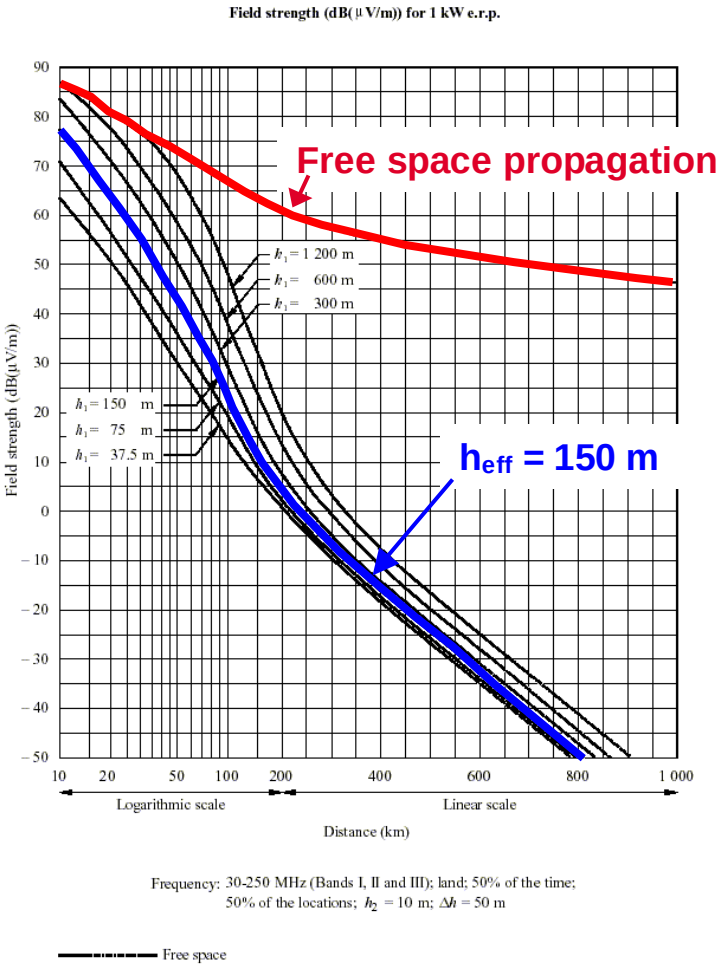
  condensed to a set of curves: fieldstrength E over a homogenous terrain as a function of distance d (10 km ... 1 000 km) for ...

  - frequency ranges VHF (30 ... 250 MHz) and UHF (450 ... 1 000 MHz)
  - power of 1kW ERP
  - effective transmitter antenna height 37.5 m ... 1 200 m (3 km ≤ d ≤ 15 km)
  - terrain roughness Δh = 50 m (10 km ≤ d ≤ 50 km)
  - receiver location over land, cold sea or warm sea
  - receiver antenna height h_R = 10 m
  - 50 % location probability
  - 1%, 5%, 10% and 50% time probability

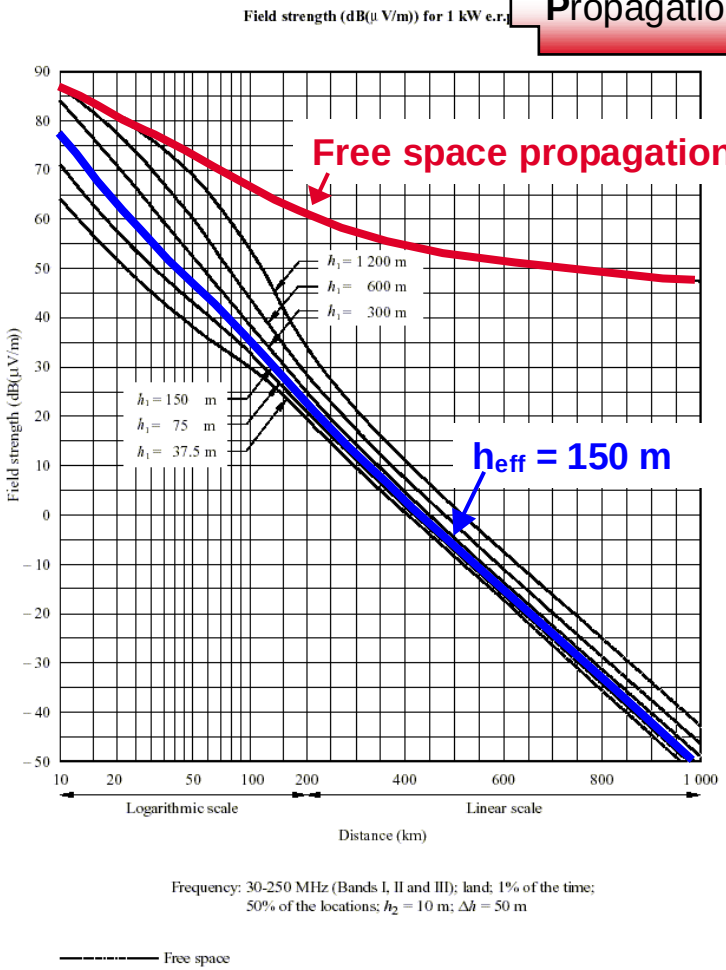
Used for highest compatibility with international planning procedures

ITU-R 370 – Propagation Curves

Propagation Prediction



propagation curve 50% time (steady or continuous)



propagation curve 1% time (tropospheric)

Major changes between ITU-R 370 and ITU-R 1546

- Interpolation and extension in frequency (between 3 curves from 30 MHz ... 3 000 MHz)
- Extension to distances below 10 km from transmitter (1 km)
- Terrain roughness is no longer a parameter
- More complex calculation near the transmitter
- calculation procedure for negative h_{eff}, curves extended to 10 m
- Interpolation for time variability (between curves)
- Location's standard deviation as a function of frequency
- More complex land sea path calculation

- empirical model for propagation along flat and homogenous urban terrain
- based on measurements for vertical polarization by Okumura and ...
- interpolated formulas by Hata

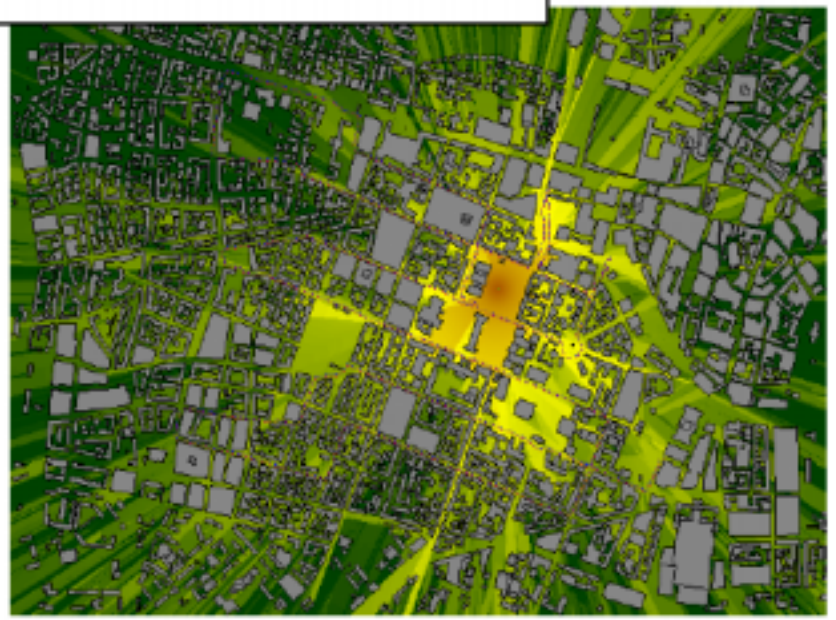
Extensions to Okumura-Hata

- calculation of effective transmitter antenna height
  $h_T \rightarrow h_{T,eff}$ (different options)
- additional diffraction term for paths without sight
- consideration of morphological heights in diffraction term
- subdivision of the 4 morphological classes of Okumura-Hata into 16 classes (morphological gain with respect to urban areas)
- correction for non flat earth (terrain slope)

Propagation Prediction

HIGH ACCURACY

Comparison of drive test and predictions done for the city area of Munich

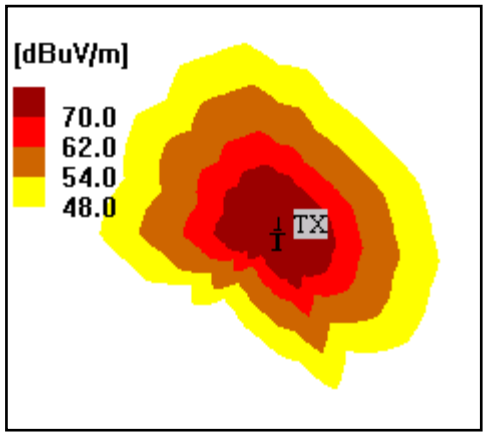


Propagation Prediction

Non-Terrain Based

- Use of "effective antenna height"
- Monotonous decline of field strength with increasing distance to transmitter

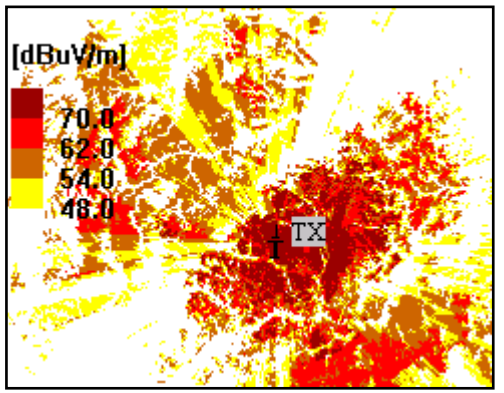
Example: ITU-R P. 370



DTM Based

- Diffraction, shading, reflection
- Terrain elevation and land use (morphology)
- 2D and 3D models

Examples: "Epstein-Peterson", "Longley&Rice", "Okumura-Hata"



Live
Planning Tool Demonstration

„CHIRplus_BC“
Planning and Coordination of Broadcast Services
(FM, TV, DAB, DVB)