Mobitex

Cell Planning Guidelines

193 38 - CNH 160 70 Uen, Rev B, 2005-01-18

Contents

1 Introduction

One of the most important steps when planning a Mobitex system is the cell planning. Cell planning incorporates both frequency reuse planning and wave propagation planning. This document briefly discusses the most important aspects of cell planning for Mobitex. Please note that the document only applies to the Mobitex with 8 kbps data transmission rate.

In some respects Mobitex can be viewed as a cellular system. There are, however, important system characteristics that distinguish Mobitex from a cellular system.

2 Main Differences between Mobitex and Cellular

The following differences between Mobitex and a cellular mobile telephone system should be noted.

The system is designed for efficient transmission of packet switched data and not circuit switched voice. This means:

- A data channel is shared by a large number of subscribers.
- Mobitex does not require any call set-up in order to transmit a message.
- System information is transmitted on a system channel, which can also accommodate data traffic.
- Hand-over, in Mobitex called roaming, is controlled by the radio modem (mobile terminal) and takes place between transmissions of messages.
- Mobitex is a semiduplex system, while cellular mobile telephone systems are duplex systems.
- Effective protocol functions in Mobitex, such as ARQ, makes it possible to obtain acceptable communication at worse radio conditions than cellular mobile telephone systems.

3 Criteria for Acceptable Communication

The criteria for acceptable data communication used in this paper is:

- **Traditional criteria**
  10% block error rate at the cell edge.

or

- **Protocol criteria**
  95% packet success rate for packets including 90 bytes (6 blocks) of user data, at the cell edge including protocol functionality at the link layer.

The criteria define the lowest acceptable signal strength and carrier to interferer ratio in a cell.

The protocol criteria is introduced to make it possible to include software functionality in cell planning. It also makes it possible to compare different software releases.

3.1 Traditional Criteria

3.1.1 Message Success Rates, Message Lengths and Number of Retransmissions.

Ten percent block error rate roughly corresponds to:

- 1% bit error rate (before error correction). Measuring method defined using pseudo random bit sequence according to CCITT Rec. O.153.·
- 80% success rate for a status message (frame head + 1 data block). With no retransmission (including error correction).
- > 99% success rate for a status message within 3 retransmissions (including error correction).
- 95% success rate for a maximum length message (frame head + 28 data blocks) within 3 retransmissions (including error correction).

3.1.2 Effects of Raised/Relaxed Traditional Criteria

A raised criteria from 10% block error rate to 5% block error rate will give 3-4 dB higher requirement on the link budgets and C/I.

A relaxed criteria to 20% block error rate will give 2-3 dB lower requirement on link budgets and C/I.

Note: These values are valid i a fading environment.

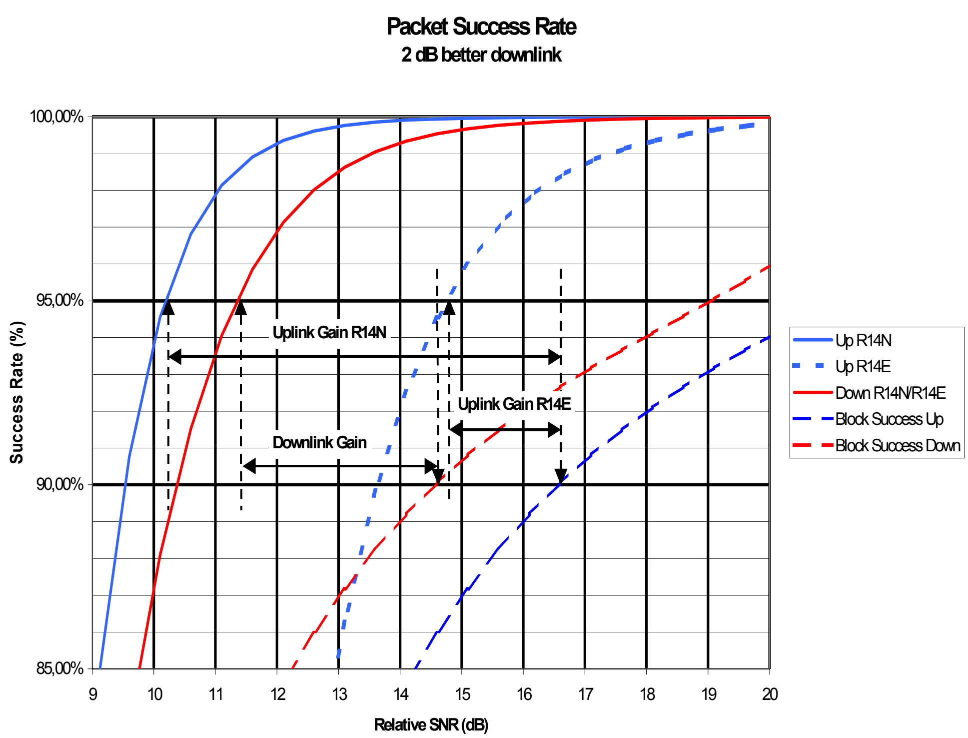
3.2 Protocol Criteria

95% packet success rate, for packets including 90 bytes (6 blocks) of user data depends on:

- Protocol implementation in base stations (Revision R14E or R14N/NTE)
- Protocol parameters (defaults for this document)
  - Max Rep (3)
  - Mare (2)
  - Block Save On/Off (On)

To be able to use the protocol criteria in link budgets, a new link budget parameter has been introduced: **Protocol Gain.**

The protocol gain is the difference in maximum pathloss between the static criteria (10% block error rate) and the protocol criteria (95% packet success rate). The protocol gain can have different values for the uplink and downlink, and is dependent of the power balance between the uplink and downlink.



Protocol gain when the power balance is 2 dB to the advantage for the downlink. Default parameters for R14N/NTE is used.

ARQ implementation, block saving and repetition schemes are examples of software functions that affect the protocol gain.

The following table shows Dynamic Protocol Gain for 95% Packet Success Rate for 90 byte packets, same packet size for uplink and down link:

Protocol Gain (dB)			
Power Balance	Downlink	Uplink R14E	Uplink R14N/NTE[1]
8 dB better uplink	5.0	-3.9	1.6
6 dB better uplink	4.9	-2.4	3.0
4 dB better uplink	4.7	-1.0	4.3
2 dB better uplink	4.3	0.1	5.2
Equal links	3.9	1.1	5.9
2 dB better downlink	**3.2**	**1.8**	**6.4**
4 dB better downlink	2.3	2.4	6.7
6 dB better downlink	1.0	2.7	6.9
8 dB better downlink	-0.5	3.1	7.0

1) Default parameters for R14N/NTE is used (Mare=2, Block save ON)

3.2.1 Effects of Raised/Relaxed Protocol Criteria

A raised/relaxed protocol criteria depends on:

- Packet Success Rate (95% is used in this document)
- Packet Sizes to plan the coverage for (90 byte packets are used for both uplink and downlink in this document)
- Fading frequency (3 Hz is used in this document).

In the table below some examples of differences in Protocol Gain are shown:

Protocol Gain (dB)				
Packet Size Byes	**Packet Size Rate**	**Downlink**	**Uplink R14E**	**Uplink R14N/NTE[1]**
1	99%	3.1	3.1	3.1
1	95%	5.5	5.5	5.5
1	90%	6.6	6.6	6.6
90	99%	1.8	-1.6	4.5
90	95%	3.9	1.1	5.9

Protocol Gain (dB)				
Packet Size Byes	**Packet Size Rate**	**Downlink**	**Uplink R14E**	**Uplink R14N/NTE[1]**
90	90%	4.8	2.2	6.5
500	99%	0.5	-3.1	4.1
500	95%	2.8	-0.2	5.5
500	90%	3.7	0.9	6.1

Protocol Gain for different requirements for the dynamic criteria. Fading frequency is 3 Hz. Balanced uplink and downlink power. Max Rep = 3.

1) Default parameters for R14N/NTE is used (Mare=2, Block save ON)
Note: The Protocol Gain is always relative 10% Block Error Rate.

4 System parameters

4.1 Definitions

To understand how cellplanning is done it is important to know the following definitions:

EIRP:	Effective Radiated Power of an isotropic antenna. A transmitter with a certain EIRP gives the same field strength as a transmitter with the EIRP as output power and an isotropic antenna.
Signal strength:	In this paper, the signal strength is defined as the power received by an isotropic antenna and is given in dBm.
Path loss:	The attenuation between two ideal isotropic antennas.
Passband:	The passbands are the frequency bands that are used for the transmitters and receivers in each system. There is one for the transmitter frequencies and one for the receiver frequencies.
Stopband	The transmitter stopband is equal to all frequencies not used by the transmitters in the Mobitex system except for the guardbands. The receiver stopband is equal to all frequencies not used by the receivers in the Mobitex system except for the guardband.
Guardband:	The guardbands are the transition zones between the passbands and the stopbands. There are two guardbands for the transmitter frequencies and two for the receiver frequencies.

The following abbreviations are used in this document:

Pin_{RM}	= Received power in radio modem	(dBm)
Pin_{BS}	= Received power in base station	(dBm)
$Pout_{RM}$	= Output power from radio modem	(dBm)
$Pout_{BS}$	= Output power from base station	(dBm)
Lf_{RM}	= Feeder loss in radio modem	(dB)
Lf_{BS}	= Feeder loss in base station	(dB)
Ld	= Attenuation due to duplex filter	(dB)
Ga_{RM}	= Antenna gain for radio modem	(dBi)
Ga_{BS}	= Antenna gain for base station	(dBi)
Lp	= Path loss	(dB)

4.2 Channel Arrangement

The Mobitex 8kbps system is implemented in the following frequency bands today.

380 - 512 MHz
819 - 870 MHz
890 - 960 MHz

The channel arrangement is calculated according to the formula below:

Channel (channel number) = Band edge (MHz) + (channel step x channel number)

Channel step is 0.00625 MHz for 800 MHz and 0.0125 MHz for 400 MHz and 900 MHz.
Channel numbers greater than 9999 begin with letter A, e.g. 10559 = A559.
To state a duplex channel, it is necessary to state two channel numbers as in the following examples:

1. For the 380 - 512 MHz band (band edge = 380 MHz)
   ch#3185 / 2625 corresponds to the duplex pair 419.8125 / 412.8125 MHz.
   Duplex distance varies depending on country and frequency band used. In this example the duplex distance is 7 MHz.

2. For the 819 MHz - 870 MHz band (band edge = 819 MHz)
   ch# 7550 / 350 corresponds to the duplex pair 866.18750 / 821.18750 MHz.
   Duplex distance is 45 MHz.

3. For the 890 MHz - 960 MHz band (band edge = 890 MHz)
   ch# 581 / 3701 corresponds to the duplex pair 897.2625 / 936.2625 MHz.
   Duplex distance is 39 MHz.

4.3 Parameters in Link Budgets

A link budget is a calculation of how large the coverage area is when the following parameters are taken into consideration.

4.3.1 Output Power

Base station, $Pout_{BS}$

The nominal output power, measured at the antenna connector (mean power).
(Equal to the maximum output power into 50 Ohm unbalanced.)

The following table shows typical values of output power for base stations:

Type of base station	$Pout_{BS}$ (450 MHz)	$Pout_{BS}$ (900 MHz)	$Pout_{BS}$ (800 MHz)
BRS2	42 dBm (16W)	40 dBm (10W)	N/A
BRU3	38 dBm (6W)	38 dBm (6W) 35 dBm (3W)	38 dBm
BRU1	30 dBm (1W)	30 dBm (1W)	-

BRS2:
The carrier output power shall remain within +/- 1 dB of the adjusted power.

It shall be possible from the computer part of the base station and from the front panel in local mode to decrease the output power to at least -10 dB relative to the maximum output power.

BRU3 & BRU1:
The nominal output power can be changed in seven steps of 3 dB and will typically be within 1.5 dB.

Mobile & Portable, $Pout_{RM}$

The following table shows typical ouput power values for base stations:

Type of radio modem	$Pout_{RM}$ (450 MHz)	$Pout_{RM}$ (900 MHz)	$Pout_{RM}$ (800 MHz)
Mobile	40 dBm *(10W)	38 dBm (6W)	-
Hand portable	33 dBm (2W)	33 dBm (2W)	33 dBm (2W)
Pager	33 dBm (2W)	33 dBm (2W)	33 dBm (2W)

* The maximum mobile output power can vary from country to country due to restrictions.

4.3.2 Receiver Sensitivity

Base station, Pin_{BS}

BRS2:	**-113 dBm** at 1% BER under static conditions, which corresponds to 10% block error rate. Measured at the antenna connector.
BRU3:	**-117 dBm** at 1% BER under static conditions, which corresponds to 10% block error rate. Measured at the antenna connector.
BRU1:	**-113 dBm** at 1% BER under static conditions, which corresponds to 10% block error rate. Measured at the antenna connector.

Radio Modems, Pin_{RM}

Mobile & Portable:	Typical value **-113 dBm** at 1% BER under static conditions, which corresponds to 10% block error rate. Measured at the antenna connector.
Pager:	Typical value **-115 dBm** at 1% BER at static conditions, which corresponds to 10% block error rate. Measured at the antenna connector.

The *ref.* **[1]** *MOBITEX Interface Specification, 8 kbps* states a minimum of **-113 dBm** for 10% block error rate (BLER).

Please note that for a radio modem, the typical sensitivity is -113dBm. The sensitivity of a radio modem may be decreased while operating in a PC. The decrease is caused by additional noise generated by the PC and the absolute noise level is dependent on the brand of the PC. A typical value of the sensitivity that could be used is -105dBm.

4.3.3 Feeder Loss

The feeder attenuation depends on the type and length of the feeder. The values given here should only be regarded as examples.

Note: The feeder length for BRU3 is normally shorter than 40m. For BRU1 normally no feeder is used.
The following table shows typical feeder loss values:

Frequency band		400 MHz	900 MHz	800 MHz
Base station:	Loss [dB/100m]	2.9	4.5	4.1
	Length [m]	40.0	40.0	40.0
(Lf_{BS})	**Total loss [dB]**	**1.2**	**1.8**	**1.6**
Radio modem:	Loss [dB/100m]	39.4	57.4	53.0
	Length [m]	2.5	2.5	2.5
(Lf_{BS})	**Total loss [dB]**	**1.0**	**1.4**	**1.3**

Portable station: No feeder, no losses, antenna mounted directly on the unit.

4.3.4 Antenna Gain

The antenna is a compromise between antenna gain, cost and possible locations in the antenna tower and the dimension of the cell.

Base station (Ga_{BS}):

Between **5.2** and **11.2 dBi** (3 - 9 dBd) for omnidirectional antennas and between **5.2** and **19.2 dBi** (3 - 17 dBd) for sectorized antennas.
For BRU1 900 MHz, **2.2 dBi** and
for BRU1 400 MHz, Tx: **1.65 dBi** / Rx: **0.5 dBi**

Note that the antenna gain relative to an isotropic antenna (dBi) is used in the calculations

Mobile station (Ga_{RM}):

A typical roof mounted car antenna has an antenna gain of approximately **2.2 - 5.2 dBi** (0.0 - 3.0 dBd).

Portable station (Ga_{RM}):

The antenna gain is 0.5 dBi (-1.7 dBd) for a typical portable station. Note that the losses due to the antenna's orientation and position relative to the human body are not included in this figure.

4.3.5 Duplex Filter

BRS2:
Duplex filter is optional for this base station.
If the isolation between the transmitter antenna output terminal and the receiver antenna input terminal(s) is greater than 50 dB within the transmitter and receiver bands are fulfilled, it is then possible to replace two separate antennas for the transmitter and the receivers with a duplex filter. In the link budget, the value of $Pout_{BS}$ and Pin_{BS} should be reduced by 1.5 dB.

BRU3:
The attenuation due to the duplex filter is already included in the value of the output power. No additional margin should be added to the link budget.

BRU1:
The attenuation due to the duplex filter is already included in the value of the output power. No additional margin should be added to the link budget.

5 Cell Coverage

5.1 Propagation Model

A widely used and established model for propagation loss is the Okumura-Hata model [2]. This model is based on practical measurements in the range of 100 - 1500 MHz. The model gives the propagation loss as a function of frequency, antenna height and distance.

Lp : Propagation loss between two isotropic antennas [dB]

fc : Frequency [MHz] (150 - 1500 MHz)

hb : Base station effective antenna height [m] (30 - 200 m)

R : Distance [km] (1 - 20 km)

hm : Mobile antenna height [m]

Urban area: Lp = 69.55 + 26.16 x LOG (fc) - 13.82 x LOG (hb)+ (44.9 - 6.55 x LOG (hb)) x LOG (R) - a (hm) (1)

where a(hm) is a correction factor used, if the antenna height of the mobile stations is less than or greater than 1.5:

a(hm) = (1.1xLOG(fc) - 0.7) x hm - (1.56xLOG(fc) - 0.8)

Suburban Area: Lps = Lp{Urban area} - 2 $[\mathrm{LOG}(fc / 28)]^2$ - 5.4 (2)

Flat Open area: (a distance of 300 - 400 meter to the nearest obstacle/building)

Lpr = Lp{Urban area} - 4.78 (LOG fc)2 + 18.33xLOGfc - 40.94 (3)

5.2 Margins

To achieve acceptable transmission quality and coverage it is necessary to add margins for fading and penetration losses into buildings.

5.2.1 Fast Fading Margins

Fast fading occurs as a result from interference between reflected signals, e.g., from buildings, cars, ground and other obstacles. This type of fading is called Rayleigh fading after the name of the distribution used to model the signal strength. There is approximately λ /2 between the points where the signal is heavily subdued, i.e., 17 cm for 900 MHz. Since the mobile antenna most of the time is lower than the surroundings, Rayleigh fading must always be taken into account. When the mobile moves, the signal strength varies fast. For 900 MHz and a velocity of 100 km/h, there are average 83 fading dips per second (fd = v/λ). These fast variations can be handle by error correction. In the Mobitex system this is done by combining three methods and these are block coding, interleaving and ARQ. When the mobile is moving slowly, the length of the fading dips is increased and when the mobile is static the fading dip may be permanent, which makes the error correction more difficult. Measurement has shown that for a fading frequency of 10Hz and 50 Hz, a fading margin of 10 dB is necessary. Even under static conditions it is necessary to add a margin to increase the probability that the signal is above the mean value. A margin of 10 dB corresponds to approximately a 90% probability that the signal is above mean value.

Fast fading margin = 10 dB

5.2.2 Margin for Outdoor Coverage, Slow Fading

The signal strength varies in an area due to shadowing and reflections from buildings, terrain formations, etc. The variation is modelled as a lognormal distribution around the average value of the area. This effect is often referred to as slow or lognormal fading.

Most cell planning tools estimate the average signal strength in an area (typical 50 x 50 m). In this way, about 50% of locations of the cell edge could have signal strength below the estimated values.

Fifty percent of the location at the cell edge will not give an acceptable coverage for mobile applications and it is therefore necessary to add a margin in the cell planning criteria, to achieve a higher coverage probability. The value of this margin is dependent on the type of terrain and the desired coverage, assuming a standard deviation of 6 dB and that the path loss attenuation is proportional to

R^{-3} (2 = free-space propagation).

- When 75% of the location, (P(R)=75%), at the cell edge has a signal strength above the threshold, approximately 90% of the cell will be covered. To achieve this, it is necessary to add a margin of 4 dB (σ x 0.675).

- To achieve 90% of the location, (P(R)=90%), at the cell edge it is necessary to add a margin of 8 dB (σ x 1.3). Approximately 95% of the area is then covered.

Note that the calculations are made for a single cell environment. In a multicell environment the coverage is increased with unchanged margins, due to overlap at the cell edges.

Slow fading margin = 8 dB

5.2.3 Margins for Indoor Coverage

This section deals with some issues concerning penetration losses in buildings in different environments. Building material, the thickness of the walls, the number and sizes of the windows, local terrain, type of buildings, etc., are very important factors when planning for indoor coverage. It is impossible to cover all the conditions that occur in reality. The figures describing penetration losses in this section can therefore only be used to get an estimation of penetration losses. To get a more accurate estimation, measurements in the actual building have to be made.

5.2.4 Definitions of Penetration Losses in Buildings

The definition of penetration loss in this paper is:

The difference between the average received signal strength measured over a small area in a building and the average received signal strength measured outside the building at street level.

It is a very practical and useful definition because the signal strength inside a building can be determined from cell planning tools, which predict the signal strength outside at street level.

Approximate total margins for indoor coverage

In this section a typical value (T.V) for the indoor margin is estimated. This value is **very** approximate and can not be seen as a general value.

In the table below a summation is made to achieve the **total lognormal distribution**, that represents both slow fading and penetration losses. In this table the standard deviation (σ) for slow fading is collected from section *5.2.2 "Margin for Outdoor Coverage, Slow Fading"*. To reach sufficient indoor-coverage without extreme high indoor margins, a 90% over-all-coverage (OAC 90%) is recommended. It is about the same as 75% coverage at the cell edge, when the standard deviation is around 10 dB.
The table shows the total lognormal distribution that describes penetration losses in buildings and lognormal (slow) fading at 900 MHz.

Type of area		Penetr. loss		Fad. loss	Total		Margin for OAC 90%
		M.V (db)	σ (dB)	σ (dB)	M.V (db)	σ (dB)	(dB)
Urban	T.V (fl.1) Hongkong Chicago	18 23.0 17.8	8 6.5 7.7	6 6 6	18 23.0 17.8	10 8.8 9.8	25 29 25
Suburban Buildings	T.V (fl.1) Stockholm Chicago	12 10.5 12.9	8 7 9.1	6 6 6	12 10.5 12.9	10 9.2 10.9	19 17 21
Suburban Houses (U.S)	T.V (fl.1) Basement Floor 1	6 14.9 5.5	8 7.6 8.7	6 6 6	6 14.9 5.5	10 9.7 10.6	13 22 13

Where: T.V = Typical value
M.V = Mean value

For urban areas a total margin of approximately 25 dB at the cell edge gives 90% over-all-coverage at the first floors in large buildings. Higher floors on the indoor coverage is better. In suburban buildings a margin of approximately 19 dB at the cell edge gives a 90% over-all-coverage. To obtain 90% over-all-coverage at the first floor (ground floor) in suburban small houses, a total margin of roughly 13 dB at the cell edge has to be applied.

Note that these values are typical for a certain area and type of building and not general. Please compare to measured values at different environments in table 6. The calculations are made in a single cell environment. In a multi cell environment the degree of coverage is increased with unchanged indoor margins.

Table 6 is valid for 900 MHz. Turkmani et Al *ref.* **[3]** *Measurements of building penetration loss on radio signals*, measured the penetration losses for 441 and 896.5 MHz. Their conclusion was that the average penetration losses decreased by approximately 1.5 dB when the frequency increased from 441MHz to 896.5 MHz. Turkmani et Al refers to others who have shown nearly the same result. Sanden *ref.* **[4]** *Building penetration loss in small cell enviroment* has come to a conclusion that is the opposite of Turkmani et Al. The method of measurement was different, however.

5.3 Link Budget

5.3.1 Maximum Path Loss

The maximum path loss is the difference between the transmitted EIRP and the minimum signal strength. The maximum path loss is dependant on the studied link. Six cases are possible: base to mobile, base to portable, base to pager, mobile to base, portable to base and pager to base.

BRU3 (900 MHz) has been used in the example below. The base station software version is R14N/NTE.

Transmitter	**BASE**	**Mobile**	**BASE**	**Pager**	**Ref. see chapter**
Output power (dBm)	35	38	35	33	4.3.1
Feeder loss (dB)	-1.0	-1.0	-1.0	0	4.3.3
Attenuation due to duplex filter	Optional	N/A	Optional	N/A	4.3.5
Antenna Gain (dBi)	11.2	2.2	11.2	0.5	4.3.4
EIRP Levels (dBm)	**45**	**39**	**45**	**33**	
Receiver	**Mobile**	**BASE**	**Pager**	**BASE**	**Ref. see chapter**
Receiver sensitivity (dBm)	-113	-117	-115	-117	4.3.2
Rayleigh fading (dB)	10	10	10	10	5.2.1
Feeder loss (dB)	1.0	1.0	0	1.0	
Attenuation due to duplex filter (dB)	N/A	Optional	N/A	Optional	4.3.5
Antenna Gain (dBi)	-2.2	-11.2	-0.5	-11.2	4.3.4
Minimum signal strength (dBm)	**-104**	**-117**	**-105**	**-117**	
Outdoor coverage:	**Mobile down link**	**Mobile up link**	**Pager down link**	**Pager up link**	**Ref. see chapter**
Path loss, P(R)=50%	149 dB	156 dB	150 dB	150 dB	
Log-normal fading, P(R)=90%	-8 dB	-8 dB	-8 dB	-8 dB	
Total maximum path loss, P(R)=90%	**141 dB**	148 dB	**142 dB**	**142 dB**	
Traditional Link advantage:	-7 dB	7 dB	0	0	

Protocol Gain	4.9	2.3	3.9	5.9	
Total max protocol path loss:	**146 dB**	150 dB	**146 dB**	148 dB	
Protocol Link advantage:	-4 dB	4 dB	-2 dB	2 dB	
Indoor coverage:					
Path loss, P(R)=50%	N/A	N/A	150 dB	150 dB	
Margin for indoor coverage:			-25 dB	-25 dB	
Total max path loss:			**125 dB**	**125 dB**	
Traditional Link advantage:			0	0	
Protocol Gain			3.9	5.9	
Total max protocol path loss:			**129 dB**	131 dB	
Protocol Link advantage:			-2 dB	2 dB	

To achieve a power balance between the up and downlink, the underlined figures for the path loss should be used when calculating the cell size.

5.3.2 Power Balance

It is necessary to observe that when there is unbalance between the up and downlink in the system, the cellplaning criteria should be adopted to the weakest link.

Power equations:

Downlink:

$$Pout_{BS} = Pin_{RM} + Lf_{RM} - Ga_{RM} + Lp - Ga_{BS} + Ld^* + Lf_{BS} \quad (4)$$

Uplink:

$$Pout_{RM} = Pin_{BS} + Lf_{BS} + Ld^* - Ga_{BS} + Lp - Ga_{RM} + Lf_{RM} \quad (5)$$

If we exclude the reciprocal parameters in 4) and 5) and assume that Lp is reciprocal, we get the following relationship:

$$Pout_{BS} = Pin_{RM} - Pin_{BS} + Pout_{RM} \quad (6)$$

* Optional

It could be noted that it is better to choose a high antenna gain at the base station, to achieve the desired coverage area instead of a high output power, since this will give a better coverage for radio modems with low output power, i.e., portables.

If the cell has been planned for a certain maximum output power for the radio modem, it is necessary to make sure that radio modems with less maximum output power have a balance between the up- and down link. Adding an offset margin to the roaming parameters GOOD_BASE and BAD_BASE does this.

If the cell size has been planned in such a way that radio modems at the coverage edge exists with higher nominal output power than necessary to achieve a balance between up- and down link, for example a base station with low output power, the base station orders all radio modems above a certain limit to reduce their power.

Further information can be found in *[1] "MOBITEX Interface Specification, 8 kbps"*: Section: Link Layer

5.3.3 Dynamic Output Power Control

In order to reduce interference in the system, the radio modems should reduce their transmitter output power when the roaming value is above GOOD_BASE + TXADJ. TXADJ is a programmable parameter in the radio modem and defines the threshold for dynamic output power control. The network operator can define the value in the range of 10 to 50 dB. The default value is 25 dB. The parameter GOOD_BASE is also used in the roaming algorithm, see section *8 "Roaming"*. The default value is - 98 dBm (15μV emf). It is possible to reduce the output power by 6, 12 and 18 dB. Further information can be found in *[1] "MOBITEX Interface Specification, 8 kbps"*: Section: Link Layer

5.4 Typical Cell Radius

Typical cell radius for BRU3 (900 MHz) for the example in section *5.3.1 "Maximum Path Loss"*, with hb = 40m and hm = 1.5m, is found in the table below. (Propagation model according to chapter *5.1 "Propagation Model"*)

Typical cell radius BRU3	**Mobile coverage**	**Mobile coverage**	**Pager coverage**	**Pager coverage**
	Traditional	Protocol	Traditional	Protocol
Outdoor (km)				
Urban area	1.5 - 3.5	2.5 - 4.5	1.8 - 3.2	2.3 - 4.2
Suburban area	3 - 7	5 - 9	3.4 - 6.2	4.5 - 8
Open area	12 - 22	18 - 28	11.5 - 21	15 - 28
Indoor (km)				
Urban area	N/A	N/A	0.6 - 1.0	0.7 - 1.3
Suburban area	N/A	N/A	1.1 - 2.0	1.4 - 2.6
Open area	N/A	N/A	N/A	N/A

Typical cell radius for BRU3 (800 MHz) is found in the following table:

Typical cell radius BRU3	**Mobile coverage**	**Mobile coverage**	**Pager coverage**	**Pager coverage**
	Traditional	Protocol	Traditional	Protocol
Outdoor (km)				
Urban area	2.2 - 4.2	3 - 5.5	2.4 - 4.2	3 - 5
Suburban area	4.5 - 8.2	6 - 10	4.4 - 8	5.5 - 10
Open area	15.5 - 28.5	17 - 30.5	15 - 27	16 - 30
Indoor (km)				
Urban area	N/A	N/A	0.8 - 1.2	1 - 1.8
Suburban area	N/A	N/A	1.2 - 2.5	1.8 - 3
Open area	N/A	N/A	N/A	N/A

Typical cell radius for BRU3 (400 MHz) is found in the following table:

Typical cell radius BRU3	**Mobile coverage**	**Mobile coverage**	**Pager coverage**	**Pager coverage**
	Traditional	Protocol	Traditional	Protocol
Outdoor (km)				
Urban area	4 - 7.5	5.4 - 9.5	4 - 7	5 - 9
Suburban area	7 - 12.5	9 - 16.5	6.5 - 12	9 - 16
Open area	17 - 30	20 - 31	17 - 30	20 - 31
Indoor (km)				
Urban area	N/A	N/A	1.3 - 2.3	1.7 - 3
Suburban area	N/A	N/A	2.2 - 4	2.9 - 5
Open area	N/A	N/A	N/A	N/A

The figures in the examples above are based on P(R) = 90%. However, it should be noted that if the radius for P(R) = 90% is approximately 3.5 km (urban), this does not exclude coverage outside this area. There will be a radius of approximately 6 km, with a coverage probability of 70% (P(R) = 50%). However, this figure does not take into account reduced coverage due to interference. The assumptions are the same as in section *5.2.2 "Margin for Outdoor Coverage, Slow Fading"*

6 Cell Planning Criteria

The cell planning criteria is the minimum signal strength planned for a network to achieve acceptable communication. It is calculated as the base station's EIRP minus the maximum path loss on the weakest link.

To find the weakest link for mobiles and pagers, it is necessary to compare the uplink with the downlink in each system (see section *5.3.1 "Maximum Path Loss"*).

For the example below, output power is defined as follows:

- Base station output power
  400/800 MHz = 6W
  900 MHz = 3W
- Mobile/Pager output power
  400/800/900 MHz = 2W

System with	Mobiles		Pagers	
	400/800	900	400/800	900
Cell planning criteria:				
Outdoor [dB]	**-100**	**-97**	**-100**	**-97**
Protocol Outdoor [dB]	**-104**	**-101**	**-104**	**-101**
Indoor [dB]	N/A	N/A	**-83**	**-80**
Protocol Indoor [dB]	N/A	N/A	**-87**	**-84**

7 Interference Criteria

7.1 Co-channel Interference - C/I

Due to the lack of spectrum for mobile data services, the number of available channels is limited. This means that a Mobitex system may be interference limited rather than noise limited. Consequently, close attention must be paid to the frequency reuse scheme.

The frequency plan is largely dependent on how interference-sensitive the system is. The C/I ratio is the parameter that indicates the sensitivity for co-channel interference of a system. For Mobitex, the C/I ratio is defined as the minimum C/I level required to achieve an acceptable communications environment as defined in *3 Criteria for Acceptable Communication*.

The impact of different co-channel interference environments has been simulated and evaluated. The required C/I ratio for 10 % block error rates is about 18 dB in a fast fading environment. Note that a lower C/I ratio does not mean that communication is not possible. The result of operating in an environment with lower C/I is that the transmission success rate is lower. In other words, the probability of successfully transmitting a message in the first transmission attempt is lower.

The recommended C/I is 18 dB.

There are various methods using different types of cell patterns and frequency reuse schemes that may be used to realise a specific C/I. There are many conflicting views on what C/I can be achieved using a specific reuse scheme. A description of different cell patterns is beyond the scope of this guide. The person responsible for the cell planning, who has access to all site-specific information, should select a suitable reuse scheme.

7.2 Adjacent Channel Interference - C/A

Neighbouring cells:

The Mobitex system has been designed for a high degree of adjacent channel interference protection. With a channel separation of 12.5 kHz, it is possible to use adjacent channels, in an adjacent cell. The requirements for the mobile’s adjacent channel selectivity are 54dB and the interference due to transmitted adjacent channel power is 42 dB above the desired signal. According to the roaming algorithm, the mobile will leave the current base station if another base station’s signal level is 10-15 dB higher then the current base station, so the mobile changes base station before interference will occur.

At the same site:

In the Mobitex - 8kbps system, hybrid combiners are used. The minimum channel separation is 25kHz with 12.5 kHz channel spacing and 50 kHz for 25 kHz channel spacing. The up-link is the worst interference scenario since the radio modems have different signal levels at the base station. Measurements have shown that when a "wanted" mobile is transmitting at the coverage edge, an interfering mobile can transmit at a frequency separation of 25kHz, approximately 100 meter from the base station without causing interference. It could be noted that the measurements were made with the same EIRP for the wanted and unwanted mobile.

8 Roaming

In the Mobitex system, it is the radio modem that measures the signal strength and decides when to leave the current base station. The radio modem can use three different lists when monitoring the channels. The "current list" consists of the channels used by the neighbouring base stations. This list is received by the current base station. The *"default list"* contains of all channels used in the network and is permanently stored in the radio modem. In order to speed up the roaming procedure, the radio modem has the possibility to reduce the number of channels to scan by using a *" temporary default list"*.
The criteria for leaving the current base station can be found below:

1) If the signal strength from the current base station is too low.

The default value for the parameter BAD_BASE is -98dBm (15 dBμV emf)

2) If the signal level from another base station is much higher.

The default value for the parameter BETTER_BASE is 10 dB.

Simulations have shown that the traffic the roaming algorithm generates increases considerably if the value is below 10 dB, since the changes of base station increase considerably. On the other hand a value of approximately 25 dB reduces the roaming to other base stations to zero.

3) If no acknowledge is received after MAX_REP retransmission,

This means that the radio modem has no contact in the uplink. The default value for MAX_REP is 3.

4) The radio modem has not received a valid <SVP> frame within 2 sweep cycles.

I.e., the radio modem has no contact in the downlink.

In case 2, the radio modem check once more if the best base still fulfils the criteria of best base before changing over. This is done during the next <SVP> cycle, by measuring the signal strength from this base station during the entire scan time (SCAN_TIME).

In cases 3 and 4, the radio modem leaves the current base station immediately without waiting for the end of the cycle.

When the radio modem has to find another base station, it uses a list of base stations with descending roaming values. It will look for a base station with a roaming value not less then GOOD_BASE. If it finds a base station that fulfils this criteria, it will measure this station once more during a period of SCAN_TIME.

If no suitable base station could be found, the radio modem goes into quick channel monitoring. During quick channel monitoring, it starts with the first channel from the current list and if this list is not available, it begins with the first channel of the temporary list. If this list is not available, it tries with the next channel from the default list until the radio modem finds a station that fulfils the criteria of GOOD_BASE.

The default value of GOOD_BASE is -98 dBm (15 dBμV emf). If the value of GOOD_BASE is below BAD_BASE, there will be a considerable increase of the traffic the roaming algorithm generates, since it will very quickly be necessary to change base station due to a roaming value below BAD_BASE. A more detailed explanation about the roaming algorithm, can be found in *ref.* **[1]** *MOBITEX Interface Specification, 8 kbps*
It is possible for the operator to influence the cell size by changing different parameters in the roaming algorithm. However, since the parameters should be chosen very carefully to avoid overloading the system with roaming traffic, the roaming parameters should only be used for "fine tuning" the network when the cell planning is finalised and the network is running.

9 Site Considerations

9.1 BRU1, BRU3 and BRS2

Site engineering is not within the scope of this document, however the following should be noted.

For external interference sources, the following criteria should be used:

Frequency band *PB=passband SB=stopband*	**Max interference level**
Base station TX PB	≤ – 30 dBc
Base station TX SB	≤ 30 dBc
Base station, within used RX channels and the adjacent channels	≤ – 131 dBc
Base station, 2 channels and further away from the used RX channels (within PB)	≤ – 36 dBc
Ability to withstand electrmagnetic fields RX PB	≤ 10 dBc

In the transition zone between the passband and the stopband (guardband), the values for the passband shall be used. The size of the guardband depends on the filters used.

For example, with a passband of 5 MHz and standard filters, the guardband is 5 MHz. This means that special care must be taken within 15 MHz. Additional filtering is needed to reduce this band.

For further information about parameters for environmental interference and additional filtering, please contact Ericsson.

Both radio equipment at the same site and equipment located in the same geographical area should be taken into account. It should be noted that carriers with a large frequency separation from the PB may cause interference within the passband, for example, due to a broad transmitter spectrum, spurious and out-of-band emission.

10 References

[1] MOBITEX Interface Specification, 8 kbps
LZBA 703 1001/NN

[2] CCIR, vol V
Report 567

[3] Measurements of building penetration loss on radio signals
A.M.D Turkmani, J.D Parsons and D.G Lewis, Journal of institution of electronic and radio engineers; Vol. 58; No.6 pp 169-174; September-December 1988.

[4] Building penetration loss in small cell enviroment
M.Sanden; COST 231 TD(90), Sweden (Televerket Radio): December 1990