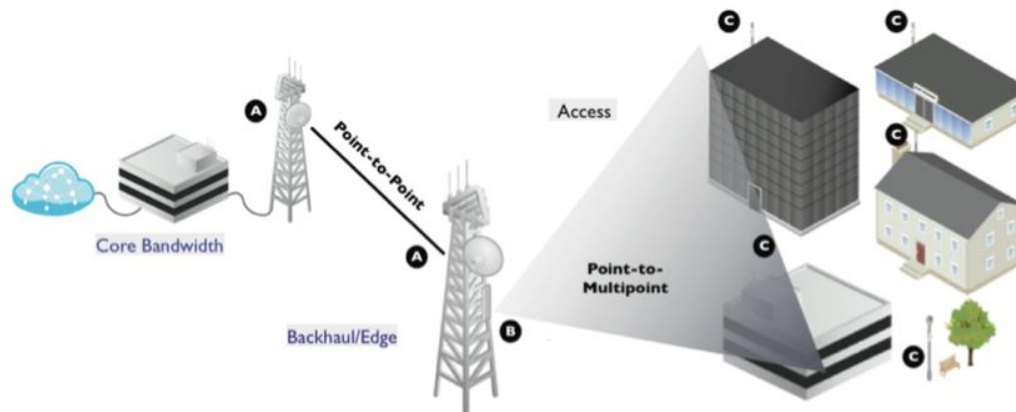


---

## Projeto de Rádio Enlaces de Comunicação

# Projeto de Rádio Enlaces de Comunicação

## Point-to-Point (PtP/P2P)



## ❖ Informações Gerais:

- ❖ Vamos utilizar os equipamentos e a ferramenta de projeto online da airLink: <https://link.ui.com>
- ❖ Será necessário criar uma conta (gratuita) no sistema da airLink.
- ❖ A Tabela 1 apresenta algumas sugestões de cenários para o projeto do rádio enlace.
- ❖ As equipes podem escolher um destes cenários ou **definir um cenário específico de seu interesse**.

<b>Sugestões de Locais para o Projeto</b> <b>As equipes podem escolher um cenário específico de seu interesse.</b>		
<b>Sugestão</b>	<b>Rádio Enlace Ponto-a-Ponto</b>	
	<b>Local 1</b>	<b>Local 2</b>
1	Centro de Curitiba	Centro de São José dos Pinhais
2	Centro de Curitiba	Centro de Pinhas
3	Centro de Piraquara	Centro de Quatro Barras
4	Centro de Araucária	Centro de Fazenda Rio Grande
5	Campus UFPR Curitiba	Centro de Pinhais
6	Local de Residência do Aluno 1	Local de Residência do Aluno 2
7	Local de Residência	Local da Empresa

# Projeto de Rádio Enlace de Comunicação

- 1) Avaliar as condições do enlace, levando em conta a altura necessária das antenas e a condição de linha de visada (LOS), para definir a necessidade de implantação de apenas um enlace ou múltiplos enlaces ponto-a-ponto.
- 2) Escolher o tipo de equipamento para o(s) enlace(s) ponto-a-ponto, definindo o modelo do equipamento e a faixa de frequência de operação (2.4GHz/5GHz).
- 3) Escolher e posicionar os pontos de instalação dos enlaces. Se possível, definir pontos de instalação que não necessitem de antenas muito altas.
- 4) Apresentar a(s) figura(s) do relevo do terreno entre os pontos de operação de cada enlace ponto-a-ponto.
- 5) Apresentar as fotos (satélite) dos pontos de instalação das antenas (prédio/terreno).
- 6) Através de gráficos comparativos, avaliar como a taxa de transmissão do enlace é afetada pelas diferentes **potências de transmissão** e **larguras de banda** de operação configuráveis no equipamento. Traçar os seguintes gráficos:
  - a) Fixando o **menor** valor de largura de banda de operação do equipamento, traçar o gráfico da taxa de transmissão em função da potência de transmissão.
  - b) Fixando o **maior** valor de largura de banda de operação do equipamento, traçar o gráfico da taxa de transmissão em função da potência de transmissão.
  - c) Para a **potência máxima**, traçar o gráfico da **taxa de transmissão** em função da **largura de banda**.
  - d) Para a **potência mínima**, traçar o gráfico da **taxa de transmissão** em função da **largura de banda**.

**OBS:** Configurar sempre os mesmos valores de **potência de transmissão** e de **largura de banda** dos dois lados do enlace.

- 7) Escolher e selecionar (configurar) uma potência de transmissão e uma largura de banda para operação dos equipamentos, com as respectivas estimativas de taxas de transmissão.
  - 8) Para a potência de transmissão e largura de banda definida no item 7), fazer o cálculo da potência recebida usando os parâmetros da ficha técnica do dispositivo e o modelo de propagação de espaço livre. Comparar a estimativa obtida com o resultado da ferramenta online. Apresentar os cálculos e parâmetros utilizados.
  - 9) Apresentar uma tabela com a estimativa de custo dos equipamentos/antenas e custo das torres.
-

---

## Escolha de Equipamentos

Point-to-Point (PtP) Links

---

### Short distance (0-5 km)

- **NanoBeam 5AC-G2:** Recommended for short links, superior performance thanks to the latest airMAX AC technology able to deliver up to 450Mbps of throughput.
- **NanoStation 5AC Loco:** Good for short distance links. Lowest cost PtP solution with airMAX AC technology.
- **NanoStation 5AC:** Very popular product for short links, frequently used for video surveillance due to its dual-Ethernet port capability, also with airMAX AC technology.
- **airFiber 5X+AF-5G23-S45:** 5GHz band. Ideal for high-performance links with up to 500Mbps aggregate throughput using only 50MHz, up to 1million pps processing power, latency around 2ms. Supports Jumbo Frames.
- **airFiber 24:** 24GHz band. Ideal for high-performance links with up to 1.5Gbps aggregated throughput (750Mbps+ Full-Duplex), up to 1million pps processing power, latency below 1ms. Supports Jumbo Frames.
- **airFiber 24HD:** 24GHz band. Ideal for high-performance links with up to 2Gbps aggregated throughput (1Gbps+ Full-Duplex), up to 1million pps processing power, latency below 1ms. Supports Jumbo Frames

<https://help.ui.com/hc/en-us/articles/205197750-airMAX-Which-product-should-I-use->

### Medium distance (5-15 km)

- [LiteBeam 5AC-23-G2](#): Recommended as CPE for most cases, superior performance thanks to the latest airMAX AC technology able to deliver up to 450Mbps of throughput.
- [PowerBeam 5AC-G2](#): Recommended as CPE for long distance links, or medium-distance PtP links. Superior performance thanks to the latest airMAX AC technology able to deliver up to 450Mbps of throughput.
- [PowerBeam 5AC ISO](#): Very similar to PowerBeam 5AC but suggested for high-noise environments.
- [airFiber5X + AF-5G30-S45](#): 5GHz band. Ideal for high-performance links with up to 500Mbps aggregated throughput using only 50MHz, up to 1million pps processing power, latency around 2ms. Supports Jumbo Frames.
- [airFiber5/5U](#): 5GHz band. Ideal for high-performance links with up to 1.2Gbps aggregated throughput (620Mbps Full-Duplex), up to 1million pps processing power, latency below 1ms. Supports Jumbo Frames.
- [airFiber11FX+Antenna](#): 11GHz Licensed band. Ideal for high-performance links with up to 1.3Gbps aggregated throughput (680Mbps Full-Duplex), up to 1million pps processing power, latency below 1ms. Supports Jumbo Frames. Licensed band.

<https://help.ui.com/hc/en-us/articles/205197750-airMAX-Which-product-should-I-use->



### Long distance (15+ km)

- [Rocket 5AC + RocketDish LW](#): Excellent choice for long distance high-performance links. Up to 450Mbps TCP/IP throughput using 80MHz. Distances of 100+ km.
- [airFiber5X + AF-5G34-S45](#): 5GHz band. Ideal for high-performance links with up to 500Mbps aggregated throughput using only 50MHz, up to 1million pps processing power, latency around 2ms. Supports Jumbo Frames.
- [airFiber11FX+Antenna](#): 11GHz Licensed band. Ideal for high-performance links with up to 1.3Gbps aggregated throughput (680Mbps Full-Duplex), up to 1million pps processing power, latency below 1ms. Supports Jumbo Frames. Licensed band.

<https://help.ui.com/hc/en-us/articles/205197750-airMAX-Which-product-should-I-use->

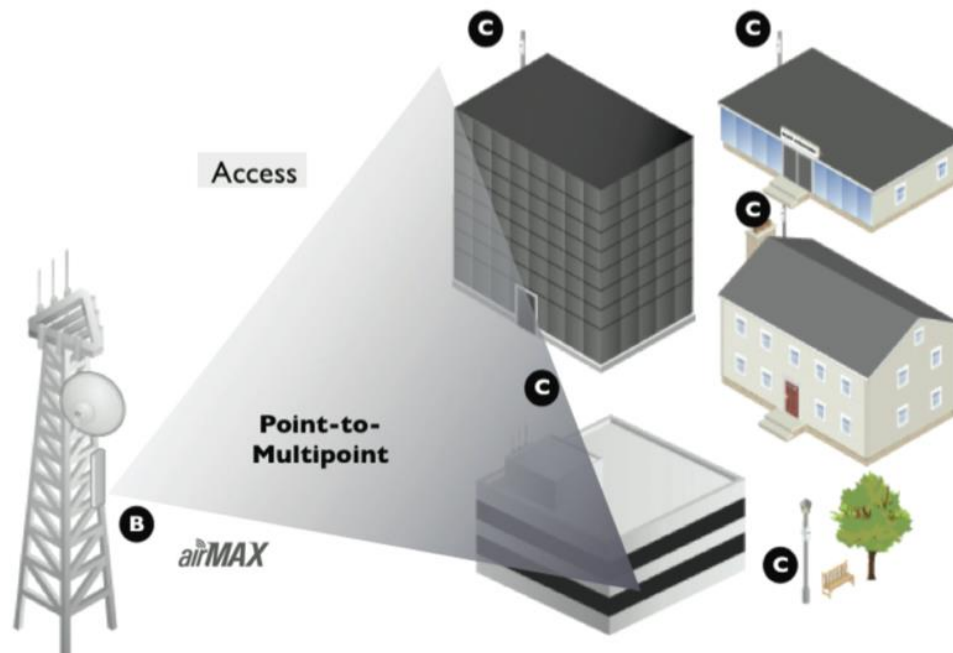
### High-Performance Backhaul

- **airFiber 24HD:** For extreme performance, the airFiber 24HD can deliver up to 2Gbps of actual throughput at distances of 2+ km in the 24GHz band, and up to 1.4Gbps in links below 9KM. However, under certain circumstances, you can use it up to 20 km.
- **airFiber 24:** For superior performance, the airFiber 24 delivers up to 1.4Gbps of actual throughput at distances of 5+ km in the 24GHz band. However, under certain circumstances, you can use it up to 13 km.
- **airFiber 5 and 5U:** Ideal superior performance in the 5GHz band, the airFiber 5/5U delivers up to 1.2Gbps in the 5GHz band. Under certain circumstances, it can be used for links up to 100KM.
- **airFiber5XHD+Antennas:** 5GHz band. Ideal for high-performance links with up to 1Gbps aggregated throughput, up to 2 million pps processing power, latency around 2ms. Supports Jumbo Frames.
- **airFiber2X+Antennas:** 2.4GHz band. Ideal for high-performance links with up to 500Mbps aggregated throughput using only 50MHz, up to 1million pps processing power, latency around 2ms. Supports Jumbo Frames.
- **airFiber3X+Antennas:** 3.XGHz band. Ideal for high-performance links with up to 500Mbps aggregated throughput using only 50MHz, up to 1million pps processing power, latency around 2ms. Supports Jumbo Frames.
- **airFiber4X+Antennas:** 4.7-4.9GHz Licensed band. Ideal for high-performance links with up to 500Mbps aggregated throughput using only 50MHz, up to 1million pps processing power, latency around 2ms. Supports Jumbo Frames. Ideal for Public Safety since it operates in 4.7-4.9GHz band.
- **airFiber11FX+Antenna:** 11GHz Licensed band. Ideal for high-performance links with up to 1.3Gbps aggregated throughput (680Mbps Full-Duplex), up to 1million pps processing power, latency below 1ms. Supports Jumbo Frames. Licensed band

<https://help.ui.com/hc/en-us/articles/205197750-airMAX-Which-product-should-I-use->

## Escolha de Equipamentos

Point-to-Multipoint (PtMP) Links



### Low Capacity and Short distance Base Stations



**User Tip:** These are ideal for starters in areas with low interference.

- [Rocket M](#) + [airMAX OMNI antenna](#): up to 60+ concurrent stations when all devices are airMAX capable. Highly susceptible to interference and recommended only for very rural areas. (Only M clients can connect.)

### High Capacity & High-Performance Base Stations

- [Rocket 5AC PRISM G1/G2](#) + [airMAX AC Sector Antenna](#): Carrier-grade system for highest performance Base Stations. Eight 45° antennas for 360° coverage. Takes advantage of the airPRISM technology which significantly reduces co-adjacent noise.
- [Rocket 5AC Lite](#) + [Titanium Sector Antennas](#): High-performance solution for medium-high density areas. Variable beamwidth (60-120°) antennas for scalable growth. Uses latest airMAX AC technology.
- [LiteAP AC](#): Ultra-lightweight airMAX AC sector + radio with incredible performance and disruptive pricing. 120° coverage.
- [IsoStation 5AC](#): High isolation horn sector. Ideal for hi-density urban deployments or micro-POPs. Comes with 45°/15dBi horn sector w/ options 30°, 60° and 90° horn sector.
- [PRISMStation 5AC](#): High isolation horn w/ active PRISM RF Filtering and GPS allow for improved co-location, noise rejection and up to 500Mbps.

### Customer Premise Equipment (CPE)

#### Short distance (0-3 km)

- [NanoBeam 5AC-G2](#): Slightly greater range than the NanoBeam 5AC-19 M and more directive

#### Medium distance (3-7 km)

- [LiteBeam 5AC-23-G2](#): Low-cost CPE, very narrow beamwidth, and MIMO technology. It's the new industry-standard for airMAX AC CPEs.
- [PowerBeam 5AC-G2](#): Highly directive CPE, better range and lower noise.

#### Long distance (7+ km)

- [PowerBeam 5AC-500/620](#): Higher power device, super directive antenna, better range and lower noise, aesthetically pleasing compared to bulky dishes.
- [Rocket 5AC-Lite](#) + [RocketDish LW](#): Best performing option, higher cost than integrated designs, can be unsightly as a CPE and supports [IsoBeam](#) accessory for better isolation, which comes with RF chokes.

---

## Faixas de Frequência

FCC

CE

## Outdoor License Free Bands



## 900MHz (M900) - Advantages & Disadvantages

- ✓ Better tolerance for trees and small obstacles vs. higher frequencies.
- ✗ Usually higher noise levels
- ✗ Only 26MHz bandwidth
- ✗ Not unlicensed worldwide

## 2.4GHz (M2) - Advantages & Disadvantages

- ✓ Worldwide unlicensed
- ✗ Only three non-overlapping 20MHz channels (1, 6, 11)
- ✗ It's a very crowded band; there's a lot of interference from cordless phones, SOHO Wireless Router, other WISPs, etc...
- ✗ 40MHz channels not recommended



## 3.x GHz (M3-M365) - Advantages & Disadvantages

- ✓ 300MHz bandwidth in countries where 3.4-3.7GHz band is available
- ✓ Noise-free in most areas
- ✗ Only 25MHz bandwidth in countries where 3.65GHz can be used
- ✗ Requires license

## 5 GHz (5AC/AF5/AF5X) - Advantages & Disadvantages

- ✓ Worldwide unlicensed
  - ✓ Higher EIRP limits allow higher gain antennas, and long distance links
  - ✓ Large amounts of spectrum available, easier to co-locate nearby devices
  - ✗ Weaker propagation vs. lower frequencies when obstacles are present (trees, walls, etc.)
-

## 10 GHz (M10) - Advantages & Disadvantages

- ✓ Noise-free in most cases, very useful when the 5.8GHz band is crowded.
- ✓ Very small Fresnel zone
- ✗ Only available in a few areas
- ✗ Licensed band
- ✗ Requires perfectly clear Line of Sight

## 11 GHz (AF11FX) - Advantages & Disadvantages

- ✓ Noise-free in most cases, very useful when the 5.8GHz band is crowded.
- ✓ Very small Fresnel zone
- ✗ Only available in a few areas
- ✗ Licensed band
- ✗ Requires perfectly clear Line of Sight

---

Antenas

---

- **Yagi:** Directive, used for PTP and CPE applications. Frequently used in low frequencies, such as 900MHz, due to size
- **Grid:** Directive, used for PTP and CPE applications. Great wind-loading properties. However, this type only works in one polarity (1x1), so lower performance than 2x2 antennas (Dish, Panel, etc.)
- **Panel:** Directive, used for PTP and CPE applications. Compact design is very attractive in situations where dishes are not preferred.
- **Dish:** Most Directive, highest performing airMAX antennas for PTP applications. Usually larger and heavier.
- **Omni:** Provides 360 degrees of horizontal coverage (omni-directional). Ideal for low capacity and wide-coverage AP / Base Station applications)
- **Sector:** Ideal choice for high performance Base Stations. Offer higher gain and directivity than omnidirectional antennas. Usually offered in 45, 60, 90, or 120 degree options.