Case study

EUCARAY® Radiating Cables in high-bay warehouses

Kabelwerk EUPEN AG

cable

Content. **EUCARAY®** High-bay warehouse 09/2019

High-bay warehouse
Kabelwerk EUPEN AG

Advantages at a glance

Equipping high-bay warehouses with radio technology is a particular challenge.
However, there is an elegant way to solve this with the help of Radiating Cables.

This case study explains the requirements of a WLAN system in a warehouse environment and how it can be implemented with Radiating Cables.

In many WLAN installations, **Radiating Cables** have shown advantages versus antennas:

- they offer better, **seamless and uninterrupted coverage**
- they allow a **gross data rate of up to 150 Mbps**
- they allow a **smaller number of access points**
- they require a **smaller number of used channels**
- they produce a **lower high-frequency load**
- they create **fewer channel overlaps**
- they create **fewer interference effects**
- they require **less network infrastructure overall** (cabling, switch ports, etc.)

For operators of high-bay warehouses, the use of Radiating Cables pays off above all because

- a **smooth operation** is ensured
- a **lower default risk** and thus a **higher utilization of the plant** can be achieved.

High-bay warehouse: a challenging environment

Particular case for radio communication with Radiating Cables

Radiating Cables have been used in the field of automation for more than 10 years. In contrast to tunnels or mines, for example, the environment in a production hall is much less 'confined'. An empty hall - especially if it has metal walls - is easy to cover completely with only one transmitter. The challenges arise with the respective equipment installed in the hall. And with the requirement to have a reliable and performant radio network. With the growth of Internet-based retailing by more and more online retailers such as Amazon, Zalando, etc. the demand for storage space is rising sharply. High-bay warehouses are the most effective way of constructing warehouses and are highly automated nowadays. Since the beginning of WLAN developments, high-bay warehouses have been regarded as a particularly difficult environment. This is due to the fact that on the one hand a stable radio field must be guaranteed, whilst on the other hand the goods stored in the warehouses can change frequently and thus also the basic conditions for radio coverage. The high and close-fitting shelves divide the hall into several narrow aisles. Inside these aisles, the forklift cars or cranes move in and out in order to fill the shelves or pick the goods.

Many narrow aisles

- **Many narrow aisles**
- **Unpredictable environment**
- **High ceilings**
- **Metal walls and shelves and other obstacles**
- **A real challenge for radio systems**

High ceilings

Radio communication to mobile units

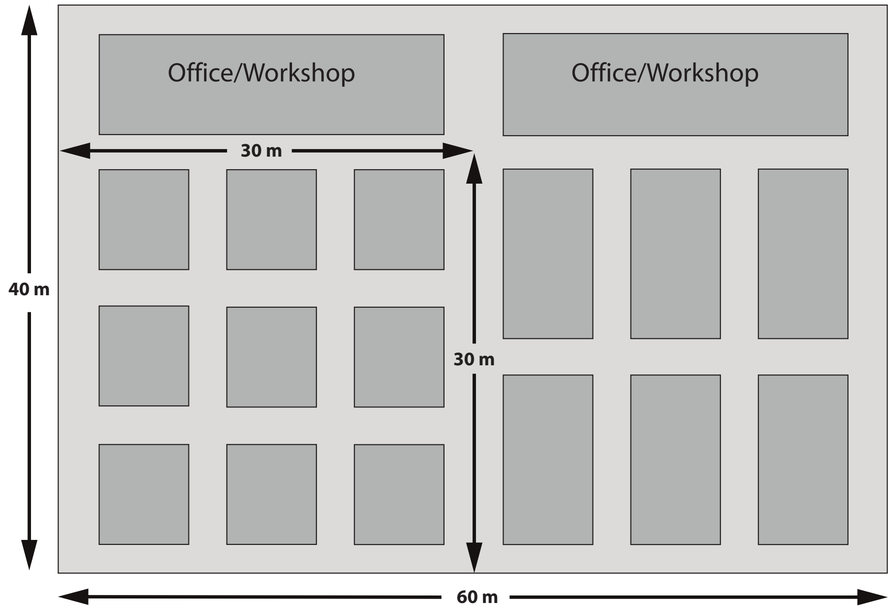
- Radio communication to **mobile units** e.g. forklifts, laptops, driverless transport systems (AGV)
- Transmission of control and monitoring information, e.g. pick order and item, order picking
- **No real-time** requirements, but
- **Interruption leads** to delays in process
- Modern systems are **driverless and run around the clock**

The smooth and fast stock turnover is the most important factor for the warehouse operator. The faster the vehicle can be loaded and unloaded, the more effectively the warehouse is operated. This is directly reflected in the costs. The aim of controlling the warehouse is therefore to reduce the empty runs of the vehicles and to keep their transport distances as short as possible. This can best be achieved by effective and permanent communication between the control system and the vehicle. It is not necessary to make the communication real-time capable or particularly fast. It is much more important to make it reliable. This means that information packets are transmitted immediately and without interruptions or repetitions.

They must be capable of being received and sent at any location in the warehouse. 'Radio holes' are leading to weak coverage and may increase if the material of the goods stored in the warehouse has higher attenuation. For instance if one day only paper is stored and the other day metal parts fill the racks, the environmental conditions for the radio coverage change from one day to the other, too. Today's modern warehouses are operated completely without human drivers. So the system has to be even more stable and failsafe. The challenge for the radio system is already high if you want to meet the aforementioned requirements.

Case study of a typical warehouse application

Every aisle in the warehouse should receive good radio coverage.



In order to demonstrate the requirements of a high-bay warehouse on the radio system and to compare the possible solutions, we define a warehouse that is 60m long and 40 m wide. The ceiling height or the height for installing a radiating cable is 10 m. Office or workshop are located at the upper end of the warehouse. The actual area covered by the storage vehicles is then 30 times 60 m in size. On the left-hand side of the warehouse there are smaller shelf types, so that three rows of shelves are created. On the right 30m the shelves are bigger, so that there is only one central aisle. This results in seven vertical and three horizontal aisles. So we are dealing with a real maze of corridors. In each of the aisles, good radio coverage is required.

High-bay warehouse:

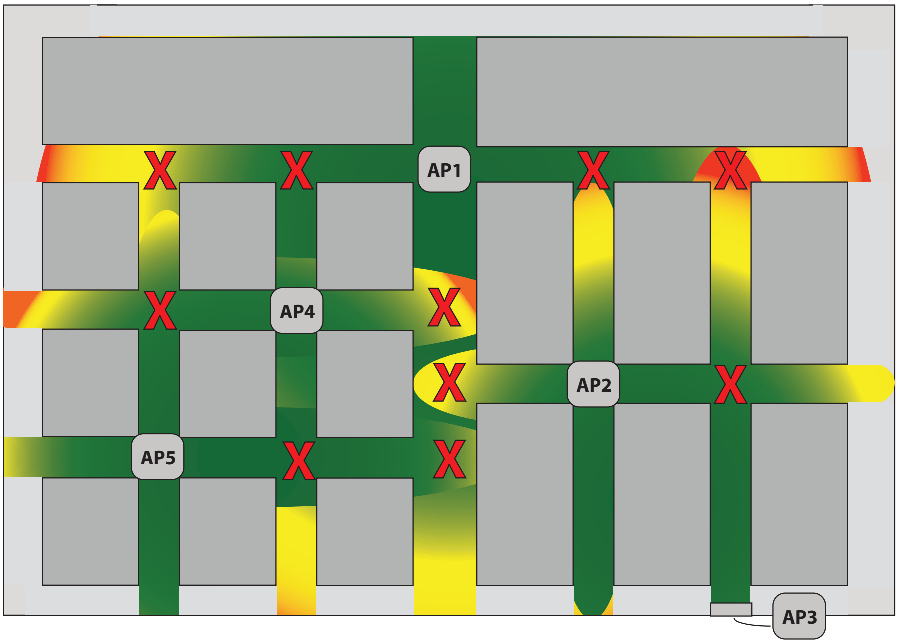
Length: **60 m**

Width: **40 m**

Length of one corridor: **approx. 30 m**

Ceiling height: **10 m**

Solution with single antennas



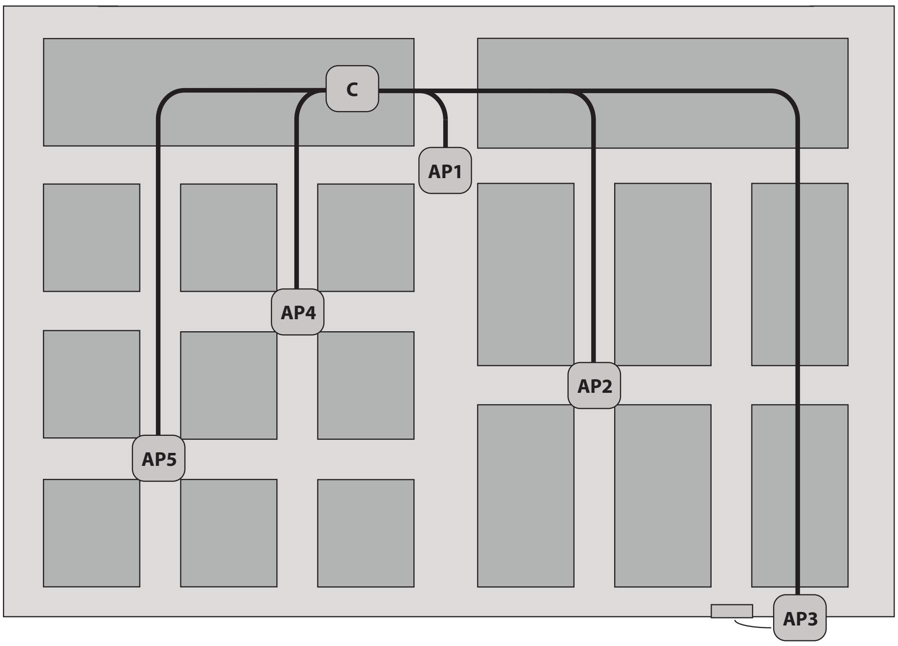
The maze like design of the warehouse doesn't make it easy to achieve the required radio coverage in an effective and reliable way, when using single antennas. Single antennas are the typical approach used in most WLAN installations today. According to the standard that defines Wireless LAN as the wireless extension of Ethernet for mobile applications, IEEE802.11, the WLAN radio network is built out of Access Points (AP) which communicate with the mobile Clients. WLAN Access Points are usually supplied with small stub antennas, which are not useful for optimized coverage. So here we assume that good omni- or directional antennas are used, which are powerful enough to cover every aisle. However, as the winding corridors do not allow for an unhindered spread of the WLAN, almost every single corridor has to be equipped with its own WLAN Access Point + antenna combination. In our example, this requires at least five individual devices plus antennas. Most of the times, 2,4 GHz WLAN is chosen rather than 5GHz, because it is less sensitive to attenuation by walls or racks. Here, WLAN according to IEEE802.11 reaches its limits, as described on the next pages.

Typical WLAN radio parameters:

- Used frequency **2.4 GHz**
- Range with good usability
  Data rate (45 Mbps gross)
  approx. **30 m - 50 m**
- Parallel usable channels:
  three channels ⟶ conflicts!
- **At least 5 WLAN APs** with antennas are required
- Each **intersection** is a problem for the WLAN client.
- If the client sees multiple APs, this leads to **performance degradation**
- **Communication interruption** through roaming
- WLAN controllers also reach their **limits**
- Extremely **high complexity**

In the 2.4 GHz band, only three non-overlapping channels are available. This alone leads to potential channel conflicts with five Access Points that brodcast in the hall, even if the shelves provide strong shade for the network. In our example, there are ten intersection points where the transmission loops of the antennas overlap directly. WLAN according to IEEE802.11 obliges the Access Points, comparable to lighthouses, to send out 'beacons' in order to signal to the Client that they are close to it.
The Client must listen to these beacons at all times, even if it already has a good connection to one of the Access Points. Even without user data being transmitted, WLAN devices are constantly working to maintain their communication and generate a base load in the wireless network, which increases as the situation becomes more complex.
Each of the intersection points is therefore a reason for the Client to search for a possibly better visible AP. In extreme cases, it deals more with sorting out and reconnecting than with data transmission. In the worst-case scenario, the data stream can completely break off, even though the level of the received radio networks is full power.

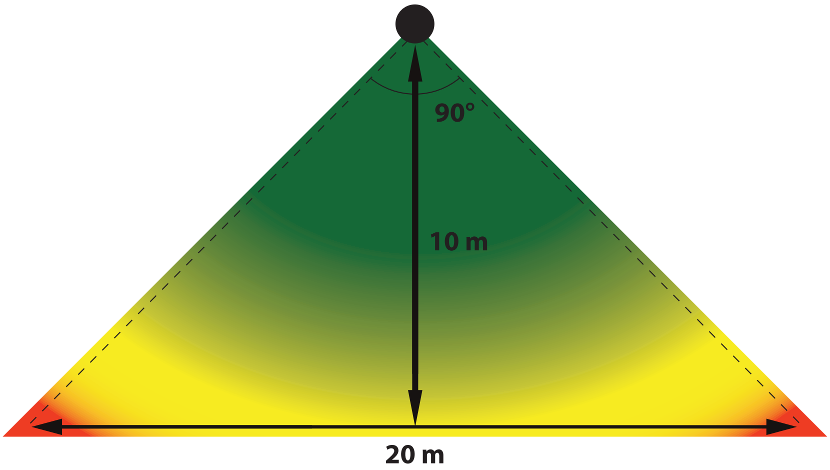
The manufacturers of WLAN devices have reacted to this and developed central controller units which are supposed to defuse channel conflicts by means of control mechanisms and to improve the switching of the Client from one cell to the next. However, the basic structure of the IEEE802.11 protocol cannot be changed by these devices either. As soon as there are a higher number of Clients in the warehouse, the complexity of the control increases considerably. So by adding controller units, which demand to also add more Access Points, an increased number of devices is created. This increases the effort to get the network operation under control. The higher amount of data bandwidth used just for the control of the devices reduces the available network performance for the operational data throughput.



The higher number of Access Points (AP) plus Controller device (C) also increases the need for cabling.

Transmission characteristics of a Radiating Cable

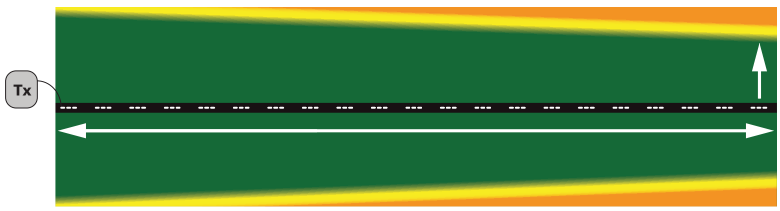
A Radiating Cable actually is a kind of long antenna. The radio field is radiated along the length of the cable. The slots, which are transmitting the radio signal, are located on one side of the cable. This results in an opening angle of about 90°, in the range of which the same field strength can be received. According to Pythagoras' triangular formula, a cable hanging at a height of 10 m on the ceiling covers a corridor almost 20 m wide.



The opening angle of the cable is 90°.

High-bay warehouse:

- Ceiling height: **10 m**
- "beam angle" = **90°**
- **Covered width = 20 m**
- The use of the Radiating Cable guarantees the illumination of the full width and length of the aisle.



The radio field is radiated along the length of the cable.

Calculation of cable length

*

Selected cable is
EUCARAY® RMC12-CL

- CL@2,4 GHz: 54 dB (@ distance of 2 m)
- LL@2,4 GHz: 14,7 dB/100 m

A sample calculation shows how the maximum usable cable length is determined. The WLAN Access Point delivers an output power of 20 dBm. The WLAN Client, which moves in the aisle of the high-bay warehouse, must still receive a radio field with the power of -80 dBm in order to transmit data. As a summary, you have a budget of 100 dBm between transmitter and receiver.

On its way between transmitter (Access Point) and receiver (Client), the signal though suffers a number of losses.

Ⓐ The cable and the plug from the AP to the Radiating Cable already reduces the signal power by 2 dB from the signal.

Ⓑ The coupling loss can be found in the data sheet of radiating cables and indicates the loss of the signal through the air at 2 m distance. It has to be adjusted accordingly, as the transmission distance in our example is 10 m.

In contrast to antennas, which emit spherical radiation from a single point, a cylindrical dispersion characteristic is applied. As result of this calculation, the signal emitted by the radiating cable* is reduced by a coupling loss of 60 dB on the distance of 10 m towards the receiver.

Ⓒ In addition, it is possible that the signal must not only pass through the air but also through a window. We'll use another 2 dB attenuation here.

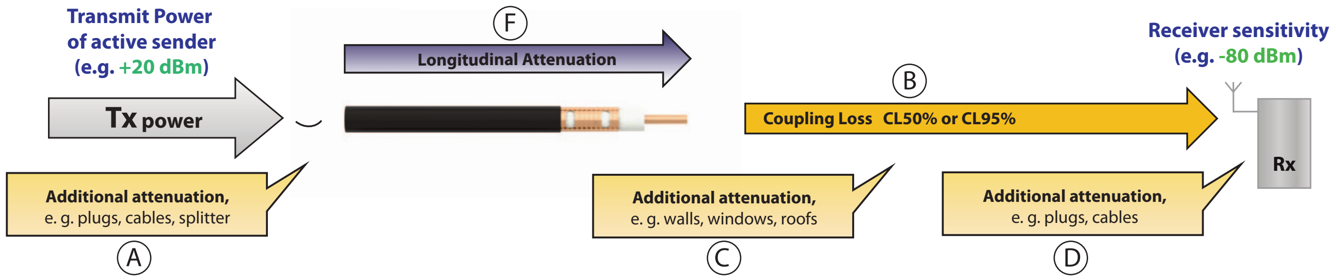
Ⓓ And between the Client's receiving antenna (which is assumed to have a gain of 0 dBi, as it is typical for small stub antennas) and the Client's radio module, there are also plugs and cables that nibble off another 2 dB.

Ⓔ In order to still have a margin for possible further losses in practice, another 10 dB will be deducted.

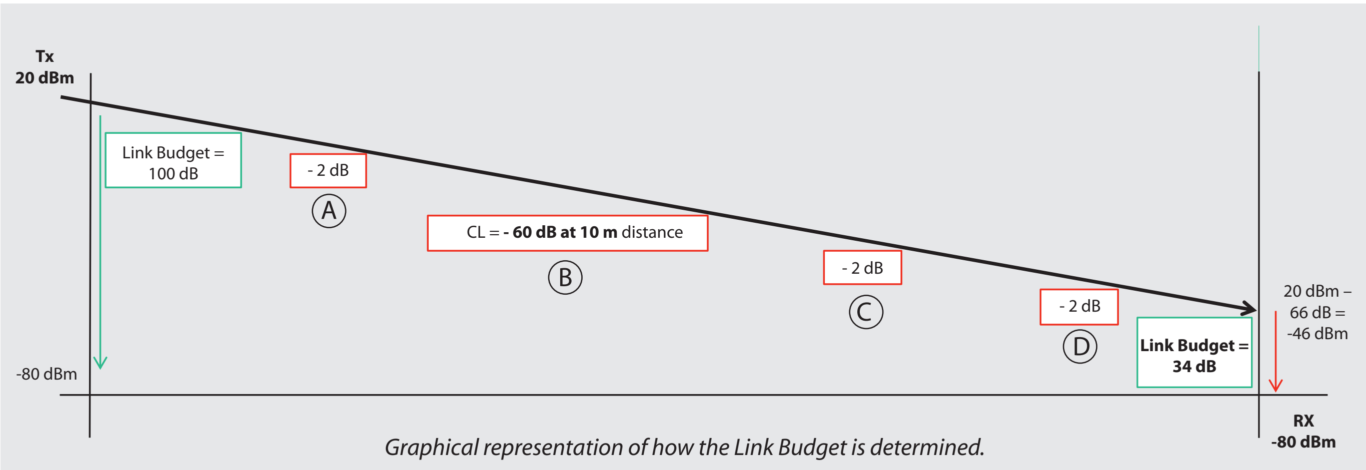
Thus, only -56 dBm of the original 20 dBm are left, whereas at this point the longitudinal attenuation is not included. The budget up to -80 dBm reception sensitivity of the Client has shrunk from 100 dB to 24 dB.

Ⓕ The selected cable* has a given attenuation of 16 dB/100 m. By dividing the remaining budget by the longitudinal attenuation, this results in a usable length of 160 m.

Path from transmitter to receiver with all occurring attenuations



Step 1: Addition of all losses on the path from transmitter to receiver, initally without longitudinal attenuation.



Graphical representation of how the Link Budget is determined.

Step 2: Calculation of the link budget incl. margin

Tx power + abs(Rx sensitivity) – (additional attenuations) – Coupling Loss – Margin = Link Budget

Tx power	abs(Rx sensitivity)	(additional attenuations)	Coupling Loss	Margin	Link Budget
20 dBm	80 dBm	-6 dB	-60 dB	-10 dB	**24 dB**
		A + C + D	B	E	

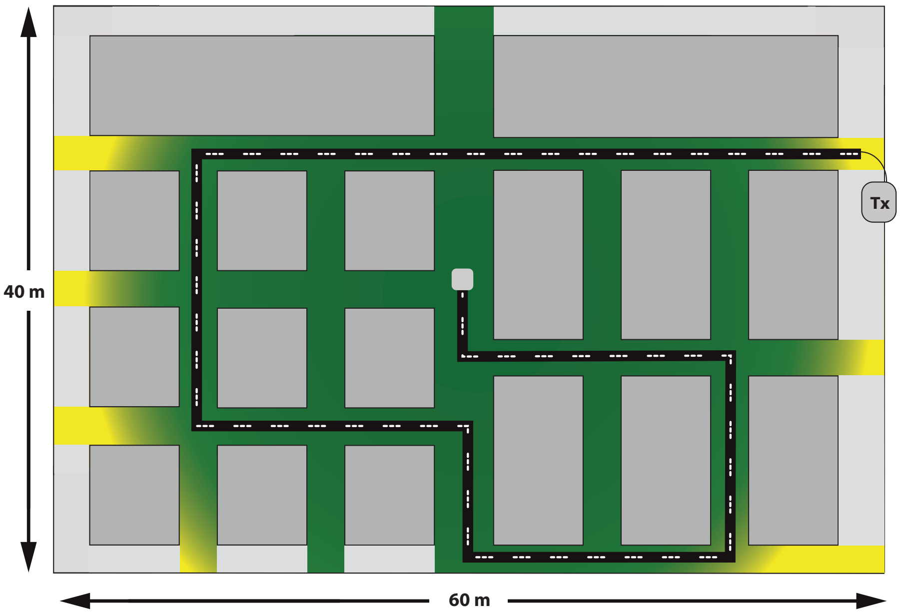
Step 3: Calculation of the maximum cable length in function of the longitudinal attenuation

Link Budget / Attenuation (dB/100m) *100 = Cable Length

Link Budget	Attenuation (dB/100m)	Cable Length
24 dB	**15 dB/100 m**	**160 m**
	F	

Solution with Radiating Cables

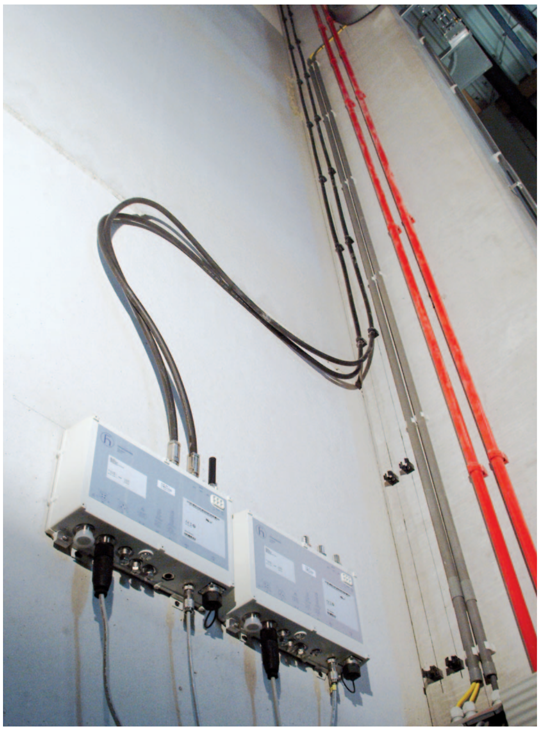
Now, since the possible cable length is known, the challenge is to install the 160 m cable in the high-bay warehouse in such a way that on the one hand the aisles are well covered and the length of the cable is still long enough to cover as many aisles as possible. Since the width of the covered area can be approx. 20 m, the side aisles to the right and left are covered as well. In addition, the cable is located above each forklift truck or crane track. Their WLAN receivers have a direct line of sight to the transmitting cable. This increases the transmission stability even more, as the signals run directly between transmitter and receiver and are not dependent on reflections. The result shows that the entire hall is homogeneously covered with a single Access Point and the radiating cable. The WLAN Clients do not have the additional burden of having to listen to and respond to multiple Access Points. There is no change to other Access Points and thus no interruption of data communication.



Solution with Radiating Cable

Typical WLAN parameters

- Only **1 WLAN AP** with **160 m** Radiating Cable
- **No channel conflicts**
- **No interruptions** due to roaming



Installation of the WLAN access point in the EUPEN high-bay warehouse

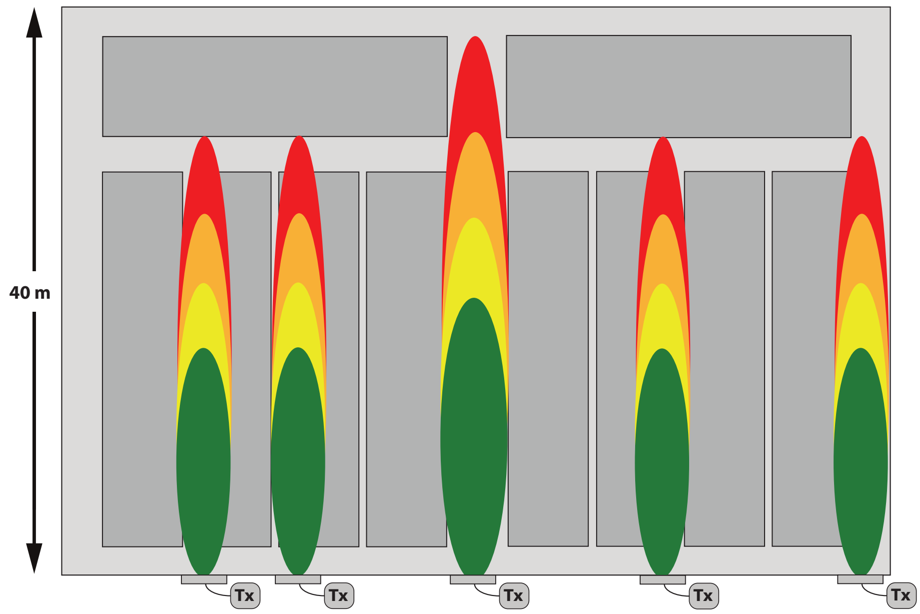
Movable shelves

Sliding shelves complicate radio coverage additionally

High-bay warehouses are becoming increasingly effective due to their design. The available storage space can be further increased by moving the shelves. This means that only one aisle is opened at a time in order to access the storage compartment. However, this design also poses new challenges for the radio network. Coverage with Access Points and individual antennas must be designed differently. The antennas must be positioned in such a way that they cover the aisle which is opened at the moment. This means that an AP with antenna must be provided for each possible opened aisle. In the example shown here, the number of necessary devices increases to nine. And a central control of the Access Points by a controlling device becomes more important, since only the one Access Point that is needed for radio communication in the opened aisle at that moment should be active. As a result, the complexity of the system is shifting, but not decreasing.

High-bay warehouse

- Sliding shelves increase **storage capacity**
- **Position** of free aisle between shelves **changes**
- **Cost** for a solution with antennas increases
- At least **9 WLAN AP** would be needed in this example
- An **additional device** becomes necessary for controlling the network



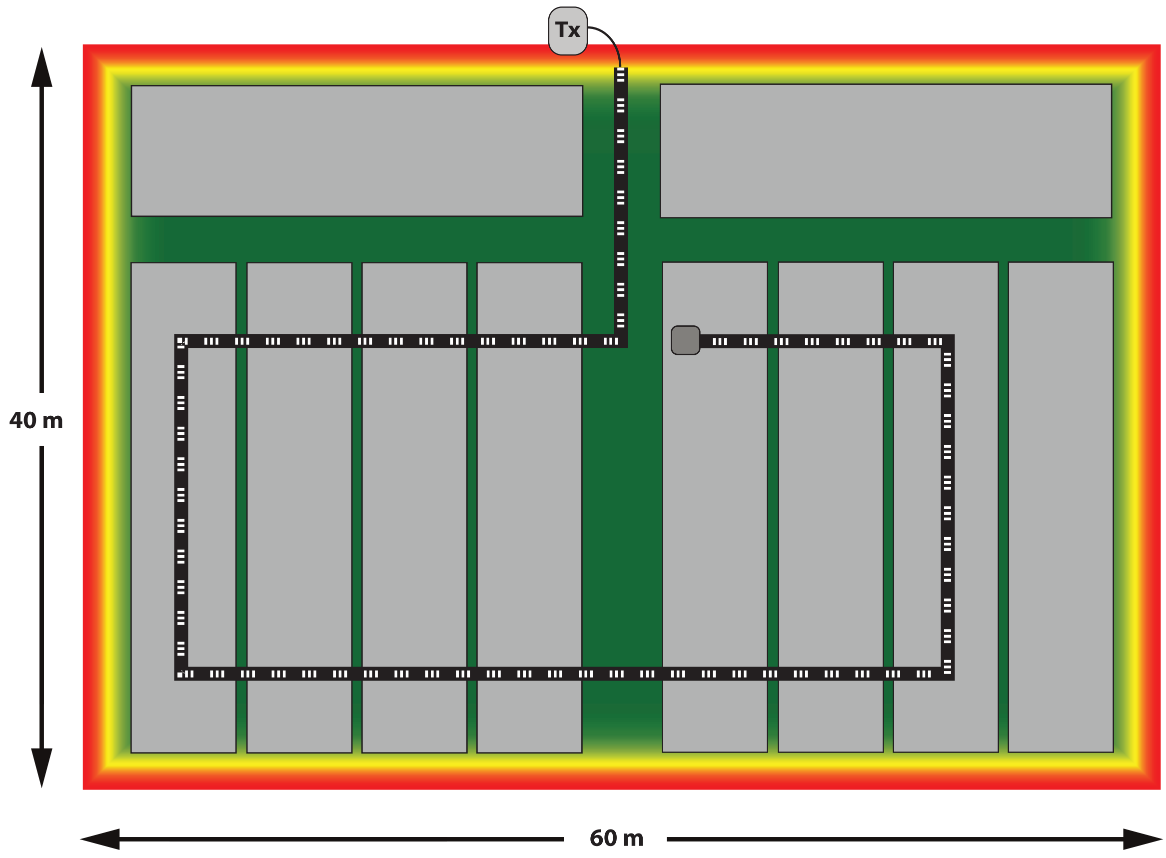
Movable shelves would require APs placed at every possible aisle

Moving shelves with Radiating Cables

The advantage of the Radiating Cable is also evident here. It transmits and receives at any point of its length. If it is placed across the aisles, each open aisle is covered. Again, only one Access Point is needed to feed the entire system.

High-bay warehouse:

- Shelves are moving
- **Position** of the free aisle **is changing**
- **1 WLAN AP** together with the Radiating Cable covers every aisle
- **Does not need additional control**
- **Solution with much less complexity**



Conclusion

High-bay warehouses are becoming increasingly widespread. Their effectiveness grows with automation, which is solved with the help of WLAN communication.
A high-bay warehouse places high demands on wireless coverage. The common method to answer higher demands by increasing the number of devices is not a solution here.
Radiating Cables reduce complexity and help to cover the entire system efficiently. Possible causes of errors such as channel conflicts or frequent roaming are reduced.

EUCARAY® Radiating Cables from Eupen have shown that they are technically and economically an optimal solution for WLAN applications in warehouses.

High-bay warehouse Kabelwerk EUPEN AG

Suitable products

EUCARAY[fi] RMC 12-CL

1/2" radiating cable optimized for applications at 2.4 GHz such as WLAN.

Radiating Cables

Eupen EUCARAY[fi] radiating cables have been developed to provide RF-coverage for wireless applications in confined areas. They provide homogeneous and continuous RF-coverage, and allow simultaneous transmission of multiple wireless services. EUCARAY[fi] radiating cables are engineered and produced in Belgium to highest quality standards for best performance and longest lifetime.

Product Description

The EUCARAY[fi] RMC 12-CL is a radiating cable best performing at 2.4 GHz, e.g. to be used with WLAN inside buildings, tunnels, rail and production environment. The size of 1/2" features low weight and low bending radius.

Features and Benefits

- From 30 to 2500 MHz with resonant frequencies*
- Robust Cable, with low bending radius
- Main Applications: WLAN (2400-2485) MHz

Certification and Fire Behaviour

Halogen-free, Low-smoke and Flame-retardant outer jacket:

- Low corrosive gas emission acc. to IEC 60754-2
- Flame retardant acc. to IEC 60332-1-2 and IEC 60332-3 Cat. C
- Low smoke emission acc. to IEC 61034
- Reaction to fire according EN60332-1-2 E_{ca}
- Compliant to EN 50575
- Fulfils the requirements of EN 45545-2:2013

Ordering Information

Ordering name: **RMC 12-CL-HLFR**

Recommended connectors and cable preparation tool:

- 7-16 Female: 716FR12
- N Female: NF50R12; NM50R12
- Tool: SPTC50R12

*) EUCARAY[fi] achieves low coupling losses due to the patented slot design. Resonant frequencies are narrow-band VSWR peaks that usually occur in non-used bands of the radio-spectrum. Their amplitude generally decreases the higher the order.

More information under: www.radiating-cables.com www.eupen.com

EUCARAY[fi] RMC 12-CL

Technical Information

• Size		1/2"
• Frequency range	MHz	30 - 2500
• Recommended Frequency bands		WLAN (2400-2485) MHz
• Cable Type		RMC (Radiated Mode Cable)
• Material		Flame retardant polyolefin
• Slot design		Groups of slots at short intervals
• Impedance	Ω	50 +/- 3
• Velocity Ratio	%	88
• Capacitance	pF/m (pF/ft)	76 (23.2)
• Inner Conductor DC resistance	Ω/1000m (Ω/1000 ft)	1.48 (0.45)
• Outer Conductor DC resistance	Ω/1000m (Ω/1000 ft)	2.80 (0.85)
• Inner Conductor Material		Copper clad aluminium wire
• Dielectric Material		Cellular polyethylene
• Outer Conductor Material		Overlapping copper foil with slot groups, bonded to the jacket
• Diameter Inner Conductor	mm (in)	4.8 (0.189)
• Diameter Dielectric	mm (in)	12.4 (0.488)
• Diameter over Jacket	mm (in)	15.5 (0.61)
• Minimum Bending Radius, Single Bend	mm (in)	200 (7.87)
• Cable Weight	kg/m (lb/ft)	0.232 (0.156)
• Tensile Strength	daN (lbf)	110 (243)
• Indication of Slot Alignment		embossed line 180° opposite
• Storage Temperature	°C (°F)	-70 to +85 (-94 to +185)
• Installation Temperature	°C (°F)	-25 to +60 (-13 to +140)
• Operation Temperature	°C (°F)	-40 to +85 (-40 to +185)

• Longitudinal Loss and Coupling Loss[1]

Frequency	Longitudinal Loss	Coupling Loss	
	dB/100m (dB/100ft)	$C_{50\%}$ (dB)	$C_{95\%}$ (dB)
75 MHz	1.87 (0.57)	54	66
150 MHz	2.75 (0.84)	64	75
225 MHz	3.42 (1.04)	62	66
450 MHz	4.96 (1.51)	65	69
900 MHz	7.32 (2.23)	63	73
1800 MHz	11.94 (3.64)	59	67
1900 MHz	12.45 (3.80)	59	67
2200 MHz	13.90 (4.24)	58	67
2400 MHz	14.71 (4.48)	54	60
2500 MHz	15.05 (4.59)	59	67

• Resonant Frequencies	MHz	156, 469, 781, 1094, 1406, 1718, 2031, 2344
• Recommended Clamp Spacing	m (ft)	0.5 (1.64)
• Distance to Wall Recommended / Min.	mm (in)	80 - 180 (3.15 - 7.00) / 50 (1.96)

The above stated values are nominal values and subject to manufacturing tolerances as follows: Longitudinal Loss +/-5 % and Coupling Loss +/- 5 dB.

As with any radiating cable, the performance in building or tunnel may deviate from figures measured according to the IEC 61196-4 standard.

[1] Measured in tunnel according to **IEC 61196-4 - Ground Level Method**.
Distance = 2m. C50 & (C95) are the average coupling losses with 50% (95%) probability calculated in accordance with the standard.

Coupling loss measurements taken in accordance with IEC 61196-4 - Free Space Method are available on request.

All information on this datasheet is subject to change without notice.

EUCARAYfi RMC 12-EH

1/2" radiating cable optimized for LTE and high frequency applications up to 6 GHz.

Radiating Cables

Eupen EUCARAY® radiating cables have been developed to provide RF-coverage for wireless applications in confined areas. They provide homogeneous and continuous RF-coverage, and allow simultaneous transmission of multiple wireless services. EUCARAY® radiating cables are engineered and produced in Belgium to highest quality standards for best performance and longest lifetime.

Product Description

The EUCARAY®RMC 12-EH radiating cable is best performing at highest frequencies and to be used inside buildings, tunnels, rail and production environment. The size of 1/2" features low weight and small bending radius.

Features and Benefits

- From 30 to 6000 MHz with resonant frequencies*
- Robust Cable, low bending radius
- Main Applications: LTE and WLAN up to 6 GHz
- Optimized for 2600 and 3500 MHz

Certification and Fire Behaviour

Halogen-free, Low-smoke and Flame-retardant outer jacket:

- Low corrosive gas emission acc. to IEC 60754-2
- Flame retardant acc. to IEC 60332-1-2 and IEC 60332-3 Cat. C
- Low smoke emission acc. to IEC 61034
- Reaction to fire according EN60332-1-2 E_{ca}
- Compliant to EN 50575
- Fulfils the requirements of EN 45545-2:2013

Ordering Information

Ordering name: **RMC 12-EH-HLFR**

Recommended connectors and cable preparation tool:

- 7-16 / 4.3-10 Type: 716FR12; 43FR12
- N Type: NF50R12 ; NM50R12
- Tool: SPTC50R12

*) EUCARAY® achieves low coupling losses due to the patented slot design. Resonant frequencies are narrow-band VSWR peaks that usually occur in non-used bands of the radio-spectrum. Their amplitude generally decreases the higher the order.

More information under: www.radiating-cables.com www.eupen.com

EUCARAY[fi] RMC 12-EH

Technical Information

• Size		1/2"
• Frequency range	MHz	30 - 6000
• Recommended Frequency bands		LTE, WLAN up to 6 GHz
• Cable Type		RMC (Radiated Mode Cable)
• Material		Flame retardant polyolefin
• Slot design		Groups of slots at short intervals
• Impedance	Ω	50 +/- 3
• Velocity Ratio	%	88
• Capacitance	pF/m (pF/ft)	76 (23.2)
• Inner Conductor DC resistance	Ω/1000m (Ω/1000 ft)	1.48 (0.45)
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• Indication of Slot Alignment		embossed line 180° opposite
• Storage Temperature	°C (°F)	-70 to +85 (-94 to +185)
• Installation Temperature	°C (°F)	-25 to +60 (-13 to +140)
• Operation Temperature	°C (°F)	-40 to +85 (-40 to +185)

• Longitudinal Loss and Coupling Loss[1]

Frequency	Longitudinal Loss	Coupling Loss	
	dB/100m (dB/100ft)	$C_{50\%}$ (dB)	$C_{95\%}$ (dB)
2400 MHz	11.45 (3.49)	67	71
2600 MHz	12.03 (3.67)	65	69
2700 MHz	12.32 (3.76)	65	68
3500 MHz	14.65 (4.47)	64	70
5200 MHz	21.02 (6.41)	62	70
5500 MHz	22.58 (6.88)	62	71
5800 MHz	24.34 (7.42)	59	68

• Resonant Frequencies	MHz	415, 1245, 2075, 2905, 3735, 4565, 5395
• Recommended Clamp Spacing	m (ft)	0.5 (1.64)
• Distance to Wall Recommended / Min.	mm (in)	80 - 180 (3.15 - 7.00) / 50 (1.96)

The above stated values are nominal values and subject to manufacturing tolerances as follows: Longitudinal Loss +/-5 % and Coupling Loss +/- 5 dB.

As with any radiating cable, the performance in building or tunnel may deviate from figures measured according to the IEC 61196-4 standard.

[1] Measured in tunnel according to **IEC 61196-4 - Ground Level Method**.
Distance = 2m. C50 & (C95) are the average coupling losses with 50% (95%) probability calculated in accordance with the standard.

Coupling loss measurements taken in accordance with IEC 61196-4 - Free Space Method are available on request.

All information on this datasheet is subject to change without notice.

EUCARAYfi RMC 58-CH

5/8" radiating cable optimized for LTE and high frequency applications up to 6 GHz.

Radiating Cables

Eupen EUCARAYfi radiating cables have been developed to provide RF-coverage for wireless applications in confined areas. They provide homogeneous and continuous RF-coverage, and allow simultaneous transmission of multiple wireless services. EUCARAYfi radiating cables are engineered and produced in Belgium to highest quality standards for best performance and longest lifetime.

Product Description

The EUCARAYfi RMC 58-CH radiating cable is best performing at high frequencies and to be used inside buildings, tunnels, rail and production environment. The size of 5/8" features low attenuation.

Features and Benefits

- From 30 to 6000 MHz with resonant frequencies*
- Robust Cable, with low attenuation
- Main Applications: LTE, WLAN up to 6 GHz

Certification and Fire Behaviour

Halogen-free, Low-smoke and Flame-retardant outer jacket:

- Low corrosive gas emission acc. to IEC 60754-2
- Flame retardant acc. to IEC 60332-1-2 and IEC 60332-3 Cat. C
- Low smoke emission acc. to IEC 61034
- Reaction to fire according EN 60332-1-2 E_{ca}
- Compliant to EN 50575
- Fulfils the requirements of EN 45545-2:2013

Ordering Information

Ordering name: **RMC 58-CH-HLFR**

Recommended connectors and cable preparation tool:

- N Type: NF50R58; NM50R58
- Tool: SPTC50R58

*) EUCARAYfi achieves low coupling losses due to the patented slot design. Resonant frequencies are narrow-band VSWR peaks that usually occur in non-used bands of the radio-spectrum. Their amplitude generally decreases the higher the order.

More information under: www.radiating-cables.com www.eupen.com

EUCARAYfi RMC 58-CH

Technical Information

• Size		5/8"
• Frequency range	MHz	30 - 6000
• Recommended Frequency bands		LTE, WLAN up to 6 GHz
• Cable Type		RMC (Radiated Mode Cable)
• Material		Flame retardant polyolefin
• Slot design		Groups of slots at short intervals
• Impedance	Ω	50 +/- 2
• Velocity Ratio	%	88
• Capacitance	pF/m (pF/ft)	76 (23.2)
• Inner Conductor DC resistance	Ω/1000m (Ω/1000 ft)	1.90 (0.58)
• Outer Conductor DC resistance	Ω/1000m (Ω/1000 ft)	2.04 (0.62)
• Inner Conductor Material		Smooth copper tube
• Dielectric Material		Cellular polyethylene
• Outer Conductor Material		Overlapping copper foil with slot groups, bonded to the jacket
• Diameter Inner Conductor	mm (in)	6.8 (0.268)
• Diameter Dielectric	mm (in)	17.6 (0.693)
• Diameter over Jacket	mm (in)	21.0 (0.827)
• Minimum Bending Radius, Single Bend	mm (in)	250 (9.84)
• Cable Weight	kg/m (lb/ft)	0.380 (0.255)
• Tensile Strength	daN (lbf)	90 (198)
• Indication of Slot Alignment		embossed line 180° opposite
• Storage Temperature	°C (°F)	-70 to +85 (-94 to +185)
• Installation Temperature	°C (°F)	-25 to +60 (-13 to +140)
• Operation Temperature	°C (°F)	-40 to +85 (-40 to +185)

• Longitudinal Loss and Coupling Loss[1]

Frequency	Longitudinal Loss	Coupling Loss	
	dB/100m (dB/100ft)	$C_{50\%}$ (dB)	$C_{95\%}$ (dB)
2400 MHz	8.07 (2.46)	73	80
2600 MHz	8.47 (2.58)	71	76
2700 MHz	8.66 (2.64)	71	77
3500 MHz	10.23 (3.12)	72	82
5200 MHz	14.37 (4.38)	67	78
5500 MHz	15.37 (4.69)	66	76
5800 MHz	16.49 (5.03)	64	73

• Resonant Frequencies	MHz	417,3, 1252, 2086, 2921, 3756, 4590, 5425
• Recommended Clamp Spacing	m (ft)	1 (3.28)
• Distance to Wall Recommended / Min.	mm (in)	80 - 180 (3.15 - 7.00) / 50 (1.96)

The above stated values are nominal values and subject to manufacturing tolerances as follows: Longitudinal Loss +/-5 % and Coupling Loss +/- 5 dB.
As with any radiating cable, the performance in building or tunnel may deviate from figures measured according to the IEC 61196-4 standard.
[1] Measured in tunnel according to **IEC 61196-4 - Ground Level Method**.
Distance = 2m. C50 & (C95) are the average coupling losses with 50% (95%) probability calculated in accordance with the standard.
Coupling loss measurements taken in accordance with IEC 61196-4 - Free Space Method are available on request.
All information on this datasheet is subject to change without notice.

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cable

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