Cordless Phone

INSTALLATION PLANNING

Release 7.6 SP1

1 GENERAL

1.1 SCOPE

This installation planning document will give an explanation of how different factors influence on the size of the MX-ONE cordless phone system and how acceptable values can be given to these factors. The factors that determine the final configuration of a system are:

- Number of base stations (Radio Fixed Parts (RFPs))
- Number of portables (Portable Parts (PPs))
- Traffic requirement for the system
- Physical nature of the site
- Choose how the media gateways are synchronized.

Furthermore the system has a number of restrictions that gives limitations to the configuration. These items are explained in the following sections.

To make a system configuration, first the limitation of the system must be known, see chapter 2 Limitations in the system on page 6.

The traffic requirements for the system are determined by the number of portables needed, the estimated traffic generated per portable and the Grade Of Service (GOS) accepted by the customer. For more detailed description, see chapter 4 Traffic capacity on page 27.

In this document ‘ELU31/3’ refers to ROF 137 5412/3 and ‘ELU31/4’ refers to ROF 137 5412/4. If not mentioned specifically, ‘ELU31’ refers to the index /4 and /3 boards, all boards are assumed to have latest FW, co-operability is only guarantied between index /3 and /4 of latest FW.

ELU31/4 has an on-board switch. The switch can be set to “index_3 mode” or “index_4 mode”. This switch must be set to index_3 mode to have the same functionality as ELU31/3. For PCM synchronization of the media gateway feature the switch shall be set to index_4 mode. This feature allows media gateways to receive synchronization from the ELU31 board.

- ELU31/4 can replace all other ELU31 versions with some limitations. See section 2.
- ELU31/4 index_3_mode and ELU31/3 can coexist on the same ring.
- ELU31/4 index_4_mode can distribute PCM synchronization to all media gateways with the DECT synchronization ring. See chapter Introduction to the synchronization ring in CORDLESS PHONE Installation Instruction.
- System can use one external PSTN timing source, recommended, or use a free running MGU/2 to synchronize the master ELU31 board, thus with ring in index-4_mode synchronization all media gateways.
- ELU31/4 index_4_mode can have ELU31/3 boards as bus slave.
- All boards on the ring must be of the same ‘type’, ELU31/4 index_4_mode or a combination of ELU31/4 index_3_mode and ELU31/3.

1.2 SYSTEM OVERVIEW

Below is an architectural overview over an MX-ONE cordless phone system with integrated DECT.

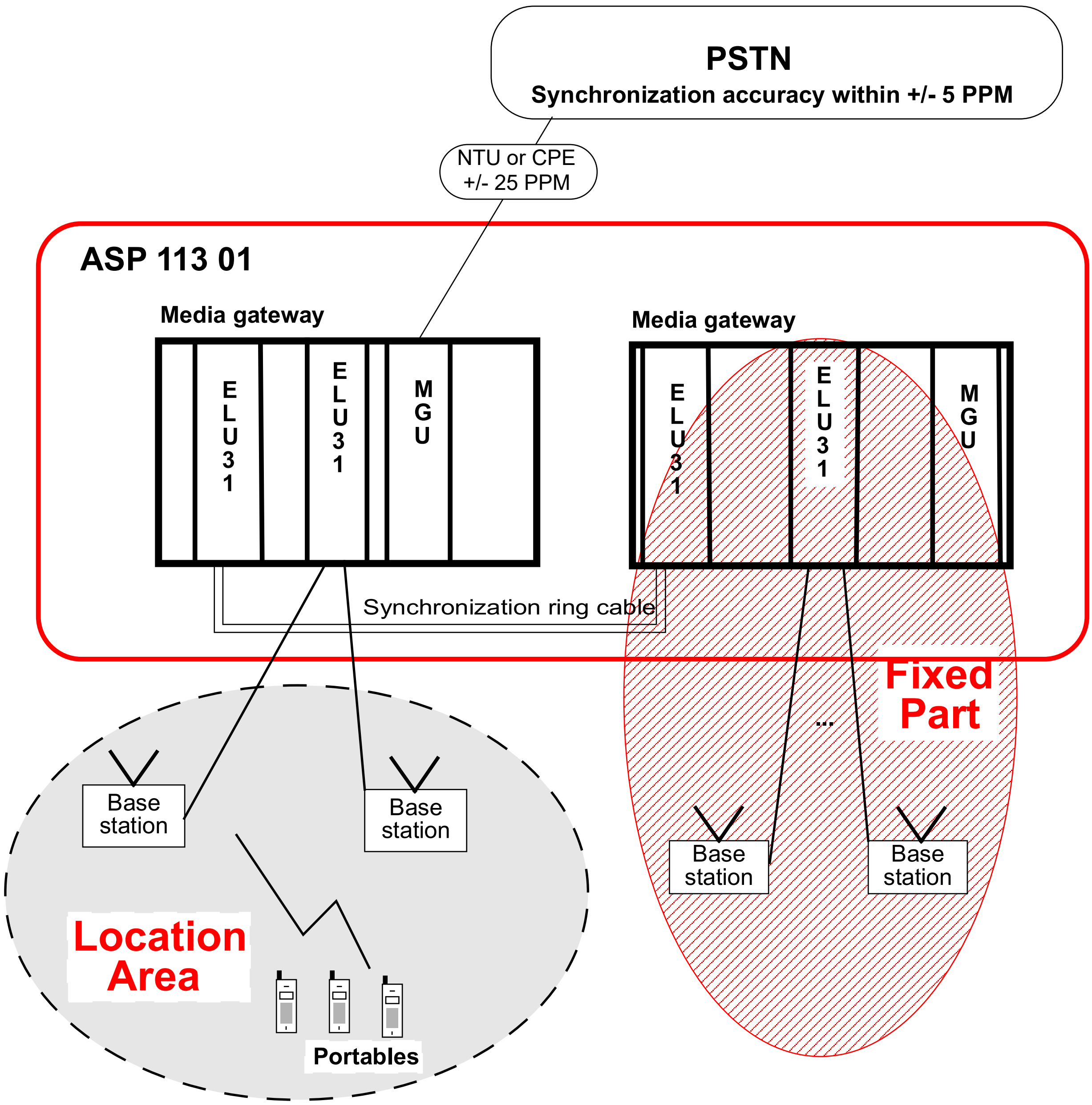


Figure 1: Architecture of a MX-ONE cordless phone system

PCM synchronization in the picture above is distributed in the synchronization ring. This puts some requirement on the configuration.

- All boards in the ring must be ELU31/4 with switch set to index_4_mode.
- All boards in the ring must be configured to enable synchronization distribution, see dect_cfp command description.
- All media gateways shall be configured to retrieve synchronization from ELU31, except the master board. With command trsp_synchronization, all ring member

boards shall be given same class and priority. Ring master board shall have class ‘no’, prio ‘no’.

- All involved media gateway must be equipped with MGU boards.

2 LIMITATIONS IN THE SYSTEM

2.1 SEAMLESS HAND OVER

In order to secure cordless phone functionality, the MX-ONE system must be synchronized to the reference timing source

Synchronization between all ELU31 boards in the system are handled by a ring structure. The ring consists of two separate electrical interfaces for synchronization. This to get the **DECT air frame** synchronization correct.

The number of ELU31 boards connected to the ring are different for different media gateway types.

- MX-ONE Classic (LBP22 with MGU) max 1 ring member
- MX-ONE Lite (LBP24 with MGU) max 1 ring member

For a more detailed description regarding synchronization and synchronization ring cable, see installation instructions for *CORDLESS PHONE*.

Note: Even if only one ELU31 board is used in the ring there has to be ring cable looped between Tx and Rx on that ELU31 board.

2.2 ELU31 BOARDS

The practical limitation of the number of ELU31 boards in a system is decided by the number of portables, how much traffic each portable generates, the Grade of Service (GOS) that is accepted by the customer and the power consumption.

When using MX-ONE Classic with MGU, the practical and power limitation is 10 ELU31 boards, evenly distributed between magazines.

When using a MX-ONE Slim (1U) box BFD 761 42/x or 87L00039 AAA-A, the number of ELU31 boards is limited to 1 due to power consumption.

Using MX-ONE Classic (with LSU-E and DSU) is not allowed/supported.

ELU31/1 is a phased-out product and is service stopped. It is not recommended to use ELU31/1

ELU31/2 is a phased-out product and is service stopped. It is not recommended to use ELU31/2

ELU31/3 must have latest FW to inter work with ELU31/4 board.

ELU31/3 can be bus slave to a ring with ELU31/4 index_4_mode.

ELU31/4, and ELU31/3 has improved ring communication and ACDM function. Therefore it is recommended to use these boards in the ring.

ELU31/4 index_3_mode, can be ring board or bus slave together with all index.

ELU31/4 index_4_mode, can only operate with other index_4_mode boards in the ring. It can be bus slave, but not recommended, in other configurations.

2.3 BASE STATIONS

Only the following MX-ONE DECT base stations are compatible with the ELU31 board:

- BS332 (80E00014AAA-A).
- BS342 (80E00015 AAA-A).

The base stations are defined in document “Installation Guide Base Station”.

The maximum number of base stations connected to one ELU31 board is 8.

The base stations BS330, 340 and 370 are service stopped.

The CORE base stations are service stopped since long, not recommended to use.

2.4 PORTABLES

The maximum number of portables that can be located/present in one LIM is limited by the software to 1000.

Note: These numbers represent the maximum possible number of portables. The number of portables that should be initiated or located depends on the amount of traffic generated by each portable, but the practical number of initiated or located portables may be lower. Note also that roaming traffic is generated when the portable is moved, even if no calls are made.

Third Party DECT needs license. For more information, refer the Third Party Device License Handling for MX-ONE Integrated DECT, Interworking Description document.

2.5 CABLING

The maximum cable length between an ELU31 board and a base station is 1700 meters, this cable length is valid for BS332 and BS342 and 0.6 mm cable with 1 EPP. For more details about requirements on the cable see installation instruction CORDLESS PHONE. For other cable dimensions and other base station, see installation instructions for *CORDLESS PHONE*.

The maximum cable length for the synchronization ring using a cable with wire diameter 0.6 mm is 1300 meters per segment, for more details about requirements on the cable see installation instruction CORDLESS PHONE.

All cables, both between the ELU31 boards and base stations as well as for the synchronization ring, must be twisted pair cables. In areas with high electric disturbances, shielded twisted pair cables are required. For new installations, it is always recommended that shielded twisted pair cables are used.

There is no theoretical limit to the number of ring segments per system. However it is recommended that if the total cable length for one sync ring is more than 3 km or if the sum of cable delays for one sync ring is more than 20 microseconds a careful verification of the sync stability is strongly recommended using the *diagnostic_print* commands for CTLP.

For a more detailed description see installation instructions for *CORDLESS PHONE*.

2.6 AN MX-ONE WITH REMOTE GWS

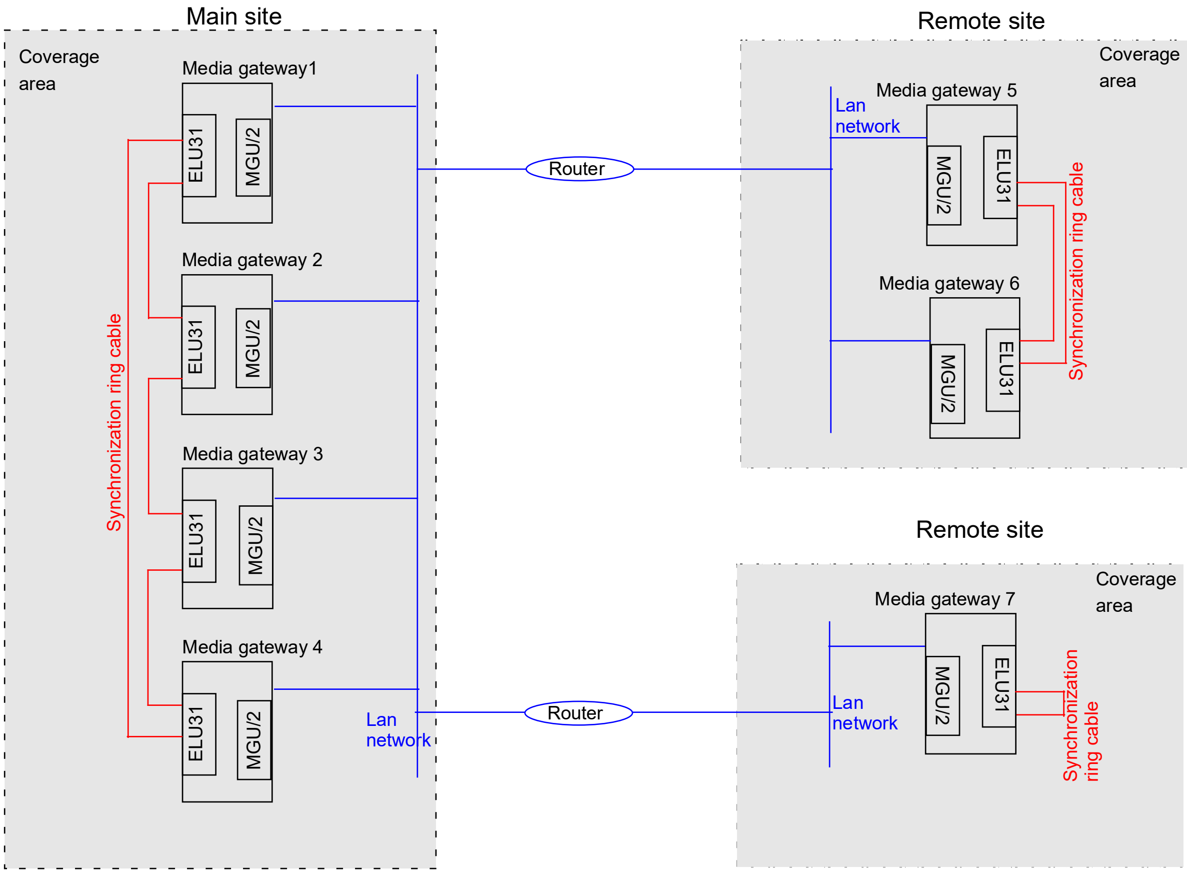


Figure 2: Example of an MX-ONE exchange with a main site and remote sites which, from the synchronization point of view, are independent from each other. Synchronization between the gateways within each site is distributed by synchronization ring. Each site is synchronized by a free running MGU index 2. This must be used when a customer site only has SIP routes.

Note: When moving between the different sites, the PP will lose connection and drop any ongoing calls. Power off and power on the PP is recommended to avoid 'No System' in the display.

If a PP is not powered off before leaving a site the portable will loose contact with the system (the display will show No system). Once the portable has reached a coverage area again (remote site) the portable will regain contact with the system, and a location registration will be made.

3 BASE STATION PLANNING

3.1 GENERAL

A major task when planning a cordless phone system is to define the number of base stations required to cover an area to a satisfactory level. This section describes how base station planning can be made in order to gain full area coverage. The section Traffic capacity explains how traffic requirements additionally influence the number of base stations.

Another aspect of the base station configuration is the power supply which is explained in detail in the installation instructions for CORDLESS PHONE.

3.2 COVERAGE AREAS

3.2.1 THE RADIO CELL

The area covered by a base station is not of a spherical shape as often suggested in pictures. If a snapshot could be taken of its form, it would become clear that its shape is much more irregular. The momentary size and shape are dependent on the material of which walls and floor are made, the position and material of furniture, machines, air-conditioning and the position of the base station in such an environment. Because of these unpredictable conditions it is not possible to give any hard rules on calculating the number of base stations in a given situation.

It is not to say that base station planning is very difficult, on the contrary, but size, architecture and structure of buildings and their influence on the field pattern cannot be foreseen. The quickest and simplest way is therefore measuring. During a so-called site survey, an average cell size can be determined, with help of a site survey tool, see chapter 3.9.1 Site survey tool on page 18. This forms the basis of a base station plan.

The guidelines listed below will help getting a better understanding of the local situation when base stations are being planned. See chapter 3.9 Site survey on page 17 how a site survey can be done.

3.2.2 LOCATION AREA

A location area is the domain in which a portable may receive and/or make calls as a result of a single location registration. In the MX-ONE cordless phone system it is the area covered by one or more base stations connected to the same ELU31 board. Thus one MX-ONE cordless phone system typically consists of several location areas. Moving between location areas causes load on the system, and it is very important to plan the system in such a way that this kind of load is minimized.

Base stations that cover the same areas shall, when possible, be connected to the same ELU31 board. In larger areas additional ELU31 boards may be needed, and these shall, when possible, be inserted in the same Media Gateway as the other boards that cover this area. In a typical installation, one ELU31 board covers one floor, another ELU31 board covers the next floor and so on.

Larger LA reduce the roaming and hand over events.

Under normal operation, the idle display is updated when information is changed and repeated during inter-LIM roaming.

In areas with insufficient coverage conditions, it is possible to initiate an extended idle display update per board (location area) to increase the likelihood of the portable receiving a display message update.

Idle display updates are sent during inter-LIM roaming and intra-LIM roaming to a location area with an extended display. This reduces battery usage due to increased paging activities.

The increased paging will cause a higher load on boards and base stations.

To handle the disturbances caused by Long Time Evolution (LTE) radio base stations, the number of radio channels can be reduced to avoid using disturbed air. This, in turn, will reduce the traffic capacity of the base stations connected to that board.

3.2.3 OUTDOOR HOUSING

The outdoor housing is a weatherproof protection case for the following base stations:

BS332 and BS342.

Typical applications are the base station coverage of car parks, large factory sites and the like to protect the base stations from wind and weather.

This case can be placed directly against a wall or fixed to a pole. It can also be used, if base stations must be mounted in-house in areas with aggressive environment (vapor, gas, liquids) or extreme dusts (industrial plants).

3.3 CONSEQUENCES OF THE BASE STATION TYPE USED

The following three base station types can be used in the cordless phone system:

- BS332 base stations with a slightly directional antenna pattern. This is the preferred base station in most installations, due to smaller size and lower power consumption.
- BS342 base station with an omni-directional antenna pattern (the same signal strength in all directions). Non-standard antennas can be used to enlarge the range of a BS342 base station, see chapter 3.5 Non-standard antennas on page 14.

For more information about transmission pattern see chapter 6 Appendix B: Radio base station signaling pattern on page 38.

3.4 TOTAL AREA COVERAGE

The base station coverage depends on the following factors:

- The indoor cell size in offices may be in a range of 10 - 40m radius, see figure 6 Example of maximum coverage of one base station on page 13.
- The cell size in exhibition- or production halls is up to 200m radius (when free line of sight).
- The outdoor cell size in free space may be up to 300m radius.
- The base stations may partially cover floors immediately above and below as well. The useful range through floors and ceiling varies between 0 and 8m (2 floors) radius See figure 10 Measurement of a typical cell size. on page 19

In this section different configurations are shown. In normal environments, all these configurations are mixed, due to the building's construction, the users movement and usual location.

Note: This section is based on standard antennas.

3.4.1 MINIMUM ROAMING AND HAND OVER TRAFFIC CONFIGURATION

To keep the roaming and hand over traffic to a minimum, to avoid roaming and hand over between floors and get best possible radio performance it is preferred that the base stations are placed vertically above each other, see figure 4 Example of a high call configuration. ELU31 has 32 B-channel configuration. on page 12. This configuration will also create a safer configuration in case a base station is out of order.

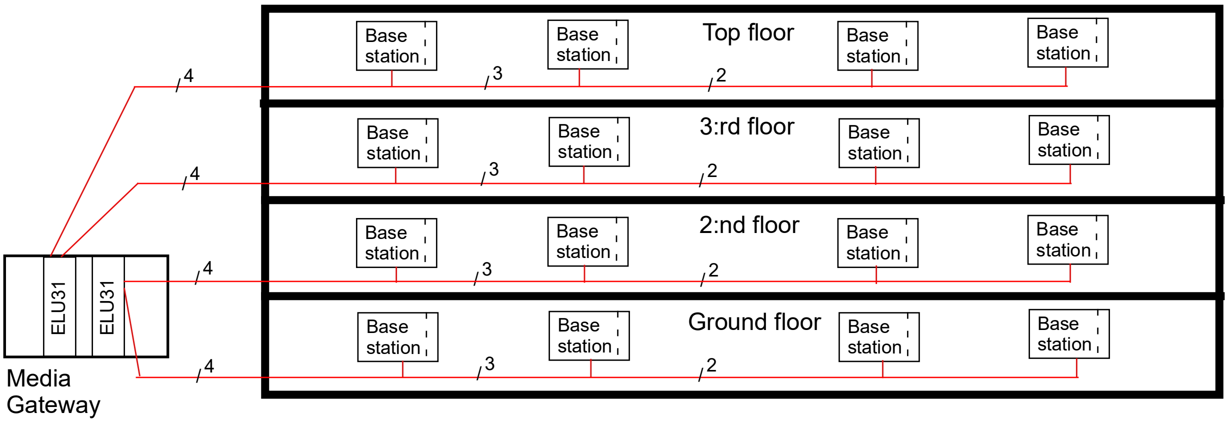


Figure 3: Example of a minimum of roaming and hand over traffic. ELU31 has 32 B-channel configuration.

3.4.2 HIGH CALL TRAFFIC CONFIGURATION

In this example there is double base station coverage such that more B-channels are available for high call rate reasons in specific areas, see figure 4 Example of a high call configuration. ELU31 has 32 B-channel configuration. on page 12.

Note: The number of ELU31 boards should not be over dimensioned without reason as it causes unnecessary load that may adversely affect portable performance.

Note: In a configuration that maximize number of base stations to reduce the number of external hand over and roaming events. Can increase the number of connection hand over events done on the board in a high mobile environment. Each connection hand over event will use 2 B-channel temporarily.

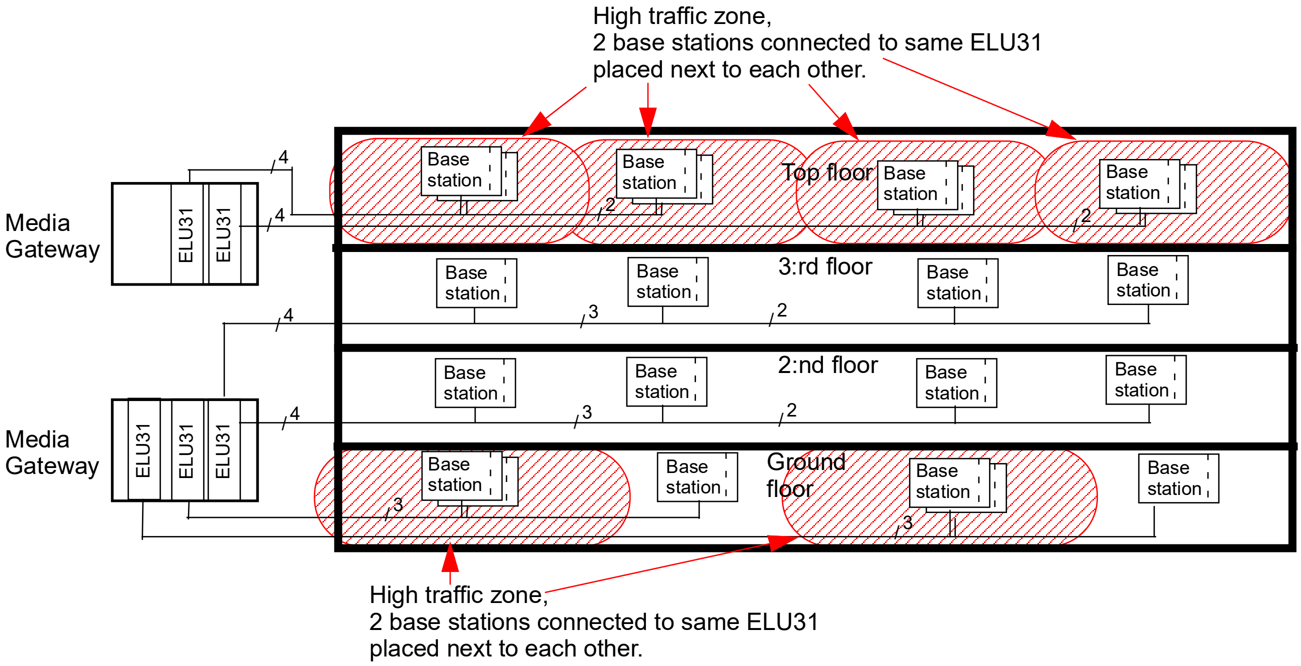


Figure 4: Example of a high call configuration. ELU31 has 32 B-channel configuration.

3.4.3 MAXIMUM COVERAGE CONFIGURATION

Below the base stations are placed in such a way that they give a maximum of coverage in a low traffic environment. The disadvantage with this configuration is that each floor is covered by base stations from other floors. Users that are moving around on one floor will cause roaming and handover traffic between the floors.

This configuration is recommended when it is desired to limit the number of base stations, but should be used with care in configurations with highly mobile users, see figure 5 Example of maximum coverage configuration. ELU31 has 32 B-channel configuration. on page 13
For maximum coverage of one floor, see figure 6 Example of maximum coverage of one base station on page 13.

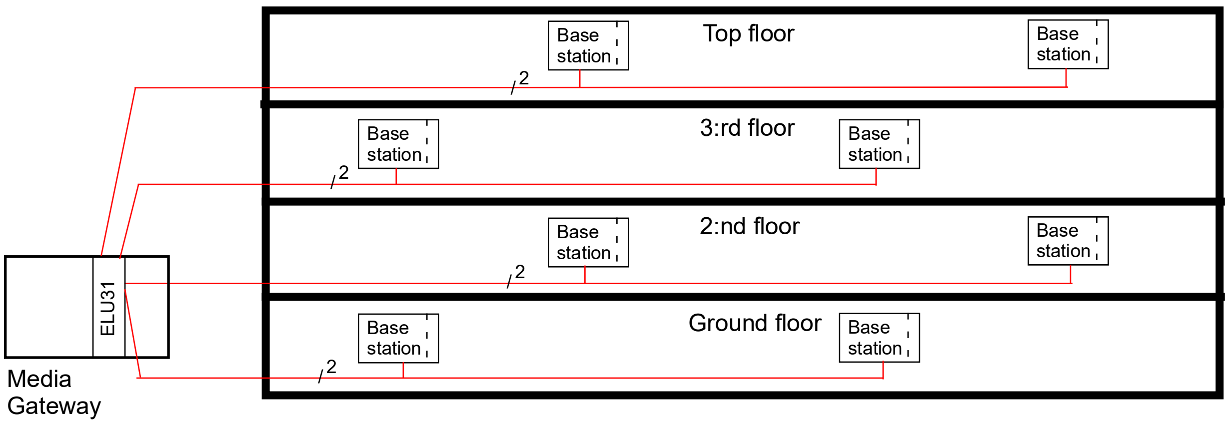


Figure 5: Example of maximum coverage configuration. ELU31 has 32 B-channel configuration.

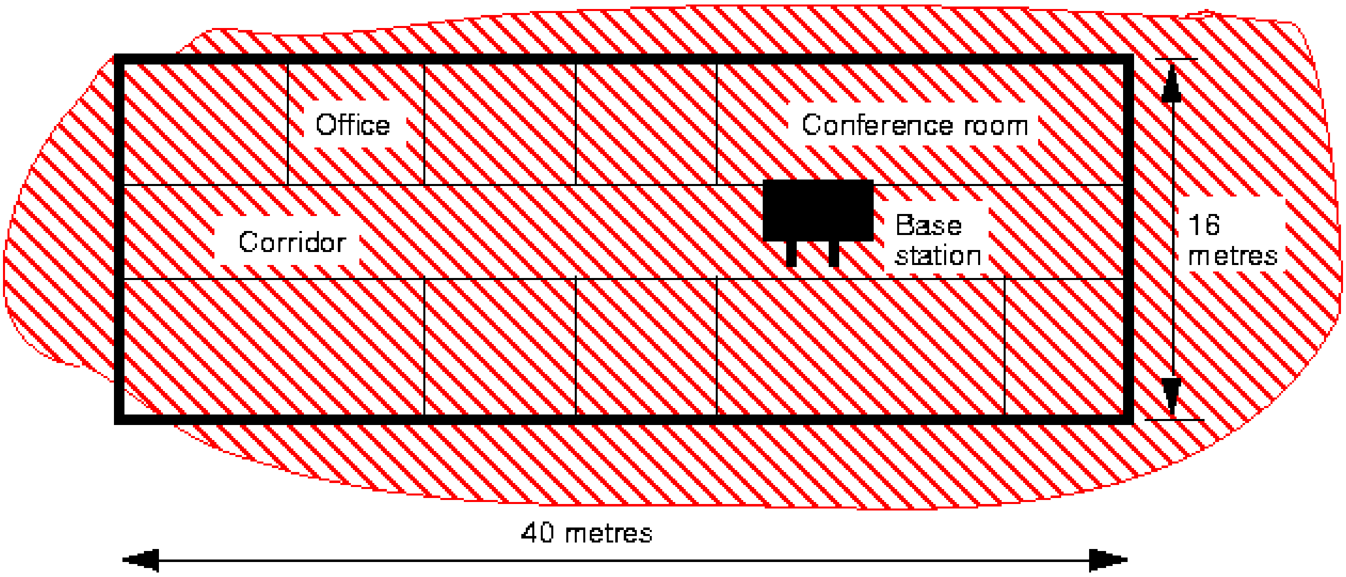


Figure 6: Example of maximum coverage of one base station

3.4.4 REDUNDANCY CONFIGURATION

If especially high redundancy is required, base stations may be connected to different Servers on different floors if possible so, that when one Server goes down or is out of order, the other will back up this area. The disadvantages of this configuration is that it will cause more inter Server roaming and hand overs.

A prerequisite for this configuration is that there is radio coverage through the floors, see figure 7 Example of a redundancy configuration. ELU31 has 32 B-channel configuration. on page 13.

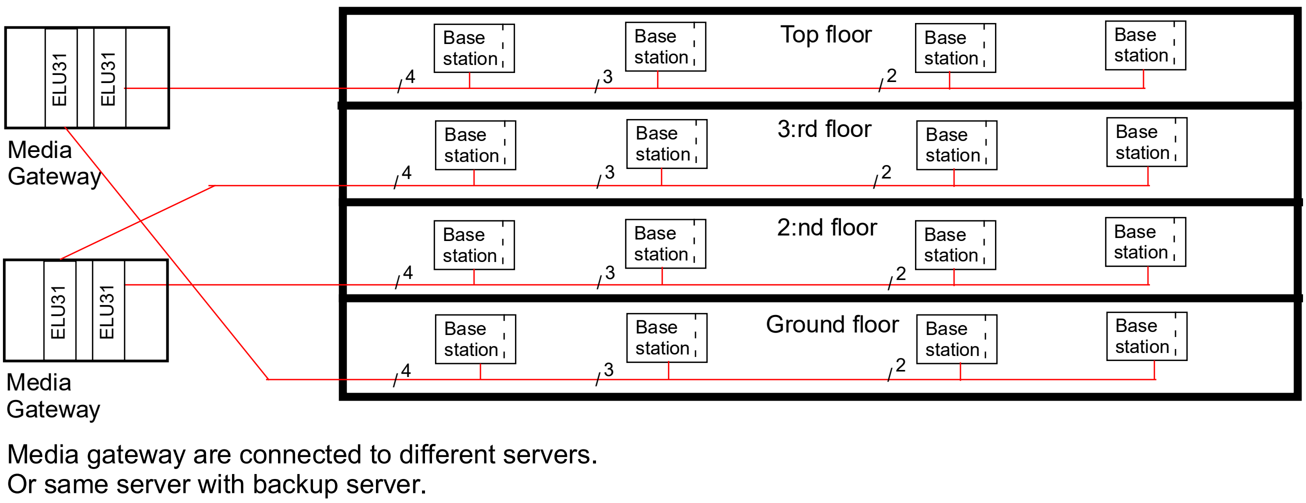


Figure 7: Example of a redundancy configuration. ELU31 has 32 B-channel configuration.

Consider also the HLR/ULR configuration also when planing for redundancy. HLR should be placed in the Server that controls the media gateways that particular PP is mostly located. If there are no contact between HLR and ULR server it will not be possible to call the PP. Also call from PP and services like hand over can be rejected.

HLR redundancy is supported. With HLR redundancy active will roaming and hand over be possible with some limitations. For more information see *MiVoice MX-ONE Home Location Register Redundancy - Description*.

When an LIM fail is the connected ELU31 not affected. The base station connected to these ELU31 will still transmit. No calls to and from CXN connected to these base stations is possible. Would ELU31 connected to the failed LIM loss its power, will connected base station stop transmitting thus create a hole in the radio coverage. CXN must perform location registration to location area that is not connected to the failed LIM.

MGU has a feature to block all ELU 31/4 boards when the connection to the service node (LIM) is lost. A service node needs 30-90 seconds to detect a fault situation; that is, for CTLP to know that contact with ELU31 is lost. MGU block time must be more than the service node block time. CTLP will de-block ELU31/4 boards after service returns to normal. This MGU feature can be activated using the commands media_gateway_info -set ELU31 -mgw 1a-name ELU31 -attrib EnableBlocking -bool true with the recom-mended time media_gateway_info -set ELU31-mgw 1a -name ELU31 -attrib BlockTimeout -int 100. If for some reason, the service node takes more time to come up than the block time MGU implements, ELU31 signals will be blocked on the air interface but will not be marked as blocked in the service node. The service node (LIM) must be de-blocked using command blocking.

3.5 NON-STANDARD ANTENNAS

Base station BS342 can be equipped with non-standard antennas. The non-standard antennas may enlarge the range of a BS342 base station and reduce the total number of base stations in a cordless system.

Indoors

The use of non-standard antennas for indoor applications is limited to specific situations where the radio coverage is the most important factor. Examples in which non-standard antennas may be used are: large production halls, long corridors (directional antennas), coverage of bad radio spots and for expanded base station coverage. When compared to the standard base station antennas, non-standard antennas are more expensive, less easy to install and usually larger. These disadvantages do normally not justify the use of non-standard antennas in an office environment.

Outdoors

In outdoor applications good coverage is usually required instead of capacity. Omni-directional antennas can be used for large areas like parking places. Directional antennas can be used for example to cover large walking distances between buildings. For outdoor placing of base stations, a special protection case is available for wall or pole mounting. See chapter 3.2.3 Outdoor housing on page 10.

3.6 ABSORPTION AND REFLECTION

The cell size is very dependent on the material of which walls, ceilings and floors are made.

- Glass, concrete, wood and plaster all absorb and pass radio signals in different ways.

- Metal walls and large metal cabinet rows reflect all signals, resulting in a greatly reduced coverage behind these areas. They can also cause reflections and bit errors.
- X-ray rooms in hospitals protected by lead walls or computer rooms in banking buildings protected against unwanted interference do not allow radio signals to enter.
- Exhibition halls or production halls may give reflections due to huge metal structures. This causes interference and bit errors, which reduces the capacity, coverage range per base station, speech quality and the practical coverage area.

3.7 ARCHITECTURE

- Central areas giving access to stairs and elevators may require extra base stations due to heavier constructions.
- Coverage in elevators may require base stations close to or in the elevator shaft.
- Corners and irregularities in the construction have influence.
- Physical fire walls and closed fire doors can have great influence.

3.8 PHYSICAL LOCATION OF A BASE STATION

To reduce the traffic load in each Media Gateway, and between Media Gateways, it is recommended to pay special attention to the physical location of the base stations and how they are connected to the MX-ONE.

Base stations that cover the same or adjoining areas, should, when possible, be connected to the same ELU31 board. When this is not possible, the base stations should be connected to ELU31 boards in the same Media Gateway.

When that is not possible should the ELU31 boards should be in a Media Gateway served by same server.

The boarder between an area covered by one server and an other server should be, if possible, where none or few persons have there working space or where there is little movement/roaming.

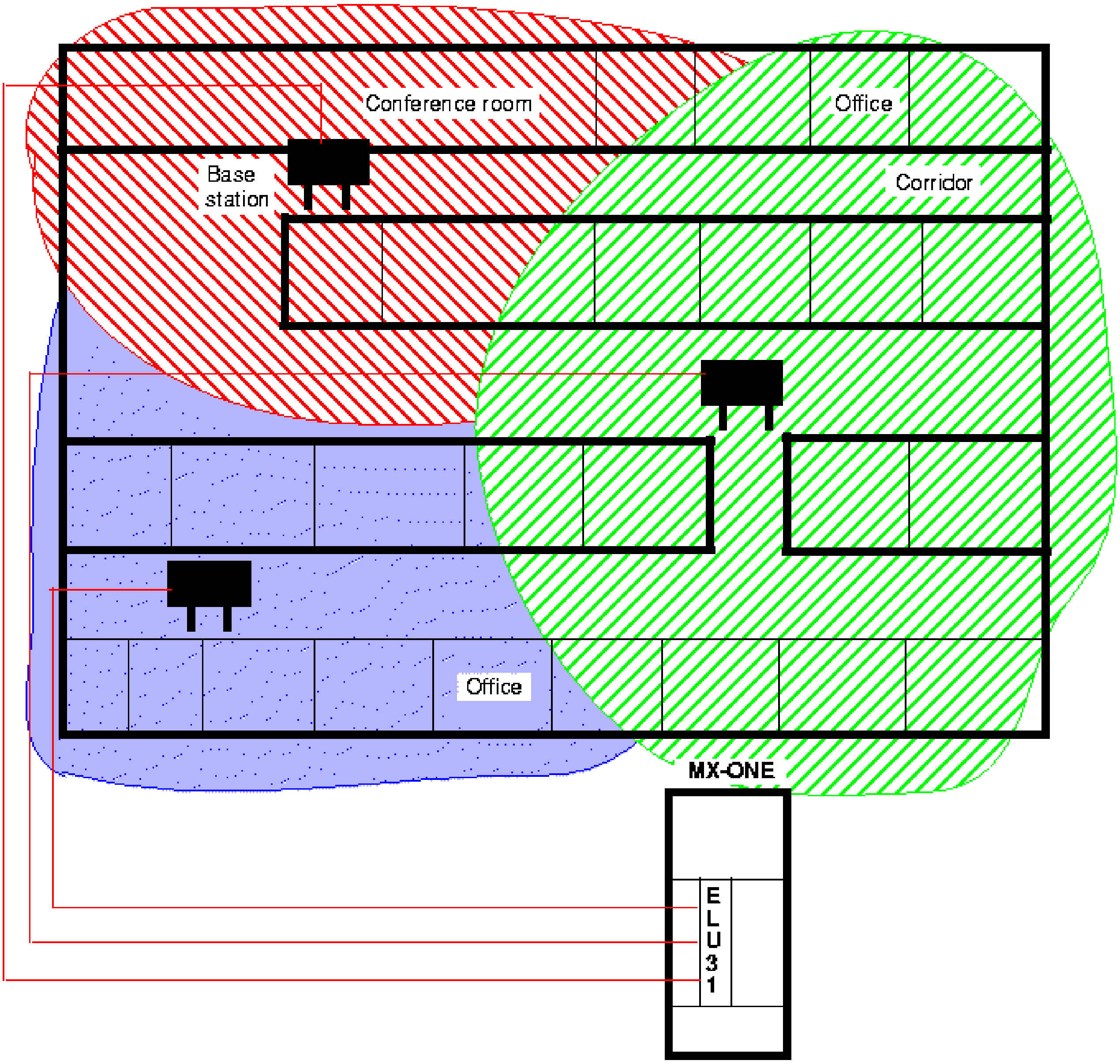


Figure 8: Physical location of base stations with standard antennas connected to the same ELU31 board

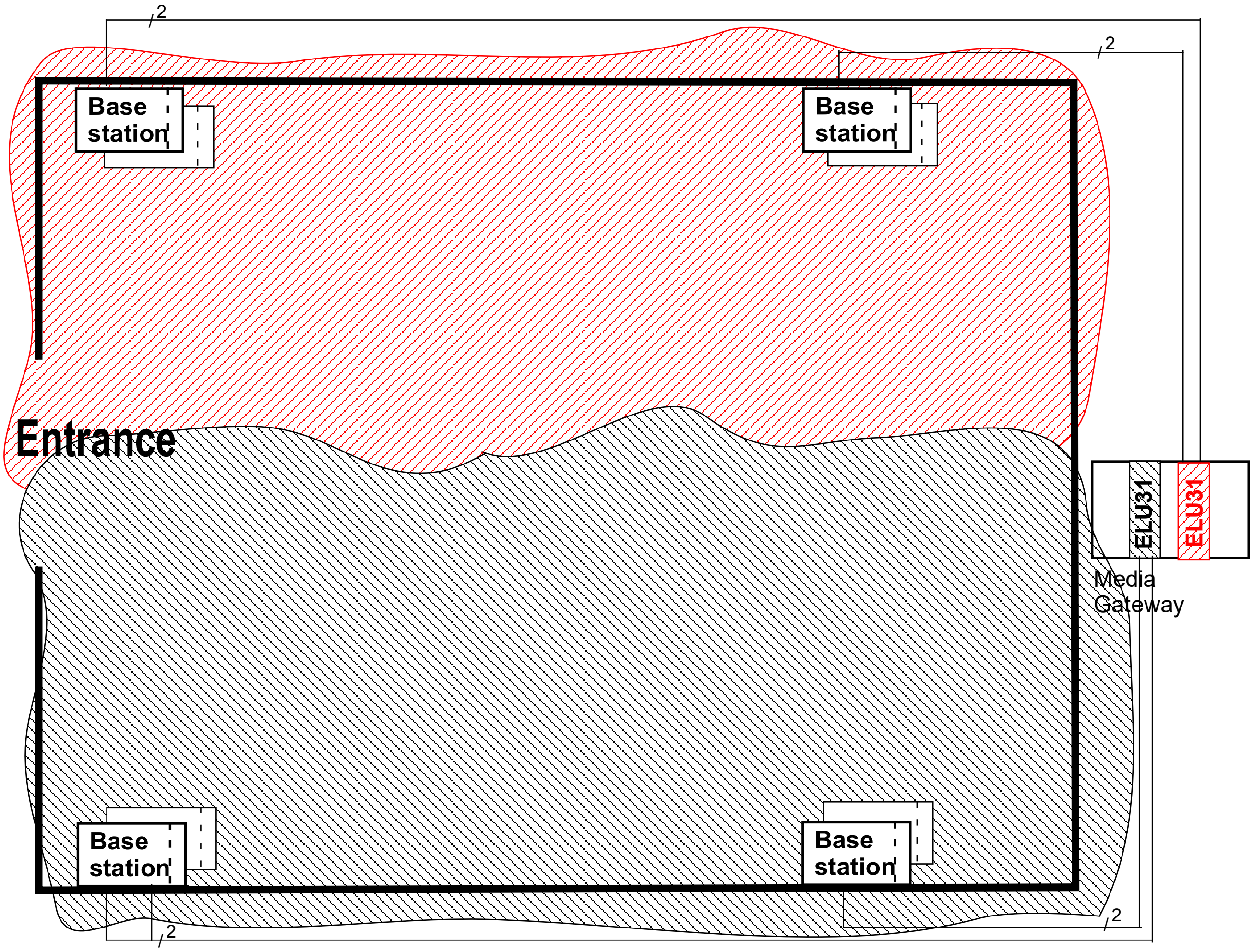


Figure 9: Example of a frequently visited area

The picture above shows an example of a frequently visited area, for example, entrances & conference rooms, see figure 9 Example of a frequently visited area on page 17.

This configuration will distribute the user traffic between different ELU31 boards in a highly mobile traffic area.

It is important to install the base stations with an equal distance from where the users frequently enter the area.

3.9 SITE SURVEY

To satisfy the area coverage and the traffic demands, the site must be surveyed in order to determine the number of base stations needed. To do a site survey, a site survey tool, see chapter 3.9.1 Site survey tool on page 18, ground plans of the floors are required. For efficient radio planning of the site. Samples must be taken to determine an average cell size. With the average cell size, base station positions can be indicated on the map, together with the area covered by each base station. Also difficult spots can be mapped. After this, the planned positions can be verified with the site survey tool and with help of the traffic requirements, a final plan can be made.

It is also important to estimate how many users that are or can be in certain areas and upon these estimates consider if double base station installations in certain areas are needed.

Expanded LA makes for less roaming and hand over load as well as less complex radio environment.

Note: A new site survey should be made after physical changes in the location area, for example, added or removed walls affect the coverage from nearby base stations, or open up a pass way thus creating possibility for new movement patterns.

Note: A new site survey should be made after adding or reducing the number of ELU31 boards

Note: When adding or removing number of base station connected to the ELU31 must a new site survey be performed.

Note: A site survey is something that often needs to be re-performed on a site. Due to reorganizations, physical change in the building, changed usage of certain areas or changed movement patterns.

3.9.1 SITE SURVEY TOOL

The Site Survey tool LTT 999 05/1 helps technical personnel to get a survey of where to mount base stations to get an optimum coverage. This can be done by placing the site survey tool/base station in a typical position and then walking around with a portable. By setting the PP in site survey mode an listening to the sound quality of the portable and looking at its display, the coverage area of a radio cell can often be found.

3.9.2 SITE SURVEY EXECUTION

The principle of a site survey is as follows:

- Observe the building to find a typical area. Modern buildings usually have standard constructions. In older buildings, due to renovations or expansions, areas with different structures may exist. However, inside these areas a uniformity in structure can be found again.

  Find an area with a typical structure for the building and of about the expected cell size. This area will be used to determine the typical cell size. When having a building with different structures, do so for each of those areas, so that differences in a typical cell size can be detected.

- Measure the horizontal cell size on the second floor, see figure 10 Measurement of a typical cell size. on page 19. The cell size can be determined as follows:

  – Install the site survey base station in the middle of the typical area. Walk away from the base station with the portable. Also walk into rooms on the left and the right side.

  – Determine the edge of the cell by means of the limit warning tone. Optionally use the site survey tool and verify the sound quality and/or the link information to define the typical cell size.

  – Do the same in the opposite direction.

- Measure the horizontal range on the floor above, see figure 10 Measurement of a typical cell size. on page 19. Go to the floor above or below, leaving the base station on its current location and measure the horizontal coverage again.

  In this way the horizontal and vertical coverage of a single base station in a typical area is found. The cell size found can be taken as an average, used to calculate the total number of base stations. Depending on the size of the building and the type of construction, one or two more random checks in typical areas can be done to verify the first measurement. The typical cell size is then found by averaging the values.

- If the measurements does not give a satisfactory coverage, consider using non-standard antennas. Consider the area a base station can cover see chapter 3.4 Total area coverage on page 10.

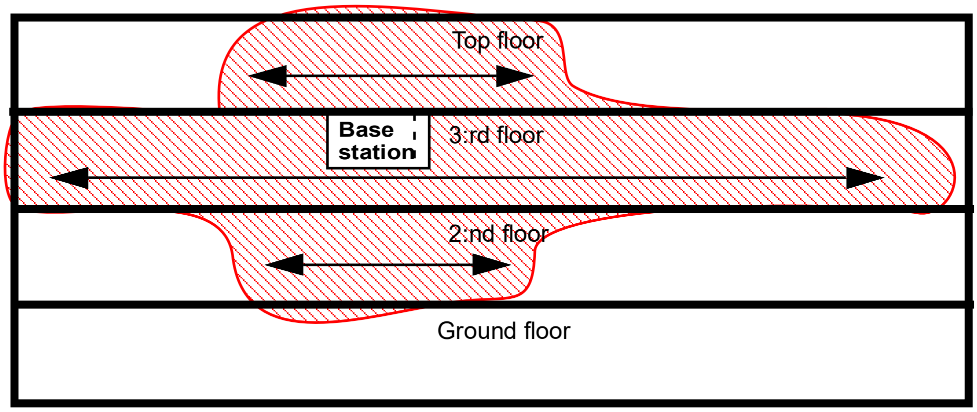


Figure 10: Measurement of a typical cell size.

- Making a plan with the typical cell found, start by making a sketch of all base station positions on the ground plan. They indicate the expected coverage for each base station on the map.
  - Verify with the site survey tool if the real coverage is as expected from the map.
  - Especially verify coverage in difficult areas such as elevators, stair ways and discontinuity in construction.
  - If weak areas are found, try if re-positioning a base station solves it, otherwise plan for an extra base station.
  - Take into consideration that in free space, with antennas in upright position the coverage is greater horizontally than vertically. Although in normal office environments this effect is negligible due to the amount of reflections, it may still be worth trying to place base stations horizontally in order to get more vertical coverage in, for example, stair ways.
- Finalizing the plan when all base station positions on the map are verified and the plan is found suitable, discuss with the client whether extra base stations are needed in particular areas due to local requirements. Then the whole area is divided into location areas in such a way that each area is from a signaling perspective optimized, see figure 11 Typical division of location areas on page 20.

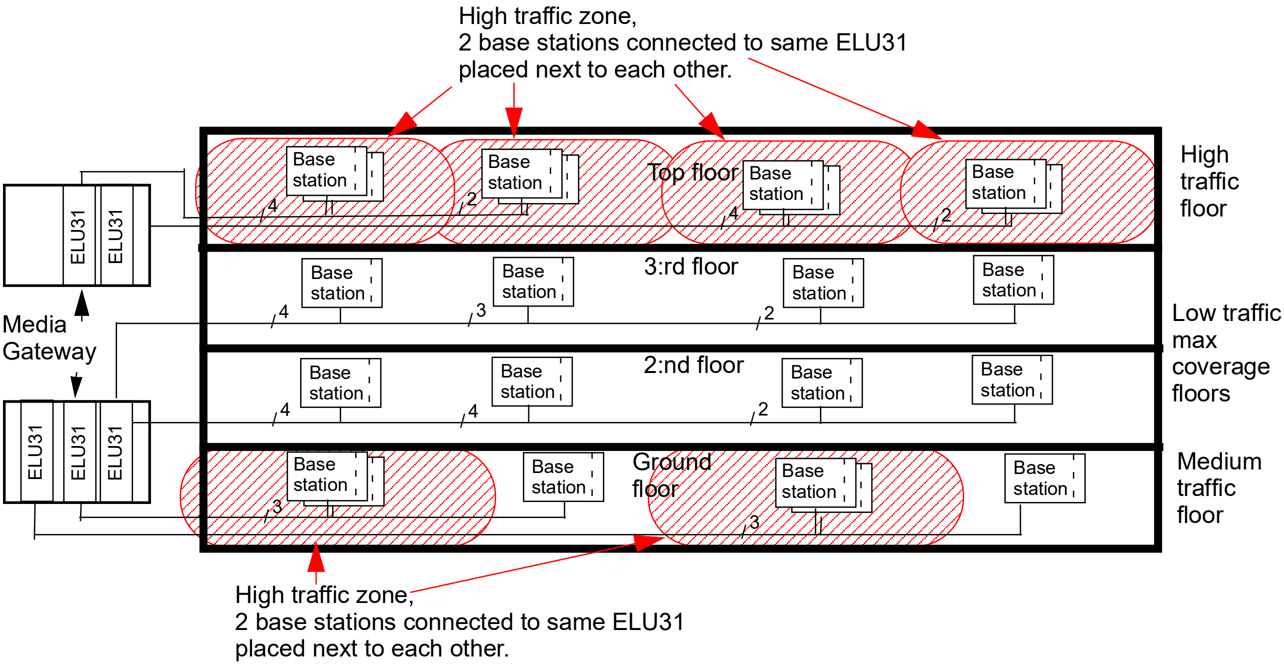


Figure 11: Typical division of location areas

3.9.3 BUILDING ELEMENTS

This section describes how different building elements can affect the coverage.

- The cell size is dependant on the material of which walls, ceilings and floors are made.
- Plain, light or reinforced concrete, wood and plaster absorb and pass radio waves in different ways.
- Metal walls and large metal cabinet rows reflect all signals, resulting in a greatly reduced coverage in areas behind these objects.
- X-ray rooms in hospitals protected by lead walls and computer rooms in banking buildings protected against unwanted interference do not allow radio signals to enter.
- Exhibition halls or production halls may give reflections due to large metal structures. This causes interference which reduces the capacity and coverage range of the base station.

3.9.3.1 Walls

Walls, ceilings and floors have large impact of the coverage range, different types of walls have different impact on the signal range. For list of the most common types and the approximate range achieved through these materials, see table 1 Wall types and impact on radio coverage. on page 21.

Table 1 Wall types and impact on radio coverage.

Type	Feature	Range in meters
Stud wall	Plaster	30-60
Concrete		10-30
Reinforced concrete	Fire wall	0-10
Stone/brick		30-50
Metal	A panel or brickwork	0-10
Wood		30-50
Wired glass	Fire protection	0-10
Surface coated float glass	Only important for coverage outside if the base station is installed inside	30-50
None	Open-plan office or outdoors	150-300

Note: The values in this table are estimated values. Furniture (cupboards etc.), and the amount of movement in the area to be covered, for example, cranes in a production hall, see chapter 3.9.5 Reflective environment on page 23, are further factors that affect the coverage range

3.9.3.2 Ceilings and floors

The difference between ceilings and floors compared to walls lies in the materials used. Concrete and reinforced concrete are the main materials and it is important to determine the level of coverage of a base station on the floor above and below. For 'normal' concrete this coverage extends to a radius of approximately 15-20 metres which provides coverage for the floors below and above. An open stairway or an atrium can in some cases be used to provide coverage to two floors at the same time, see figure 12 Open stairway or atrium on page 21.

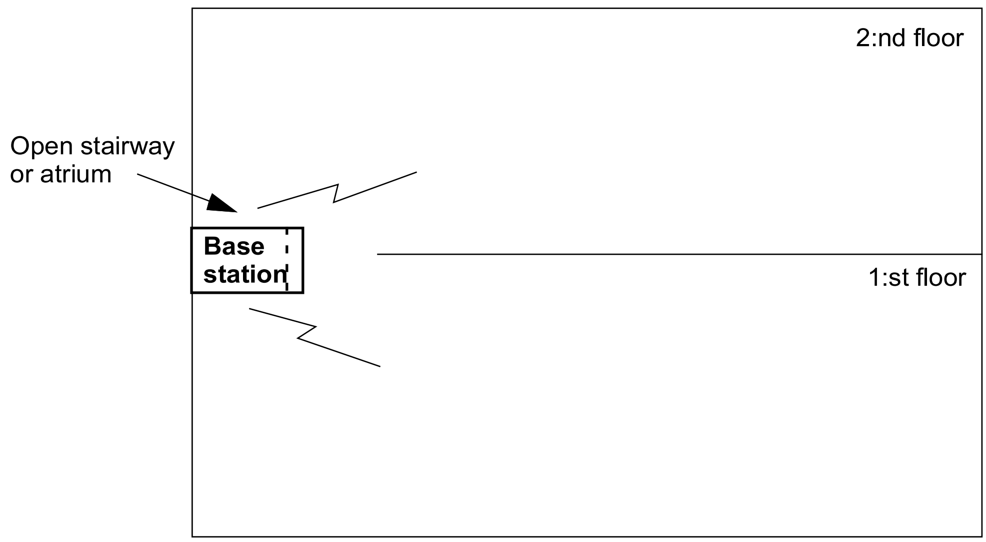


Figure 12: Open stairway or atrium

3.9.3.3 *Fire-resistant walls/doors*

The same facts applies for fire walls as for normal walls mentioned in the section above. However, fire doors are usually open during the site survey, it is important to close the fire doors before doing the final site survey measurement and before finalising the base station plan. Should a fire break out and the doors then be closed, there must of course still be sufficient coverage.

3.9.4 SPECIAL AREAS

This section describes a number of special areas which must be considered when doing a base station planning, and how to ensure full DECT coverage in these areas.

3.9.4.1 *Outdoors/car park*

Coverage outdoors is usually not a problem since there are few or no obstacles. The base station location depends on the client and on the size of the area to be covered. If the client wishes to have as few base stations as possible installed outside (because of the costs of the outdoor housing), it is possible to install one or more base stations with the antennas in front of a window.

The base station must be able to ‘see’ as much as possible of the outdoor area to be covered (that is, there must be as few obstacles as possible between the base station and the covered area). Ensure that a measurement is carried out in order to check how much coverage a base station provides to the outdoor area, the intention is not to install all the base stations in front of windows, since this is not the ideally position to provide indoor coverage (normally 1-2 base stations are sufficient).

Table 2 Type of glass and its effect on radio coverage.

Type of glass	Range in meters
Normal glass	150-300
Surface coated float glass	30-50
Wired glass (fine-mesh)	0-20

3.9.4.2 *Stairways*

The major problem with stairways is that they are often sited in a corner of the building. Coverage is not a problem in itself, but it must be seen in the context of the overall planning. There are various ways of providing coverage for a stairway. Either the base station is installed directly in the stairway as a dedicated base station for the stairway, or it is installed in the close vicinity of a stairway. The method depends on the type and location of the stairway (is it an open or closed stairway: is it sited in a corner of the building or in the centre and so on).

3.9.4.3 *Toilet room*

Toilet rooms are generally in awkward positions for a site survey: behind or next to lifts, in or next to stairwells or in a corner of the building. A base station installation in the toilet room itself can be considered. If placed outside the toilet room it should be placed in the vicinity of the toilet room in a location where the base station can ‘see’ as much as possible of the toilet room (preferably the entrance because doors are generally made of wood and these damp the signal less than the walls).

If the base station is placed in the vicinity of the toilet room, locate it in a way that it provides coverage for as much of the rest of the floor as possible.

3.9.4.4 *Maintenance shaft*

In larger buildings there is usually the requirement that coverage also be provided in maintenance rooms. The most common are the rooms for the lift and ventilation system. The lift maintenance room is often on the roof or in the basement. The ventilation maintenance room is usually on the roof. Do not omit these rooms they should be discussed with the client to avoid the client being faced with surprises. A well-positioned base station on the top floor (20 to 30 metres at most from the room where coverage is required) usually provides sufficient coverage for the maintenance rooms on the roof.

3.9.4.5 *Basement and indoor car park*

It can be difficult to provide sufficient coverage in basements and indoor car parks due to the usually heavy constructions.

3.9.5 REFLECTIVE ENVIRONMENT

When providing coverage in a metal hall (for example, a production hall or storage building), there are a number of issues which call for additional attention. The dimensions of the hall and the material used (metal, concrete, brick etc.) are important deciding factors in the hall's radio reception. Every hall is different, and it is very difficult to predict the radio reception. Check carefully, therefore, whether the walls are made of metal, what the hall's dimensions are, whether the roof is reflective, what is contained in the hall, and whether objects in the hall are stationary or constantly moving.

In the case of poor speech quality in a metal hall, this can be attributed to time delay spread and/or the actuation of the soft suppressor.

3.9.5.1 *Time delay spread*

Time delay spread can be compared with dispersion in cables and fibres. This means that the radio signal can travel by various paths to reach the user because the signal can reach the user directly but also via reflections. These possibilities are illustrated in the figure below.

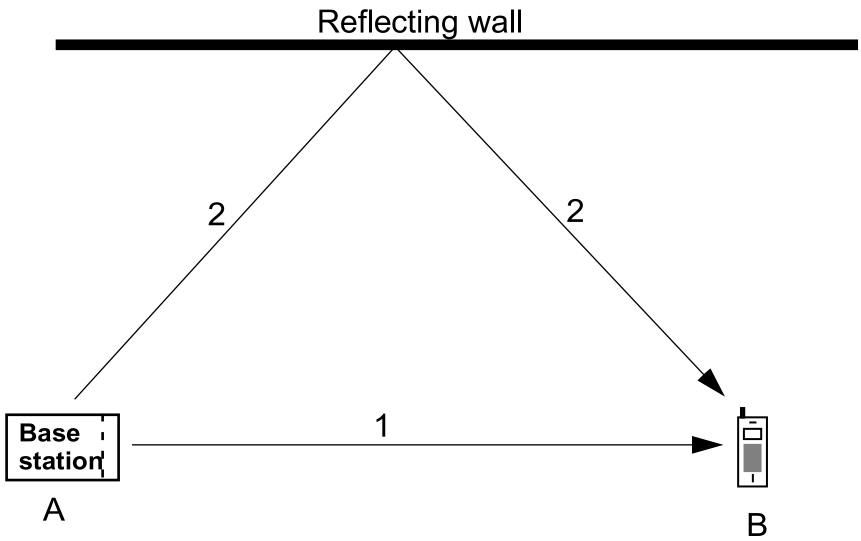


Figure 13: Time delay spread.

The base station at corner A reaches the cordless phone at corner B by means of a direct signal (signal 1) and by means of a reflected indirect signal (signal 2). Generally there are many reflected signals reaching the cordless phone. In general the paths travelled by these signals are not equal which means in turn that they will arrive at the cordless phone at different times.

A DECT signal consists of frames of 420 bits transmitted every 10 ms. The bit length for DECT is 0.868 µs. Mutes, interrupts in you speech conversation, and clicks on the line will occur if the time difference between the various received signals is of the order of 1/10 bit length. If this occurs, the receiver has difficulty in distinguishing between the different transmitted bits. Therefore, the base stations in a metal hall must be sited in a way that the time delay spread is minimized. This means in turn that you must locate the base stations such that the number of reflections is minimized

3.9.5.2 *How to identify reflective environment*

A high time delay spread will only have influence if the delayed signal is strong. In office environment we also have signals arriving to the receiver with high delay but since these signals have travelled trough walls, been reflected in attenuation materials (wood, cement, etc.) the reflections are highly attenuated. These signals with low power level will not cause any problem. However, if there are no walls and the reflective surfaces have low attenuation, e.g. metal surfaces, the power level of the reflective signals will be high, this is what we call reflective environment. So characteristics for reflective environment are:

- Although the signal strength is good there are frame errors. The frame error rate and signal strength can be measured with the portable device. Check frame errors in both uplink (towards the base station) and downlink (towards the portable device). For information on how to measure the frame error rate, see the user guide for the site survey tool.
- Often no problems when standing still but when you move around there will be problems with mutes and clicks during speech.

- Characteristics for reflective environment are large open spaces (e.g. large buildings greater than say 20 meters), metal walls, metal inventories and ceilings.

3.9.5.3 *Location for base station in reflecting environment*

Apart from the time delay spread there are a number of general rules to consider when placing a base station:

- Install a base station in line of sight, base station can see the user.
- It is possible to increase the number of base stations at those locations that are important to the client. In a typical case, the speech coverage area is 5-20 meter. This must be verified with site survey.
- Place the base station as low as possible without having something to be placed in front of the base station.
- Ensure that the distance between the base station antennas and a metal wall is at least 30 centimetres to avoid interference with the impedance of the antennas.
- To get a strong direct signal, the use of a directional antenna may improve the situation.

Note: All these considerations, depend on the dimensions of the hall and its reflective characteristics.

3.9.5.4 *Customer acceptance*

It is very important that the radio performance is verified before any agreement is signed. Verify the radio performance with a site survey tool and always use the same type of portables and also the same type of base station that is going to be installed.

Make sure that the customer understands what kind of problem that can occur because of the reflective environment. Ask the customer to listen to the speech quality. If the speech quality is not accepted by the customer, do not recommend an installation of the DECT system in this reflective environment in order to avoid future severe problems.

3.9.6 IMPACT OF OTHER RADIO SYSTEMS ON DECT

This section describes how DECT performance is impacted by other radio systems, such as GSM, 3G, LTE, and 4G. For detailed information about the effect of radio interference, see chapter 5 Appendix A: Multiple DECT system on page 34.

3.9.6.1 *Impact of GSM/3G/LTE/4G on DECT*

This section describes how to minimize the impact of interference on the DECT system.

Europe

In Europe, the DECT band ranges between 1880 MHz to 1990 MHz, and the GSM band can go up to 1880 MHz. This band range might cause interference between the GSM band and the DECT band when the LTE signal may be stronger as in the list below:

- $<$ 1768 MHz $\leq$ -26 dBm
- 1873 MHz $\leq$ -27 dBm
- 1874 MHz $\leq$ -28 dBm

- 1875 MHz ≤ -29 dBm
- 1876 MHz ≤ -30 dBm
- 1877 MHz ≤ -31 dBm
- 1878 MHz ≤ -33 dBm
- 1879 MHz ≤ -40 dBm
- 1880 MHz ≤ -51 dBm

Ensure the following to minimize the DECT band interference:

- To avoid the impact of LTE, the first measure is to position the DECT base station in such a way behind a building or anything else that the DECT base station or the antennas are no longer directly exposed to the LTE transmitter’s radio signal.
- If the base station has external antennas, the filters can be implemented between the antennas and the base station to filter frequencies close to the lower DECT spectrum.
- Switch off the lower frequencies from the DECT band. It is recommended to switch off the lowest three frequencies to avoid the performance impact of the DECT system. The number of speech slots for a base station decreases by 12 for every switched-off frequency. For information on how to switch off frequencies, see *Commands in MX-ONE Service Node Command Description*.

North America

In North America, the DECT band ranges between 1920 MHz to 1930 MHz, while the USA hosts a GSM band starting at 1930 MHz. As there are only 5 DECT carriers in North America, it is not possible to switch off the adjacent channels as it would result in significantly fewer speech slots.

To minimize the interference, place the base protected from direct impact from GSM transmitters, such as positioning them behind the walls.

4 TRAFFIC CAPACITY

4.1 GENERAL

The traffic capacity of the MX-ONE cordless phone is mainly determined by the capacity of the ELU31 board and of the MX-ONE and in exceptional cases also of the base stations.

The maximum number of ELU31 boards in a media gateway see section 2.2 ELU31 Boards on page 6. For more information of power calculation and line length see the installation instructions for *CORDLESS PHONE*.

The maximum number of base stations connected to one ELU31 board is limited to 8.

Each ELU31 board requires one board position and can be defined to use 16 or 32 slots with unix style command **board_config** or will be allocated 16 or 32 slots depending on what is available with board_config -scan.

The number of slots is equivalent with number of simultaneous call that can be carried.

Important factors that determine the dimensioning and traffic capacity of the MX-ONE are:

- The grade of service (GOS) accepted by the customer. (The GOS is the probability that a call cannot be made because of congestion in the system. The customer has to indicate which GOS that is acceptable. A GOS of 1% means an average of 1 lost call out of every 100 calls).
- Portable traffic measured in Erlang.
- Busy Hour Call Completion capacity for the individual Server, see the description for *CAPACITIES*.
- Highly mobile users also generate extra load without calling, so called roaming processing.

4.2 DEPARTMENTAL DIFFERENCES

At sales department, purchase, technical support departments and the like, usually more traffic is generated than for instance at finance and administration departments. Consequently a higher traffic capacity is needed in these areas, those requiring more base station per user.

4.3 TRAFFIC CAPACITY OF A BASE STATION

The number of available speech channels between the base station and the ELU31 board is 8. The tables below show the number of portables that can be handled by a base station as a function of traffic intensity per portable and GOS in respect to stationary users, see , GOS and highly mobile users, see , GOS.

Table 3 Number of portables (stationary user) per base station

GOS	Erlang (E)				
	0.05	0.10	0.15	0.20	0.25
0.5%	57	30	21	16	14

1.0%	64	33	23	18	15
2.0%	73	38	26	20	16

Table 4 Number of portables (highly mobile users) per base station

GOS	Erlang (E)				
	0.05	0.10	0.15	0.20	0.25
0.5%	54	27	18	13	10
1.0%	62	31	20	15	12
2.0%	72	36	24	18	14

Note: For highly mobile users the most important limitation to consider is the one mentioned in chapter 4.4.5 Signaling/Roaming traffic on page 33.

4.4 UTILIZATION OF BASE STATIONS, ELU31 BOARDS AND LIM

4.4.1 B-CHANNEL TRAFFIC

In a typical business environment a standard dimensioning value for traffic per portable is 0.2 E. This includes a solid safety margin - actual traffic is almost always lower. The tables below show the maximum number of portables that can be handled by an ELU31 board and the resulting number of portables per base station depending on number of base stations that are connected to a single ELU31 board. The tables are given for ELU31 boards with 16 channels and with 32 channels.

Table 5 Number of portables (stationary users) per ELU31 board (with 32 channels)

GOS	Erlang (E)				
	0.05	0.10	0.15	0.20	0.25
0.5%	419	212	143	109	88
1.0%	445	225	151	115	93
2.0%	478	241	162	122	99

Table 6 Number of portables (stationary users) per ELU31 board per base station (with 32 channels)

	GOS	E	number of base stations							
			1	2	3	4	5	6	7	8
PPs per	0.5	0.05	57/57	114/57	171/57	228/57	285/57	342/57	399/57	419/52
ELU31/	0.5	0.10	30/30	60/30	90/30	120/30	150/30	180/30	210/30	212/26
PPs per	0.5	0.15	21/21	42/21	63/21	84/21	105/21	126/21	143/20	143/17
RFP	0.5	0.20	16/16	32/16	48/16	64/16	80/16	96/16	109/15	109/13
	0.5	0.25	14/14	28/14	42/14	56/14	70/14	84/14	88/12	88/11
	1.0	0.05	64/64	128/64	192/64	256/64	320/64	384/64	445/63	445/55
	1.0	0.10	33/33	66/33	99/33	132/33	165/33	198/33	225/32	225/28
	1.0	0.15	23/23	46/23	69/23	92/23	115/23	138/23	151/21	151/18
	1.0	0.20	18/18	36/18	54/18	72/18	90/18	108/18	115/16	115/14
	1.0	0.25	15/15	30/15	45/15	60/15	75/15	90/15	93/13	93/11
	2.0	0.05	73/73	146/73	219/73	292/73	365/73	438/73	478/68	478/59
	2.0	0.10	38/38	76/38	114/38	152/38	190/38	216/38	241/34	241/30
	2.0	0.15	26/26	52/26	78/26	104/26	130/26	156/26	162/23	162/20
	2.0	0.20	20/20	40/20	60/20	80/20	100/20	120/20	122/17	122/15
	2.0	0.25	16/16	32/16	48/16	64/16	80/16	96/16	99/14	99/12

Table 7 Number of portables (highly mobile users) per ELU31 board with 32 channels

GOS	Erlang (E)				
	0.05	0.10	0.15	0.20	0.25
0.5%	412	206	138	103	83
1.0%	440	220	147	110	88
2.0%	474	237	158	118	95

Table 8 Number of portables (highly mobile users) per ELU31 board, (with 32 channels), per base station.

	GOS	E	number of base stations							
			1	2	3	4	5	6	7	8
PPs per	0.5	0.05	54/54	108/54	162/54	216/40	270/54	324/54	378/54	412/51
ELU31/	0.5	0.10	27/27	54/27	81/27	108/27	135/27	162/27	189/27	206/25
PPs per	0.5	0.15	18/18	36/18	54/18	72/18	90/18	108/18	126/18	138/17
RFP	0.5	0.20	13/13	26/13	39/13	52/13	65/13	78/13	91/13	103/12
	0.5	0.25	11/11	22/11	33/11	44/11	55/11	66/11	77/11	82/10
	1.0	0.05	62/62	124/62	186/62	248/62	310/62	372/62	434/62	440/55
	1.0	0.10	31/31	62/31	93/31	124/31	155/31	186/31	217/31	220/27
	1.0	0.15	20/20	40/20	60/20	80/20	100/20	120/20	140/20	147/18
	1.0	0.20	15/15	30/15	45/15	60/15	75/15	90/15	105/15	110/13
	1.0	0.25	12/12	24/12	36/12	48/12	60/12	72/12	84/12	88/11
	2.0	0.05	72/72	144/72	216/72	196/72	196/72	196/72	474/67	474/59
	2.0	0.10	36/36	72/36	108/36	144/36	180/36	216/36	237/33	237/29
	2.0	0.15	24/24	48/24	72/24	96/24	120/24	144/24	158/22	158/19
	2.0	0.20	18/18	36/18	54/18	72/18	90/18	108/18	118/16	118/14
	2.0	0.25	14/14	28/14	42/14	56/14	70/14	84/14	94/13	94/12

Note: For highly mobile users the most important limitation to consider is the one mentioned in chapter 4.4.5 Signaling/Roaming traffic on page 33.

Table 9 Number of portables (stationary users) per ELU31 board (with 16 channels)

GOS	Erlang (E)				
	0.05	0.10	0.15	0.20	0.25
0.5%	165	84	57	44	36
1.0%	179	91	62	47	39
2.0%	195	99	67	51	41

Table 10 Number of portables (stationary users) per ELU31 board per base station (with 16 channels)

	GOS	E	number of base stations							
			1	2	3	4	5	6	7	8
PPs per	0.5	0.05	57/57	114/57	165/55	165/41	165/33	165/27	165/23	165/20
ELU31/	0.5	0.10	30/30	60/30	84/28	84/21	84/16	84/14	84/12	84/10
PPs per	0.5	0.15	21/21	42/21	57/19	57/14	57/11	57/9	57/8	57/7
RFP	0.5	0.20	16/16	32/16	44/14	44/11	44/8	44/7	44/6	44/5
	0.5	0.25	14/14	28/14	36/12	36/9	36/7	36/6	36/5	36/4
	1.0	0.05	64/64	128/64	179/59	179/44	179/35	179/29	179/25	179/22
	1.0	0.10	33/33	66/33	91/30	91/22	91/18	91/15	91/13	91/11
	1.0	0.15	23/23	46/23	62/20	62/15	62/12	62/10	62/8	62/7
	1.0	0.20	18/18	36/18	47/15	47/11	47/9	47/7	47/6	47/5
	1.0	0.25	15/15	30/15	39/13	39/9	39/7	39/6	39/5	39/4
	2.0	0.05	73/73	146/73	195/65	195/48	195/39	195/32	195/27	195/24
	2.0	0.10	38/38	76/38	99/33	99/24	99/19	99/16	99/14	99/12
	2.0	0.15	26/26	52/26	67/22	67/16	67/13	67/11	67/9	67/8
	2.0	0.20	20/20	40/20	51/17	51/12	51/10	51/8	51/7	51/6
	2.0	0.25	16/16	32/16	41/13	41/10	41/8	41/6	41/5	41/5

Table 11 Number of portables (highly mobile users) per ELU31 board with 16 channels

GOS	Erlang (E)				
	0.05	0.10	0.15	0.20	0.25
0.5%	161	80	53	40	32
1.0%	177	88	59	44	35
2.0%	196	98	65	49	39

Table 12 Number of portables (highly mobile users) per ELU31 board, (with 16 channels), per base station.

	GOS	E	number of base stations							
			1	2	3	4	5	6	7	8
PPs per	0.5	0.05	54/54	108/54	161/53	161/40	161/32	161/26	161/23	161/20
ELU31/	0.5	0.10	27/27	54/27	80/26	80/20	80/16	80/13	80/11	80/10
PPs per	0.5	0.15	18/18	36/18	53/17	53/13	53/10	53/8	53/7	53/6
RFP	0.5	0.20	13/13	26/13	40/13	40/10	40/8	40/6	40/5	40/5
	0.5	0.25	10/10	20/10	32/10	32/8	32/6	32/5	32/4	32/4
	1.0	0.05	62/62	124/62	177/59	177/44	177/35	177/29	177/25	177/22
	1.0	0.10	31/31	62/31	88/29	88/22	88/17	88/14	88/12	88/11
	1.0	0.15	20/20	40/20	59/19	59/14	59/11	59/9	59/8	59/7
	1.0	0.20	15/15	30/15	44/14	44/11	44/8	44/7	44/6	44/5
	1.0	0.25	12/12	24/12	35/11	35/8	35/7	35/5	35/5	35/4
	2.0	0.05	72/72	144/72	196/65	196/49	196/39	196/32	196/28	196/24
	2.0	0.10	36/36	72/36	98/32	98/24	98/19	98/16	98/14	98/12
	2.0	0.15	24/24	48/24	65/21	65/16	65/13	65/10	65/9	65/8
	2.0	0.20	18/18	36/18	49/16	49/12	49/9	49/8	49/7	49/6
	2.0	0.25	14/14	28/14	39/13	39/9	39/7	39/6	39/5	39/4

Note: For highly mobile users the most important limitation to consider is the one mentioned in chapter 4.4.5 Signaling/Roaming traffic on page 33.

When one or two base station(s) is/are connected to the ELU31 board the limitation is the number of available channels between a base station and the ELU31 board. With 3 or more base stations connected to a board with 16 b-channels the limitation will be the number of available channels over the back plane. With 5 or more base stations connected to a board with 32 b-channels the limitation will be the number of available channels over the back plane.

It is desirable to have many base stations per board, as long as there are channels available, in order to increase the location area and reduce the signalling.

For low user densities (less than 4 users per 100 m^2), the available channels per base station may be more than what is needed to support the portables in the coverage area of the base station. In such a case, it is desirable to have many base stations per ELU31 board.

4.4.2 ELU31 WITH 16 CHANNELS

For high user densities (more than 4 users per 100 m^2), where the number of base stations is determined not by the areas to be covered, but by the number of portables to be served the maximum capacity of an ELU31 board with 16 channels is reached with 3 base stations, see Table 9, Number of portables (stationary users) per ELU31 board per base station (with 16 channels).

4.4.3 ELU31 WITH 32 CHANNELS

For high user densities (more than 4 users per 100 m 2), where the number of base stations is determined not by the areas to be covered, but by the number of portables to be served the maximum capacity of an ELU31 board with 32 channels is reached with 6 base stations, see Table 7, Number of portables (stationary users) per ELU31 board per base station (with 32 channels).

4.4.4 UTILIZATION OF ELU31 BOARDS AND MGWS

The maximum number of ELU31 per media gateway is determined by power consumption of the board it self and the line length to its radio base station and the power consumption of the base station. See section 2.2 ELU31 Boards on page 6 for typical configuration. See Installation instruction for detail about power calculation.

4.4.5 SIGNALING/ROAMING TRAFFIC

A rough rule of thumb is that a roaming between two different ELU31 boards connected to different Servers (inter Server roaming) event loads the system for about 1/10 of a call. A roaming between two different ELU31 boards connected to the same Server (intra Server roaming) is less than 1/10 of a call. Moving between different base stations on the same ELU31 board does not cause roaming events.

The load from one inter Media Gateway hand over, that is, between two Media Gateways controlled by different MX-ONE Service Nodes, is on the order of 1/2 of a call. The load from one hand over between ELU31 boards in the same Media Gateway is also on the order of 1/2 of a call. Hand over between base stations on the same ELU31 is handled on the ELU31 board and does not cause processing in the Server. However the total load from hand overs is usually much smaller than the load from roaming, since hand overs only take place when the users are talking and moving at the same time.

5 APPENDIX A: MULTIPLE DECT SYSTEM

DECT systems and how the interference between them affect the available capacity in the radio environment.

To enable the best possible performance it is important to know that there are base station planning issues that must be considered. The issues are not of high concern for planning and commissioning in a normal home or office environment, however when there is a mix of multiple residential and/or enterprise DECT systems it should be understood that the shared radio capacity available will be decreased in relation to the number of systems that are installed within the same coverage area.

This section will give an overview explanation to the technical issues concerning installation of multiple DECT systems in one area.

5.1 DECT

The DECT standard provides 12 slots on 10 carriers in each direction, see figure 14 System with three on-going traffic. on page 34. A carrier uses 2 MHz each and the TDMA frame is 10 ms, these providing 120 available channels in each direction.

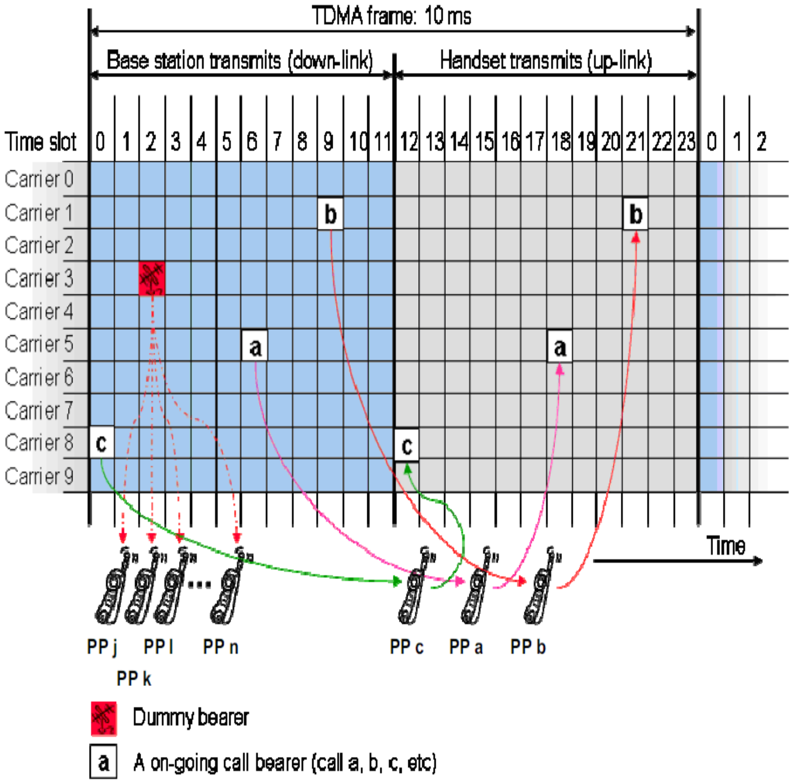


Figure 14: System with three on-going traffic.

5.2 CONTINUOUS BASE STATION BROADCAST (DUMMY BEARER)

A base station continuously transmits one or two, depending on implementation, so called dummy bearer when idle (i.e. when no calls or data are transmitted to or from the base station). The reason for continuously transmitting the dummy bearer is due to that the portable device listens to one dummy bearer and uses the information to lock-on to the system: synchronize, check base station identity, system capabilities, status and paging information for incoming voice and data call set-ups as well as for preparing hand over, call setups etc.

This means that a base station is always transmitting information regardless of which type, residential or multiple base station system. Note: The dummy bearer is only transmitted in the base station to portable device direction.

5.3 SINGLE VS. MULTIPLE BASE STATION SYSTEM

In this section we differentiate single (residential) and multiple (enterprise) base station systems. The reason is that it should be understood that they work in similar way but that they are designed to be used for different purposes.

Residential base stations are designed to be installed in homes and small offices with a natural distance between each cell. Multiple base station systems are on the other hand designed to be used and installed in traffic intense areas which also means that they can be installed very close to each other.

Residential base station systems are not synchronized. There is no need for this since the density of users and/or calls are normally low in the coverage area where these systems are supposed to be used.

Multiple base station systems have an internal intra-system synchronization, which means that all base stations are transmitting at the same time, as well as, listening at the same synchronized time. This means that multiple base station systems know, in contrast to residential base stations, which slots that are free to be used and not. This enables a very high call capacity, robustness and possibility to make intra-system hand overs (i.e. possibility to move from one base to another with an ongoing seamless voice conversation).

5.4 RADIO INTERFERENCE

A DECT system is as described earlier, designed to work, also in busy and/or hostile radio environments. This also applies to interference from other DECT systems operating in the same frequency range. If interference is found on the traffic channel, that a base station or portable device is listening to, it will communicate to the other part (portable device or base station) that a switch of slot or a hand over must be made.

Any interference will of course disturb and the actual package sent will be discarded, but it will not be noticeable to the user in the speech since the packets are very small (10 milliseconds). If it is data traffic, the sent package will be discarded and a retransmission will be made. This means that due to the excellent dynamic channel selection and allocation in DECT, no user will notice any disturbances in the conversation.

Interferences exist everywhere, unless the system is installed in an isolated laboratory environment. It may be due to other DECT systems running in the same coverage area or it may be by reflections in the own radio environment, for example due to metal plates or walls in the area. All DECT systems are robust to this, to a certain extent.

However when many un synchronized systems are used in environments with a high call traffic and/or high user density, the interference will be noticeable not only to the system itself but also to the users.

The user will randomly experience very short and disturbing periods of silence or clicks. Also dropped and/or unanswered voice calls may be the result. Data (alarm or messaging) is not as sensitive to the interference since retransmissions will be made, however delays may be experienced due to these retransmission

5.5 UN SYNCHRONIZED SYSTEMS

If two systems operating in the same cell/coverage area are synchronized with each other they will dynamically share the available 120 channels capacity. However, if the two systems are un synchronized, each call and/or dummy bearer in any of the two systems will steal two channels from the dynamically shared resources. If more un synchronized systems are installed, the issue will grow.

A multiple base station system (including repeaters to these systems) has all base stations synchronized to a central clock i.e. a base stations in such system will not disturb other base stations in the same synchronized system. If two of these systems (un synchronized) or one residential base station are installed within the coverage of the system, the theoretical capacity in the shared radio resource will obviously decrease. In practice and to some extent, reuse of the channels will be done depending on the position of portable devices and base stations.

Imagine that you have one system and that you add another one. Then think about what will happen when additional residential base stations are installed instead of one multiple base station system or a combination of these in one single coverage area? Add to this the normal radio environment conditions like sliding collisions, interference from for example reflections, portable devices in the outer part of the coverage area with low field strength, also hearing high field strength from neighbor base stations, etc. All in all it creates load on the base stations and the radio environment will sooner or later be drained out of free bearers.

It is obvious that if many DECT systems are placed within the same coverage area an increased disturbance will be experienced.

The disturbances described above are normally not a problem since DECT as a standard is designed for coexistence with multiple systems and that any portable device or base station that experiences a disturbance or error on the slot will communicate to the other part (portable device/base station) that they should switch to another non-disturbed slot. However a hand over from one slot to the other does take some time and the more system disturbances experienced the harder it will be to find a stable and non-disturbed slot.

If the dynamically channels selection algorithms in the different systems are not tuned well, clicks, cracks, disturbances and dropped calls as well as blocked calls will be the result. If the algorithms are well tuned the user experience will not be as critical, however the radio capacity will still be lower.

How this in all affects the end-users depends on how high traffic it is, how dense the cell is with other systems and how important the communication is to the users work process. If the radio environment (in worst case) is so extremely interfered or busy that the dummy bearer partly can not find an available slot, then the users will experience that it is not possible to neither make nor to receive calls and the portable devices will show “No system” in the display until a dummy bearer is found and the portable device has made a new registration to the system.

5.6 PLANNING CONSIDERATIONS

There is no doubt that a DECT multiple base station system is preferred compared to a high number of single cell systems. How smooth a lot of single cell systems will work depends on the traffic capacity need. With low call rate more systems may be used, with high call rate fewer system can be used. As the call rate increase sliding collisions appear more frequently in un synchronized systems.

A recommendation is that when a multiple base station system is to be installed, an inventory of existing systems shall be made and consideration to move subscription of the residential portable devices to the multiple base station system or to replace them all with portable devices subscribed in the multiple base station system shall be made. In an office environment with high call traffic only very few DECT systems may be operational. In a low traffic environment a few residential base stations may be used within the enterprise and will most certainly not be a problem.

If un synchronized systems are installed, the radio units should be placed as far as possible apart from each other to limit the interference. Base stations from different systems shall if possible not be placed directly beside or underneath each other.

6 APPENDIX B: RADIO BASE STATION SIGNALING PATTERN

Illustration of transmission patterns for different base stations.

6.1 BS332

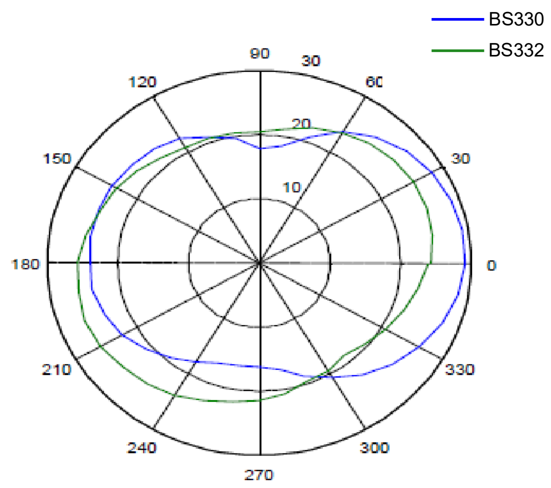


Figure 15: Shows antenna pattern for BS332 external dipole and BS330 external dipole.

Illustration of transmitting patterns are valid for both antennas.

6.2 BS342

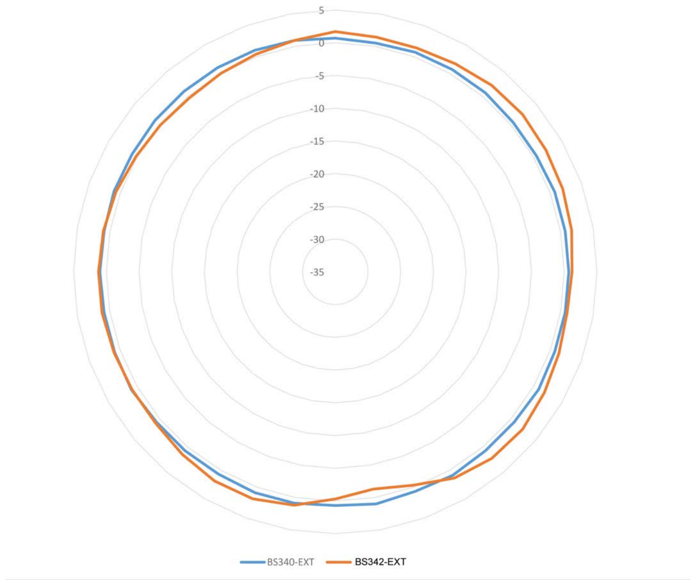


Figure 16: Shows antenna pattern for BS342 and BS340 with external standard antennas.

Illustration of transmitting patterns are valid for both antennas.

6.3 BS33X

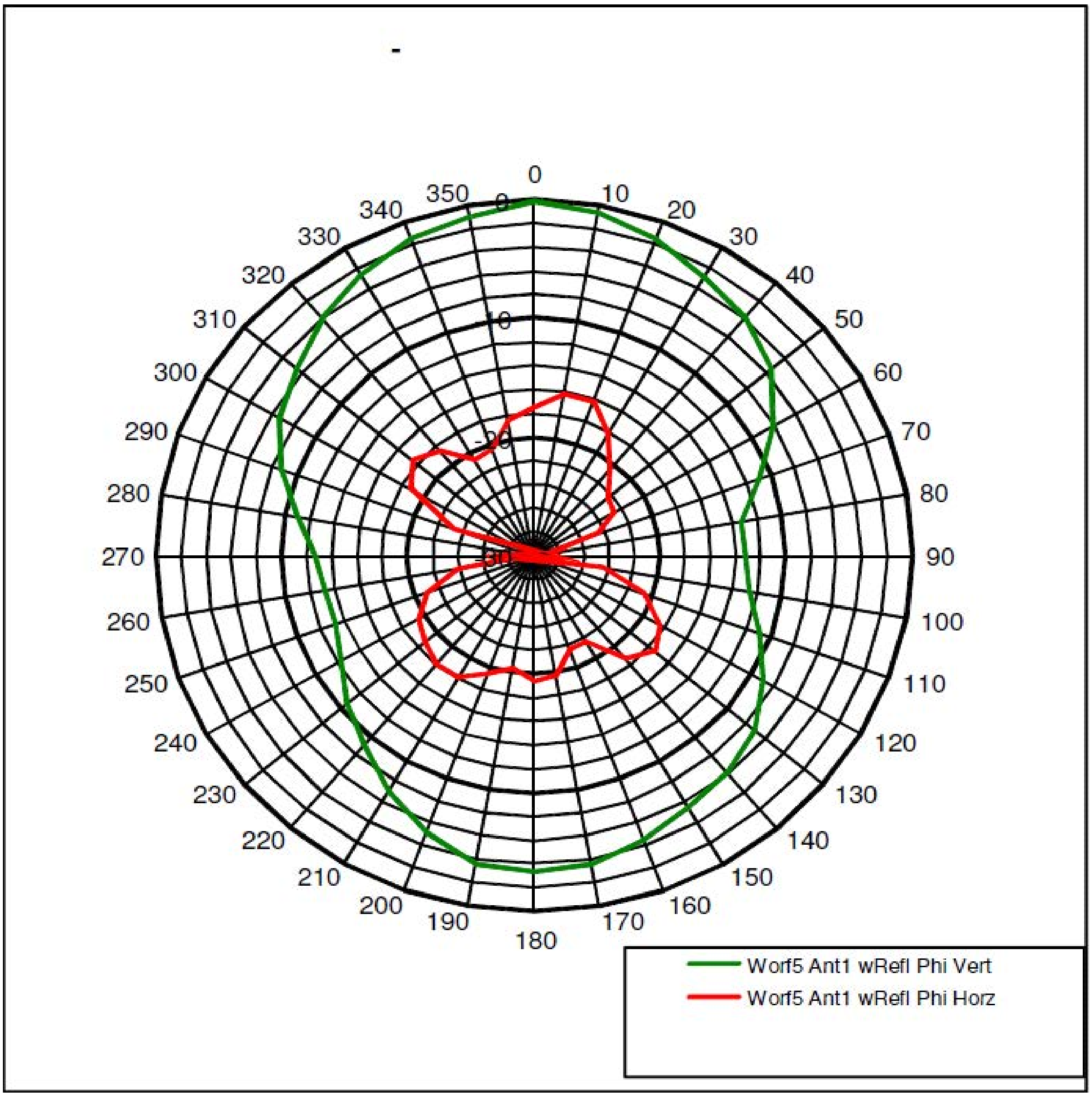


Figure 17: Measured antenna pattern for antenna 1, vertical and horizontal. Same pattern for antenna 2, but 90 degrees shifted.

6.4 BS34X

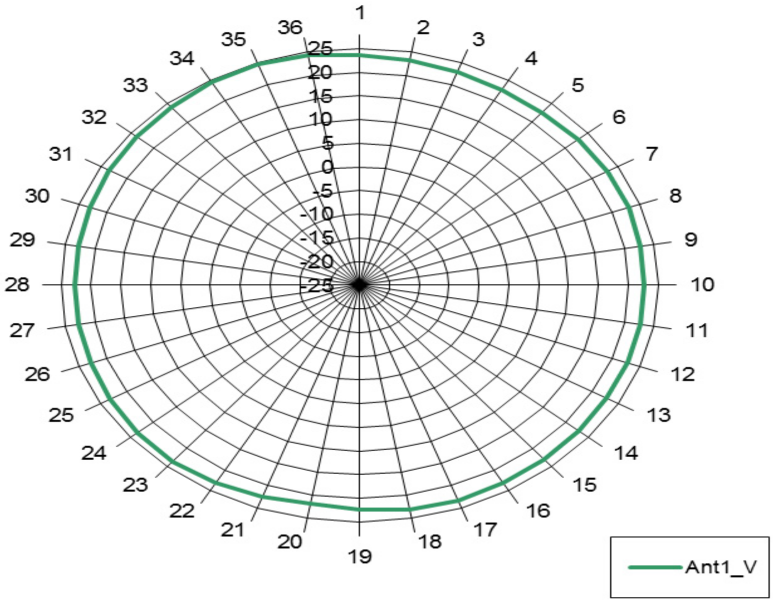


Figure 18: BS34x-ant1 Vertical Polarization.

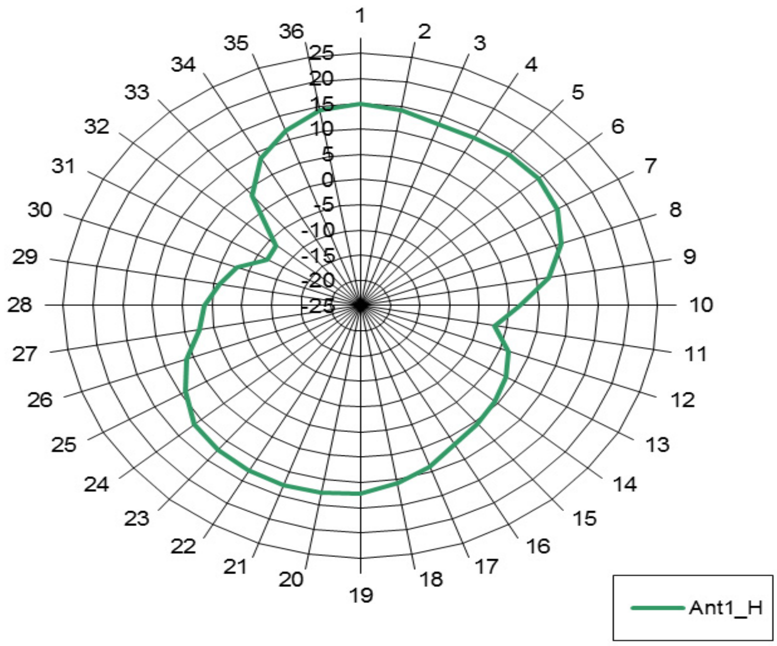


Figure 19: BS34x-ant1 Horizontal Polarization.

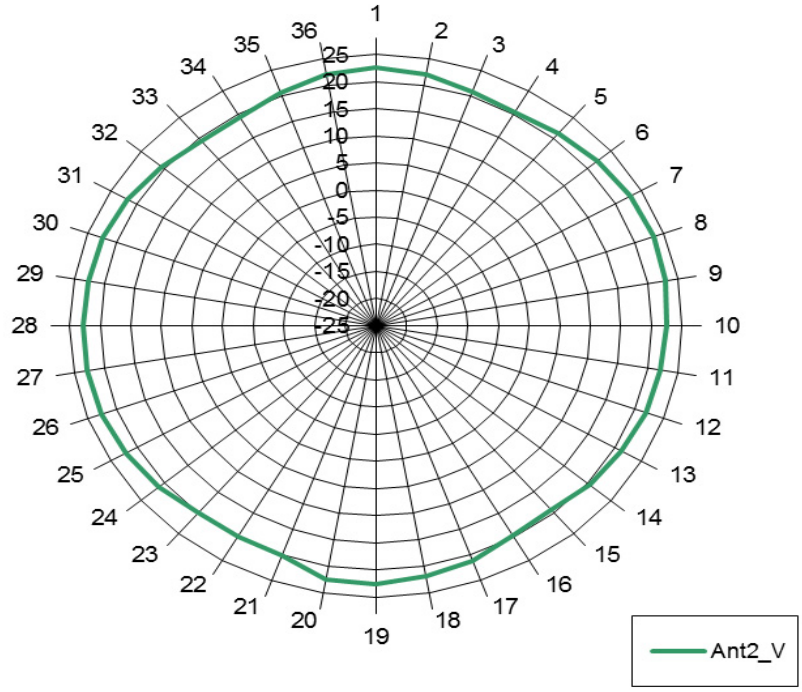


Figure 20: BS34x-ant2 Vertical Polarization.

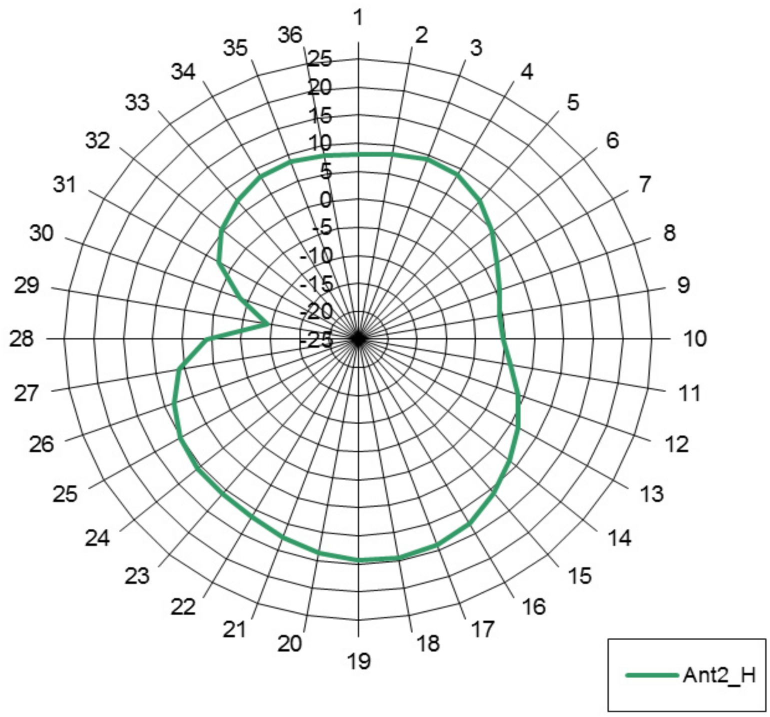


Figure 21: BS34x-ant2 Horizontal Polarization.

6.5 NON STANDARD ANTENNAS

See figure 22 Transmission pattern of base station BS34x with non-standard antennas on page 43 illustrates the different transmission patterns of the omni-directional antenna (NTM/KRENB 101 119/1) and the directional antenna (NTM/KRENB 101 121/1). See figure 23 Transmission pattern of base station BS34x with non-standard antenna on page 44 illustrates the different transmission patterns of the directional single antenna (NTM/KRENB 101 118/1). The outdoor cell size in free space may be up to 450 m radius for the omni-directional antenna and a distance of 600 m for the directional antenna.

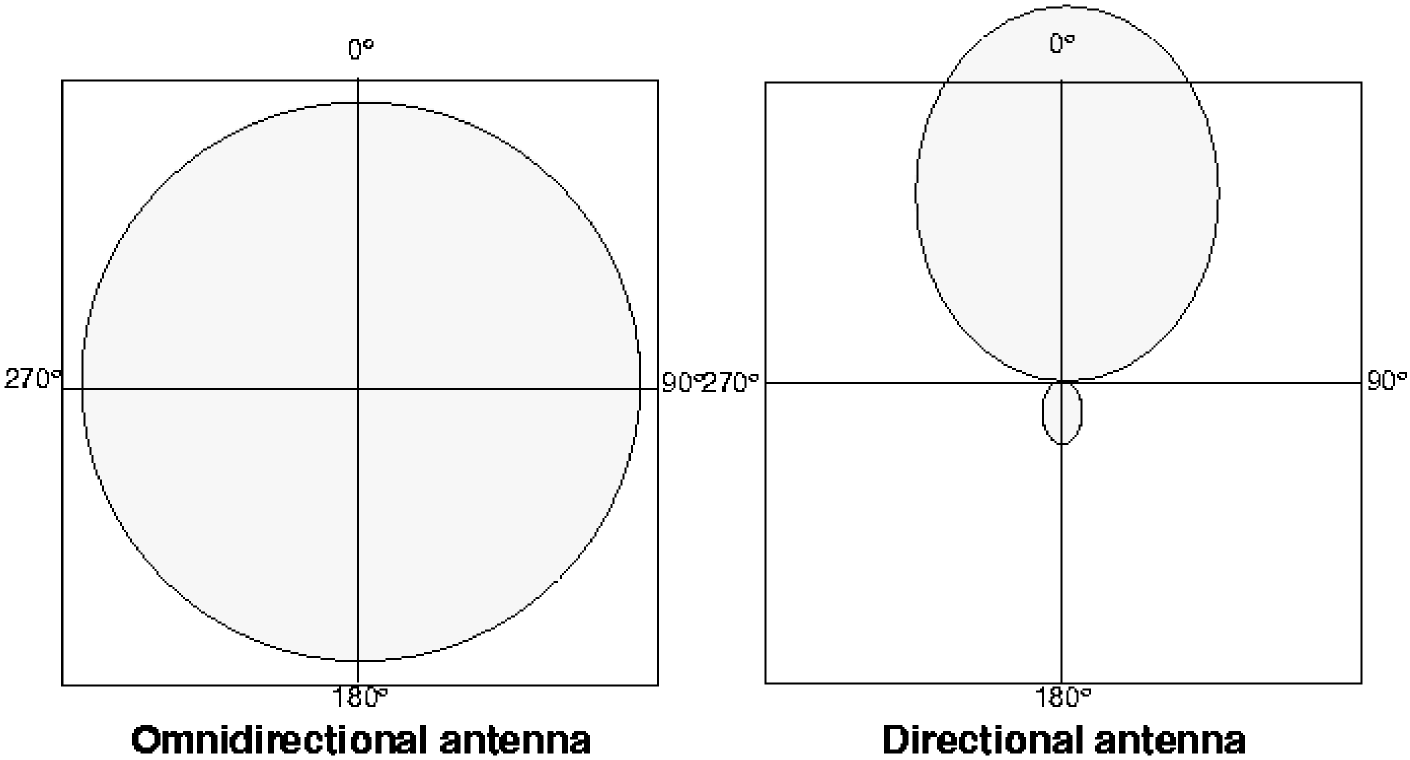
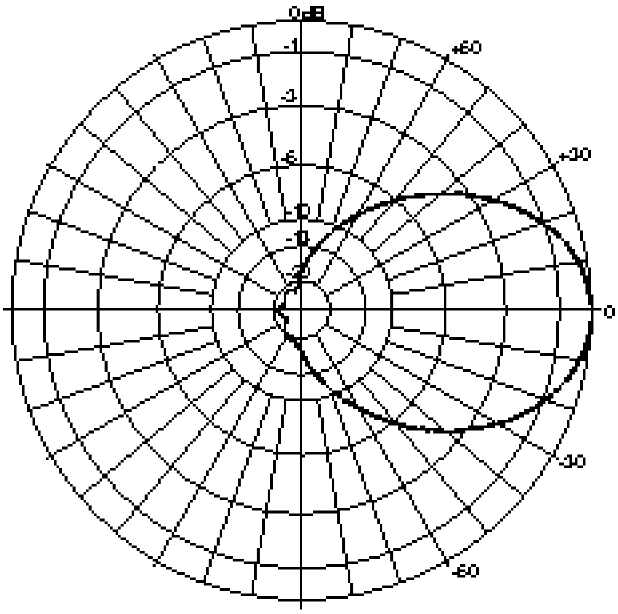
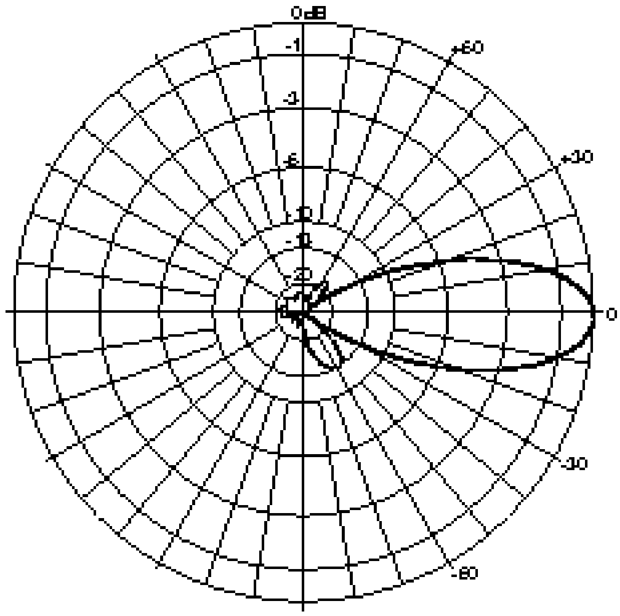


Figure 22: Transmission pattern of base station BS34x with non-standard antennas



Typical radiation in horizontal plane



Typical radiation in vertical plane

Figure 23: Transmission pattern of base station BS34x with non-standard antenna