Meridian 1

Meridian Companion

Site Planning Reference Manual

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About this manual

This manual is used by the Companion site planner to plan and install the best possible Companion system for the site.

For the basics of Companion site planning, refer to your *Guide to Site Planning.*

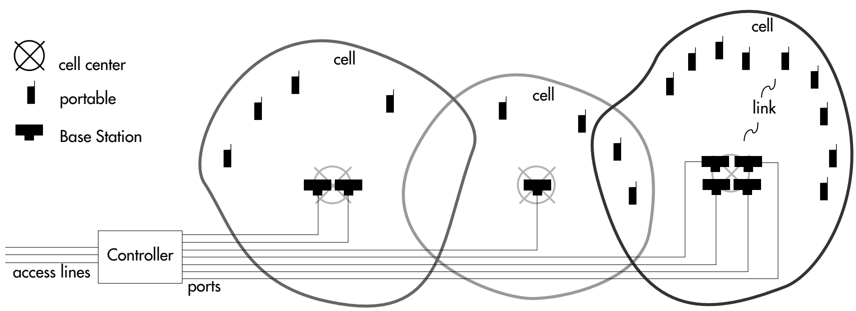
Companion system overview

Introduction to the Companion system

The Companion system allows you to make and receive calls throughout your site using a wireless telephone.

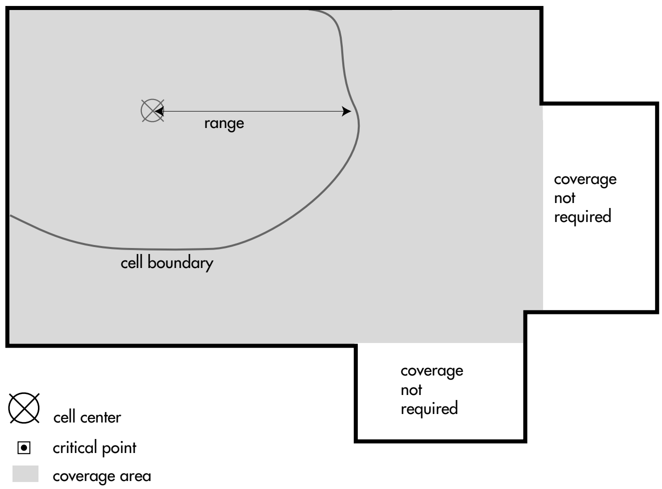
As shown in Figure 1, the basic Companion system consists of a Controller, Base Stations and a portable for each user. The *Controller* provides the connection between the external telephone system, using access lines, and the Companion system, using ports. *Base Stations* relay call information between the Controller and portables. *Portables* are wireless telephones.

Figure 1 : The basic Companion System



As shown in Figure 2, the *coverage area* is the part of the site where the customer wants to use their Companion system. The coverage area can be indoors and outdoors.

Figure 2 : Coverage terminology



When planning a site for coverage by a Companion system, the outermost points from the center of the coverage area are *critical points*. These points may be difficult to provide radio coverage for so are covered first when planning a site.

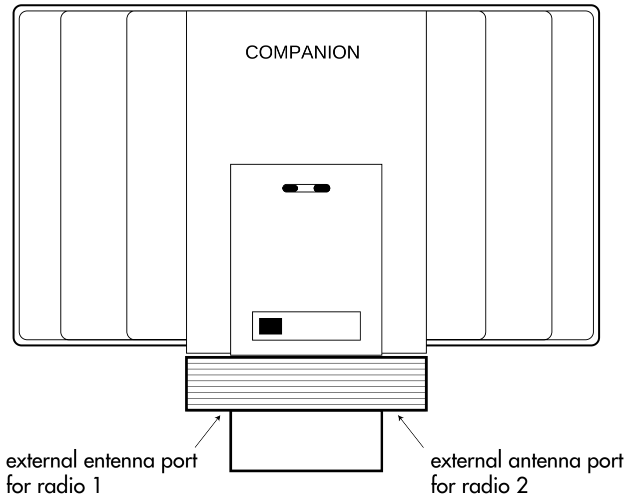
Coverage is provided by grouping Base Stations into *cell centers* throughout the coverage area. A cell center provides telephone coverage to a *cell*. The point where coverage is no longer provided by the cell center is the *cell boundary*. The distance from the cell center to the cell boundary is the *range*.

The radio communication between a portable and Base Station is a *link*. When a user walks from one cell into another, the link is transferred to a Base Station in that cell by a *hand-off* between the two Base Stations. Any portable registered to the system can *roam*, because it can make or receive calls in any cell.

Base Stations

The Base Station, as shown in Figure 3, transmits call information between the Controller and the portable. The Base Station is connected to the Controller using standard telephone wiring. The Base Station uses a wireless connection (radio) to communicate with the portable.

Figure 3 : Base Station



Radios and antennas

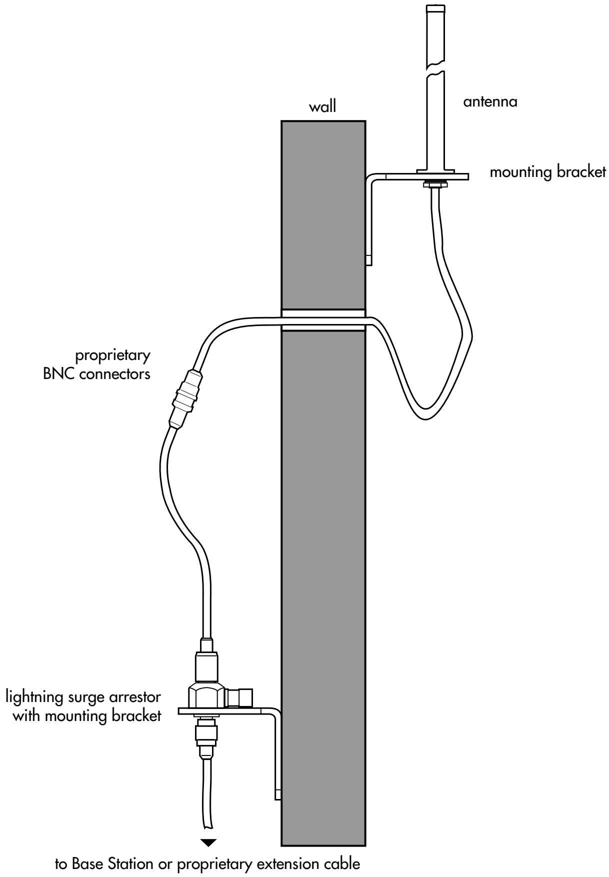
The Base Station has two radios, each with two internal antennas and one external antenna port. Using the two internal antennas one at a time, the radio selects the internal antenna that has the best signal strength. This process is antenna diversity.

The external antenna ports for each Base Station radio can be connected to external antennas by coaxial cables. In this case, the installer configures the radios to use only the external antenna ports and there is no antenna diversity.

The antenna and lightning surge arrestor assembly for PCI is shown in Figure 4.

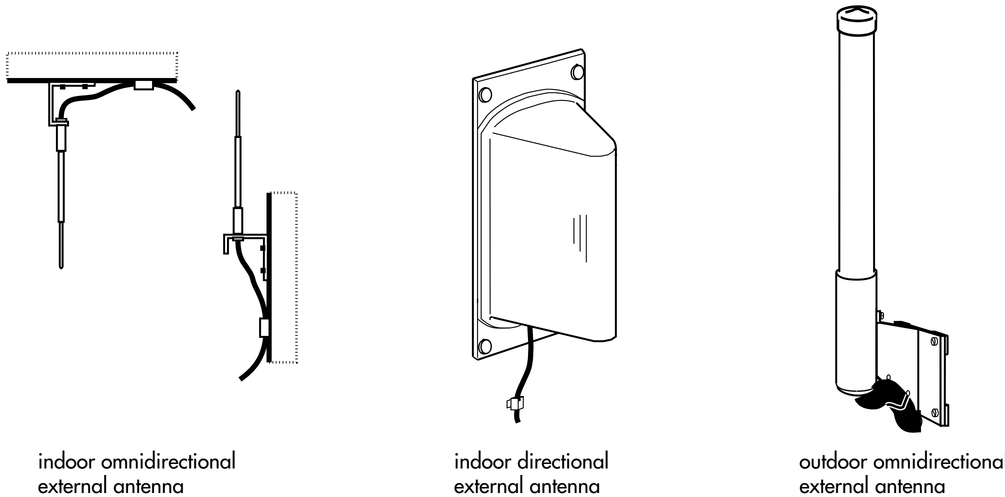
Several types of antennas for CT2Plus are shown in Figure 5.

Figure 4 : Antenna and lightning surge arrestor for PCI



Note: The antenna has a gain between –1.2 and 1.5 dBi.

Figure 5 : Examples of external antennas for CT2Plus



Note: Not all types of external antennas are available in all countries.

Install external antennas at a cell center as close together as possible, with a minimum distance of 40 in. (1 m). Table 1 shows the pattern and gain of these antennas.

Table 1 : External antenna types

Type of antenna	Pattern	Gain
indoor	omnidirectional	0 dB in all directions.
	directional	3 dB in direction of beam, 0 dB at right angles to direction of beam.
outdoor	omnidirectional	2 dB in the horizontal plane. Gain is negative above or below the antenna.

Base Station location

Base Station installation guidelines

- Ensure that the installation complies with your local electrical code.
- Do not plan to install Base Stations in ducts, plenums or hollow spaces that transport air, except where a suspended ceiling creates the duct, plenum or hollow space with lay-in panels or tiles.
- Install Base Stations indoors where there is no condensation and the temperature remains between 32° and 120°F (0° and 50°C). The ideal temperature is between 60° and 95°F (15° and 35°C).
- Install all Base Stations within 4,000 ft (1 200 m) (wiring length for 24 AWG) of the Controller.
- Do not position Base Stations on large concrete or marble columns. Base Stations must be at least 40 in. (1 m) from columns and located at a cell center on the same side of the columns.
- Position Base Stations on ceilings or upright against walls at a height where there is the least number of obstructions between the Base Stations and the cell edge (usually close to the ceiling).

  Installing Base Stations on the ceiling has the following advantages over installing Base Stations on a wall:

— it is easy for you to keep the Base Stations beyond the minimum distance from where users frequently use their portable, such as in offices

— it gives you more planning flexibility

Install Base Stations on the ceiling unless

— the ceiling has architectural or decorative features that prohibit the installation of Base Stations

— the ceiling construction prevents you from mounting a Base Station on it

— the ceiling is made of a material that does not allow you to run wiring to Base Stations mounted on it

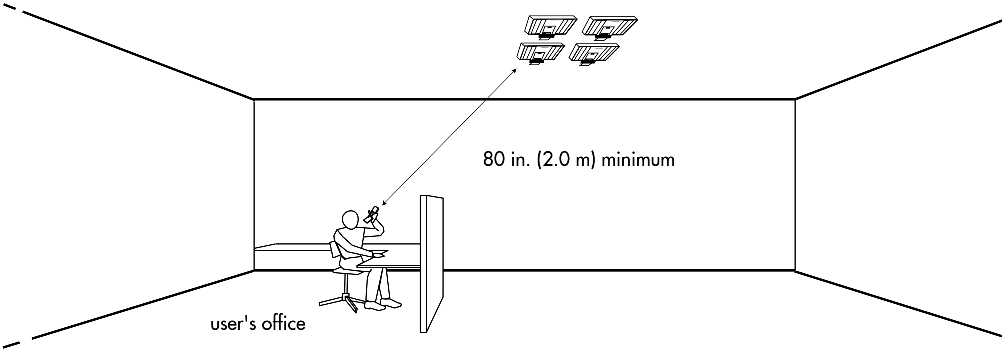
— the customer requests that Base Stations not be mounted on the ceiling

- Position Base Stations away from where a portable is used in an office by at least the amount shown in Table 2, and as illustrated in Figure 6. Installing the Base Stations on ceilings or high on walls helps to maintain these minimum distances.

Table 2 : Minimum distance between office areas and Base Stations

Number of Base Stations in the cell	Minimum distance between office areas and Base Stations
1	40 in. (1.0 m)
2	56 in. (1.4 m)
3	72 in. (1.8 m)
4	80 in. (2.0 m)

Figure 6 : Minimum distance of portables to Base Stations



Installing multiple Base Stations in a cell center

In cases where there is more than one Base Station at a cell center, follow these guidelines:

- Position all of the Base Stations on the same surface with matching composition.
- Allow a clearance of at least $3^1/_2$ in. (9 cm) between the Base Stations and surrounding objects.
- Do not position more than four Base Stations in a single cell.

For CT2Plus protocol

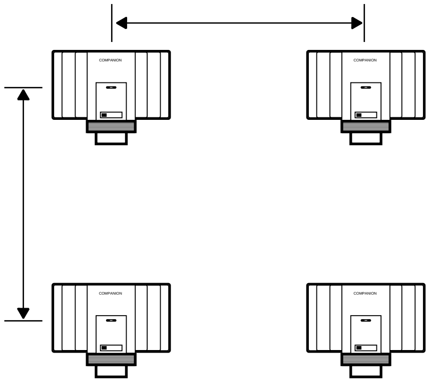
- Position all the Base Stations that are at the same cell center no more than 5 ft (1.5 m) and no less than $3^1/_2$ in. (9 cm) from each other.
- Position the Base Stations on a ceiling as shown in Figure 7.

For PCI protocol

- Position the Base Stations as close together as possible but maintain a minimum distance of 54 in. (1.35 m) apart (center to center) at the same cell center.
- Do not mount Base Stations in rows.

- If there are three or four Base Stations at the cell center, install them on the ceiling.
- If there are one or two Base Stations at the cell centers, you can install the Base Stations upright on a wall, or on a ceiling as shown in Figure 7.

Figure 7 : Base Station positioning



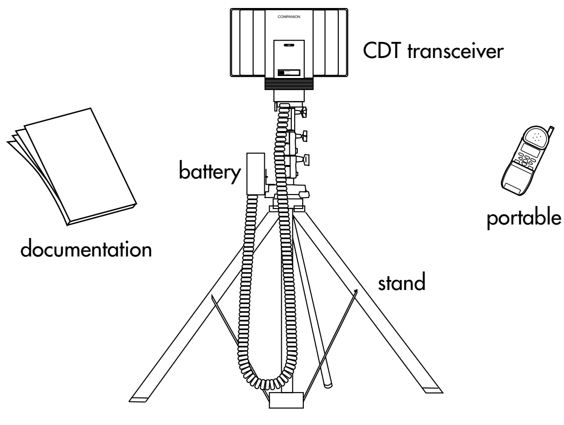
Companion Deployment Tool

Using the CDT

This section describes how you use the Companion Deployment Tool (CDT) to determine cell centers and cell boundaries.

For more information on using the CDT, refer to *Companion Deployment Tool User Guide*.

Figure 8 : Companion Deployment Tool



CDT components

The CDT consists of the following components:

- a stand
- a CDT transceiver

  Note: The CDT transceiver will not function as a Base Station. You cannot connect it to the Controller.

- a battery inside a battery holder
- a portable
- CDT documentation

When used with the CDT transceiver, the portable continuously displays two values. The signal strength is on the left and the cyclic redundancy check error rate is on the right. The signal strength is the signal transmitted by the portable and received by the CDT transceiver. For an explanation of the cyclic redundancy check, refer to *Companion Deployment Tool User Guide*.

How the CDT works

Refer to *Companion Deployment Tool User Guide* for instructions on assembling the tool, establishing a link, setting the cell boundary value, and choosing the external antenna with the CDT transceiver.

The CDT uses the internal antennas as a default, but this default can be changed to the external antenna. The cell boundary value is the signal strength used with the CDT to determine the cell boundary and can also be changed.

When you have established a link with the portable, enter the numbers as shown in Table 3 into the dialpad to set which antennas and what cell boundary value you want to use.

Table 3 : Selecting the CDT antenna and setting the cell boundary value

Entered number	Operation
*894	shows the present selection and setting for 1 second
*895	selects the internal antennas and sets the cell boundary value
*896	selects the external antenna and sets the cell boundary value
*897	sets the cell boundary value

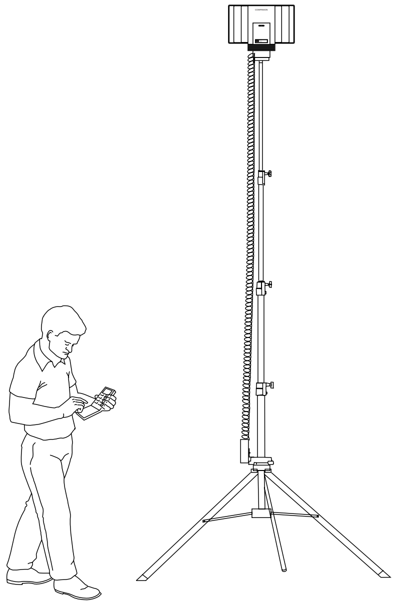
Note: When the CDT transceiver is powered off, the cell boundary value resets to the default value and the internal antennas are selected.

You will hear tones from the portable that indicate the received signal strength. Use the tones to determine the cell boundary. The received signal strength value also appears on the portable's display but the tones should be used to determine cell centers and cell boundaries.

Note: The signal strength on the portable's display uses dBm units.

When you set the CDT transceiver at a critical point, raise the CDT transceiver as high as it can go or until it is at the height that you recommend for Base Stations.

Figure 9 : Fully raised CDT



Note: The CDT stand is available in three heights: 8 ft (2.4 m), 12 ft (3.6 m) and 16 ft (4.8 m).

Do not position your CDT transceiver next to large concrete or marble columns. These structures affect the contour of the cell boundary. Keep the CDT transceiver at least 40 in. (1 m) from columns.

Interpreting the portable's tones

The portable makes the following tones to indicate how close you are to the CDT transceiver:

- Steady tone—The signal strength is stronger than the cell boundary value.
- Double beep, followed by a rhythmic high-low tone—The signal strength is weaker than the cell boundary value. The rhythmic high-low tone persists as long as you remain where the signal strength is weak.

- Triple beep, followed by a steady tone—The signal strength has increased to 6 dB stronger than the cell boundary value. The CDT resets for you to make another measurement.
- No sound—If you lose the link, no tones are generated. If you move closer to the CDT transceiver within 10 seconds, the link reestablishes itself.

Conducting a CDT operational check

Charge the battery for the CDT transceiver the day or night before and have a fresh set of batteries for the portable. For details on how to charge the battery, refer to *Companion Deployment Tool User Guide*.

Note: Do not set up the CDT transceiver outdoors. The CDT is not intended for outdoor use.

CDT using CT2Plus protocol

1. Establish a link.
2. In an open area, stand 33 ft (10 m) from the CDT transceiver with the portable. Keep the CDT transceiver in plain view and have no obstructions nearby (including people).

   If the display shows -44, the CDT works properly. If the display does not show -44, repeat this procedure with a different portable. If the display still does not show -44, replace the transceiver.

CDT using PCI protocol

1. Establish a link.
2. In an open area, stand 10 ft (3 m) from the CDT transceiver with the portable. Keep the CDT transceiver in plain view and have no obstructions nearby (including people).

   If the display shows -35, the CDT works properly. If the display does not show -35, repeat this procedure with a different portable. If the display still does not show -35, replace the transceiver.

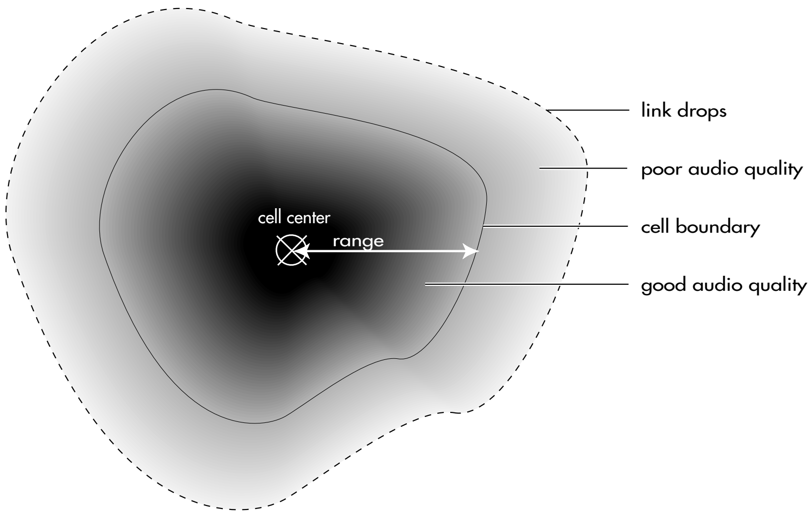
Cell boundary values

The strength of the radio signal the portable receives decreases as you walk away from the cell center. As shown in Figure 10 on page 18, the cell boundary is the farthest place from the cell center where you hear a good radio signal.

Links can be made outside the cell boundary but the audio quality of the link is poor. The link drops when the portable and the Base Station are too far apart.

The range from the cell center to the cell boundary, or the distance to a potential cell center from a critical point, is determined using the cell boundary value and the CDT. The CDT uses a default value for the cell boundary value. This value can be reset to suit your planning needs.

Figure 10 : Cell boundary terminology



Use Table 4, “: Cell boundary values,” to determine which cell boundary value you should use.

Table 4 : Cell boundary values

Indoors (with office)	Indoors (without office)	Outdoors
-70 dBm	-73 dBm	-75 dBm

Note: You can set the cell boundary values into your portable. Refer to your portable’s user guide for instructions.

Use -73 dBm as the cell boundary value if there are no, or only a few, users’ offices within the prospective cell. Use -70 dBm as the cell boundary value if a group of offices is within the cell. Use -75 dBm for outdoor areas that are served by indoor Base Stations. For outdoor areas that cannot be reached by an indoor Base Station, see “Covering outdoor areas” on page 26.

Note: An office is any area where users can make and receive calls on their portables while sitting at their desks or in their cubicles.

Using the CDT to determine cell boundaries

You use the CDT and a portable to determine the radio range. Listen to the tone the portable makes while walking briskly away from the CDT transceiver until the tone changes, indicating the cell boundary value. When the portable detects the cell boundary value, the distance between you and the CDT transceiver is the range. For more information, see “Interpreting the portable’s tones” on page 16.

Note: The farther you move away from the CDT transceiver, the more negative the number you read. For instance, a reading of -66 indicates that you are farther from the transceiver than a reading of -50.

Measuring radio range

Note 1: When you are determining the range, hold the portable approximately 40 to 50 in. (1.0 to 1.3 m) from the floor. Do not bring it too close to walls or other objects.

Note 2: Walk briskly as you listen to the tones. This is necessary to get an average reading of the link's signal strength.

1. Stand at a position near the CDT where the portable displays a signal strength that is at least 10 dB stronger than the cell boundary value and where you hear a continuous tone.
2. Walk briskly away from the CDT transceiver until the tone changes. Stop and record your position on the floor plan with a small x.

Note: It is the location where the tone first changes that is important. The signal strength value on the display may fluctuate and the tone may change after you stop walking.

Site planning basics

The basics of planning a site

Planning a site involves the following tasks:

- determining site-specific information
- planning for outdoor coverage (as required)
- surveying the site
- determining how much equipment is required to cover the site
- reviewing your work

“Planning a Sample Site” on page 43 uses an example to describe these tasks. Methods and examples for surveying more detailed sites are described in “Planning complex sites” on page 57.

You will use one or more of the following surveying methods in your site survey:

- single floor
- multiple adjacent floors
- subsequent system installation
- high portable density area
- multiple systems installation

Site planning prerequisites

Before you go to the site, make sure that you have the following:

- a working CDT and portable telephone
- any keys needed for secured areas where you require coverage
- copies of the site floor plan (one working and one clean copy)
- a pencil, an eraser, a ruler and colored pens
- a page from the appropriate Companion Provisioning Record
- any required safety equipment, such as a hard hat or safety glasses
- the appropriate Companion installation guide

Required site information

You need the following information to accurately plan a site:

- the name and telephone number of the site contact
- the number of portables, the boundaries of the coverage area, and the proposed Companion system
- the location of the telephone switching room
- whether the customer requires outdoor coverage
- whether the customer wants to reduce the number of Base Stations by not covering areas that require more intensive coverage, such as restrooms, stairwells or basements
- whether there is another system on the site
- whether users have a desk telephone in their office

  Note: An office is any area where users can make and receive calls on their portables while sitting at their desks or in their cubicles.

- how to get access to secured areas
- whether it is acceptable to install Base Stations on the ceiling
- whether the Base Stations must be hidden from view

You also need to determine the mobility of the users. For instance, you need to know whether the users move from cell to cell or whether they will always be within one cell.

Use one copy of the floor plan as a working copy to identify critical points, cell centers and cell boundaries. Use the other copy as a clean copy and attach it to the site Provisioning Record for the installer, customer, maintenance and anyone else who needs to see your work.

Note: The floor plans should include a scale. The scale is used for the range for outdoor coverage and to check wiring distances from the Controller to the Base Stations.

Labeling a floor plan

Clearly mark information on the floor plans during planning. Your customer, the sales group, the installer and maintenance personnel need to read these floor plans.

Use a different color for each cell. Use the same color for each cell center and its corresponding cell boundaries. Indicate the information on the floor plan as follows:

- critical points—mark  on the floor plan
- cell centers—mark  on the floor plan. Label each cell center xCn where x is the floor and n is the next sequential cell center.

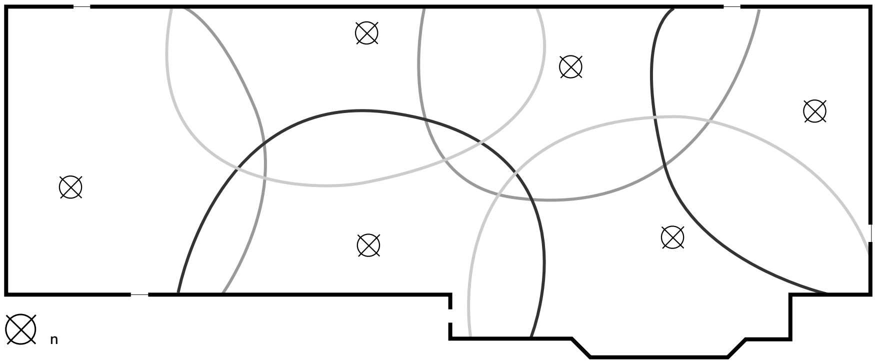
  For example, label a cell center on the second floor 2C4. The 2 tells you that the cell center is on the second floor; the 4 tells you that this cell is the fourth cell in sequence in the planning process.

Table 5 : Example cell labels

Floor	Cell label
second floor	2C4, 2C5
first floor or outdoors	1C1, 1C2, 1C3
basement	-1C6, -1C7

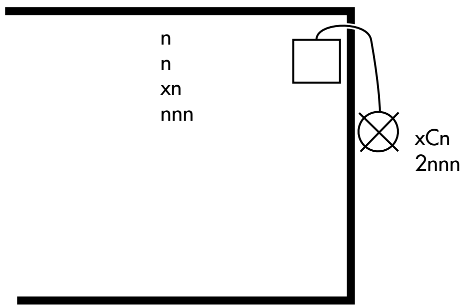
- cell boundaries—mark wide, colored lines on the floor plan

Figure 11 : Example cell boundaries



Identify external antennas and which Base Station connects to them, as shown Figure 12.

Figure 12 : Labeling external antennas on the floor plan



Note: The system administrator needs to know the position of any external antennas and the position of the Base Station that connects to them.

Cell center location

Covering outdoor areas

Note: The customer decides whether the site requires outdoor coverage.

Cover outdoor areas before covering indoor areas.

Use the CDT to determine the outdoor coverage provided by a Base Station located indoors. Because you cannot use the CDT transceiver outside, use Table 6 on page 28 to estimate the coverage of outdoor external antennas.

For each cell center requiring outdoor external antennas, it is best to plan for two, four, six or eight outdoor external antennas. Connect each pair of outdoor external antennas at a cell center to the same Base Station. If you only connect one radio to an external antenna serving the same cell center, it is best to disconnect the other radio. If you use external antennas and you have the two radios in the same Base Station serving different cells, users in the area could have poor audio quality links and they could drop their calls.

Steps for outdoor planning

1. Note each of the critical points that you want to reach.
2. Position the CDT transceiver indoors at the potential location for a cell center that is closest to the critical point (preferably next to a window).
3. Take your portable outdoors and determine if the critical point is within the cell boundary.

   If the critical point is within the cell boundary, your cell center is at the position of the CDT transceiver. Determine and record the cell boundary for the cell center (both indoors and outdoors) on the floor plan (see “Cell center location” on page 26).

   If the critical point is not within the cell boundary, determine and record on the floor plan the cell boundary that you did reach.
4. For each critical point that cannot be reached, determine a potential location for outdoor external antennas using the following criteria:

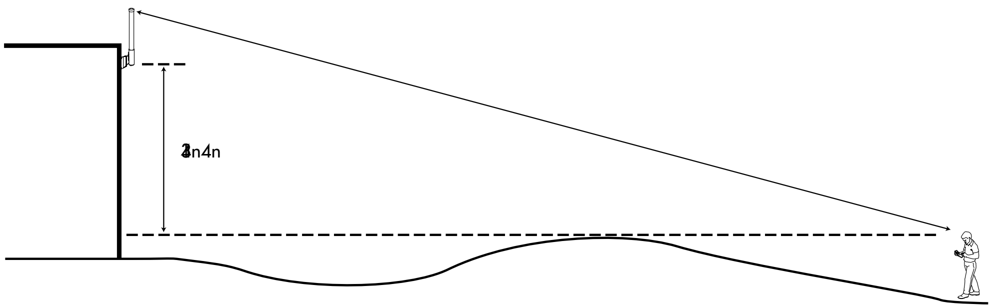
   — Is it outdoors?

   — Is it as close as possible to the critical point you need to reach?

— Is it within 33 ft (10 m) (wiring length) of a place where you can install a Base Station?

— Is it more than 13 ft 4 in. (4 m) above the highest ground you need to cover? (Installing the antenna at a lower height reduces the range.)

Figure 13 : Elevation of outdoor external antenna and terrain



5. Determine the path required to run a coaxial cable from where you plan to install a Base Station to the potential location of outdoor external antennas.

6. Determine the length of these coaxial cables. Keep their length as short as possible (33 ft [10 m] or less).

7. Using the length of the coaxial cables and the outdoor terrain, refer to Table 6, “: Range for outdoor external antennas (ft [m]),” to estimate the range for outdoor coverage.

Note 1: Use Table 6 only when the external antenna is 13 ft 4 in. (4 m) or more above the highest terrain.

Note 2: The range does not encompass any structures or earth mounds greater than 7 ft (2 m) tall and 7 ft (2 m) wide.

Table 6 : Range for outdoor external antennas (ft [m])

Coaxial cable length	Maximum outdoor range		
	Lawn or ponds	Woods	Full parking lots
3 (1)	550 (168)	130 (39)	230 (70)
7 (2)	540 (165)	125 (38)	220 (67)
10 (3)	530 (162)	125 (38)	210 (64)
13 (4)	520 (159)	125 (38)	200 (61)
17 (5)[1]	515 (155)	120 (37)	190 (57)
20 (6)	510 (152)	120 (37)	180 (55)
23 (7)	500 (149)	115 (36)	170 (51)
27 (8)	480 (146)	115 (36)	160 (48)
30 (9)	470 (143)	115 (36)	150 (45)
33 (10)[1]	460 (140)	115 (36)	140 (42)

1. For PCI protocol, only these lengths of cable are available.

8. Using the potential location for outdoor external antennas as a center point, draw a circle on the floor plan with the radius equal to the range found in Table 6, ": Range for outdoor external antennas (ft [m]),". Remember to crop the arc of the circle around structures and earth mounds.

   Use the most suitable coverage area to select your cell center–either the coverage area based on Table 6 or the coverage area determined in step 2 using the CDT.

   Note: If you recommend external antennas, inform the customer that you estimated the coverage area.

   If you could not reach the critical point determine whether the customer wants you to continue planning.

9. Repeat this procedure until you completely cover all of the outdoor areas.

Covering a single floor indoor area

Surveying the site

Survey the site by working from one side of the coverage area to the middle of the coverage area. Then go to the other side of the coverage area and work back toward the middle until you have mapped all of the coverage area. Check your floor plan to ensure there are no areas where a portable in the required coverage area could be outside the range of a cell center.

Note 1: By surveying your site in this way, cell centers are distributed throughout the site. If you survey the site from one end to the other, you could cluster cell centers at one end of the site.

Note 2: Repeat this procedure until all areas in the required coverage area are within range of a cell center. Defining a cell typically takes 25 to 40 minutes.

Identifying critical points

1. Identify the initial critical points needed to determine a cell center. (A critical point is an outer corner of the coverage area, or a point that may be difficult for the radio signal to reach.)
2. Mark the critical points on the floor plan with ⊡.

Note: When determining the location of a cell center, you typically use one or two critical points.

Locating cell centers

1. Set up the CDT transceiver at a critical point and establish a link.
2. Check the floor plan to see if the critical point is within an office area.

   If the entire area is office area, use -70 dBm as the cell boundary value. If there are no, or only a few, users' offices, use -73 dBm as the cell boundary value.

   Note: Refer to your portable user guide for instructions on how to store cell boundary values for later recall.

3. Measure the range into the coverage area in a few directions to determine where a cell center can be located and still be within range of the critical point.

4. Mark a small x on the floor plan where you reach cell boundary values. Draw a thin contour line through the x's.

5. Select another nearby critical point and repeat steps 1 to 4.

   Note: The intersection of the contour lines is a potential cell center.

6. Choose a position on the floor plan for the cell center that

   — is farthest from the critical points and is still within range

   — complies with the Base Station installation guidelines

   — is in the coverage area

7. Label the cell center on the floor plan with xCn, where x is the floor and n is the cell number in sequence of the entire plan.

Locating cell boundaries

1. Set up the CDT transceiver at the cell center and establish a link.

2. Check the floor plan for possible users' offices within the cell.

   If the entire area is office area, use -70 dBm as the cell boundary value. If there are no, or only a few, users' offices, use -73 dBm as the cell boundary value.

3. Find the cell boundary position by measuring the range and recording it on the floor plan with a small x.

4. Move back toward the CDT transceiver until the tone from the portable changes from intermittent beeps to a continuous tone.

Note 1: Walk into all of the areas (rooms) necessary to determine the complete cell boundary. Radio signals travel farther in uncluttered areas than they do in cluttered areas.

Note 2: Repeat steps 3 and 4 until you make enough x's to draw a contour line around the cell center (12 x's for a full 360° around a cell center are enough).

5. If you chose a cell boundary value of -73 dBm and a user's office is within the cell, confirm that the office is within -70 dBm of the cell center. Reset the CDT to -70 dBm and find the cell boundary in the office area. If any of these users' offices are not within -70 dBm of the cell center, consider these users' offices as outside the cell.

6. Mark each office within the cell that is not in the office area.
7. Label any subsequent critical point on the floor plan with ⊡.

Completing the single floor plan

As you locate cells, trace the cell boundaries and label the cell centers with colored markers.

Repeat “Locating cell centers” and “Locating cell boundaries” to define the cells for the subsequent critical points.

Single-floor coverage techniques

This section shows you three single-floor planning techniques:

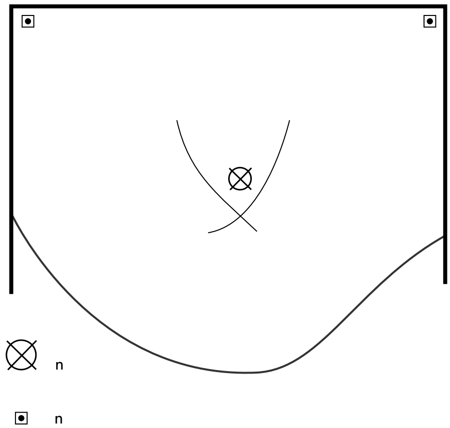
- single-cell—used to cover the distance between two outside corners at the end of a coverage area with one cell
- double-cell—used to cover the distance between two outside corners at the end of a coverage area with two cells
- multi-cell—used to cover the distance between two outside corners at the end of a coverage area with more than two cells

You always start planning with the single-cell technique because you do not always know what the range is or how many cells you will need to cover the area between the critical points.

Single-cell technique

Always start with the single-cell technique regardless of the distance between the two critical points. With this technique you find one cell center that serves two critical points, as shown in Figure 14.

Figure 14 : Single-cell distance technique



1. Identify the initial critical points and mark them on the floor plan with .

   Note: When determining the location of a cell center, you typically use one or two critical points.

2. Follow the steps of “Locating cell centers” on page 29.

   If the contour lines do not cross, or they cross close to the edge of the coverage area between the two critical points, follow the steps in the “Double-cell technique” on page 33.

3. Follow the steps of “Locating cell boundaries” on page 30.

4. Repeat these steps for the remaining coverage area from the boundaries of the coverage area toward the center until you cover all of the floor.

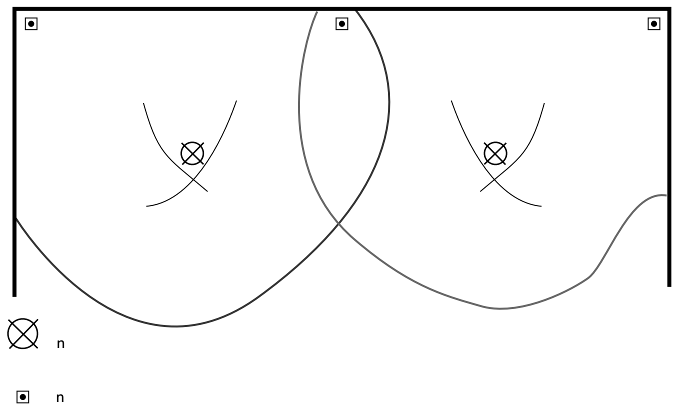
   If the cell boundary covers any other critical points, ignore them when proceeding with coverage planning.

Double-cell technique

Note: Follow the double-cell technique only if you are referred here from the single-cell technique.

Before you begin this technique you should have two critical points that one cell center cannot serve. Using the double-cell technique, you find two locations for cell centers that cover three critical points, as shown in Figure 15.

Figure 15 : Double-cell distance technique



1. Mark a third critical point midway between the two critical points already identified and place the CDT there.
2. Establish a link and walk briskly into the coverage area within range of the first critical point until you reach the cell boundary.
3. Mark a small x on the floor plan where you reached the cell boundary.
4. Repeat steps 2 and 3 several times, walking in different directions to get an idea where the cell center can be located and still be within range of the third critical point.
5. Draw a thin contour line through the x's on the floor plan.
6. Repeat steps 2 to 5, walking into the coverage area of the second critical point.

   Note: If the contour lines do not cross, or if the point where they cross is close to the edge of the coverage area between the midway critical point and either of the first two critical points, follow the steps of "Multi-cell technique" on page 34.

7. Choose a location for the cell center on the floor plan that

   — is the farthest from the midway critical point and one of the first two critical points, and is still within range of the critical points

   — complies with the Base Station installation guidelines

   — is within the coverage area

8. Mark each cell center on the floor plan  and label them 1C1 and 1C2.

9. Follow the steps of "Locating cell boundaries" on page 30 for each cell center.

10. Repeat this technique for the remaining coverage area from the boundaries of the coverage area toward the center until you cover all of the floor.

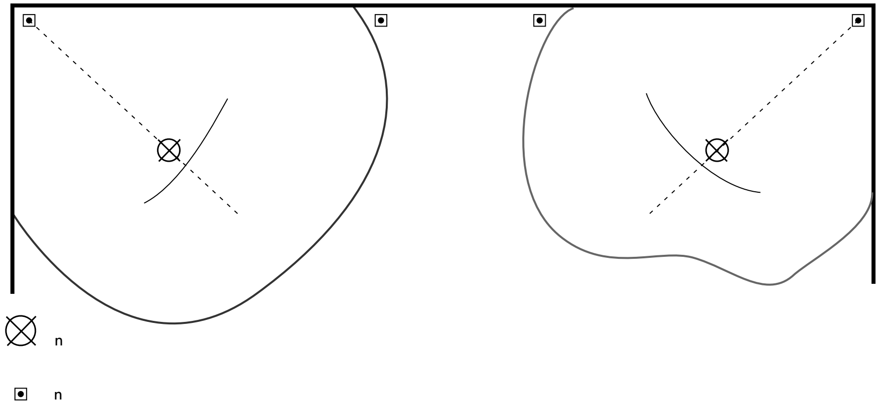
    If the cell boundary covers any other critical points, ignore them when proceeding with coverage planning.

Multi-cell technique

Note: Follow the multi-cell technique only if you are referred here from the double-cell technique.

Before you begin this technique you should have two critical points that one cell center cannot serve. Using the multi-cell technique you find two cell centers, each one serving one of the two critical points, as shown in Figure 16.

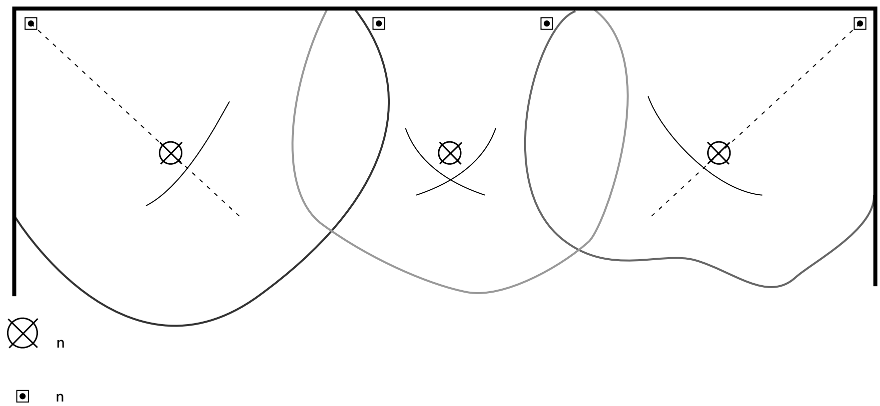
Figure 16 : Multi-cell distance



1. Choose a location for the cell center on the floor plan that
   - — is the farthest from one of the critical points and is still within range
   - — lies on the dividing line between the two edges of the coverage area
   - — complies with the Base Station installation guidelines
   - — is within the coverage area
2. Mark each cell center on the floor plan  and label them 1C1 and 1C2.
3. Follow the steps of “Locating cell boundaries” on page 30 for each cell center.
4. Define and mark on the floor plan any subsequent critical points where each cell boundary crosses the edge of the coverage area.

   Note: Use the subsequent critical points to fill in the coverage area between the first two cells using the “Single-cell technique” on page 32. An example of using the single-cell technique to plan a multi-cell distance is shown in Figure 17.

Figure 17 : Filling a multi-cell gap with a single cell



If the cell boundary covers any other critical points, ignore them when proceeding with coverage planning.

5. Repeat the multi-cell technique for the remaining area to be covered from the boundaries of the coverage area toward the center until all of the floor is covered.

Determining the number of Base Stations per cell

1. Divide the floor plan into cell areas, one area per cell, splitting cell overlap areas in half (see Figure 22 on page 48).
2. Count the number of users' offices in each cell area and record this number on the floor plan in each cell area.
3. Create a traffic table as shown in Table 7, with one column for each cell.

Table 7 : Blank traffic table

	1C1	1C2	1C3	1Cn
Users inside the cell with an office				
Users with an office outside of cell who walk into the cell				
Users without an office				
Anticipated number of portables per cell				

Note 1: For each cell, complete steps 4 through 7.

Note 2: Assume that users will be in the cell where their office is 70 percent of the time and in another cell 30 percent of the time.

4. Calculate the total number of users in the cell with an office.

Users with an office in the cell x 0.7 = Users inside the cell with an office

Enter this number in the row, "Users inside the cell with an office."

5. Calculate the total number of users with an office outside the cell who walk into the cell.

Note: Do not count users without an office in this step.

$$\frac{\text{(Total users with an office – Users with an office inside the cell) x 0.3}}{\text{Total number of cells – 1}}$$

Enter this number in the row, "Users with an office outside of cell who walk into the cell."

6. Divide the number of users without an office by the number of cells.

$$\frac{\text{Total number of users without an office}}{\text{Number of cells}}$$

Enter this number in the row, “Users without an office.”

7. Add the values for each column (cell) and enter the result in the row, “Anticipated number of portables per cell.”

8. Determine the number of Base Stations per cell (see Table 8, “: Base Station requirements per cell,”).

Table 8 : Base Station requirements per cell

Anticipated number of portables per cell		Number of Base Stations
Users with a portable telephone and desk telephone	**Users with only a portable telephone**	
greater than 0 up to 3	greater than 0 up to 2	1
greater than 3 up to 12	greater than 2 up to 7	2
greater than 12 up to 27	greater than 7 up to 15	3
greater than 27 up to 44	greater than 15 up to 23	4
greater than 44	greater than 23	high density area[1]

1. Refer to “Planning an area of high portable density” on page 63.

Note: For more detailed planning, see “Appendix A: Derivation of traffic procedure” on page 85.

Special cases

Combination of users with and without desk telephones

You may have some users with access to desk telephones and some users without access to desk telephones. If this is the case:

1. Determine the anticipated number of portables per cell for users with desk telephones.
2. Determine the anticipated number of portables per cell for users without desk telephones.
3. Adjust the anticipated number of portables per cell value for the users without desk phones (see Table 9).

Table 9 : Adjustment for users without desk telephones

Anticipated number of portables for users without desk telephones	Adjusted anticipated number of portables per cell
0	0
1	1.4
2	3.0
3	4.7
4	6.5
5	8.3
6	10.1
7	12.0
8	13.8
9	15.7
10	17.5
11	19.4
12	21.3
13	23.2
14	25.1
15	27.0
16	29.1
17	31.2

Table 9 : Adjustment for users without desk telephones (continued) (continued)

Anticipated number of portables for users without desk telephones	Adjusted anticipated number of portables per cell
18	33.3
19	35.4
20	37.5
21	39.7
22	41.8
23	44.0

4. Add the adjusted anticipated portable value and the anticipated portable value of the users with desk phones together.

5. Use the column “Users with a portable telephone and a desk telephone” in Table 8 on page 38 to determine the number of required Base Stations per cell.

Note: Every pair of external antennas requires a Base Station. If external antennas are intended for the cell center, use two external antennas for each Base Station. If only one antenna is used the system will assign the two Base Station radios to different cells.

For more information on using external antennas, see “Covering outdoor areas” on page 26 and “Appendix B: Using indoor external antennas” on page 89.

No office information

If you do not know where any of the users’ offices are, calculate the anticipated number of portables per cell using the following formula:

$$\frac{\text{Number of portables}}{\text{Number of cells}}$$

Reviewing your work

Review your work to insure that the sales group can use it, and that it is complete, legible and acceptable for the installer, maintenance personnel and your customer.

Before finishing your work, you must know:

- the location of the cell centers
- how many Base Stations you need to install at each cell center
- where and how many external antennas to install
- if there were any areas you could not cover

Checking system capacity

❑ The number of Base Stations, portables and access lines for the system does not exceed the capacity of the system to be installed.

❑ The appropriate number of cells. (You may need to replan the site with multiple systems. If so, see “Planning multiple systems” on page 67.)

❑ The recommended location of the Controller is not more than 4,000 ft (1 200 m) (wiring length for 24 AWG) from all cell centers. If it is more, look for other locations for the Controller.

Reviewing with the customer

When you finish, show the customer:

- the final positions of the Base Stations
- any locations where there are too many portables
- installation (and location) of any recommended outdoor external antennas
- any areas where you could not meet the coverage requirements

Note: If you recommend external antennas for outdoor coverage, inform the customer that the coverage is an estimate.

Providing floor plan information

Neatly transfer the information from the working copy of the floor plan to the clean copy. Use colored pens to mark the cell boundaries and corresponding cell centers.

Record the following information on the floor plans:

- all areas needing coverage (indoor and outdoor)
- the location of the Controller
- the locations of the remote power interconnects (RPIs)
- the total number of Base Stations
- all the named cell centers (for example, 2C5) and their corresponding cell boundaries
- all the critical points
- any installation restrictions
- any notes detailing the installation at a particular cell
- the location of external antennas and their Base Stations

Attach a completed traffic table with the floor plans.

Providing provisioning record information

Record the following information on the applicable provisioning record:

- date prepared
- customer information
- site planner information
- cell numbers
- number of Base Stations in each cell
- location of the Base Stations (cell centers)
- anticipated number of users in each cell

Planning a Sample Site

Using what you learned

The following sections show the planning process applied to a sample site.

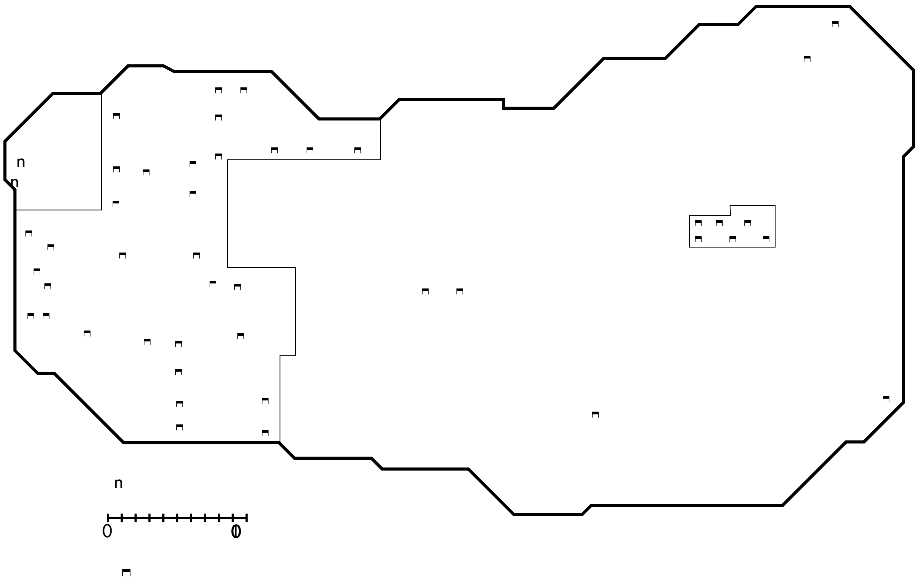
Sample Site: Site information

Before you go to the site, you know the following information:

- The customer is Able Studio Inc. You need a guest lab coat from your contact to be on the site.
- The sales representative has recommended the appropriate Companion system.
- All 44 of the users have offices and desk telephones.
- The customer does not need coverage in restrooms.
- The telephone switch room is beside the restroom.
- The customer has no installation restrictions.

The following figure shows the coverage area, including offices and office areas, the factory area, restrooms and the telephone switch room.

Figure 18 : Sample site coverage area

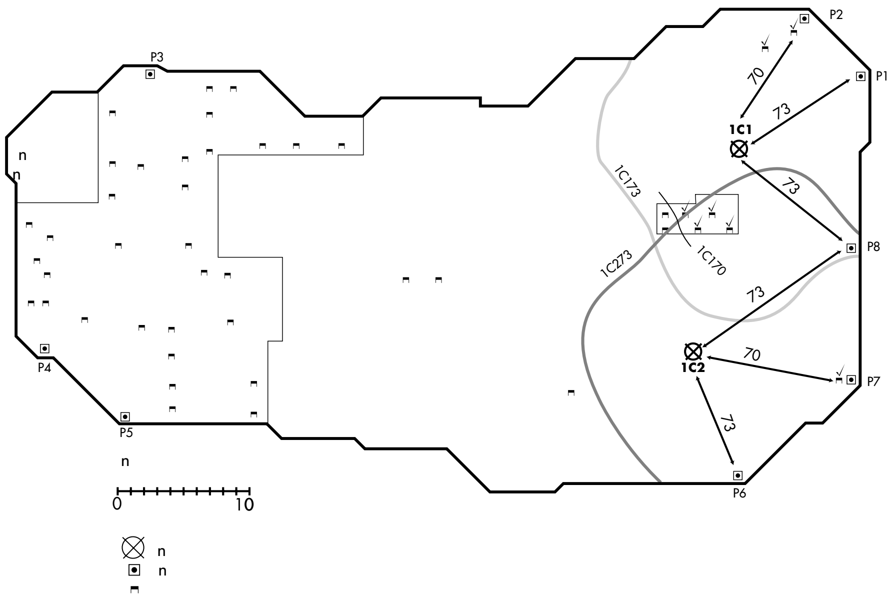


Sample Site: Indoor cell center location

Note: When surveying a site, outdoor areas are surveyed before indoor areas, however there is no outdoor coverage required for Able Studio Inc. For an example of outdoor coverage, refer to “Example outdoor cell center location” on page 54.

As shown in Figure 19, you use the floor plan of Able Studio Inc. to identify the initial critical points P1, P2, P3, P4, P5 and P6. Using critical points P2 and P6, you find that one cell cannot reach both critical points so you add critical point P8 and plan to cover the end of the building with two cells (see “Double-cell technique” on page 33). You use -70 dBm as the cell boundary value from P2, and -73 dBm from P1 and P8 to locate cell center 1C1. You use -70 dBm from P7 and -73 dBm from P6 and P8 to locate cell center 1C2. You use -70 dBm from P2 and P7 because there are users’ offices at these critical points.

Figure 19 : Floor plan detailing cells 1C1 and 1C2

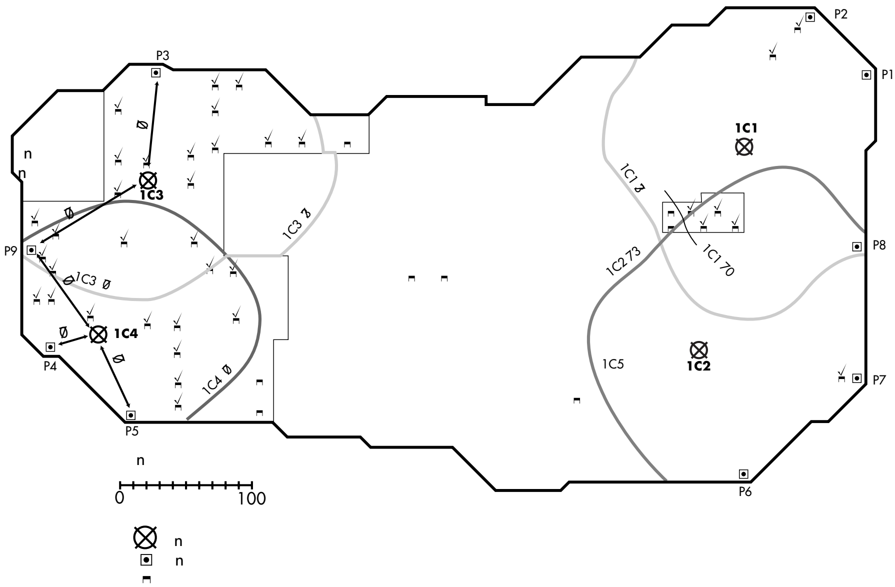


With the CDT placed at 1C1, you find the cell boundary in the factory area using -73 dBm. You confirm that 1C1 covers one other user’s office in the factory area using -70 dBm. Four users’ offices are in the office area within -70 dBm of 1C1. Two users’ offices in the office area are within -73 dBm, but they are not within -70 dBm of 1C1. Therefore, 1C1 does not cover these users' offices.

Cells 1C1 and 1C2 cover seven users' offices, which you show with checkmarks.

In Figure 20 you set up the CDT transceiver at critical points P3 and P5, and find that one cell center cannot serve both critical points. You add critical point P9 midway between P3 and P5. Using critical points P3 and P9, you find cell center 1C3. Because P3 is in an office area, you use -70 dBm from P3. Because P9 is also in an office area, you use -70 dBm from P9.

Figure 20 : Floor plan detailing cells 1C3 and 1C4



To find cell center 1C4 you use -70 dBm from critical points P9, P4 and P5.

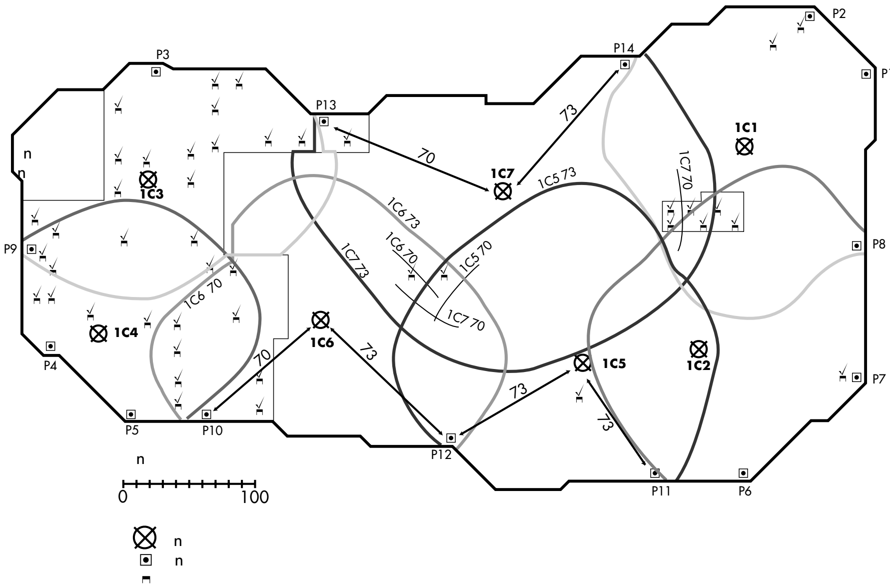
With the CDT placed at 1C3, you use -70 dBm in the office area and -73 dBm in the factory area.

With the CDT placed at 1C4, you use -70 dBm because the entire cell is within an office area.

You mark with a check 29 users' offices as covered by cells 1C3 and 1C4.

In Figure 21 you add critical points P10 and P11. You find that one cell center cannot serve both critical points, so you add critical point P12 midway between P10 and P11 to find cell centers 1C5 and 1C6. You use -70 dBm from P10 and -73 dBm from P11 and P12.

Figure 21 : Completely covered floor plan



You set up the CDT transceiver at cell center 1C6 and find the cell boundary using -70 dBm in the office area and -73 dBm in the factory area. Cell center 1C6 covers one office in the factory area at -73 dBm and two more in the office area at -70 dBm.

From cell center 1C5 you use -73 dBm as the cell boundary value because the entire cell is in the factory area. Cell 1C5 covers one users' office near the cell center.

You add two more critical points (P13 and P14). You find that both of these critical points can be served by cell center 1C7. You use -70 dBm when determining the cell boundary value from P13 in the office area and -73 dBm from P14 in the factory area. You find the cell boundary value using -73 dBm from cell center 1C7 and -70 dBm to confirm the coverage of four users' offices. Cell 1C7 covers the remainder of the site.

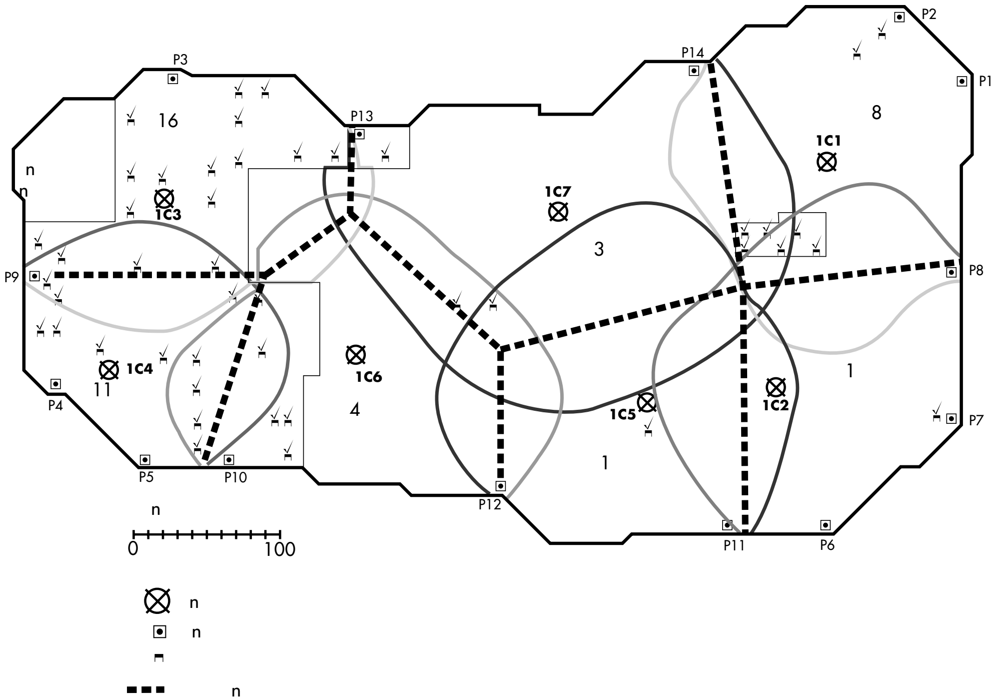
Cell centers 1C5, 1C6 and 1C7 cover eight users' offices.

Sample Site: Determining the number of Base Stations per cell

As shown in Figure 22, the coverage area for Able Studio Inc. has been divided into seven cells with 44 users: eight users' offices in cell 1C1, one user's office in cell 1C2, 16 users' offices in cell 1C3, 11 users' offices in cell 1C4, one user's office in cell 1C5, four users' offices in cell 1C6, and three users' offices in cell 1C7. All the users have desk telephones in their offices.

There are no users without an office.

Figure 22 : Dividing the coverage area



Cell center 1C1

1. Number of users inside the cell with an office:

   $$8 \times 0.7 = 5.6$$

2. Number of users with an office outside the cell who walk into the cell:

   $$\frac{(44 - 8) \times 0.3}{7 - 1} = 1.8$$

3. Anticipated number of portables per cell:

   $$5.6 + 1.8 + 0 = 7.4$$

Cell center 1C2

1. Number of users inside the cell with an office:

   $$1 \times 0.7 = 0.7$$

2. Number of users with an office outside the cell who walk into the cell:

   $$\frac{(44 - 1) \times 0.3}{7 - 1} = 2.15$$

3. Anticipated number of portables per cell:

   $$0.7 + 2.15 + 0 = 2.85$$

Cell center 1C3

1. Number of users inside the cell with an office:

$$16 \times 0.7 = 11.2$$

2. Number of users with an office outside the cell who walk into the cell:

$$\frac{(44 - 16) \times 0.3}{7 - 1} = 1.9$$

3. Anticipated number of portables per cell:

$$11.2 + 1.9 + 0 = 13.1$$

Cell center 1C4

1. Number of users inside the cell with an office:

$$11 \times 0.7 = 7.7$$

2. Number of users with an office outside the cell who walk into the cell:

$$\frac{(44 - 11) \times 0.3}{7 - 1} = 1.65$$

3. Anticipated number of portables per cell:

$$7.7 + 1.65 + 0 = 9.35$$

Cell center 1C5

1. Number of users inside the cell with an office:

   $$1 \times 0.7 = 0.7$$

2. Number of users with an office outside the cell who walk into the cell:

   $$\frac{(44 - 1) \times 0.3}{7 - 1} = 2.15$$

3. Anticipated number of portables per cell:

   $$0.7 + 2.15 + 0 = 2.85$$

Cell center 1C6

1. Number of users inside the cell with an office:

   $$4 \times 0.7 = 2.8$$

2. Number of users with an office outside the cell who walk into the cell:

   $$\frac{(44 - 4) \times 0.3}{7 - 1} = 2$$

3. Anticipated number of portables per cell:

   $$2.8 + 2 + 0 = 4.8$$

Cell center 1C7

1. Number of users inside the cell with an office:

$$3 \times 0.7 = 2.1$$

2. Number of users with an office outside the cell who walk into the cell:

$$\frac{(44 - 3) \times 0.3}{7 - 1} = 2.05$$

3. Anticipated number of portables per cell:

$$2.1 + 2.05 + 0 = 4.15$$

Enter the information for cells 1C1 through 1C7 in a traffic table.

Table 10 : The Sample Site completed traffic table

	1C1	1C2	1C3	1C4	1C5	1C6	1C7
Users inside the cell with an office	5.6	0.7	11.2	7.7	0.7	2.8	2.1
Users with an office outside of cell who walk into the cell	1.8	2.15	1.9	1.65	2.15	2	2.05
Users without an office	0	0	0	0	0	0	0
Anticipated number of portables per cell	7.4	2.85	13.1	9.35	2.85	4.8	4.15

Using Table 8 on page 38 and recalling that the users have desk telephones in their office, you need a total of 13 Base Stations.

Table 11 : The Sample Site required Base Stations

	1C1	1C2	1C3	1C4	1C5	1C6	1C7
Base Stations	2	1	3	2	1	2	2

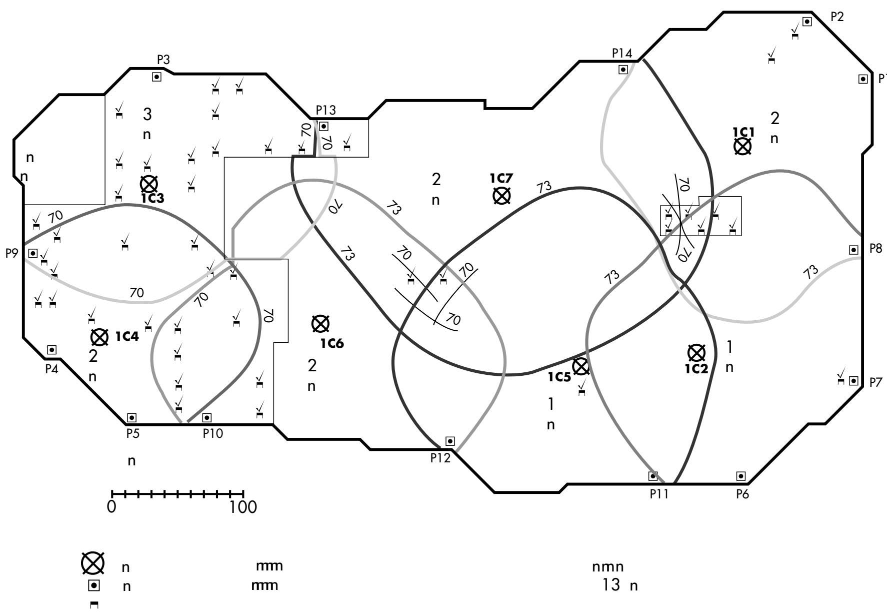
Sample Site: Reviewing your work

When you have completed the site plan you should have the following:

- a clean, complete floor plan (see Figure 23)
- a traffic table
- a completed provisioning record
- a satisfied customer

Submit the site plan, traffic table and the provisioning record to the sales group.

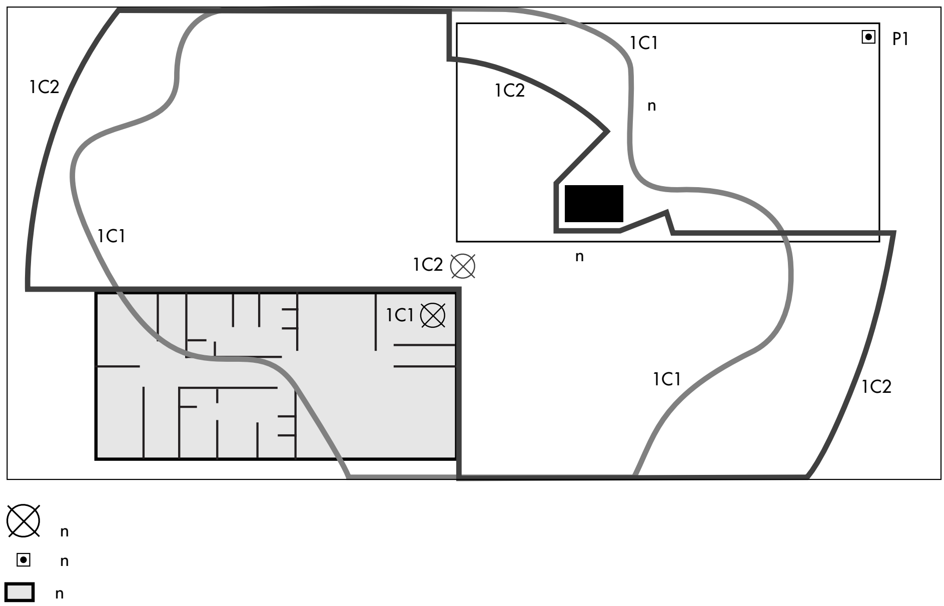
Figure 23 : Example of a completed floor plan



Example outdoor cell center location

Point P1 in Figure 24 is the critical point in the outdoor coverage example.

Figure 24 : Outdoor coverage



You position the CDT transceiver indoors at a window at 1C1 because it is the closest indoor point to critical point P1. You check the parking lot for outdoor coverage. You draw the cell edge of 1C1 and find that it does not reach critical point P1.

You decide on a potential location for outdoor external antennas at 1C2. You estimate 40 in. (1 m) as the length of the coaxial cables required to connect a Base Station at 1C1 to the outdoor external antennas at 1C2. Using Table 6 on page 28 you determine that with a 40 in. (1 m) cable the range for the parking lot is 230 ft (70 m), and 550 ft (168 m) for the lawn. You draw a circle on the floor plan with a radius of 230 ft (70 m) over the parking lot and 550 ft (168 m) over the lawn. You crop the arcs around the garbage bin, the building and the coverage area.

In this example, the CDT at 1C1 covers the parking lot better than the predicted area using the outdoor external antennas. You recommend the location of the cell center at 1C1.

Inform the customer of the actual coverage area and that the range could not reach the critical point.

Planning complex sites

Planning a multi-floor coverage area

This section shows you how to plan for coverage on multiple adjacent floors. Consider this procedure if the coverage area is on more than one floor and the floors are adjacent to each other.

Consider the coverage of a cell through the floor when planning a multi-floor building.

Measure the signal strength when you are directly above or below the cell center of an adjacent floor. If you read a signal strength greater than -45 dBm, plan the building using the multi-floor coverage area methods. If it is less than -45 dBm, you can plan the floors independently.

Note: When planning a multi-floor building do not stack the cell centers from floor to floor.

Multi-floor coverage is important in the following places:

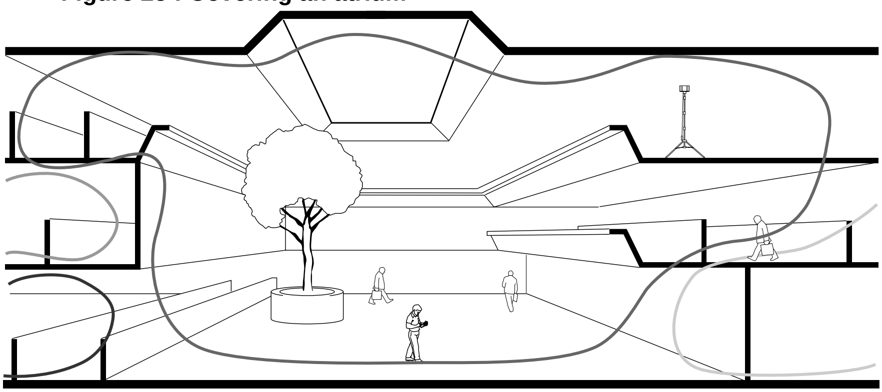
- atriums
- high-rise buildings, or buildings where all the floors are the same shape
- buildings where the floors are not the same shape

Atriums

Cells in an atrium are usually larger than the cells of the rest of the building (see Figure 25). Although there are no precise steps to follow when planning an atrium, consider these points:

- Plan atriums to their full height.
- Do not plan an atrium floor by floor but as one full size room.
- Place cell centers within an atrium only when they are intended to cover the atrium.
- Do not put cell centers in an atrium if they are intended to serve adjacent areas. To serve adjacent areas put the cell centers in these areas.
- If cell centers in adjacent dense areas serve one floor of an atrium, check the coverage of the cell on all of the floors that meet with the atrium.
- If the atrium is large enough (more than one third the size of the building or more than one cell in size), consider planning the atrium first, as you would plan outdoor coverage.

Figure 25 : Covering an atrium



High-rise buildings

This section describes the steps in planning a building from the top floor down. When planning multiple adjacent floors in a high-rise building, consider the radio signals passing through the adjacent floors above and below.

Left-right-skip

The left-right-skip technique keeps the cell centers from being stacked on top of each other. A cell center has coverage on its own floor as well as on the floors above and below it. You plan a high-rise building in sets of three floors as shown in Figure 26.

1. Using the CDT, plan the cell centers on one floor using the techniques described in "Covering a single floor indoor area" on page 29. When you finish this step, you should know how many cell centers are required to cover one floor.

   This floor is the "left" floor. The floor below the left floor is the "right" floor.

2. On the floor plan, plan the right floor with the same number of cells as there are for the left floor. Stagger the right cell centers with respect to the cells on the left floor, as shown in Figure 26. Use the CDT to verify the coverage.

   The floor below the right floor is the "skip" floor.

3. Cover the skip floor from cell centers above on the right floor and from cell centers below on the left floor.

   Note: Do not install cell centers on the skip floor.

4. With the CDT at each of the cell centers on the right floor, find the cell edges on the skip floor.

   The floor below the skip floor is another left floor. If the floors of the high-rise are built the same, the cell centers of this left floor are the same as the first left floor.

5. With the CDT at each of the cell centers on the second left floor, determine the coverage on this floor and on the skip floor above. Confirm that you have completely covered all of the floors.

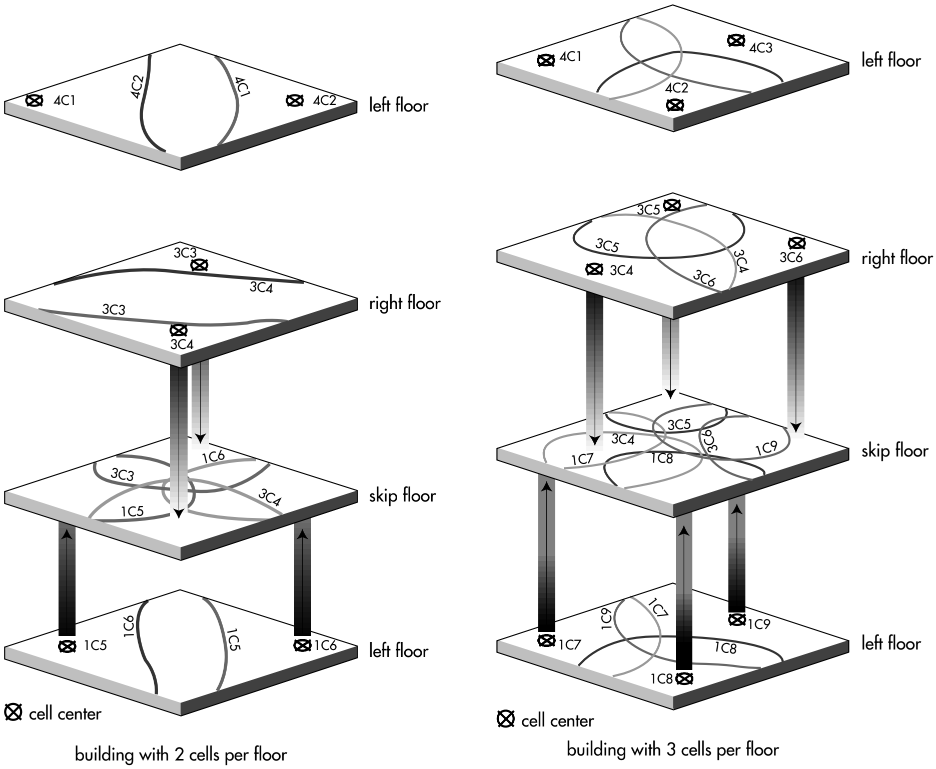
6. Continue this procedure for the remaining floors.

Note: The skip floor should not be the first or the last floor of the coverage area. As shown in Figure 26, one half of the skip floor is covered by the cells on the floor above and the other half is covered by the cells on the floor below.

If the number of adjacent floors is a multiple of three, use the sequence right-skip-left.

Figure 26 shows examples for two different buildings, requiring two and three cell centers for each left and right floor.

Figure 26 : Left-right-skip examples



Note: Areas of high portable density and floors that are constructed differently can cause gaps in the coverage. These areas should be treated as special cases. Do not use the left-right-skip technique.

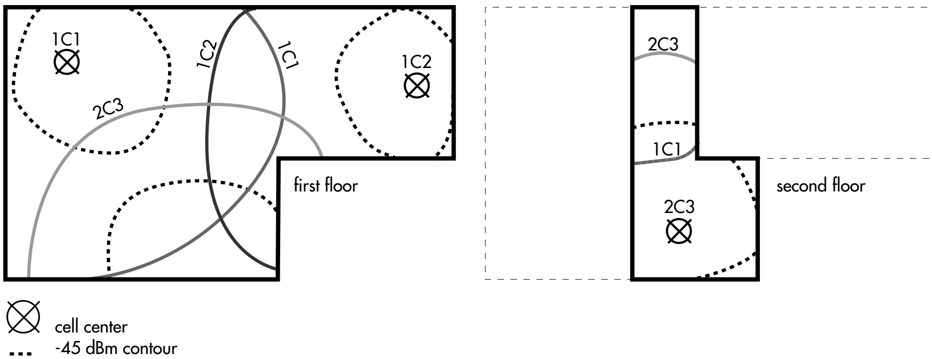
Differing floor areas

This section shows what you need to consider when planning a building with floors of different shapes.

Ensuring that cells are not too close

Links between Base Stations and a portable could be held too long as the user moves between cells if the -45 dBm cell contours overlap. Keep areas of overlap to a minimum, as shown in Figure 27.

Figure 27 : Cell overlap



For each cell center:

1. Using the CDT, find the -45 dBm contour on the floor of the cell center and on the floors above and below. If these contours overlap an atrium, find the contours on all of the floors that are adjacent to the atrium.
2. Check that the -45 dBm contours of all the cells do not overlap each other.

Note: The two cells do not have to be on the same floor. An overlap of the -45 dBm contour can occur between two cell centers that are two floors away.

Ensuring that cell centers are not too far apart

All of the coverage areas must be within the cell boundary contour. For each cell center, use the CDT to check that all of the areas requiring coverage are within the cell boundary contour.

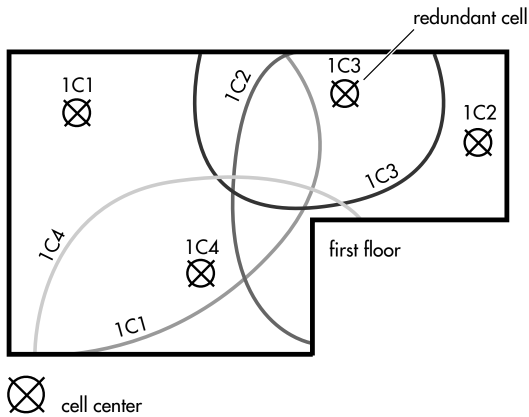
Note: The cell center does not have to be on the same floor or an adjacent floor of the area that it is covering, but the signal strength of the coverage area must be greater than the cell boundary value.

Checking for redundant cells

When you plan a site with differing floor areas you may have planned redundant cells.

Check the coverage area of each cell and verify that there is at least one area that each cell serves that is not served by another cell. If all of a cell is served by other cells, and this cell is not required for high portable density, remove the cell (see Figure 28).

Figure 28 : Locating redundant cells



Planning an area of high portable density

Note: Only use the high portable density procedure in this section if instructed to do so from Table 8 on page 38.

When you plan an area of high portable density, your first objective is to keep the anticipated number of portables for each cell center less than or equal to 44 if the users have desk telephones in their offices and 23 if the users do not have desk telephones.

Your second objective is to ensure that each link connects to the closest cell center by confirming that the -45 dBm contours of different cells do not overlap (they may do so marginally if necessary).

Only replan the areas of the site that have a high portable density. Measure the -45 dBm contour the same way you measure the cell boundary value, but do not use the tone (see "Using the CDT to determine cell boundaries" on page 19). If you set the tone to change at -45 dBm, the tone will not reset to let you make several measurements. Keep the setting for the tone at the cell boundary value and use the display for measuring the -45 dBm contour.

Planning an area of high portable density

1. Count the number of users in the area of high portable density. Include any floors above and below as well (if applicable).
2. Divide the number of users by 44 or 23. Round up the result to the next whole number. This figure is the number of cells you need to plan in the high portable density area.
3. Measure with the CDT the cell boundary contour and the -45 dBm contour of one cell in the high portable density area. If the building requires coverage on adjacent floors, include these floors as well.
4. Estimate the location of the cell centers where the -45 dBm contours of the cells will not overlap and the cell boundary will cover the required area. Use the number of cells as calculated in step 2.
5. With the CDT, verify and record the cell centers you planned on paper in step 4. You must verify the -45 dBm contour and the cell boundary contour. Include any adjacent floors above or below as required.

   If there are gaps in the coverage or the -45 dBm contours overlap, repeat step 4.

6. Calculate the anticipated number of portables per cell using Table 8 on page 38. If any of the cells has an anticipated number of portables per cell that is more than 44 or 23, repeat step 4.

If you have too many portables in an area, inform your customer.

Note 1: If the -45 dBm contour lines overlap, users may hear long mutes, voice interruptions, crackling speech, or they may drop calls.

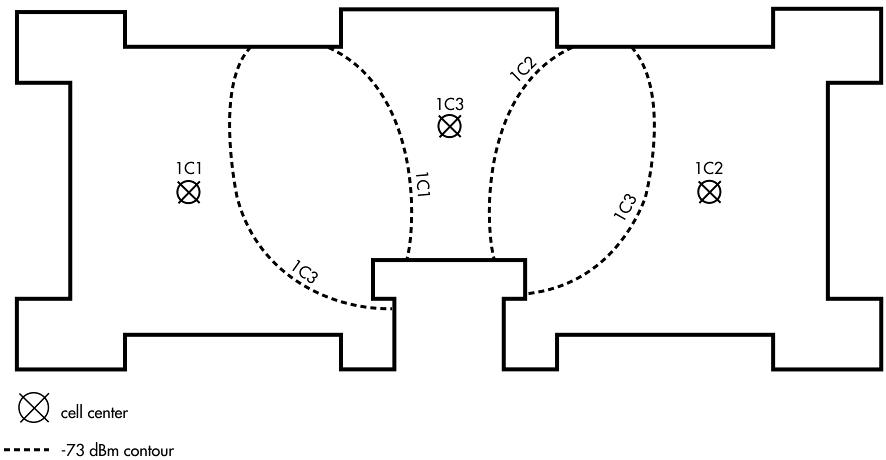
Note 2: You do not need to verify that the offices and office areas in a high portable density system are at -70 dBm or better because all links will be greater than -70 dBm.

Example of a high portable density area

Children's Hospital wants to provide a wireless system for its nurses. It wants to provide up to 200 portables to be covered anywhere on the floor. The sales group recommends the Meridian Companion system.

You survey the site as if it is an area that is not high portable density and find that the site can be covered with three cells, as shown in Figure 29.

Figure 29 : Example of standard cell planning

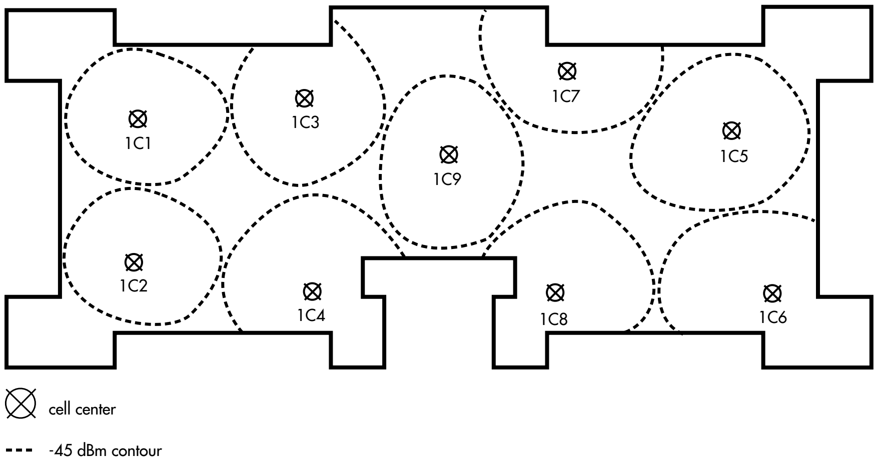


None of the 200 users have an office on the floor, so you compute the anticipated portable count to be 67 (200 ÷ 3) users for each cell. Using Table 8 on page 38, you find that the anticipated number of portables per cell count exceeds 23, therefore you must plan the floor for high portable density.

The number of users in the high portable density area is 200, so you calculate the required number of cells to be nine (200 ÷ 23).

On the floor plan you estimate nine locations for the cell centers to get complete coverage and for the -45 dBm contours not to overlap (see Figure 30).

Figure 30 : Example of high portable density planning



With the CDT, you verify the coverage with the cell boundary contour and the -45 dBm contours.

The anticipated portable count for each cell is now 22.2 (200 ÷ 9). Using Table 8 on page 38 you find that each cell needs four Base Stations. Therefore, the total site requires 36 Base Stations.

Planning where there is an existing Companion system

Adjacent systems

If you are planning a system beside another system, note whether the following are valid:

- there is no common coverage area between the two systems
- there is little possibility that a user from one system will want service from the coverage area of the other system

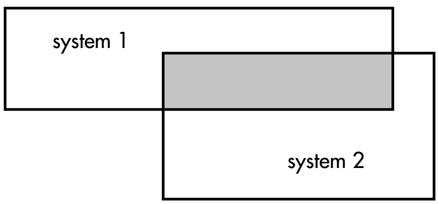
If these points are valid, you can plan the sites independently of each other, but you must keep the cell centers between the two systems at least 23 ft (7 m) apart.

Overlapping systems

Two or more systems that have cells that serve a common area, as shown in Figure 31, are overlapping systems.

Note: Avoid overlapping one system with another whenever possible.

Figure 31 : Overlapping systems



Different systems covering the same area prevent links from being established, degrade voice quality, induce long mutes, and drop calls for all systems involved. This situation progressively degenerates as the number of links between the systems increases.

Keep the Base Stations between these systems at least 23 ft (7 m) apart. This distance decreases the number of occurrences of poor voice quality and long mutes, but does not eliminate them. The customer may complain of poor quality service.

Planning multiple systems

This section shows you how to plan multiple Companion systems for the same site. If the number of required portables or the number of required cells is more than one system can serve, consider using this procedure. To determine the limits of your Companion system, refer to the appropriate system documentation.

Note: Before using the procedures in this section, you should understand the basics of site planning (see “Site planning basics” on page 21).

For a site with multiple systems, you need to consider the following:

- Do you plan for all of the systems to cover all the area, part of the area or separate areas?
- On an incoming call, do all the systems search for the portable or does just one system search for the portable?
- Do all of the systems use the same or different system names?

Table 12 and the section “Parameters affecting multiple systems” help you to decide which multiple system case applies to your site.

Parameters affecting multiple systems

Number of portables The number of portables is either high or low. If the number of portables is greater than the maximum number that you can register to one system, the number of portables is high.

Number of cells The number of cells is either high or low. If the number of cells is greater than the maximum number for your system, the number of cells is high.

Mobility of the users The mobility of the users is either restricted or roaming:

- a roaming user can make or receive calls in any cell
- restricted mobility keeps each user confined to one cell

Note: Restricted mobility is chosen by the customer, that is, the system still permits roaming.

Table 12 : Planning multiple systems

Case	Portable count	Cell count	Mobility	Characteristics
restricted mobility	does not matter	does not matter	restricted	• no overlap • one system searches • different system names
low portable count/ high cell count	low	high	roaming	• no overlap • all systems search • same system names
high portable count/ low cell count	high	low	roaming	• 100% overlap[1] • one system searches • different system names
high portable count/ high cell count	high	high	partial roaming	• partial overlap • one system searches • different system names

1. Avoid 100% overlap where possible. Study user mobility patterns and minimize the amount of system overlap.

System names

For CT2Plus systems, use different system names. For outgoing calls, users need to know where each system name is used. Portables in CT2Plus systems must be set on “scan all systems” to receive incoming calls. This is set by the installer.

If the PCI systems have different names the users must know the system names to make or receive any calls. The systems may all use the same name if there are no multi-system users.

Guidelines

Plan a multiple system for a single site with the following guidelines:

- Use the smallest number of systems required to serve the site.

- Learn where the users need service. If all of the users do not need to go everywhere, the audio quality of the service can be maximized.
- Avoid overlapping systems. If you must overlap systems, minimize the number of overlapping cells.
- Keep all users in the same area on the same system. If users in the same area must be on different systems, keep most of them on one system. This strategy minimizes the required number of Base Stations and maximizes audio quality.
- Where possible, group the cells of each system together on the floor plan. For example, system A serves the east side of a site and system B serves the west side.
- To determine the anticipated number of portables per cell, use the total number of cells of the systems to which a user is registered.

Planning for multiple systems

1. Gather site information. Include the system recommended by the sales group.
2. Survey the site as if it is a single system. See either “Covering a single floor indoor area” on page 29 or “Planning a multi-floor coverage area” on page 57, as required for your site.
3. Do traffic calculations for the entire site as if it is a single system to determine the number of Base Stations for each cell (this is an estimate), then add the number of Base Stations for the entire site (see “Determining the number of Base Stations per cell” on page 37).
4. Use the appropriate Companion installation documentation to determine the number of systems required to serve the site based on the users’ movements.
5. Divide the site into the number of required systems based on the users’ movements.
6. Recalculate the number of Base Stations required for each cell for each system (see “Determining the number of Base Stations per cell” on page 37). If required, include the number of additional users and Base Stations a system can support.

7. Review the preliminary system proposal recommended by the sales group with the customer. Adjust the proposal according to customer requirements.

8. Finish planning the site as shown in “Site planning basics” on page 21.

Examples of four types of multiple systems

Restricted mobility problem

The Apex Department Store has 300 employees working in 45 departments on the store floor. Each employee works in only one of the departments. The store’s inventory is so large that the employees climb 27 ft (8 m) high shelving on lateral moving ladders to reach the merchandise, which makes it impossible for the employees to use desk telephones.

Employees constantly answer a speaker broadcast system to know what merchandise to get. If the employees on the ladders do not understand the message, they climb down the ladder and walk to the nearest phone to find out what was said. Outside calls are also discouraged because of the time spent locating an available phone.

Twelve employees work the front counter taking orders from customers. These employees often wait for their turn to call out the orders on the speaker broadcast system.

Your customer wants to give each of the store’s 300 employees who climb the ladders a portable telephone and remove the speaker broadcast system. The sales group recommends a Companion (C200) system.

Solution

Since none of the users have an office with a desk, you plan the coverage area using -73 dBm. You survey the site and find that the store requires 18 cells for full coverage. The mobility of the users is more vertical than it is horizontal. Except in a few cases, one cell covers entire departments. This means the users’ work restricts the mobility of each user to one of the cells.

You devise Table 13 based on “Determining the number of Base Stations per cell” on page 37.

Table 13 : Anticipated number of portables per cell for restricted mobility

Cell	Anticipated number of portables per cell
1C1	22
1C2	14
1C3	7
1C4	21
1C5	6
1C6	23
1C7	19
1C8	18
1C9	15
1C10	13
1C11	15
1C12	21
1C13	20
1C14	22
1C15	12
1C16	16
1C17	19
1C18	17

Note: The following assumption is made for cases of restricted mobility:

Total number of users with an office = Users inside the cell with an office

You calculate the number of Base Stations required for each cell in Table 14, using Table 8 on page 38.

Table 14 : Required Base Stations for restricted mobility

Cell	Base Stations
1C1	4
1C2	3
1C3	2
1C4	4
1C5	2
1C6	4
1C7	4
1C8	4
1C9	3
1C10	3
1C11	3
1C12	4
1C13	4
1C14	4
1C15	3
1C16	4
1C17	4
1C18	4

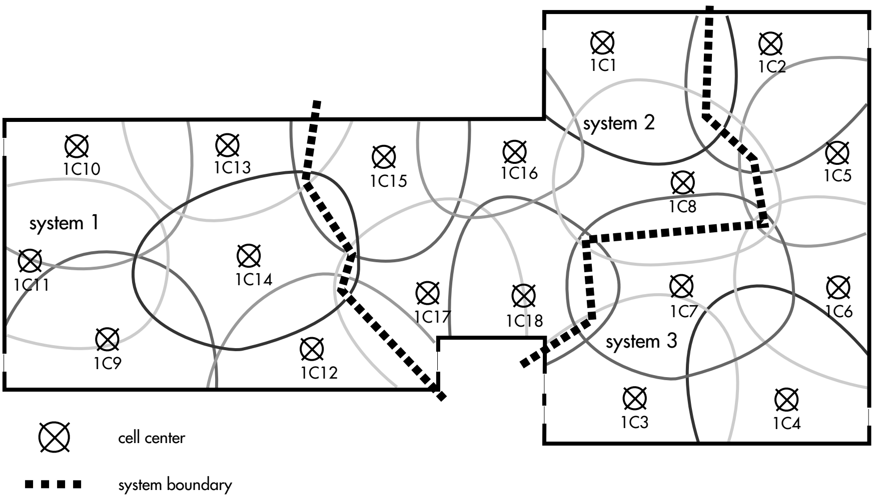
Apex Department Store needs 63 Base Stations.

Using the appropriate table in your Companion installation documentation, you determine that one Companion system cannot serve 300 users with 63 Base Stations. You require a minimum of three systems where:

- system 1 covers cells 1C9, 1C10, 1C11, 1C12, 1C13 and 1C14, with 89 users and 19 Base Stations
- system 2 covers cells 1C1, 1C8, 1C15, 1C16, 1C17 and 1C18, with 101 users and 22 Base Stations
- system 3 covers cells 1C2, 1C3, 1C4, 1C5, 1C6 and 1C7 with 110 users and 22 Base Stations

Figure 32 shows the floor plan of the Apex Department Store with the multiple systems.

Figure 32 : Restricted mobility example



Apex Department Store’s coverage requirements

- none of the systems overlap
- each cell uses only one system
- all of the users in the same cell are on the same system
- each call that comes into the Apex Department Store searches only for a portable on one of the three systems

- all three systems use different system names
- three systems is the smallest number of systems required to serve the site
- most users work within the area of only one of the cells
- the cells of each system are grouped together on the floor plan

Low portable count/high cell count problem

Amusement Park consists of an office complex and ten pavilions. There are 60 customer relations, security and maintenance personnel. These employees spend most of their time moving about the park and spend little time in the office complex; however, they must be in contact with the office personnel.

The sales group recommends a Companion (C200) system.

Solution

You survey the site. You use the CDT set at -73 dBm in all the pavilions. You assure coverage in the office complex at -70 dBm. As a result, you calculate a need for 177 cells. You do the traffic calculations with most of the personnel being in the pavilions. You determine that the park needs 187 Base Stations.

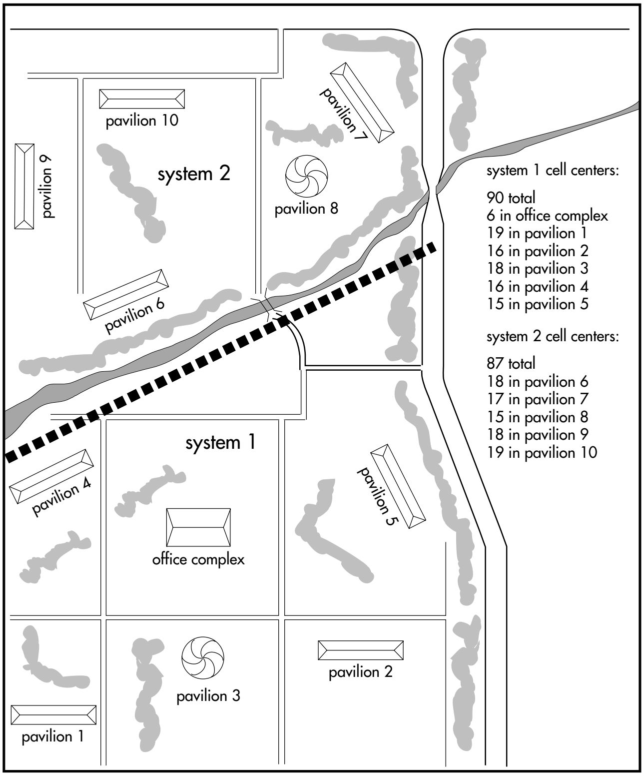
Using the appropriate table in your Companion installation documentation, you find that one Companion system cannot serve 177 cells with 187 Base Stations and 60 portables. You require a minimum of two systems where

- system 1 covers 90 cells, 1C1 through 1C90, with 60 registered users and 96 Base Stations
- system 2 covers 87 cells, 1C91 through 2C177, with 60 registered users and 91 Base Stations

All of the users can go anywhere in the office complex or the pavilions because the installer registers all of the users to both systems.

Figure 33 shows the coverage for a site with a small number of portables and a large number of cells.

Figure 33 : Low portable count/high cell count example



Park's coverage requirements

- none of the systems overlap
- each cell uses only one system
- each call that comes into the park searches for the portable on both systems
- both systems use the same system name
- two systems is the smallest number of systems required to serve the site
- all of the users need to go everywhere, therefore all of the users are registered to both systems
- the cells of each system are grouped together on the floor plan

High portable count/low cell count problem

Life Bank has a 28-story building with 450 employees. Often you cannot reach these employees because they are looking around the building for each other. Over half of the phone calls result in messages. One third of the users have pagers and most of the answering machine messages refer to calling again on the pager number. This rarely happens because the caller simply leaves a voice message. There have been reports of pagers not working in some parts of the building.

The sales group's investigation of user mobility shows that most people, when not in their offices, are usually on the floor of their office or are just one floor up or down. About one quarter of the users use the cafeteria and lounge on the top floor throughout the day for breaks, informal meetings and lunch.

The sales group recommends a Meridian Companion system on their existing Meridian product line. All of the users have a desk phone.

In the Life Bank building, the ground floor is Floor 1 and the thirteenth floor is Floor 13.

Solution

The whole Life Bank building is office space, so you survey one floor at -70 dBm and determine that the floor needs two cells. Using the left-right-skip technique (see "Left-right-skip" on page 58), you find that the building needs 38 cells. From the traffic calculations, you determine that the building needs 88 Base Stations.

Using the appropriate table in your Companion installation documentation, you find that one Meridian Companion system cannot serve 88 Base Stations and 450 portables. The site requires three Meridian Companion systems as follows:

- System 1, as shown in Table 15, needs 22 cells. Twenty cells, 28C1 through 14C20, cover the fourteenth through the twenty-eighth floors, for 113 users. Two more cells, 12C39 and 12C40, allow system 1 users to go down a floor. System 1 needs 36 Base Stations.

Table 15 : Example traffic table (System 1: high portable count/low cell count)

Cell	Number of offices	Number of offices x 0.7	Users from another cell	Users without an office	Anticipated number of portables	Base Stations
28C1	1	0.7	1.6	0	2.3	1
28C2	5	3.5	1.5	0	5.0	2
26C3	12	8.4	1.4	0	9.8	2
26C4	5	3.5	1.5	0	5.0	2
25C5	7	4.9	1.5	0	6.4	2
25C6	2	1.4	1.6	0	3.0	1
23C7	26	18	1.2	0	19.4	3
23C8	5	3.5	1.5	0	5.0	2
22C9	2	1.4	1.6	0	3.0	1
22C10	6	4.2	1.5	0	5.7	2
20C11	5	3.5	1.5	0	5.0	2
20C12	8	5.6	1.5	0	7.1	2
19C13	2	1.4	1.6	0	3.0	1
19C14	0	0	1.6	0	1.6	1
17C15	3	2.1	1.6	0	3.7	2
17C16	13	9.1	1.4	0	10.5	2
16C17	4	2.8	1.6	0	4.4	2
16C18	0	0	1.6	0	1.6	1
14C19	7	4.9	1.5	0	6.4	2

Table 15 : Example traffic table (System 1: high portable count/low cell count) (continued)

Cell	Number of offices	Number of offices x 0.7	Users from another cell	Users without an office	Anticipated number of portables	Base Stations
14C20	0	0	1.6	0	1.6	1
12C39	0	0	1.6	0	1.6	1
12C40	0	0	1.6	0	1.6	1

- System 2, as shown in Table 16, needs 14 cells. Eight cells, 13C21 through 8C28, cover the eighth through the thirteenth floors, for 153 users. Two more cells, 6C41 and 6C42, allow system 2 users to go down a floor. Two more cells, 15C43 and 15C44, allow system 2 users to go up a floor. Two more cells, 28C45 and 28C46, allow system 2 users to be in the cafeteria and lounge. System 2 needs 35 Base Stations.

Table 16 : Example traffic table (System 2: high portable count/low cell count)

Cell	Number of offices	Number of offices x 0.7	Users from another cell	Users without an office	Anticipated number of portables	Base Stations
13C21	39	27	2.6	0	29.9	4
13C22	30	21	2.8	0	23.8	3
11C23	0	0	3.5	0	3.5	2
11C24	26	18	2.9	0	21.1	3
10C25	0	0	3.5	0	3.5	2
10C26	27	19	2.9	0	21.8	3
8C27	14	9.8	3.2	0	13.0	3
8C28	17	12	3.1	0	15.0	3
6C41	0	0	3.5	0	3.5	2
6C42	0	0	3.5	0	3.5	2
15C43	0	0	3.5	0	3.5	2
15C44	0	0	3.5	0	3.5	2
28C45	0	0	3.5	0	3.5	2
28C46	0	0	3.5	0	3.5	2

- System 3, as shown in Table 17, requires 14 cells. Ten cells, 7C29 through 1C38, cover the first through the seventh floors, for 184 users. Two more cells, 9C47 and 9C48, allow system 3 users to go up a floor. Two more cells, 28C49 and 28C50, allow system 3 users to be in the cafeteria and lounge. System 3 needs 36 Base Stations.

Table 17 : Example traffic table (System 3: high portable count/low cell count)

Cell	Number of offices	Number of offices x 0.7	Users from another cell	Users without an office	Anticipated number of portables	Base Stations
7C29	35	25	3.4	0	27.9	4
7C30	0	0	4.2	0	4.2	2
5C31	52	36	3.0	0	39.4	4
5C32	5	3.5	4.1	0	7.6	2
4C33	3	2.1	4.2	0	6.3	2
4C34	12	8.4	4.0	0	12.4	3
2C35	50	35	3.1	0	38.1	4
2C36	15	11	3.9	0	14.4	3
1C37	7	4.9	4.1	0	9	2
1C38	5	3.5	4.1	0	7.6	2
9C47	0	0	4.2	0	4.2	2
9C48	0	0	4.2	0	4.2	2
28C49	0	0	4.2	0	4.2	2
28C50	0	0	4.2	0	4.2	2

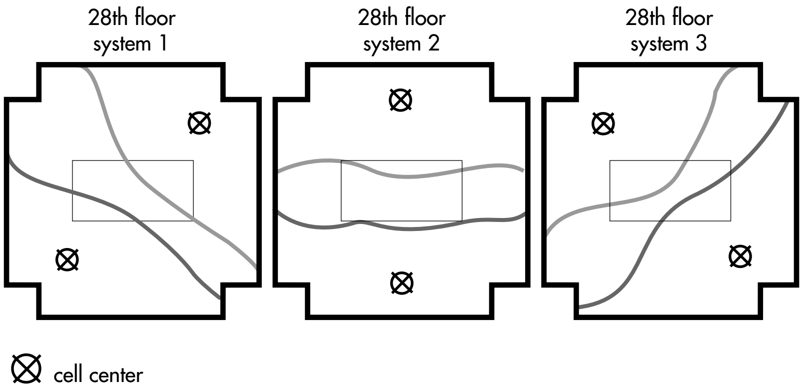
You covered every floor with one Meridian Companion system, including the skip floors where the cells on the adjacent floors above and below the skip floors are on the same Meridian Companion system. (The skip floors are floors 3, 6, 9, 12, 15, 18, 21, 24 and 27.)

Because of some overlapping of the coverage area served by each Meridian Companion system, the final requirements are 107 Base Stations and 48 cells.

Life Bank coverage requirements

- the coverage areas served by the three systems overlap, but you minimized the number of overlapping cells
- each call that comes into Life Bank searches for the portable on one system
- the three Meridian Companion systems use different system names
- three systems is the smallest number of Meridian Companion systems required to serve the site
- all of the users do not need to go everywhere
- you kept all of the users in the same area on the same system, except on the twenty-eighth floor where the cafeteria and the lounge are
- you grouped the cells of each system together in the building, but each system has two cells serving the twenty-eighth floor, as shown in Figure 34

Figure 34 : Life Bank, 28th floor



High portable count/high cell count problem

Highgrade Oil has a refinery with 760 employees, 650 of whom work in the refinery doing routine maintenance, emergency maintenance, tests and new construction. Usually, you cannot reach these employees until they come in for break, lunch, prearranged meetings or the end of the work day.

The emergency maintenance staff uses two-way radios but it is so busy that they often have to wait their turn to speak.

Emergency maintenance, the medical emergency staff, security and the system managers need total access to the entire site. These departments have a combined staff of 50. Most users work in a department that is responsible for one section of the refinery.

The sales group recommends a Meridian Companion system on the Meridian product line.

Solution

You survey the site using -75 dBm for outdoor locations, but you use -73 dBm for the seven departmental office buildings scattered throughout the site and -70 dBm for offices. You find that the site needs 217 cells.

From the traffic calculations, you find you need 282 Base Stations if you assume that everyone has a desk phone, or 304 Base Stations if you assume everyone does not have a desk phone.

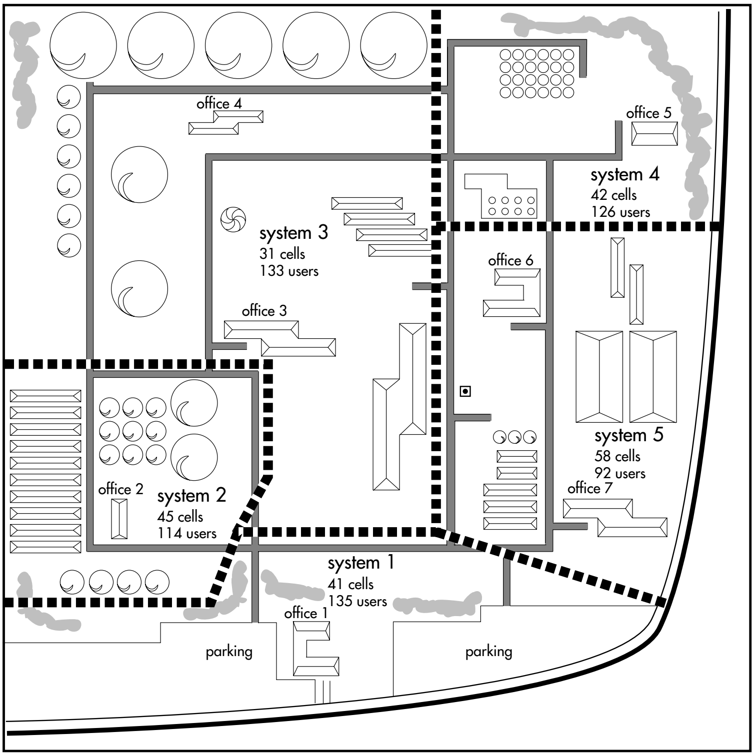
Using the appropriate table in your Companion installation documentation, you find that one Meridian Companion system cannot serve 650 users with 282 Base Stations. The refinery requires five Meridian Companion systems as follows:

- System 1 needs 41 cells for 135 single system users and 50 multi-system users, and 59 Base Stations. The installer can register seven more users to this system.
- System 2 needs 45 cells for 114 single system users and 50 multi-system users, and 62 Base Stations. The installer can register 28 more users to this system.
- System 3 needs 31 cells for 133 single system users and 50 multi-system users, and 48 Base Stations. The installer can register nine more users to this system.
- System 4 needs 42 cells for 126 single system users and 50 multi-system users, and 61 Base Stations. The installer can register 16 more users to this system.
- System 5 needs 58 cells for 92 single system users and 50 multi-system users, and 74 Base Stations. The installer can register 34 additional users to this system.

When determining the number of Base Stations required for each cell for the five Meridian Companion systems, you calculate the anticipated number of portables per cell for the single system users using the number of cells of their particular system. For the 50 multi-system users, you calculate their anticipated number of portables per cell using the total 217 cells. You consider these 50 multi-system users as users without offices.

Figure 35 shows the site with a large number of portables and a large number of cells.

Figure 35 : High portable count/high cell count example



Highgrade Oil coverage requirements

- The systems have minimal overlap.

- Except for the 50 multi-system users, each call that comes into Highgrade Oil searches for the portable on one Meridian Companion system. For the 50 multi-system users, an incoming call searches on all five Meridian Companion systems.
- Five Meridian Companion systems is the smallest number of systems required to serve the site.
- All of the users do not need to go everywhere.
- All of the users in the same area are on the same system.
- The cells of each system are grouped together on the site.

Appendix A: Derivation of traffic procedure

Derivation of traffic procedure

Use the method described in “Detailed traffic procedure” on page 86 when there is a predetermined Erlang per portable rate for your site. For a description of the other traffic methods, see “Determining the number of Base Stations per cell” on page 37.

Basic traffic procedure

The traffic procedure used to derive the table on page 37 is based on the following parameters:

- A link uses the nearest cell center more than 99.5 percent of the time.
- The system locates users in the cell of their office 70 percent or more of the time. Conversely, the system locates users in another cell of the system 30 percent or less of the time.
- The average user with a desk telephone uses their portable less than 0.07 Erlangs per portable during the busiest hour of the day.
- The average user without a desk telephone uses their portable less than 0.15 Erlangs per portable during the busiest hour of the day.
- The Engset traffic forecasting model is used to determine the required number of Base Stations because the number of users in a Companion cell is relatively small. Conversely, the Erlang B traffic forecasting model is based on an infinite number of portables in a cell.

- A user without an office has equal probability of making or receiving a call in any cell.

The number of Base Stations required for each cell is based on the probability of locating each possible number of users, from no users through to the total number of users, using an anticipated number of portables per cell.

Detailed traffic procedure

To more precisely plan your site, use Table 18 to determine the number of portables a cell can support (the anticipated portable value) given the number of Base Stations and the Erlangs per portable. Table 18 is derived from Figure 36.

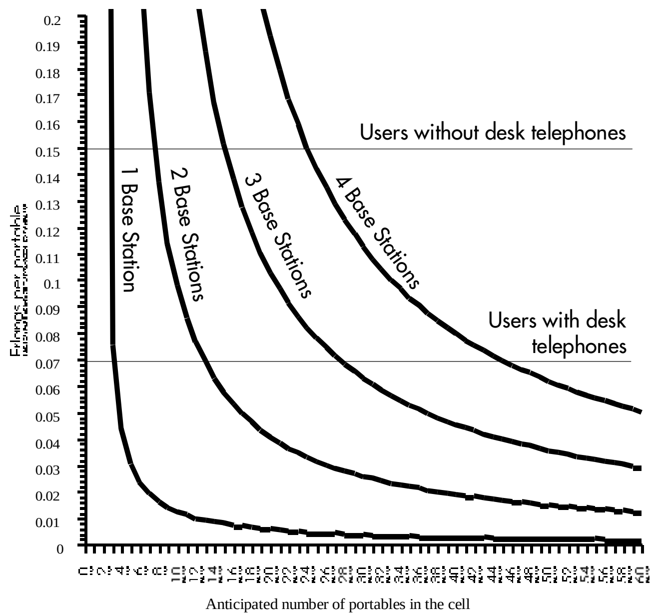
Table 18 : Anticipated number of portables per cell

		Erlangs per portable				
		0.03	**0.07**	**0.11**	**0.15**	**0.19**
Number of Base Stations	**1**	5	3	2	2	2
	2	27	12	10	7	6
	3	59	27	18	15	12
	4	96	44	30	23	20

Use Figure 36 to determine

- the number of portables (the anticipated number of portables per cell) a cell can support given a particular number of Base Stations and a number of Erlangs per portable
- the maximum number of Erlangs per portable given the number of Base Stations and the number of portables in a cell
- the number of Base Stations required given the number of portables in the cell and the Erlangs per portable

Figure 36 : Erlangs per portable versus portables in the cell



Appendix B: Using indoor external antennas

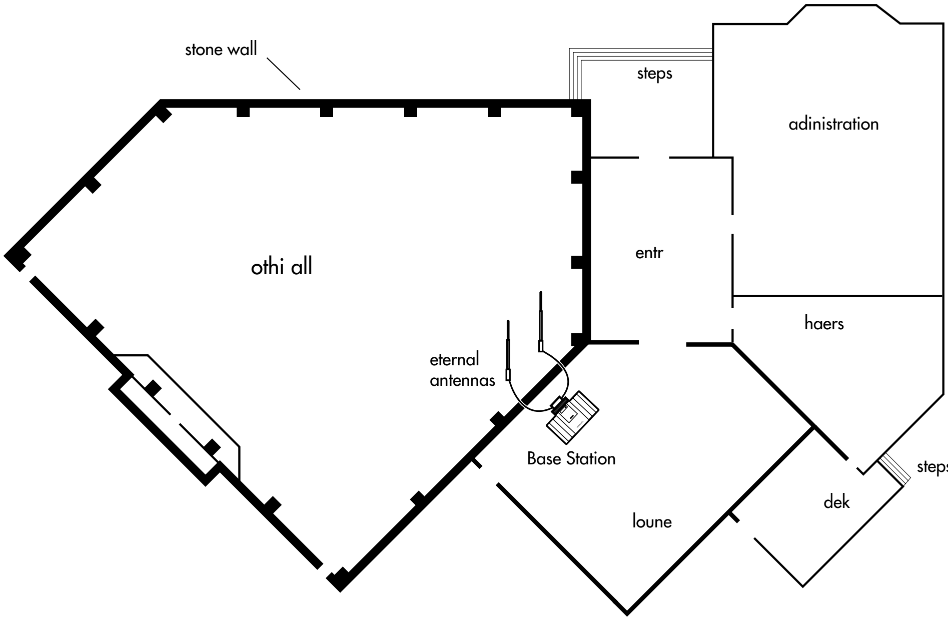
Selecting the appropriate indoor antenna

Use indoor external antennas to cover indoor areas when the following conditions are met:

- you require coverage on the side of a strong radio barrier where you cannot place a Base Station
- because of a strong radio barrier, a Base Station cannot provide coverage in the required area

For example, Gothic Hall requires coverage but is enclosed by a stone wall. Base Stations cannot be installed inside Gothic hall. Because of the stone wall, a Base Station installed in either the entry or the lounge will not serve the entire Gothic Hall. Indoor external antennas should be used in Gothic Hall.

Figure 37 : Example of indoor external antenna



Select the appropriate antenna pattern of indoor external antenna based on the following guidelines:

Table 19 : External antenna use

Type of antenna	Antenna pattern	When to use
Indoor external antenna[1]	omnidirectional	when coverage is required all around the antenna
	directional	when coverage is required only on one side of the antenna

1. All the indoor external antennas at a cell center must have the same pattern.

For each cell center requiring indoor external antennas, it is best to plan for two, four, six or eight indoor external antennas. Connect each pair of indoor external antennas at a cell center to the same Base Station.

If you connect only one radio to an external antenna serving the same cell center, it is best to disconnect the other radio. If, with external antennas, you have two radios in the same Base Station serving different cells, users in the area could have poor audio links and could drop their calls.

Simulating indoor external antennas with the CDT

Use one of the following methods to plan a cell requiring external antennas.

Using coaxial cable and an external antenna

Use this method when an external antenna and coaxial cable are available for planning.

When using a CDT transceiver with the coaxial cable and external antenna, set the CDT to external antenna and a cell boundary value of 6 dB higher than the value given in Table 4 on page 19. For example, -67 dBm is 6 dB higher than -73 dBm. The additional 6 dB is required because external antennas do not have antenna diversity.

For more information on this method, see “Base Stations” on page 5.

Changing the cell boundary value

Use this method when the external antenna and cable are not available for planning.

Calculate a new cell boundary value from the antenna’s gain, the coaxial cable’s loss, and the cell boundary value given in Table 4 on page 19. Set the

CDT to internal antenna and use the following formula to calculate the new cell boundary value:

cell boundary value + 6 + (0.7 x cable length in meters) - antenna gain

Table 20 : External antenna gain

Type of antenna	Antenna pattern	Antenna gain
indoor external antenna	omnidirectional	0 dB in all directions
	directional[1]	3 dB in direction of beam; 0 dB at right angles to direction of beam

1. The direction of the beam is perpendicular to and outward from the mounting surface.

Example

You require 33 ft (10 m) of RG 58/U coaxial cable for each indoor omnidirectional antenna. The area is indoors and there are no offices in the cell.

From Table 4 on page 19, the cell boundary value for no office indoors is -73 dBm. You determine

-73 + 6 + (0.7x10) - 0 = -60 dBm

You set the CDT transceiver to the internal antennas, and set the cell boundary value to -60 dBm.

Note: Use indoor external antennas only if you are unable to cover the area with a CDT transceiver located in an area where you can install Base Stations.

Appendix C: Fading

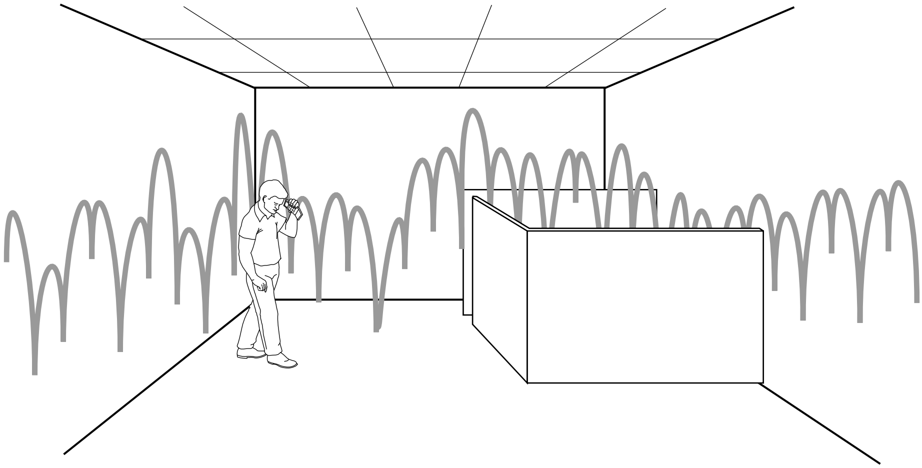
Fading

Fading causes a signal to vary in strength from good in one moment to poor in the next moment. When the signal is poor it is considered to be in a “fade.” The length of time that a fade persists can vary from as little as milliseconds to as much as several seconds.

A slight change in position of the portable can produce great variations in signal strength. The signal strength change is random, and frequently drops 5 to 15 dB below average. Fading is more severe for someone staying in one place than for someone walking. The person staying in place could have their portable in a faded area for longer periods. The person walking passes quickly through the fades.

The signal strength in a small room can vary greatly across the width of the room. As shown in Figure 38, the room is full of constructive and destructive patterns due to the signal traveling through the building and reflecting in many directions.

Figure 38 : Constructive and destructive signal patterns



A constructive pattern raises the signal strength above average. A destructive pattern lowers the signal strength below average. The distance between a constructive and a destructive pattern spans only a quarter wave length of the signal. For frequencies around 900 MHz, a quarter wave length is 3 to $3^1/_2$ in. (8 to 9 cm). For frequencies at 1.9 GHz, a quarter wave length is only $1^1/_2$ in. (4 cm).

Walking briskly when taking measurements minimizes the effects of fading and gives a more accurate average signal strength.

A quick audio check that indicates an acceptable level of service in a particular area does not necessarily mean that the signal quality will consistently remain at that level. Because of fading, the audio quality in any area can change from moment to moment.

Appendix D: Key planning concepts

Key planning concepts

An efficient Companion system depends on the following planning concepts:

- synchronization
- power control
- Base Station and cell relationships
- portable originated call
- system originated call
- hand-off

Synchronization

When the portable transmits, the Base Station receives, and when the Base Station transmits, the portable receives. In all systems, all portables transmit and all Base Stations receive at the same time. One millisecond later, all portables receive and all Base Stations transmit at the same time. This synchronization allows you to put Base Stations together at a cell center.

Because of synchronization when one portable transmits none of the other portables receive it because they are transmitting (as shown in figure Figure 39), and when one Base Station radio transmits none of the other Base Station radios receive it because they are transmitting (as shown in figure Figure 40).

Figure 39 : Base Stations receiving, portables transmitting

Figure 40 : Base Stations transmitting, portables receiving

Other key planning concepts, for example power control and hand-off, depend on synchronization to function optimally.

Power control

Power control determines the transmission power of the portable. The portable transmits in either high or low power. Low power is approximately 16 dB lower than high power. The strength of the radio power does not affect the volume or loudness of the sound that the user hears.

Portables

All portables within a cell appear to be at different distances to a Base Station.

A Base Station radio signals nearby portables to go to low power for the benefit of the other Base Station radios at the same cell center. The other Base Station radios need nearby portables to transmit in low power so they can hear more distant portables.

When the Base Station radio perceives a weak signal strength, because the portable is far away, the Base Station radio signals the portable to transmit in high power.

Base Stations

All Base Station radios at a cell center appear to be the same distance away from a portable. Because of this common distance, Base Stations remain in high power.

A portable receives all the Base Station radios at the same cell center at approximately the same signal strength. Since none of the signals are stronger than the rest, the portable can discern the signal that it needs, whether the signal from the Base Station is weak or strong.

Optimizing power control

- Position Base Stations close together at cell centers.
- Keep different cell centers apart from each other.
- Do not plan to install Base Stations individually throughout the coverage area.
- Each cell center should have enough Base Stations to handle the traffic for the cell. Do not plan cells to depend on neighboring cells to handle extra traffic.
- Do not use overlapping systems.

Base Station and cell relationships

After the installer starts a Companion system, the system requires the following site-specific information:

- which Base Stations are in each cell center
- total number of cell centers
- which cell centers are adjacent neighbors
- which cell centers are radio neighbors

For systems using CT2Plus and PCI protocols, the system determines the Base Station and cell relationships by auto administration.

Auto administration

If planned properly, the auto administered cells are the same as the planned cells.

Note: Auto administration does not plan the system into cell centers. It allows the system to learn what the site planner has done. You are responsible for planning the system into cells with cell centers. If you do not plan the system properly, auto administration cannot correct your mistakes.

Optimizing auto administration

- All Base Stations or external antennas in a cell must be as close together as possible at the cell center.
- Keep different cell centers apart from each other.
- Do not put a barrier (such as a large concrete or marble column, or a concrete wall) between Base Stations at a cell center.
- Stagger cell centers on adjacent floors.
- Use the left-right-skip method to plan multi-floor sites.
- Do not spread Base Stations throughout the coverage area.

Portable originated calls

Figure 41 : Portable originated call

The portable requests a link on one of the 100 kHz channels and hails the system's name. All Base Station radios throughout the system that are not handling calls monitor for a portable originated call. These Base Station radios monitor one channel at a time, scanning repeatedly through all the channels. (Base Station radios scan independently of each other.)

Note: The first Base Station radio to tune into the channel that the portable is hailing on and to recognize the system's name, answers the portable. (This Base Station is not necessarily the one that is closest to the portable.)

Once the system establishes a link, and if the signal strength is below a threshold value, the Base Station radio requests a hand-off in case another cell center is closer to the portable.

For the PCI protocol, the link is set up with a Base Station radio at the same cell center as the signaling channel.

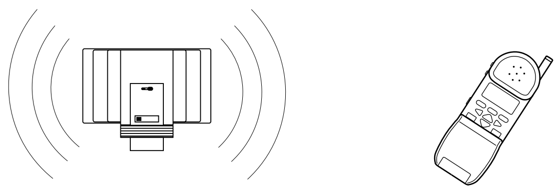
Optimizing portable originated calls

- Base Stations must be close together at the cell center.
- Cell centers should not be too close to each other.
- The -45 dBm contours of different cells should not overlap each other; however, a slight overlap is not serious.
- Use the left-right-skip method should to plan multi-floor sites.

System originated call

System originated calls are a result of calls presented to access lines.

Figure 42 : System originated call



System

The system searches for the portable.

Note: The system notifies only one Base Station radio of an auto administered cell to hail the portable.

Portable

The portable is idle most of the time, but about once every second it monitors the signaling channel to see if there is a call. If there is a call, it establishes a radio link.

After the system establishes a link, the link is moved to the best radio for the link if the Base Station cell centers are not too close together (that is, the -45 dBm cell contours do not overlap).

Optimizing system originated calls

- Base Stations for a cell center should be close together.
- Base Station radios at a cell center should have exactly the same coverage.
- Base Stations at a cell center should not be too close to a concrete or marble column.
- Base Stations should be on the same side of a concrete or marble column.
- Cell centers should be kept apart from each other.
- The -45 dBm contours of different cells should not overlap each other; however a slight overlap is not serious.
- Use the left-right-skip method to plan multi-floor sites.

Hand-off

Hand-off occurs when an active radio link to a portable is transferred to another radio in the system. When a link is not connected to the closest available Base Station radio, or the user moves from one cell center to another, the system "hands off" to an available Base Station radio at a closer cell center.

Audio quality depends on keeping the distance between the portable and Base Station as short as possible. The Base Station radio requests a hand-off when there is any decrease in signal strength, no matter how slowly the decrease occurs. There is no absolute threshold at which the hand-off request is made. It is only important that the signal strength decreases.

The system waits for responses from the prospective Base Station radios and assigns the Base Station radio with the strongest signal strength to pick up the call.

The system requests only one Base Station radio in each of the adjacent cells and the radio neighbour cells to check the link.

Optimizing hand-off

- Cell centers must be far enough apart so that their -45 dBm contours do not overlap.
- Base Stations must be close together at the cell center.

Meridian 1

Meridian Companion

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