# Radio Mobile

#### COS730

#### Network Topologies & Administration







UNIVERSITY of the WESTERN CAPE





# Motivation / Goal

- Understanding of Radio Mobile basic concepts
- Free software (for the Windows platform)
- Provides a detailed propogation model for radio links
  - With the use of freely available Digital Elevation
     Maps

## Radio Mobile

- Developed by Roger Coudè for radio amateurs
- Based on the well known Longley-Rice Irregular Terrain Model
- Predicts radio propogation from 20 MHz to 20 GHz
- Simulate 1 or more radio links and perform "what if?" simulations
  - changing various link parameters

# **Radio Link Simulators**

- A link simulator can save you considerable time during link planning and analysis
- e.g. If a link is proven to be impossible in simulation, there is little need to perform a site survey
  - other options will need to be considered
    - e.g. the use of repeater sites.

## **Radio Link Simulators**

- There are many programs that can be used to simulate radio links and base station coverage
  - some of these programs cost...



# Why use Radio Mobile?

- It provides all sorts of details for point-to-point links, including:
  - expected signal levels at any point along the path
    - including diffraction losses due to obstacles



# Why use Radio Mobile?

- It automatically builds a profile between 2 points on a digital map, showing:
  - Fresnel zone and earth curvature clearance
  - Required antenna heights
- ... a wonderful tool for exploring "what if?" scenarios

# Downloading of Radio Mobile

- Older version:
  - http://www.cplus.org/rmw/download/download.html
- Self-extracting version (recommended):
  - http://www.g3tvu.co.uk/Radio\_Mobile.htm
  - Will save you a lot of PAIN!
- Instructions are provided on how to download the digital elevation maps for your area of interest

# Map info

- The Digital Elevation Maps come in 1 degree longitude, X degree latitude tiles
  - you might need to download a few tiles for your application
- A resolution of 30 and 3 arc seconds (or better!) are available for all regions of the world
- Once you have downloaded the maps, you no longer need Internet access

# Using Radio Mobile

- Assumption that Radio Mobile is correctly installed
- We will review the procedure to simulate a simple wireless network composed of a few nodes
- Radio Mobile will then be used to perform link budget calculations, coverage analysis and "what if?" simulations

## Example 1

- Use of Radio Mobile to simulate radio links in the Cape Town area
- The **GPS** coordinates are (approximations):
  - UWC CS department 33° 56' 3.7788" S, 18° 37' 46.7292" E
  - Tyger Valley Shopping Centre 33° 52' 18.6780" **S**, 18° 37' 55.4124" **E**
  - Parow Centre 33° 54' 22.2264" **S**, 18° 35' 56.5368" **E**
  - Middestad Mall 33° 54' 14.1552" S, 18° 37' 48.8460" E
  - Canal Walk Shopping Centre 33° 53' 34.3140" **S**, 18° 30' 40.1940" **E**

# Using Radio Mobile: DEMs

- Download the Digital Elevation Maps of your area of interest
  - Cape Town
- The simplest way
  - Let Radio Mobile download it automatically
  - It will store the data for future use

## Cape Town DEM

 File → Map properties → Select a city name → Cape Town

			33*55'48''S 018*28'12''E JF96FB	ок
<b>Orgenties of\base.map</b>	Size (pixel)		Campos Dos Goytacazes Can Tho Canberra Candia Cangzhou Canoas Canterbury	Cancel
33°55'48.0"S 018°28'12.0"E JF96FB	800 (pixels) Feight (pixels)	Extract	Canton Cape Town	
Latitude Longitude -33.93 18.47	Size (km) Width(km) Height (km)	Cancel	Capri Caracas Caranicuiba	
Use cursor position	40.00 30.00	Top Left 33°47'42''S	Caratinga	
World map	Elevation data source	018°15'11"E	Cardiff	
Select a city name	None :\tradio mobile\srtm0.3 Browse	Top Right 33°47'42''S 018°41'13''F		
Enter LAT LON or QRA	None  C:\radio mobile\srtm1 Browse	Bottom Left		
Select a unit	SRTM C:\radio mobile\srtm3 Browse	34°03'54''S 018°15'11''E		
	None c Browse	Bottom Right 34*03'54''S		
Adjust units elevation	None c Browse	018°41'13''E		
Merge pictures     Force gray scale	✓ Ignore missing files     Bottom layer       Initialize matrix with elevation (m)     0	50.0 m/pixel 1.62 arcsecond		

## Cape Town Map



Menu "Edit" select item "Merge pictures..." Select Internet OpenStreetMap with Zoom = 11Operation: Add/Copy Click on "Draw" "Keep in picture"

We can add road details by using the below procedure



OpenStreetMap

Arge pictures over ... \base.jpg

Internet OpenStreetMap

C Land Cover

C ADRG - CADRG

C Internet Terraserver - USA

C Internet Toporama - Canada

Source

C File C Another picture Land cover

Draw

Cancel Operation

Copy

C Add C Multiply

C Bitwise

Contrast=1 4

Brightness=1

Reset

Public domain

Zoom = 11

#### Cape Town DEM



# Radio Mobile Terminology

- In order to create radio links, we need to learn a few new terms:
  - A system: a particular choice of a radio and antenna
    - (TX power, gain, radiation pattern, etc.)
  - A unit: a system installed in a particular location
    - (coordinates, height of antenna, etc.)
  - A network: a set of units, part of the same radio network
    - (all at the same frequency)

# Using Radio Mobile: systems

- Creation of 2 different systems (WiFi @ 2.4GHz)
- SmallRadio:
  - $P_{TX} = 16 dBm$
  - $-S_{RX} = -90 dBm$
  - Omni 8dBi
- BigRadio:
  - $-P_{TX} = 20 dBm$
  - $-S_{RX} = -96 dBm$
  - Omni 8dBi
- Other: default

🔏 Networks properties	
List of all systems	Default parameters Copy Net Paste Net Cancel OK
SmallRadio BigRadio Svstem 3	Parameters Topology Membership <b>Systems</b> Style
System 4 System 5 System 6	00  Select from VHF UHF
System 7 System 8 System 9	System name SmallRadio
System 10 System 11 Sustem 12	Transmit power (Watt) 981072E-02 (dBm) 16
System 13 System 14 System 15	Receiver threshold (μV) 7.0795 (dBm) -90
System 16 System 17	Line loss (dB) 0.5 (Cable+cavities+connectors)
System 19 System 20 Sustem 21	Antenna gain (dBi) 8 (dBd) 5.85
System 22 System 23 System 24	Antenna height (m) 2 (Above ground )
System 24 System 25 System 26	Additional cable loss (dB/m) 0 (If antenna height differs )
System 27 System 28 System 29	Add to Radiosys.dat Remove from Radiosys.dat

# Using Radio Mobile: units

- Creation of **5 units** at the **5 sites**:
  - UWC CS department
  - Tyger Valley Shopping Centre
  - Parow Centre
  - Middestad Mall
  - Canal Walk Shopping Centre

# Units

🐕 Units properties		
UWC CS Dept Tyger Valley Shoppin Parow Centre Middestad Mall Canal Walk Shopping Unit 6 Unit 7 Unit 8 Unit 9 Unit 10 Unit 11 Unit 12	Name     Elevation       UWC CS Dept     +       Position     33°56'03.8''S 018°37'46.7''E       Copy     JF96HB       Decked       Enter LAT LON or QRA	(m) OK Clear ste Undo unit Move up
Unit 11 Unit 12 Unit 13 Unit 14 Unit 15 Unit 16 Unit 17 Unit 18 Unit 19 Unit 20 Unit 21 Unit 22 Unit 23 Unit 24 Unit 25 Unit 26 Unit 27 Unit 28 Unit 29 Unit 31 Unit 31 Unit 32	Enter LAT LON or QRA Place unit at cursor position Place cursor at unit position Style - UWC CS Dept Finabled C Left Centre R Transparent No label Icon 16x16 pixels Show only units that are members of a visible network	Image: State of the state
		Unit 31 Unit 32

#### Units visible on map



## Membership

- After creation, assign the proper system to each unit:
  - UWC CS department  $\rightarrow$  **BigRadio**
  - Tyger Valley Shopping Centre  $\rightarrow$  SmallRadio
  - Parow Centre  $\rightarrow$  SmallRadio
  - Middestad Mall  $\rightarrow$  SmallRadio
  - Canal Walk Shopping Centre  $\rightarrow$  SmallRadio

#### Membership

Networks properties				
List of all nets Base	Default parameters Copy Net	Paste Net Cancel	OK	
Net 2 Net 3 Net 4 Net 5 Net 6 Net 7 Net 7 Net 8 Net 9 Net 9 Net 10 Net 11 Net 12 Net 13 Net 14	List of all units       UWC CS Dept       Tyger Valley Shoppin       Parow Centre       Middestad Mall       Canal Walk Shopping       Unit       Unit	Member of Base Role of UWC CS Dept Command System BigRadio Antenna height (m)		
Net 15 Net 16 Net 17 Net 18 Net 19 Net 20 Net 21 Net 22 Net 22 Net 23	Unit 8 Unit 9 Unit 10 Unit 11 Unit 12 Unit 13 Unit 13 Unit 14 Unit 15	List of all nets Base Net 2 Net 3 Net 4	Default parameters Copy Net Parameters Topology Mer	Paste Net Cancel OK  mbership Systems Style
Net 24 Net 25 Net 26 Net 27 Net 28 Net 29	Unit 16 Unit 17 Unit 18 Unit 18 Unit 19	Net 5 Net 6 Net 7 Net 8 Net 9 Net 10	List of all units  UWC CS Dept  Tyger Valley Shoppin  Parow Centre  Middestad Mall	Member of Base Role of Tyger Valley Shoppin Subordinate
		Net 11 Net 12 Net 13 Net 14 Net 15 Net 15 Net 16 Net 17 Net 18 Net 19 Net 20 Net 21 Net 22 Net 22 Net 23 Net 24 Net 25	Canal Walk Shopping Unit 6 Unit 7 Unit 8 Unit 9 Unit 10 Unit 11 Unit 12 Unit 13 Unit 14 Unit 15 Unit 16	Antenna height (m) System 2 Other 0.5 Antenna direction
		Net 25 Net 26 Net 27 Net 28 Net 29	Unit 17 Unit 18 Unit 19	View pattern

#### Network

To view your network on the map, just select
 "View" → "Show networks" → "All"



# Topology

🔀 Networks properties		<				
List of all nets	Default parameters         Copy Net         Paste Net         Cancel         OK					
Base Net 2 Net 3 Net 4 Net 5 Net 6 Net 6 Net 7 Net 8 Net 9	Parameters Topology Membership Systems Style					
Net 10 Net 11 Net 12 Net 13 Net 13 Net 14 Net 15 Net 16 Net 17	<ul> <li>Voice net (Command/Subordinate/Rebroadcast)</li> <li>Data net, star topology (Master/Slave)</li> </ul>					
Net 18 Net 19 Net 20 Net 21 Net 22 Net 23 Net 23 Net 24 Net 25 Net 25 Net 26 Net 27 Net 28 Net 29	C Data net, cluster (Node/Terminal)					

## Setting the correct frequency

- To be able to correctly calculate the loss due to propogation, set the correct frequency
- Since we are using the 2.4GHz band, set the range 2400-2485

ist of all nets	Default parameters Copy	Net Paste	e Net	Cancel	ОК
Base Net 2 Net 3 Net 4	Parameters Topology	Membersł	nip	Systems	Style
Net 5 Net 6 Net 7 Net 8 Net 9	Net name Base Minimum (requency (MHz)	2400	Surface Grour	e refractivity (N-I nd conductivity	<sup>Units)</sup> 301 (S/m) 0.005
Net 10 Net 11 Net 12 Net 13	Maximum frequency (MHz)	2485	Relativ ⊢ Climate	ve ground perm	ittivity 15
Net 14 Net 15 Net 16 Net 17	Vertical O Hor     Mode of variability	rizontal	C Equ	iatorial itinental sub-trop	pical
Net 18 Net 19 Net 20 Net 21	C Spot % of loc % of loc	of time 90 ations 90	C Mar	itime sub-tropica ert	al
Net 22 Net 23 Net 24 Net 25	C Mobile C Broadcast % of situ	ations 70	C Con	itinental tempera	ate over land
Net 26 Net 27 Net 28	Additional loss	% 0	C Mar	itime temperate	over sea

#### Network



Link colours have changed!

#### Results

- The scenario has been set...
- Calculate the link budgets
- "Tools"  $\rightarrow$  "Radio link"

🕅 Radio Link							$\mathbf{X}$
Edit View Swap							
Azimuth=0.92*	Elev. angle=0.247*	Clearance at	1.62km	Worst Fresnel=	0.5F1 D	istance=3.39km	
PathLoss=119.5dB	E held=53.0dBµV/m	Hx level=-84.	odBm	Hx level=13.40	uv R	x Helative=5.5dB	
							===
Terrenilter			Deseiver				_
		- cq	heceiver				\$9+10
				hd - II			33410
Juwe es Dept	Comment		Dala	Mali	Calmentingto		
	DiaDiadia		Du sustan y		Subordinate		
Tx system name	periginadio 0.1.W 20.4	Pm I	Required F	Field		~	
Line loss	0.5 dB 20 d	DIII	Antenna ga	in	8 dBi		+
Antenna gain	8 dBi 5.8 d	dBd +	Line loss		0.5 dB		
Radiated power	EIRP=0.56 W ERP	≥=0.34 W	Rx sensitivi	ty –	7.0795µV	-90 dBm	
Antenna height (m)	8 • +	Undo	Antenna he	eight (m)	2	• • 0	ndo
Net			Frequency	(MHz)			
Page			Minir	num 2400	Ma:	ximum 2485	
Dase		<b>_</b>		12400		12400	

#### Results

• You can switch to a detailed view that gives a textual description of the output of the simulation

🕅 Radio Link						×	
Edit View Swap							
Distance between UWC CS Dept and Middestad Mall is 3.4 km (2.1 miles) True North Azimuth = 0.92°, Magnetic North Azimuth = 26.24°, Elevation angle = 0.2466° Terrain elevation variation is 15.9 m Propagation mode is line-of-sight, minimum clearance 0.5F1 at 1.6km Average frequency is 2442.500 MHz Free Space = 110.8 dB, Obstruction = 2.2 dB TR, Urban = 0.0 dB, Forest = 0.0 dB, Statistics = 6.5 dB Total propagation loss is 119.5 dB System gain from UWC CS Dept to Middestad Mall is 125.0 dB System gain from Middestad Mall to UWC CS Dept is 127.0 dB Worst reception is 5.5 dB over the required signal to meet 70.000% of situations							While on <b>Radio Link</b> , click " <b>View</b> " → " <b>Details</b> "
r Transmitter			Receiver				
/ <b></b>		S0			S	50	
UWC CS Dept		<b>•</b>	Middestad Mall			•	
Role	Command		Role	Subordinate			
Tx system name	BigRadio	•	Rx system name	SmallRadio		-	
Tx power	0.1 W	20 dBm	Required E Field	47.47 dBµV/m			
Line loss	0.5 dB		Antenna gain	8 dBi	5.8 dBd	+	
Antenna gain	8 dBi	5.8 dBd _+	Line loss	0.5 dB			
Radiated power	EIRP=0.56 W	ERP=0.34 W	Rx sensitivity	7.0795µV	-90 dBm		
Antenna height (m)	8 ·	+ Undo	Antenna height (m)	2 ·	+ Und	io	
Net			Frequency (MHz)				
Base		•	Minimum 2400	Maximu	m 2485		

#### Coverage

- "Tools"  $\rightarrow$  "Radio Coverage"  $\rightarrow$  "Single Polar"
- This will start the calculation of the coverage area of a selected station in your network

🖲 Single polar Radio coverage		Signal (dBm) < -30 -86 -82 -78 -74 -70 -66 -62 -58 -54 -50
Centre unit UWC CS Dept	Draw	The second
Mobile unit Middestad Mall		
Network Base		
Link Direction Centre Tx - Mobile Rx Centre Rx - Mobile Tx Worst case	Badial range (km)       Minimum     Maximum       0.1     40	
Plot	Azimuth range (*) Minimum Maximum Step 0 360 0.1	
✓ Rainbow       Blur       Complete.wav	Antenna pattern Use network antenna settings omni.ant	
Threshold     ✓ Auto set       C S-Unit     ✓ Auto set       G dBm     -90.0       C μV     To       C dBμV/m     -50.0	View pattern	A.

The lower the receiving sensitivity, the better the radio receiver.

#### Coverage with Network



## "What if?"

- With the help of Radio Mobile it is very easy to simulate
  - different scenarios
  - different values of the antenna height and/or gain, TX power, etc.

## Note

- Keep in mind the following:
  - The link margin must be positive, and should be maximized
  - (should be at least 10dB or more for reliable links).

#### Results

🕅 Radio Link			
Edit View Swap			
Azimuth=0.92*	Elev. angle=0.348* Clearance a	t 1.62km Worst Fresnel=	0.8F1 Distance=3.39km
PathLoss=114.0dB	E field=58.5dBµV/m Rx level=-75	1.0dBm Rx level=25.09	μV Rx Relative=11.0dB
	S9+10		S9+10
UNCE CS Doot	-	Middoated Mall	
	- Comment		C. hardinate
Role	Lommand	Role	Subordinate
l x system name	BigRadio	Hx system name	SmallRadio
Tx power	0.1 W 20 dBm	Required E Field	47.47 dBμV/m
Antenna gain	9.dB 5.8.dBd +	Anterina gain Line Joss	
Radiated power	EIRP=0.56 W ERP=0.34 W	Rx sensitivity	7.0795⊎V
Automa haisht (s)			
Antenna neight (mj		Antenna neight (m)	
Net		Frequency (MHz)	
		Minimum 2400	Maximum 2405
Base	<b></b>	12400	11031110111 J2400

#### Adjustments



Antenna heights Antenna gains

## Radiated Power Terms and Concepts

- EIRP (Effective Isotropic Radiated Power) for
   2400 –2483.5 MHz
  - Maximum Radiated Power
  - 100 mW (20 dBm) in Europe and South Africa!
  - -1-4 W (30 -36.021 dBm) in other countries
- EIRP = Transmitter Power (Losses in cables and connectors) + Antenna Gain (dBi)
- This leads to network **re-design** in our case

# Antenna heights (Rooftop base)

- A rooftop base telecommunication station may not extend more than 3m in height above the part of the building that it is attached to.
- Should it extend more than the permitted **3m**, prior approval from the City of Cape Town is required.

# Antenna heights (Freestanding base)

- If a freestanding base telecommunication station is authorized as a **primary use** on a property, the freestanding telecommunication station may be as high as **25m**.
  - (City of Cape Town)
- Environmental affairs however kick in for antennas higher than 15m.

#### Conclusions

- Radio Mobile makes it possible to simulate 1 or more radio links and perform "what if?" simulations, changing various link parameters
- While it cannot prove that a link is 100% possible, it can prove that a link is not possible

– (or would be very difficult)

 By combining DEM data and free overlay maps, it is possible to make very informative reports about coverage, link quality and other radio parameters

# Thank you

