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The bridge to possible

8 Tips for Deploying Indoor Wireless Mobility

with Cisco Industrial Wireless

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BRKIOT-2601

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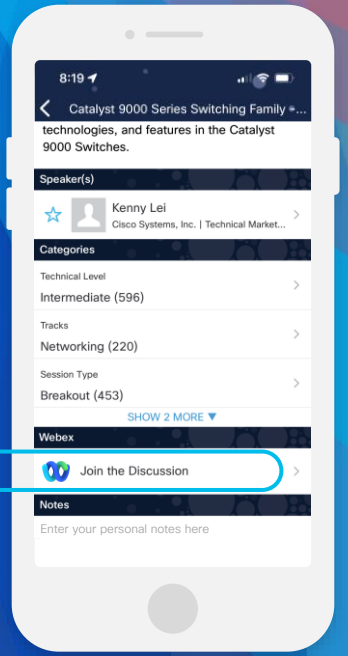
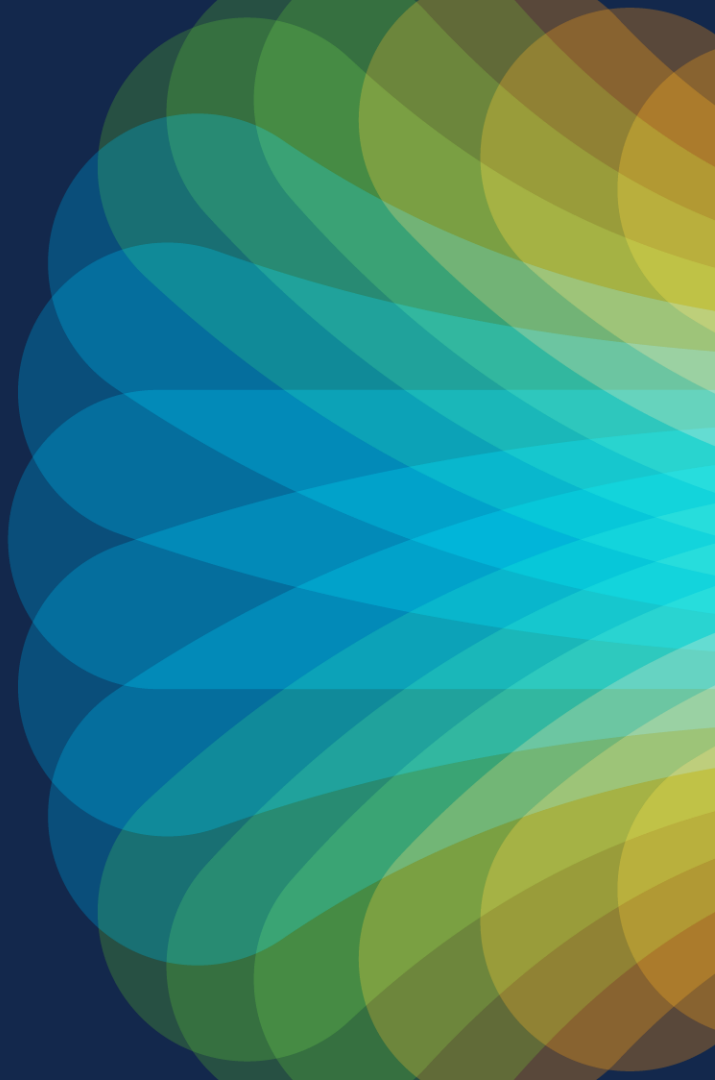


https://ciscolive.ciscoevents.com/ciscolivebot/#BRKIOT-2601

Agenda

- Introduction
- Analyzing the application
- Choosing the technology
- Choosing hardware
- Spectrum, Antennas, and more
- Commissioning, tuning, and troubleshooting
- (avoid the) Concussion

Introduction



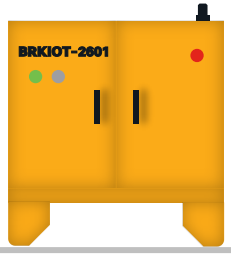
What is...
Industrial Wireless?

- 802.11 based technologies
  - n, ac, and ax products
- WiFi and Cisco Ultra-Reliable Wireless Backhaul (Cisco URWB)

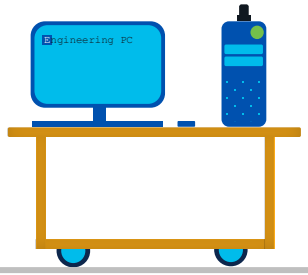
What is Mobility?

- Wireless use cases in industry can generally be categorized as:
  - Fixed
  - Portable
  - Moving – this is what we will focus on

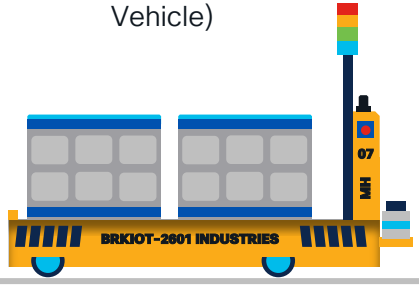
Industrial Control Cabinet



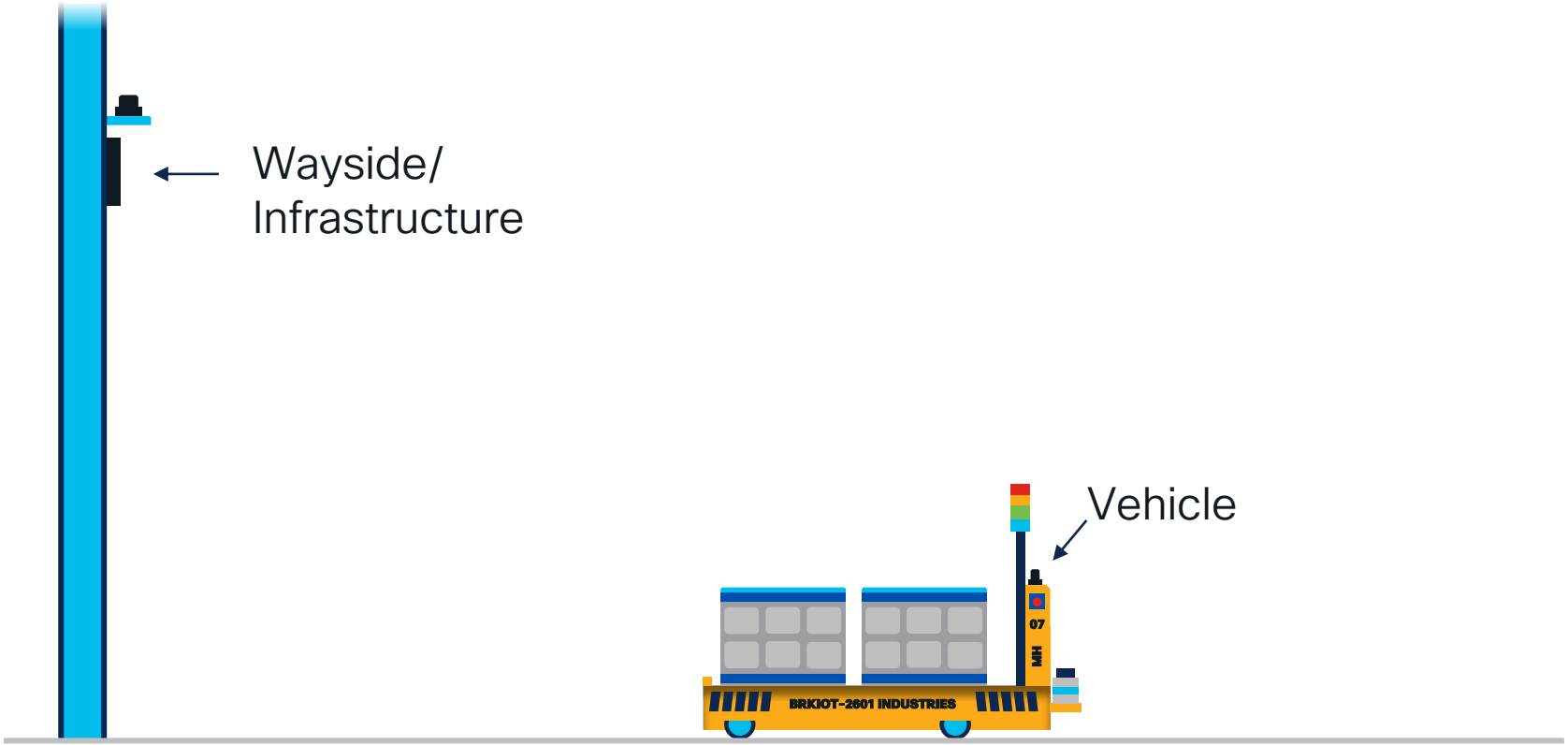
Engineering PC on cart



AGV (Automated Guided Vehicle)

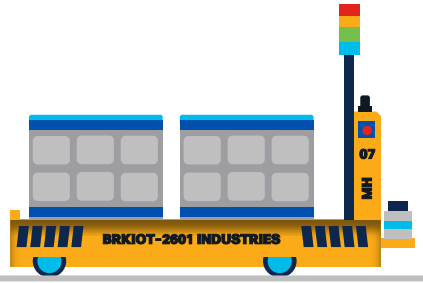


Moving Mobility Nomenclature



Moving Mobility Use Cases (Indoor)

- Automated Guided Vehicles / Autonomous Mobile Robots
- Moving Machinery
- Overhead Cranes
- Forklifts / Material Handlers (human operated)

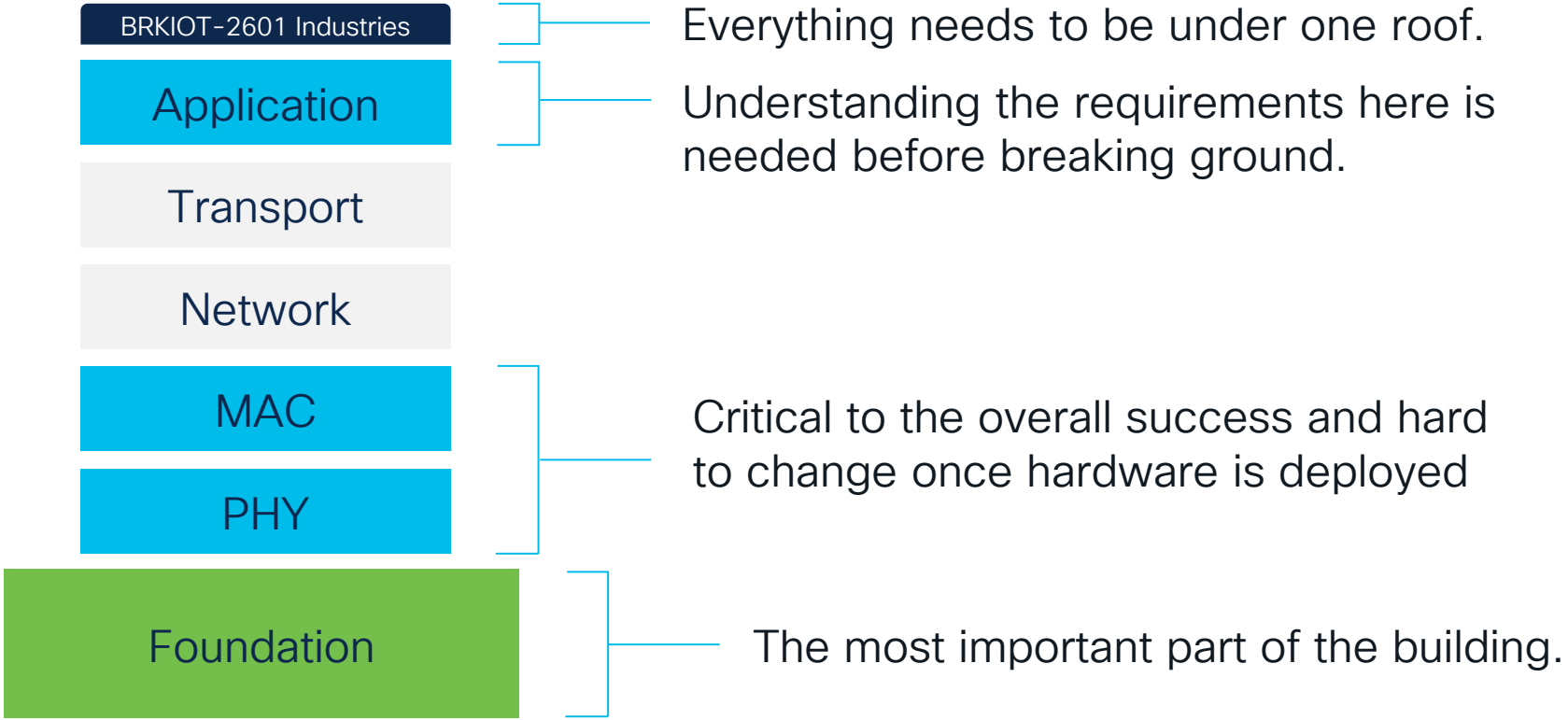


Why is indoor mobility for industry different?

- Complex RF environments
- Needs to be highly reliable

- Targeted for automation
- Wireless and automations system are co-dependent in many cases

Where do we start?



Tip #1
Understand the application

Genres of industrial control communication

- Deterministic
- Non-deterministic

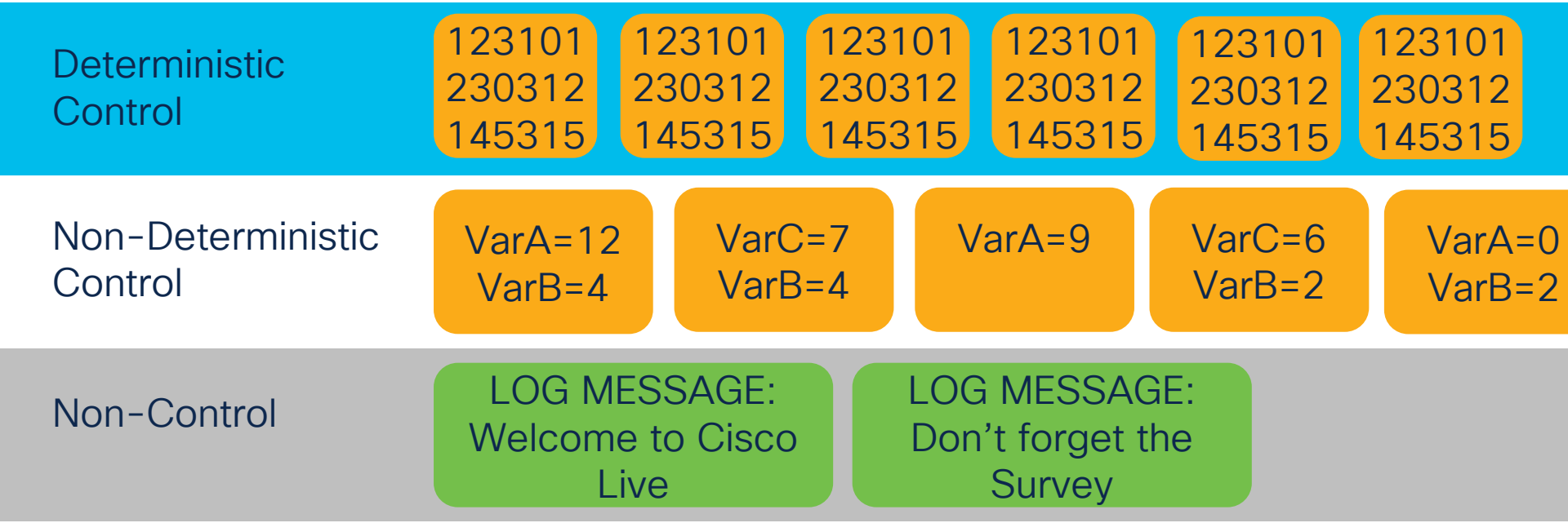
- Understanding the application communication thoroughly is critical

Tip #2

“It’s the network...”

“until proven innocent”

Types of Traffic



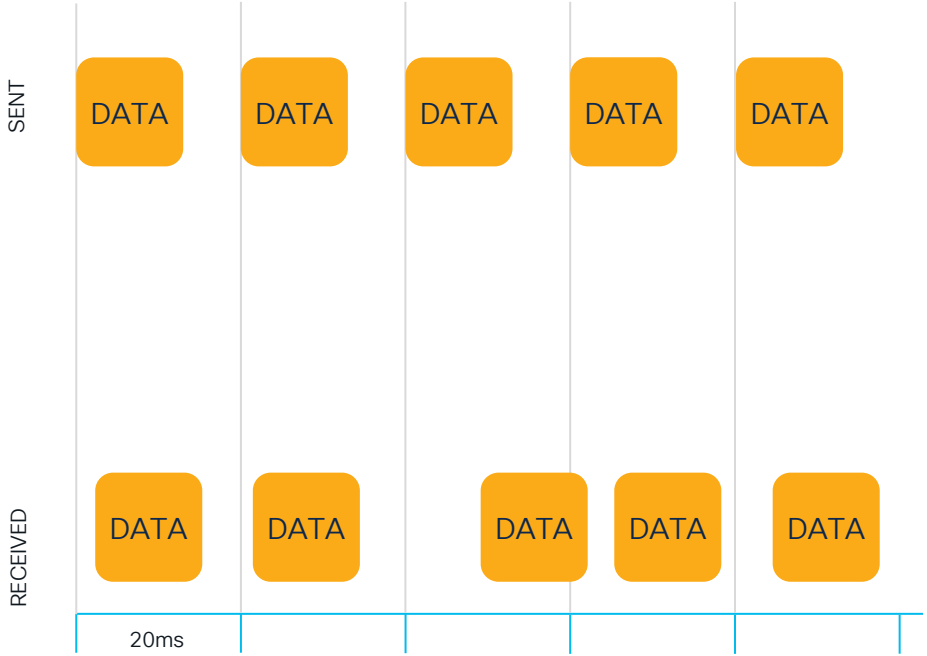
Deterministic communication

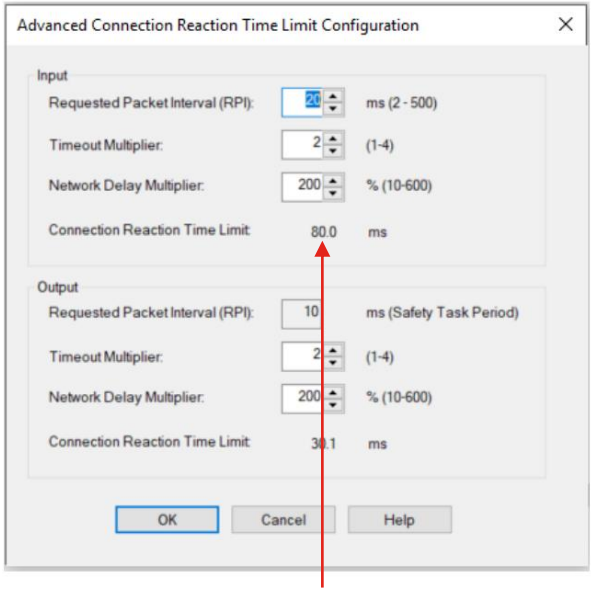
- Two most common:
  - Common Industrial Protocol (CIP) over Ethernet/IP – Rockwell
  - Profinet – Siemens
- Both are used for safety applications
- Latency over Delivery

CIP Safety Implicit Messaging

- Connection is established over TCP, data flows over UDP
- A new copy of data is sent at regular intervals (RPI)

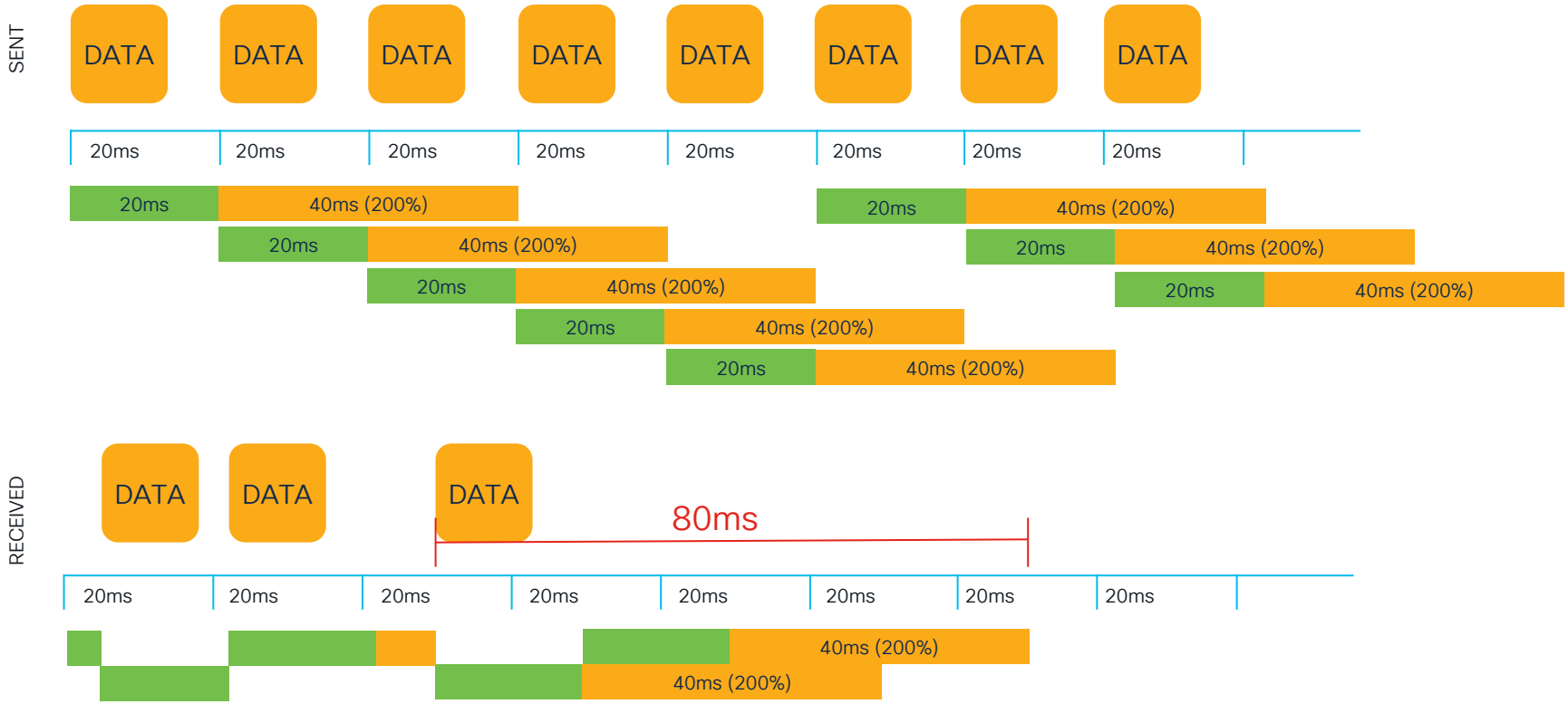
Timeouts can be tricky



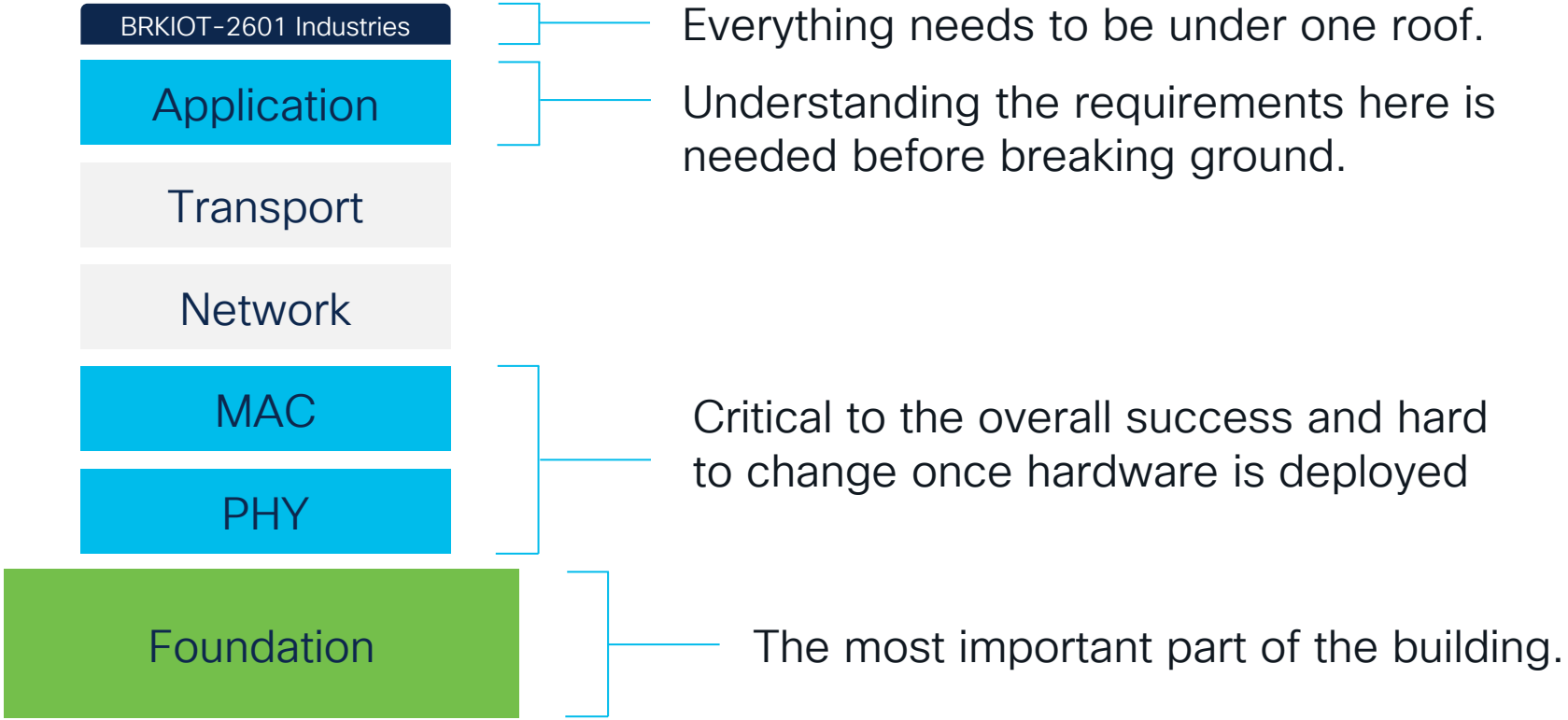


Studio 5000 gives 80.0ms for the Connection Reaction Time Limit (CRTL)

Timeouts can be tricky



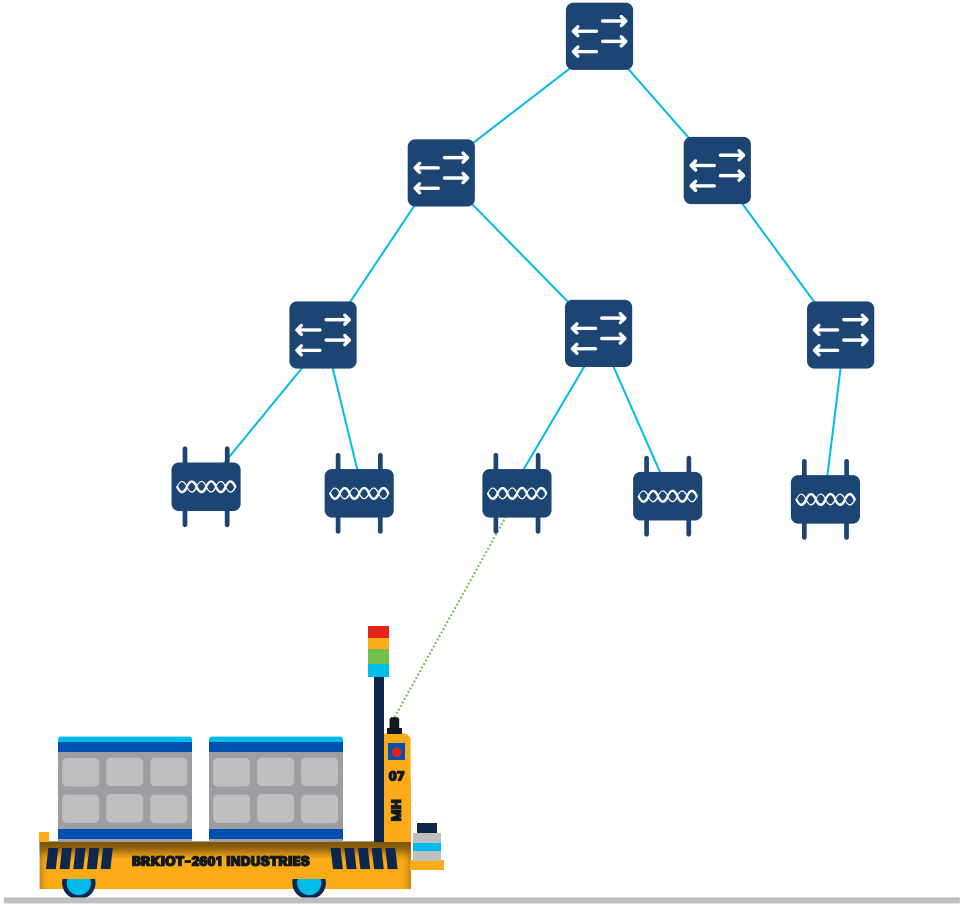
Where do we start?



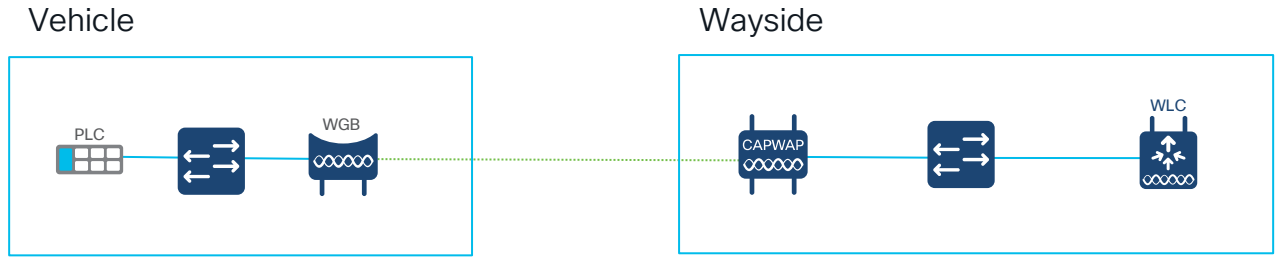
Tip #3
Choose the right technology

The layers of mobility

- Network
  - MAC (Layer 2)
  - IP Address (Layer 3)
- Wireless
- Roaming Challenges



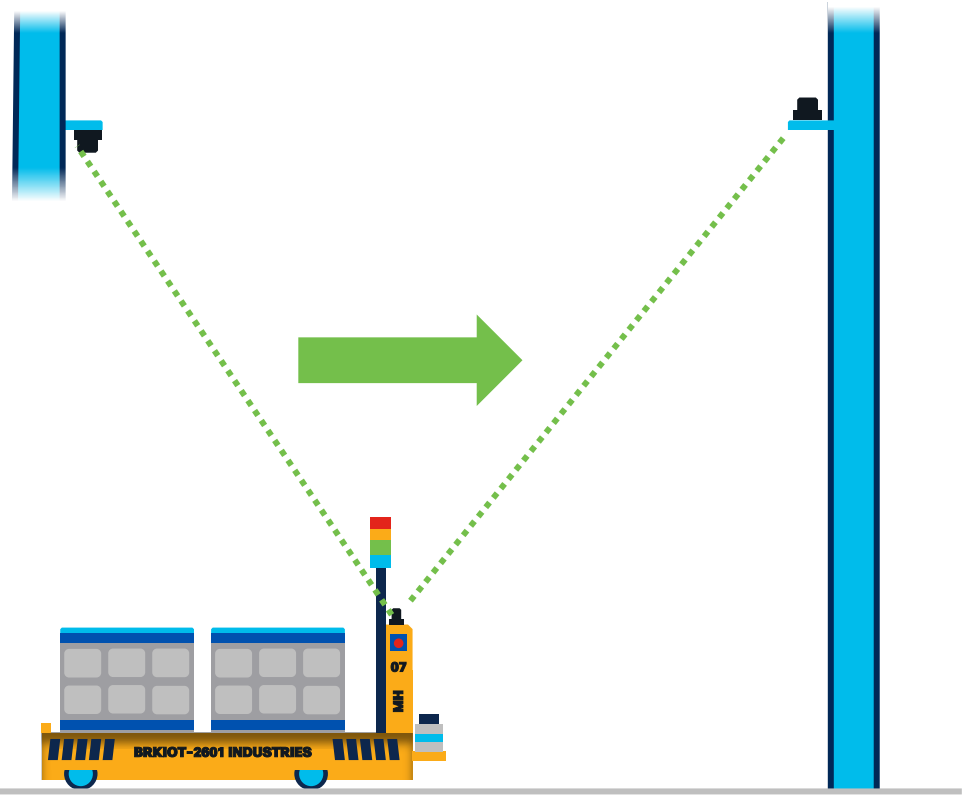
WiFi and Workgroup Bridge (WGB)



- WGB joins SSID on WLC. Wired clients behind
- WGB sends information about wired clients to WLC using IAPP
- Roaming is triggered based on RSSI or data rate

The challenges roaming presents

- Triggering and hysteresis (when to roam)
- Scanning (if needed)
- Authentication
  - PSK vs EAP
  - 802.11r helps, but…

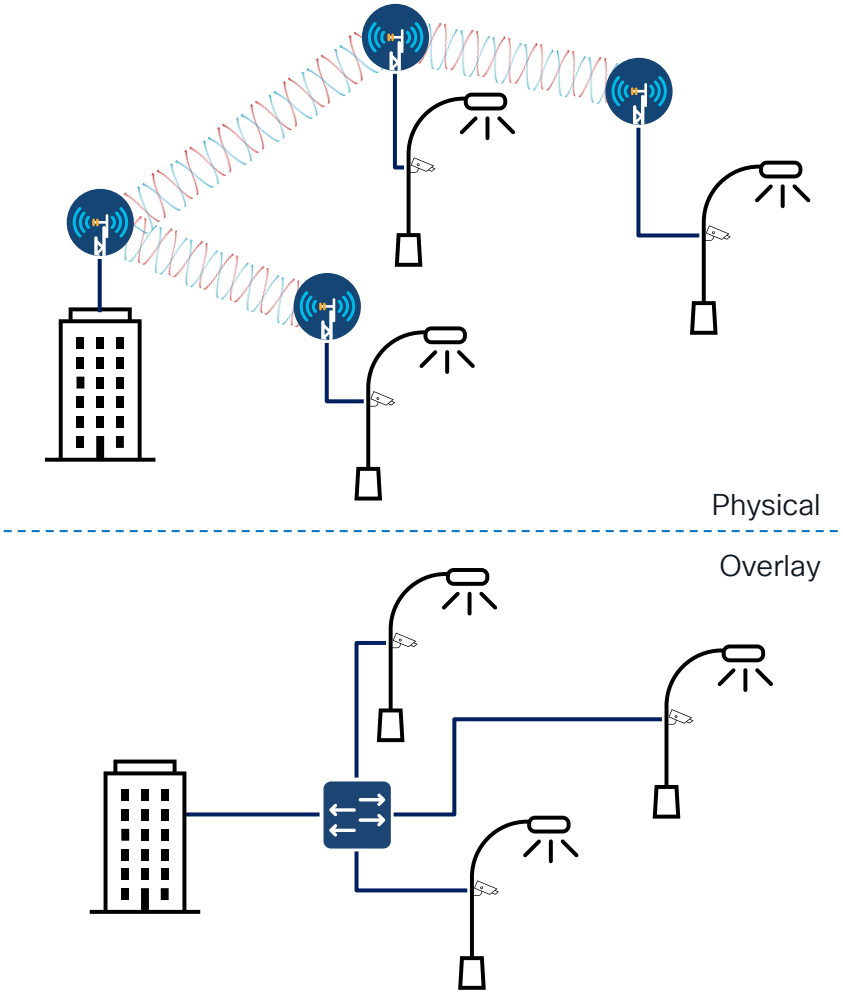


WGB Performance

- Performance – typically characterized by roaming time
- Roaming time is the end-end solution
- WGB
  - Roaming Decision Time
  - Scan time (avoided for SCA, minimized with scan list)
  - Association and Authentication (minimal with 802.11r, but can vary)
- Infrastructure plumbing time
  - Local mode – controller processing time
  - Flexconnect – L2 update times

What is Cisco URWB?

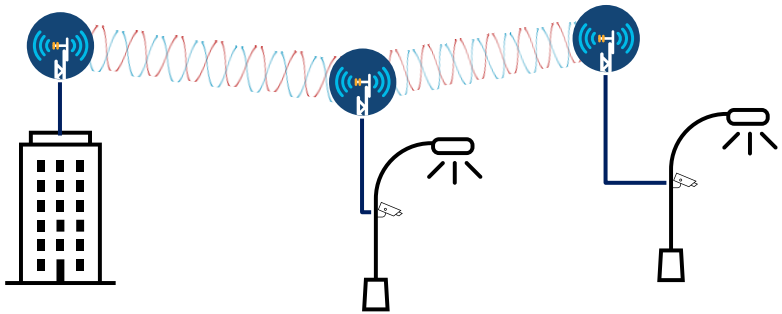
- Cisco UWRB is an overlay technology that emulates a virtual switch over wireless links
- Extends your network to fixed and mobile locations
- Supports VLANs and QoS
- Layer 2 switching or Layer 3 (for advanced mobility architectures)



Backhaul modes of operation

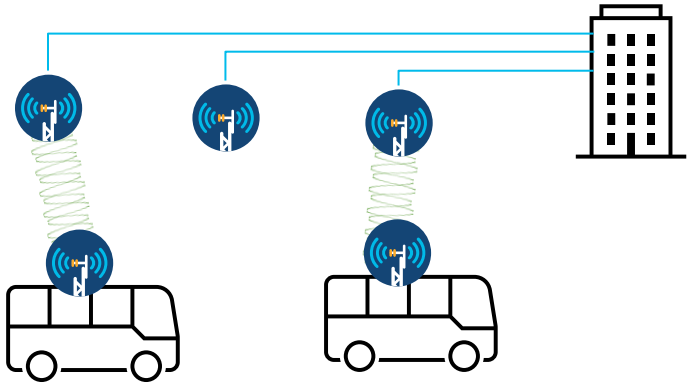
Fixed

Connect wired networks between static or nomadic locations

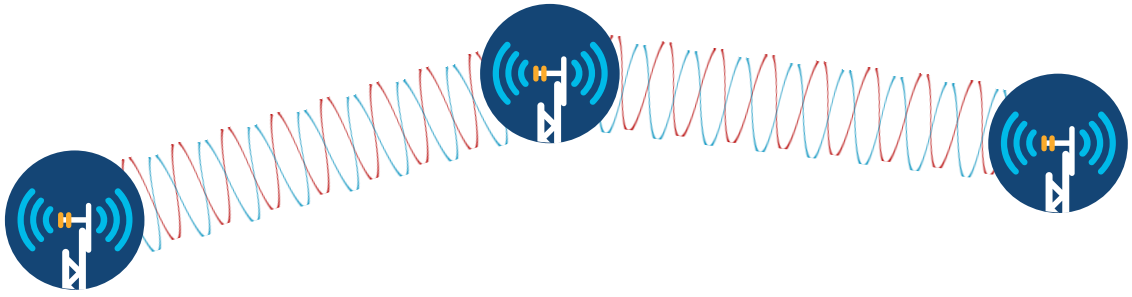


Mobility

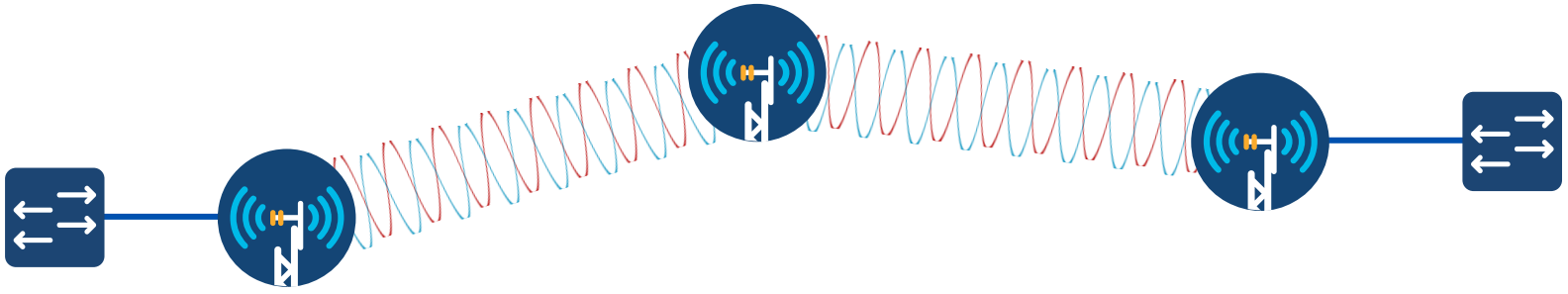
Extension of fixed functionality to optimize connectivity for mobile assets with predictive handoffs



URWB Wireless Links

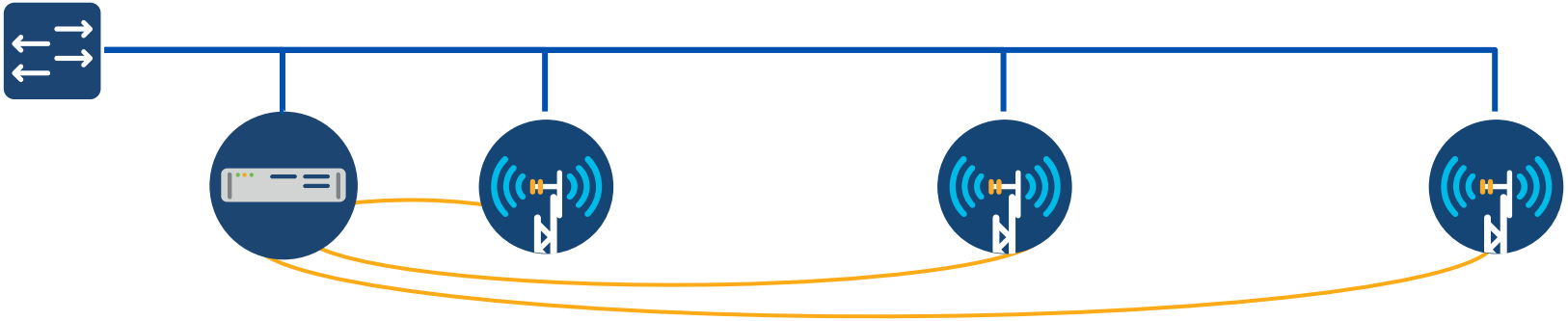


URWB Overlay

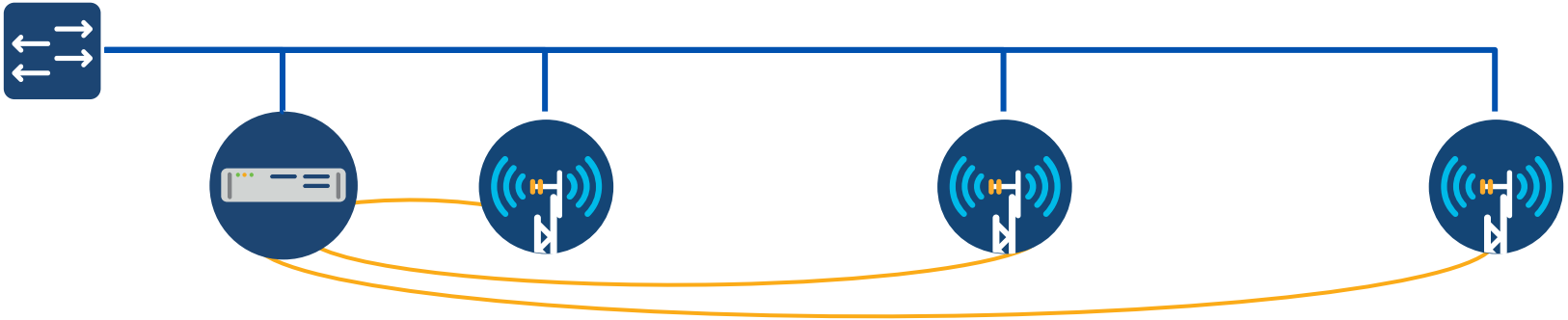


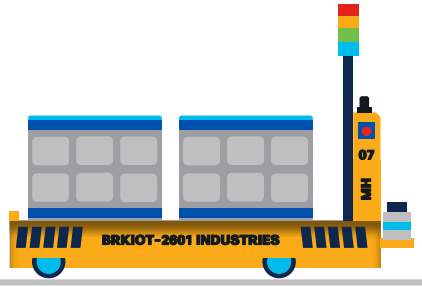
URWB Mobility

URWB Mobility

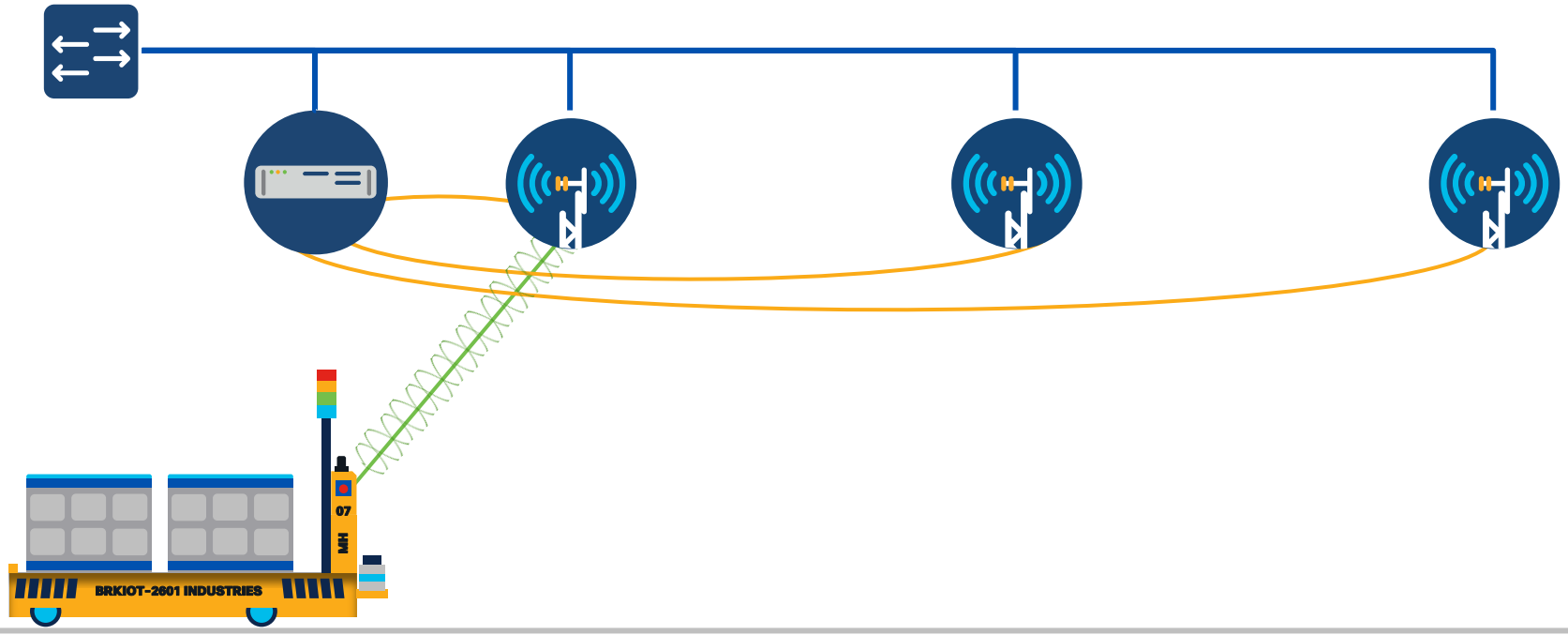


URWB Mobility

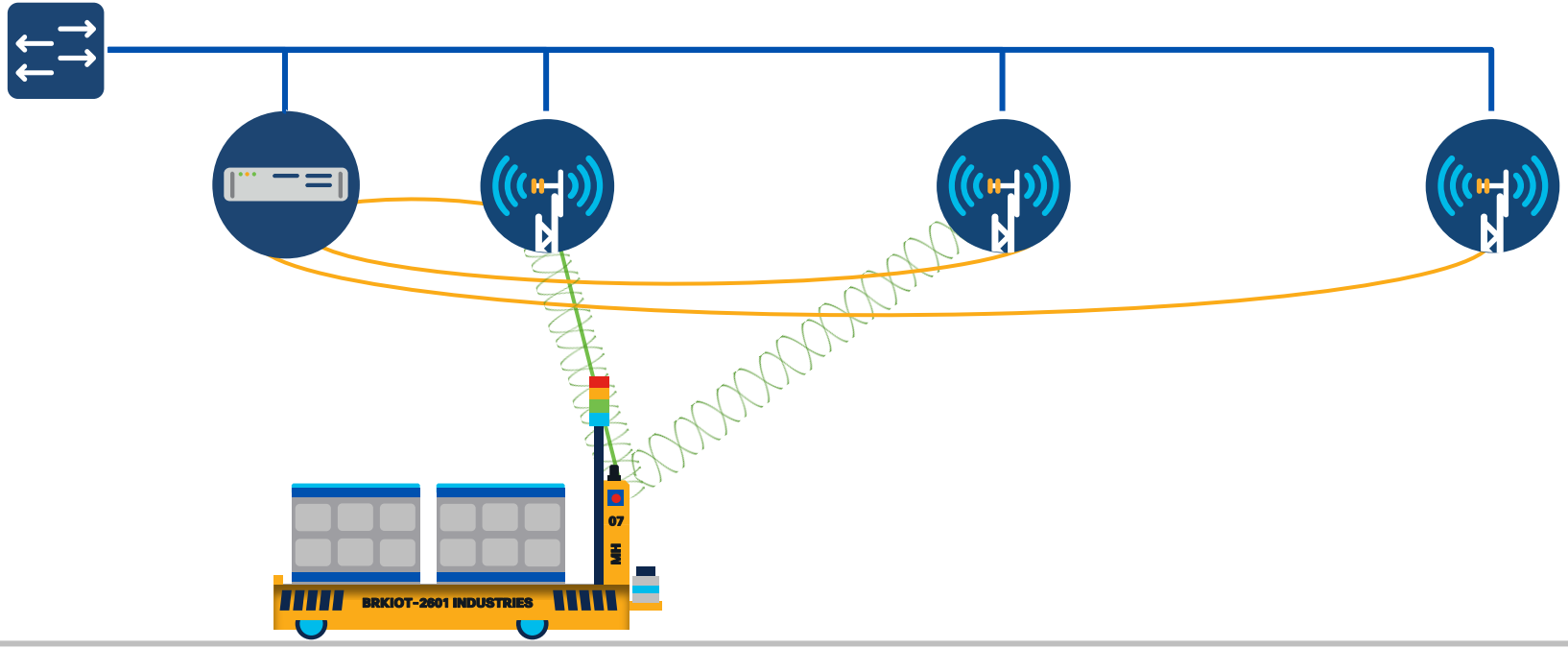




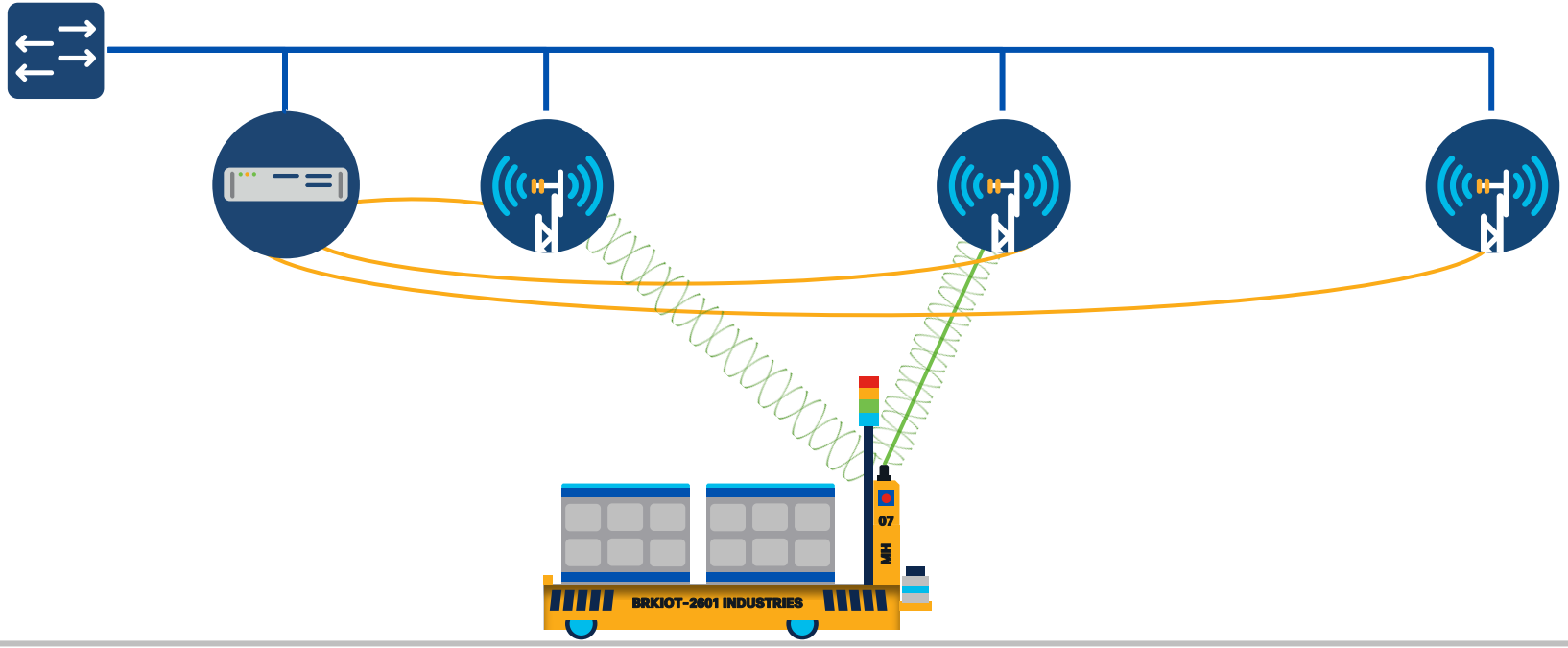
URWB Mobility



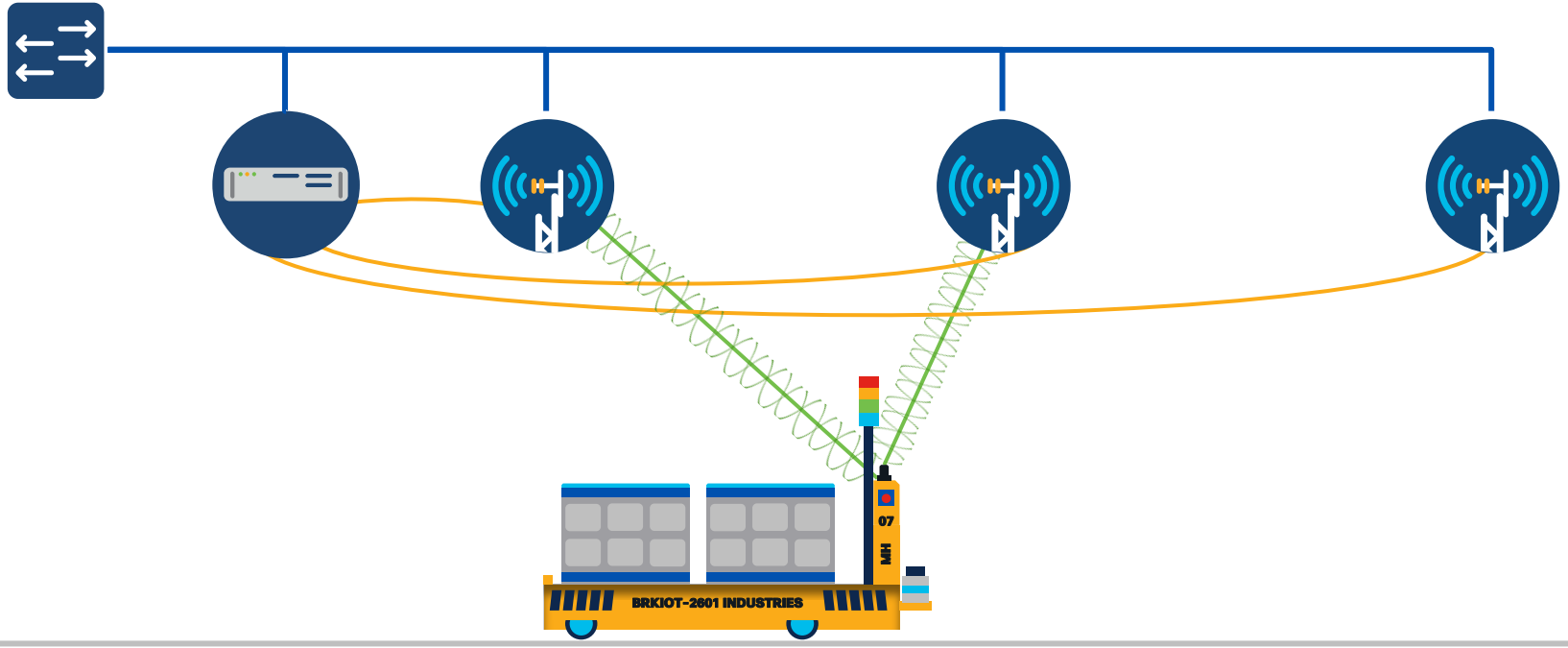
URWB Mobility



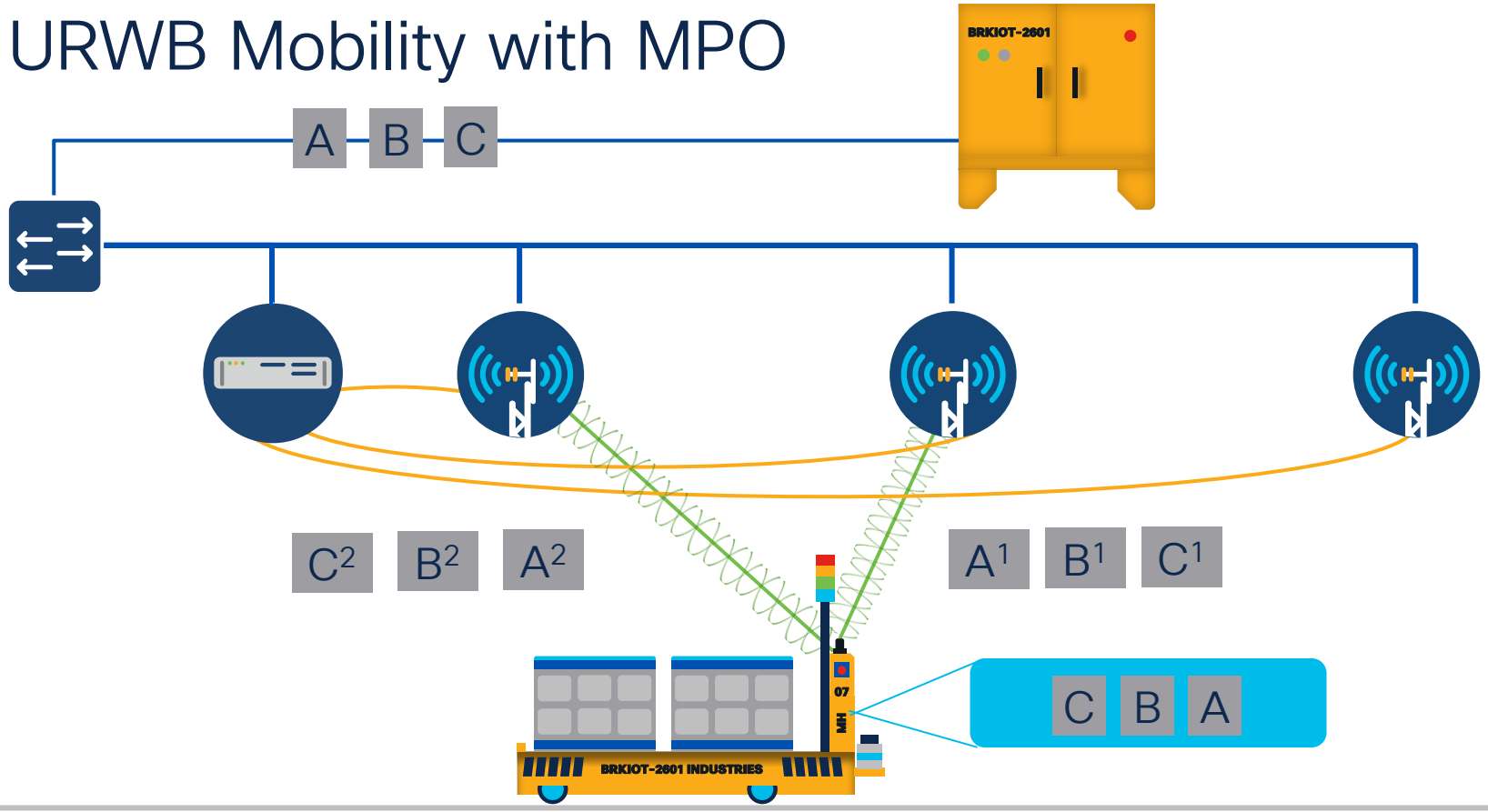
URWB Mobility



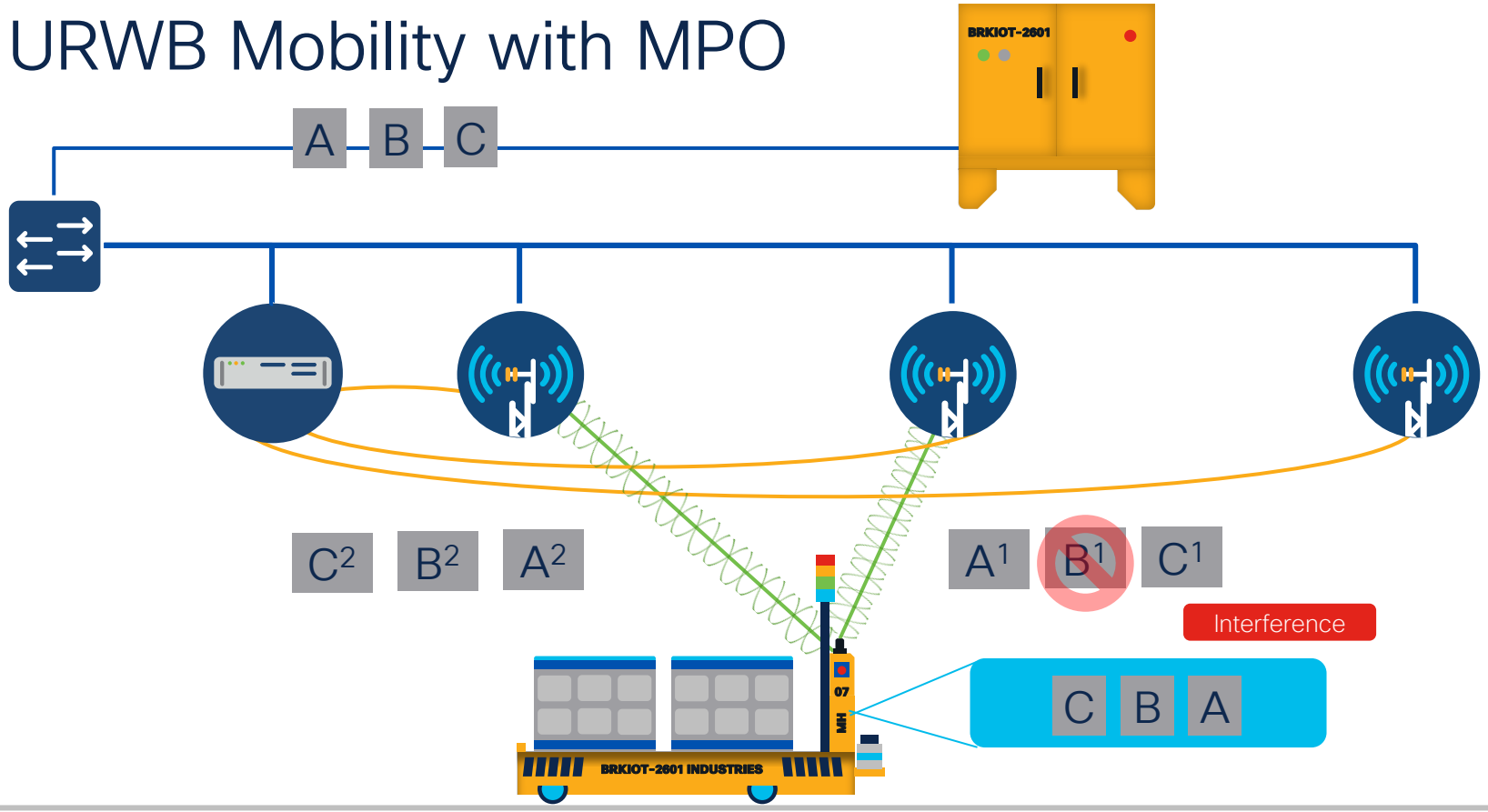
URWB Mobility



URWB Mobility with MPO

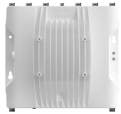


URWB Mobility with MPO



Tip #4
Choose the right Hardware

IW Family Overview for Indoor Mobility

	 IW9165E	 IW9167
Application	Wireless client for mobile assets	Wireless backhaul for fixed and mobile assets
Radio	2 x 802.11ax radios (5GHz, 5/6GHz)	3 x 802.11ax radios (2.4GHz, 5GHz, 5/6GHz)
Antenna	4 x RP-SMA	8 x N-Type (f)
Modulation	2x2 MIMO	4x4 MIMO
Wireless Mode	WGB or URWB	WiFi, WGB, URWB
Ethernet	1 x 2.5Gbps + 1 x 1Gbps RJ45 Optional M12 adapter	1 x 5Gbps RJ45 + 1 x SFP+ Optional M12 adapters
Expendability	BLE, GNSS, GPIO	BLE, GNSS
Certifications	IP30, EN50155 -20C to +50C	IP67, EN50155 -50C to +75C

IW9167E Heavy Duty vs IW9165E Rugged

Prototype devices pictured. Production device may vary.

WGB Selection for Mobility

IW3702
(IOS)

IW9165E
(AP-COS/UIW)

IW9167E
(AP-COS/UIW)

Cisco URWB Hardware Selection

IW9165E

IW9167E

The “k9c1” feature set

- “Unified Industrial Wireless” (UIW)
- Combines URWB and WGB†
- Boot time target <2 minutes

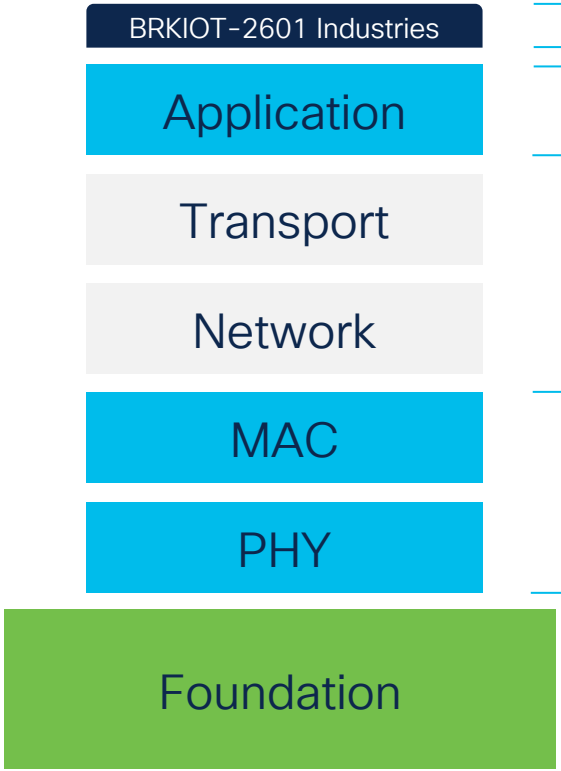
- Still based on AP-COS platform

Filename:
platform-featureset-tar.version.tar

FeatureSet	
k9c1	Unified Industrial Wireless URWB and/or WGB†
k9w8	Full lightweight IOS/AP-COS

† WGB available on IW9165 with IOS-XE / UIW release 17.13.1+

Where do we start?



Everything needs to be under one roof.

Understanding the requirements here is needed before breaking ground.

Critical to the overall success and hard to change once hardware is deployed

The most important part of the building.

Tips #5
Survey the Spectrum

The “foundation”

- RF is the part that hard to see

The “medium”

- Spectrum availability is the largest limiting factor
- Coordination, surveillance, and elimination

Tip #6
Antennas matter!

Propagation in indoor industrial environments

- Large spaces or small spaces, often tall or short
- Lots of reflective surfaces

- Usually not equal attenuation in walls, if present

- Multipath and fading play a major role in propagation paths

Fast-fading and moving clients

- Motion complicates the already complex propagation path

- 5 GHz radio waves are ~5.8cm long
- Every point in space can have a different propagation path and resultant signal

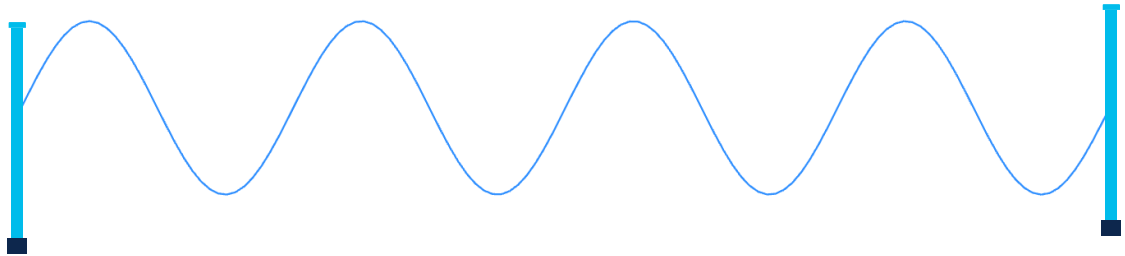
What role do antennas play?

- Antennas farther complication the equation (physics)

- Two major factors:
  - Antenna Polarization
  - Antenna Pattern

What is antenna polarization

Linear Polarized

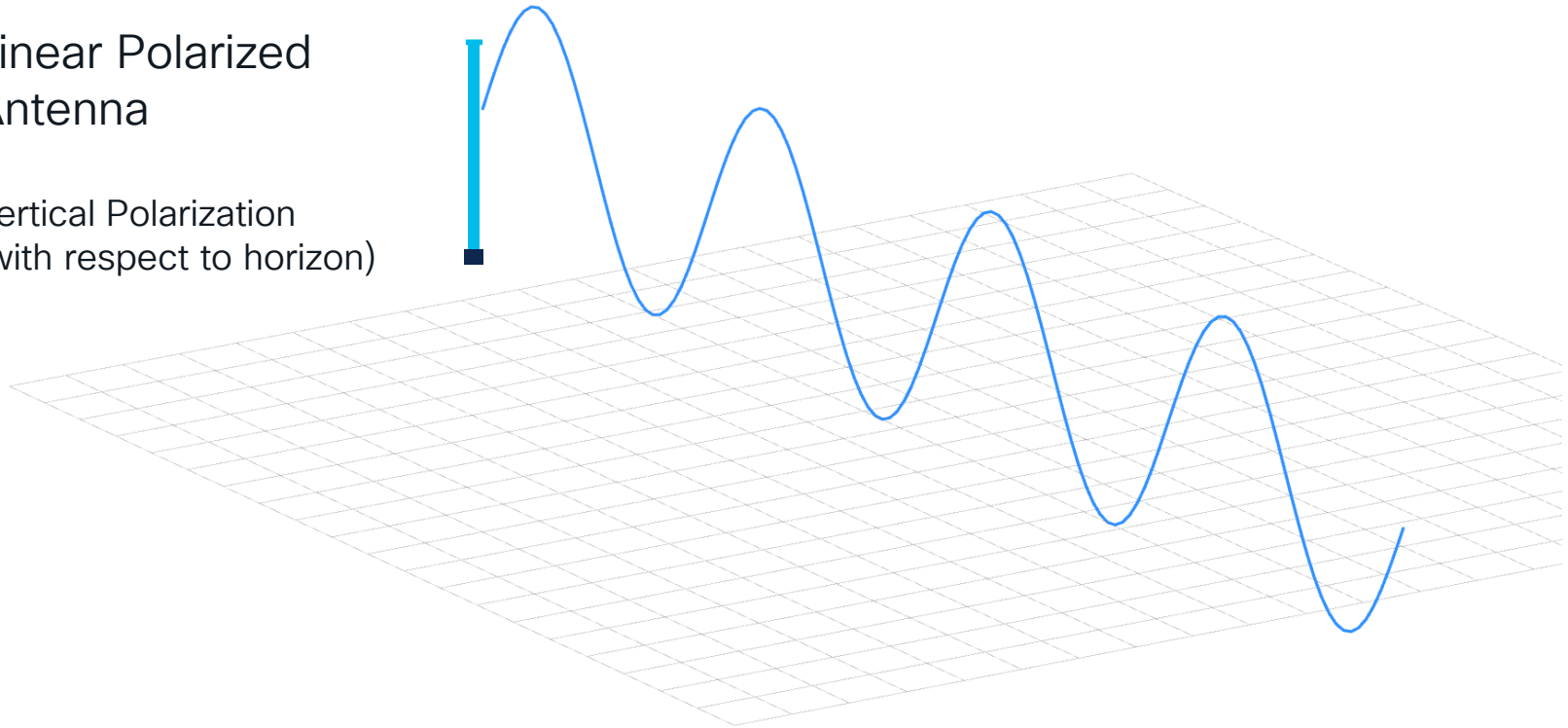


~ “direction of the electromagnetic fields produced by the antenna as energy radiates away from it”

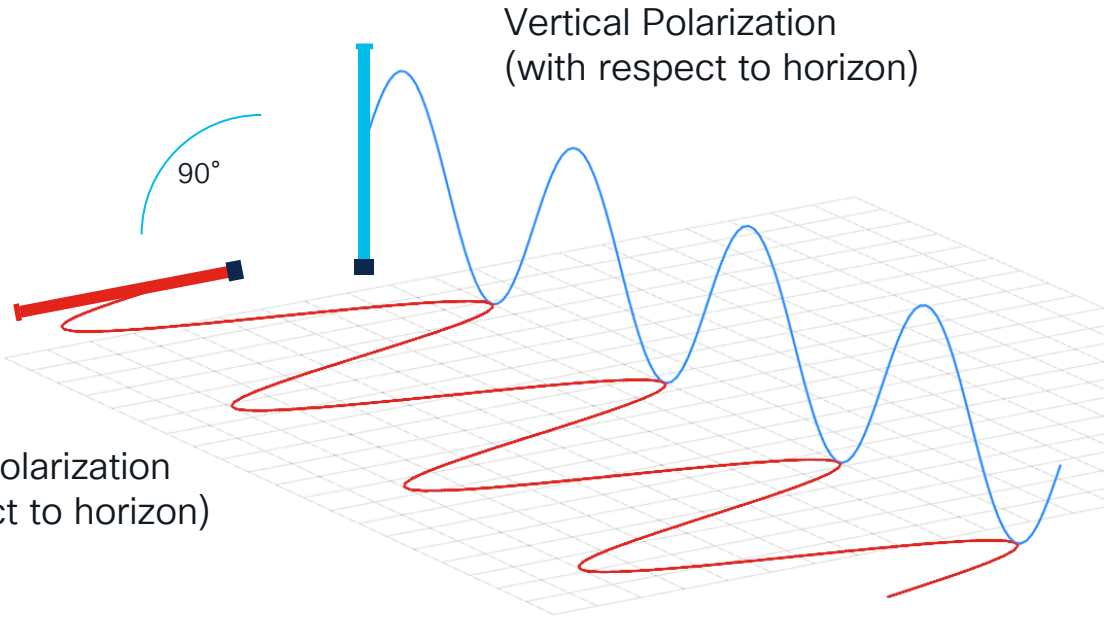
Antenna Polarization

Linear Polarized Antenna

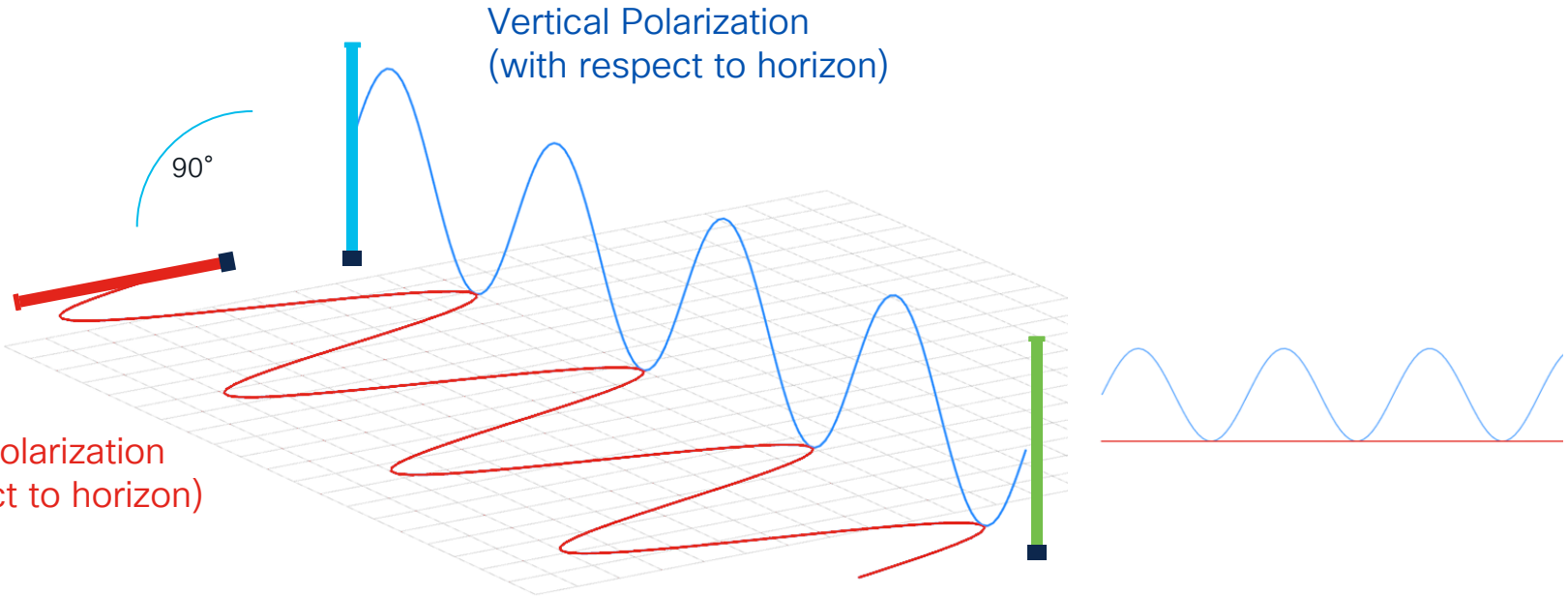
Vertical Polarization
(with respect to horizon)



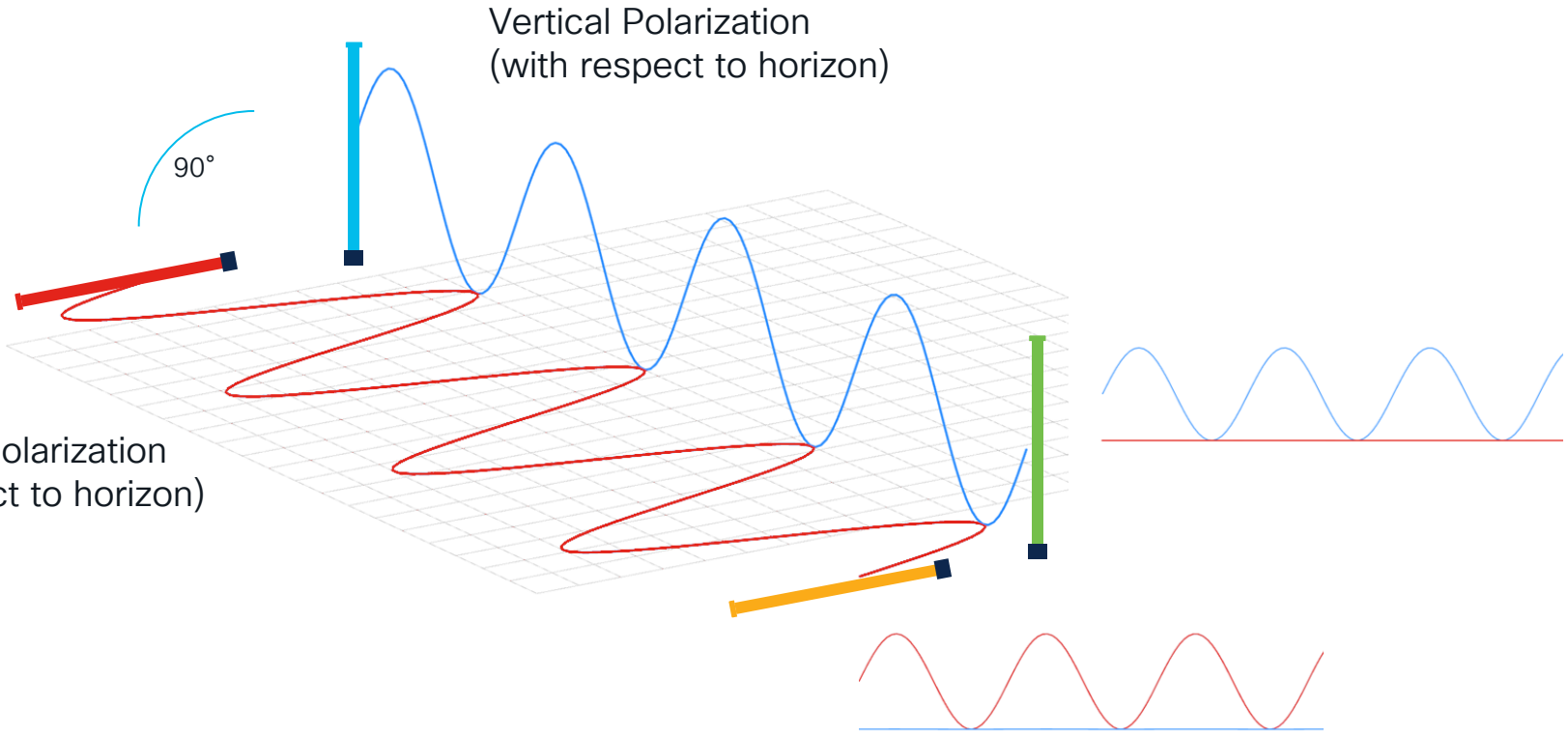
Antenna Polarization



Antenna Polarization

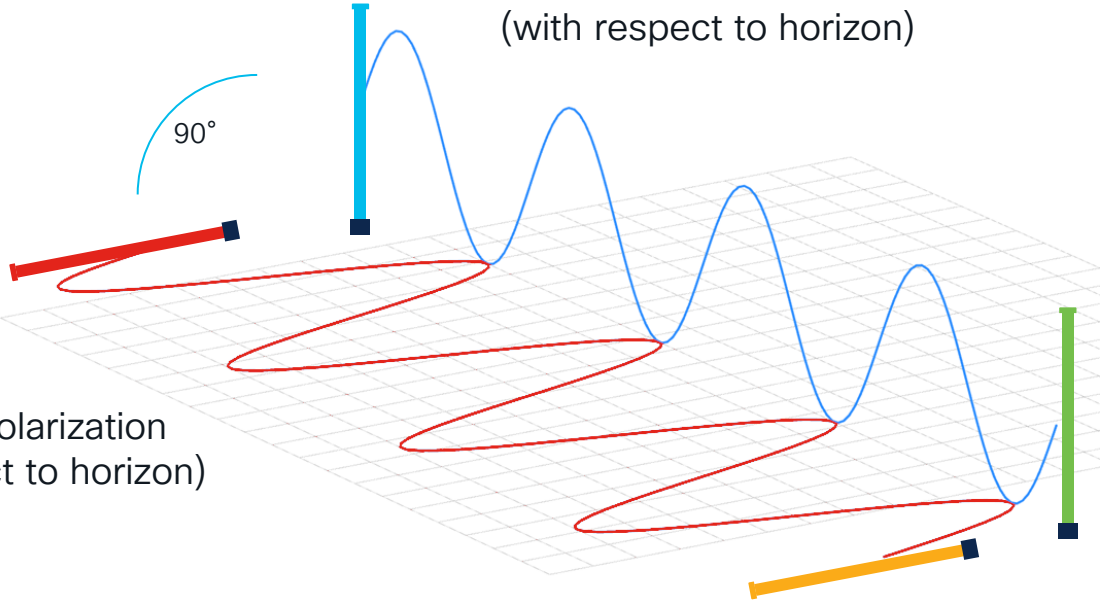


Antenna Polarization

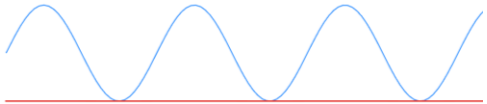


Antenna Polarization

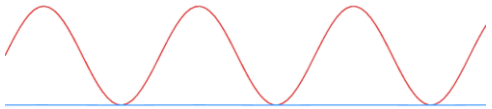
Vertical Polarization
(with respect to horizon)



orthogonal orientations:
∞ dB loss (theory)
20+ dB loss (practical)

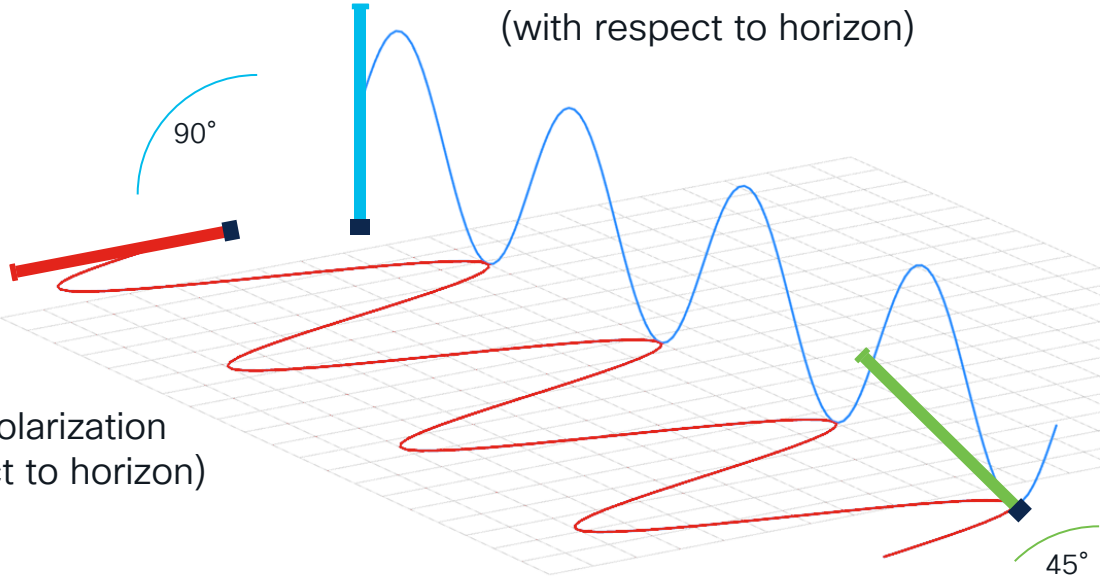


Horizontal Polarization
(with respect to horizon)



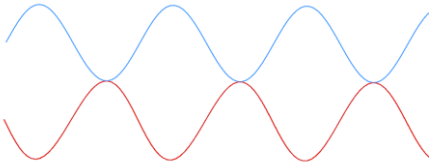
Antenna Polarization

Vertical Polarization
(with respect to horizon)



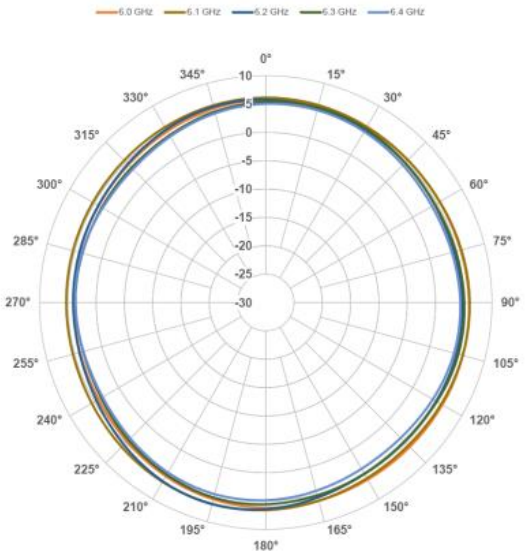
Horizontal Polarization
(with respect to horizon)

45° orientations:
3 dB loss

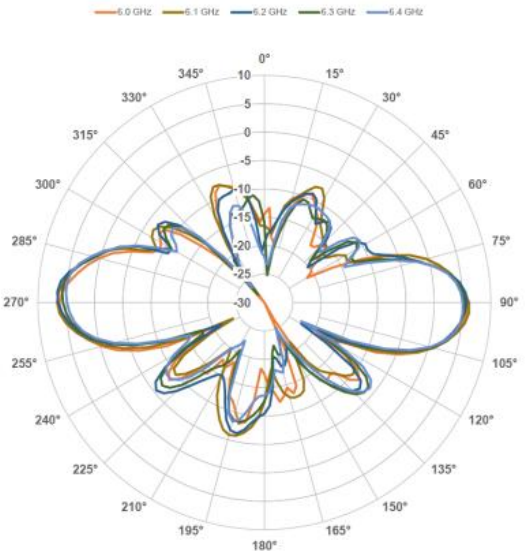


Why antenna patterns matter

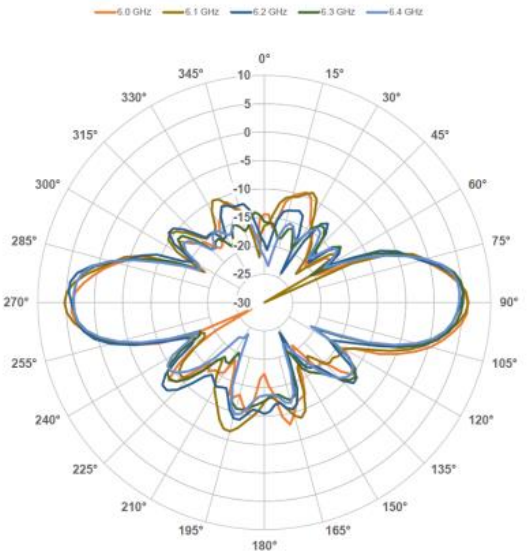
Azimuth Plane



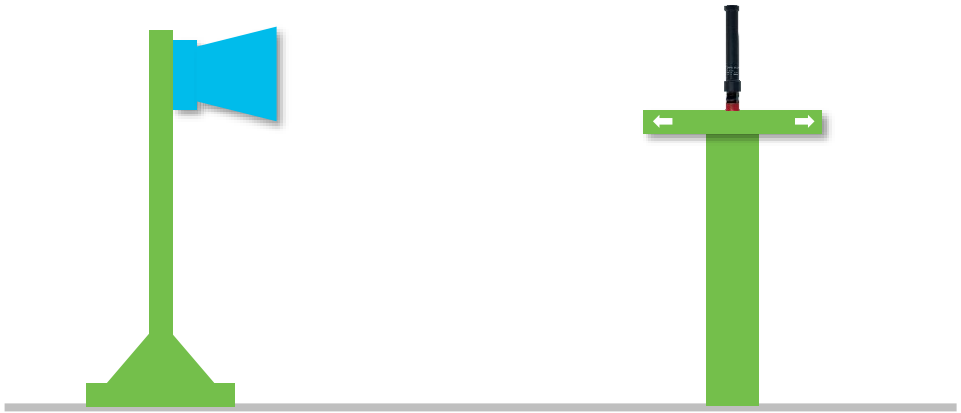
Phi 0° Plane

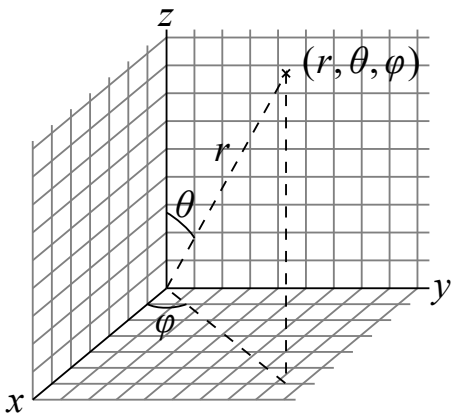


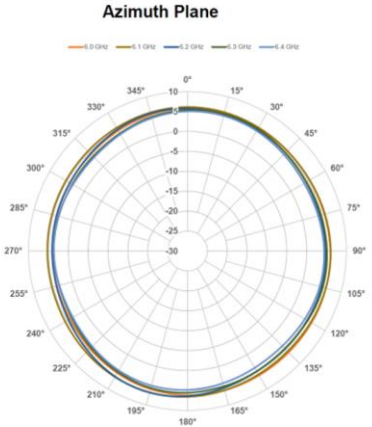
Phi 90° Plane



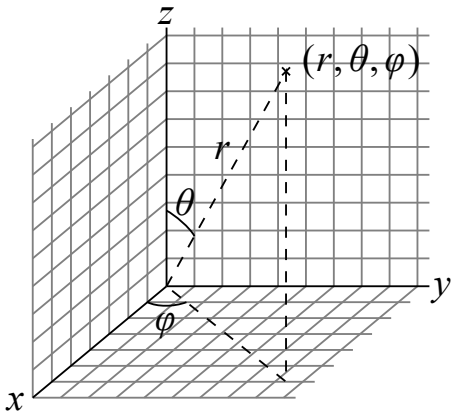
Antenna Patterns

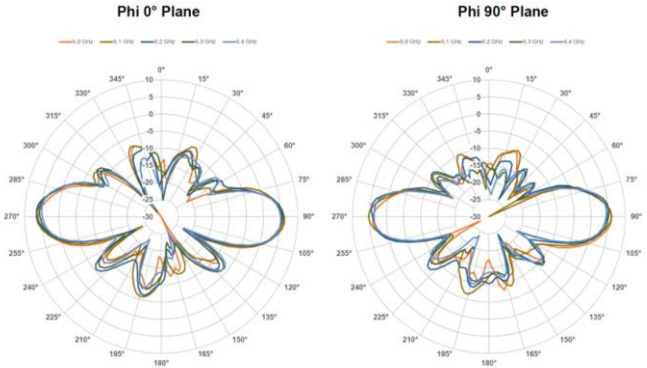




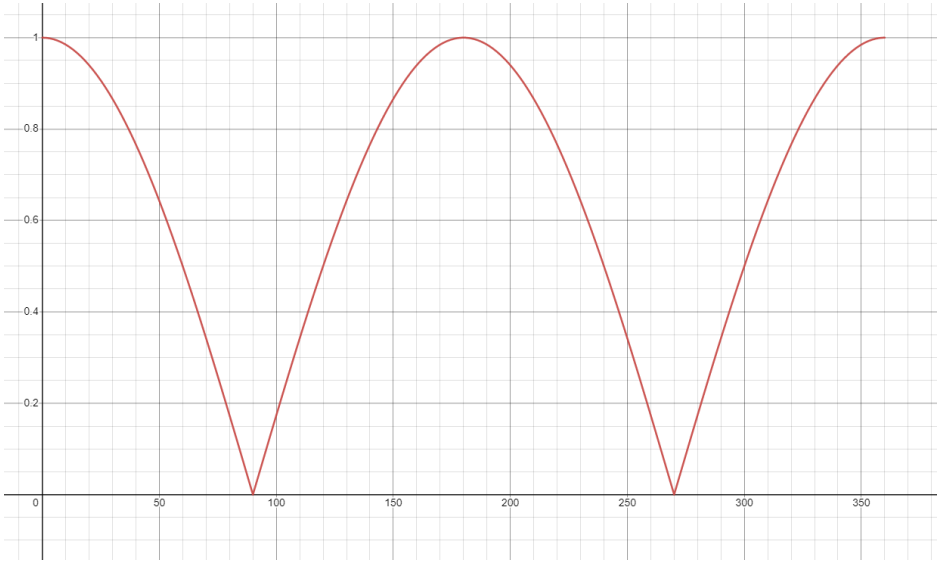


Antenna Patterns

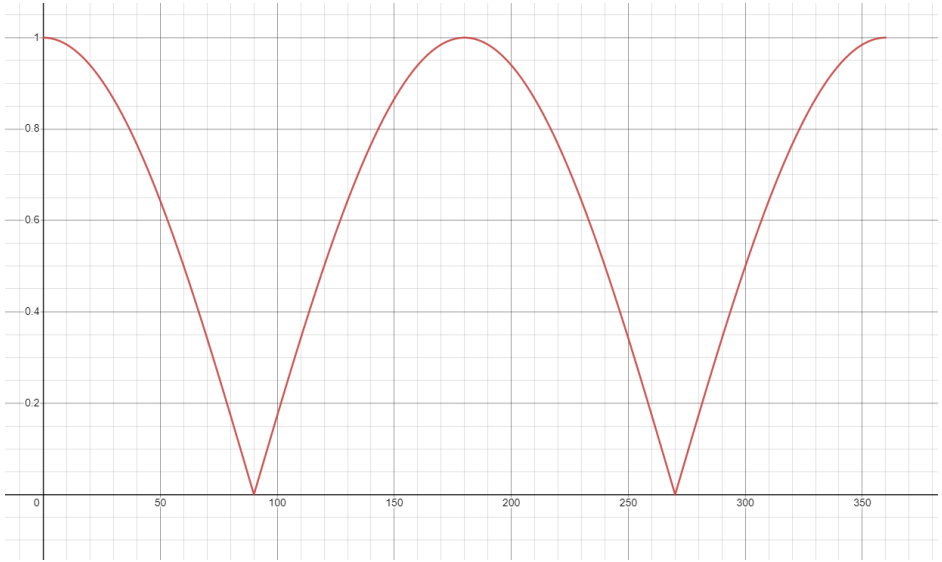


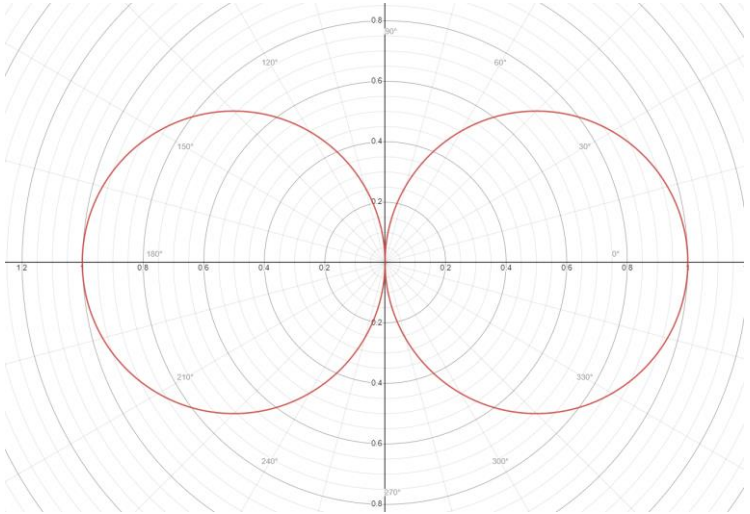


Polarization and Antenna Patterns

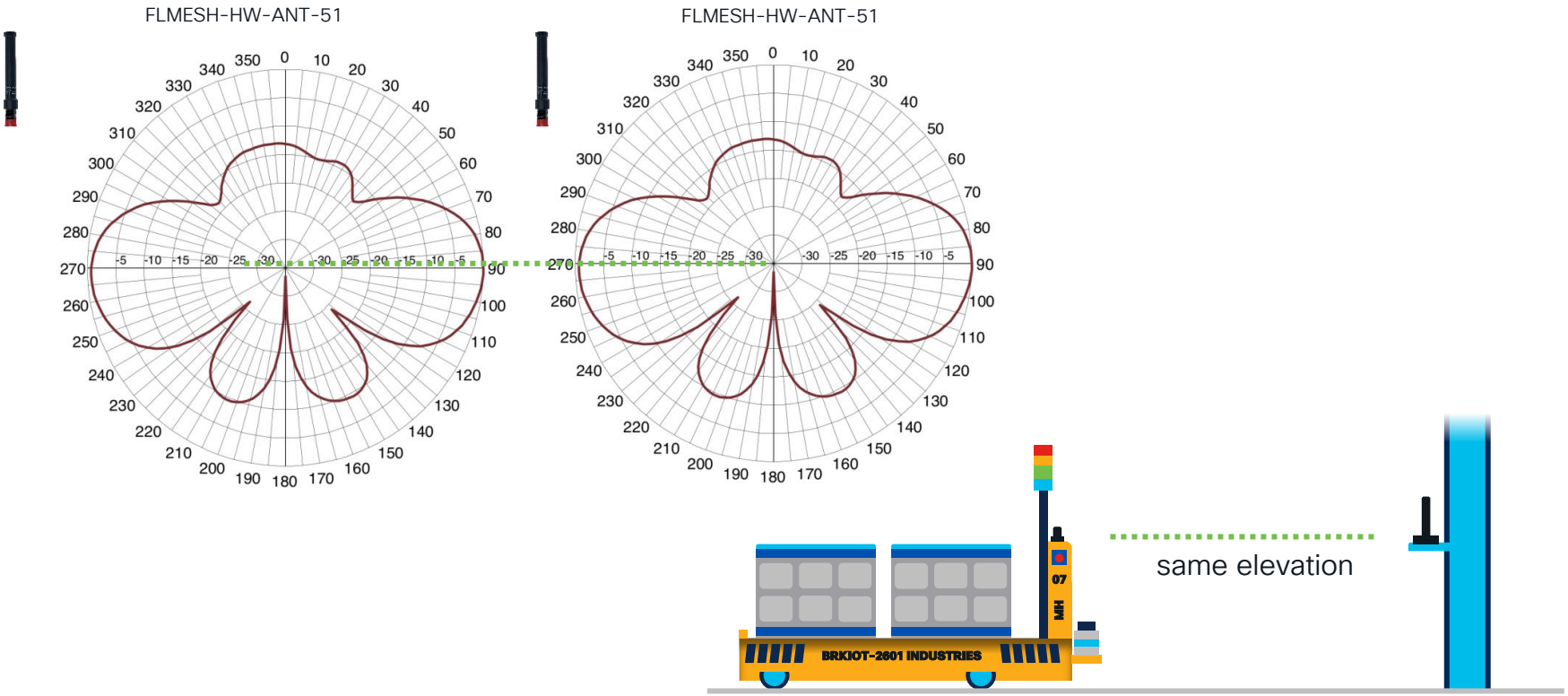


Polarization and Antenna Patterns



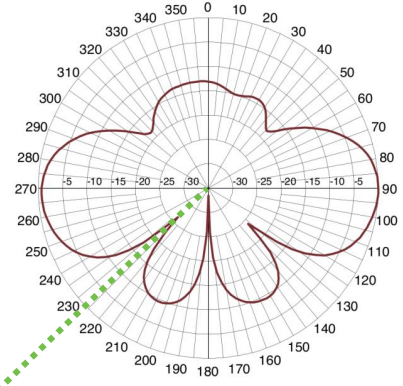


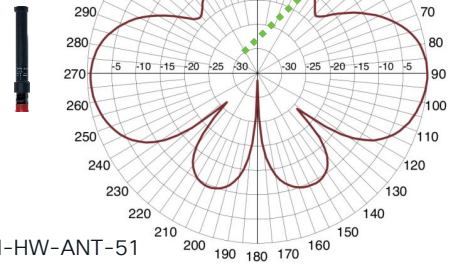
Wayside Antenna placement



Wayside Antenna placement

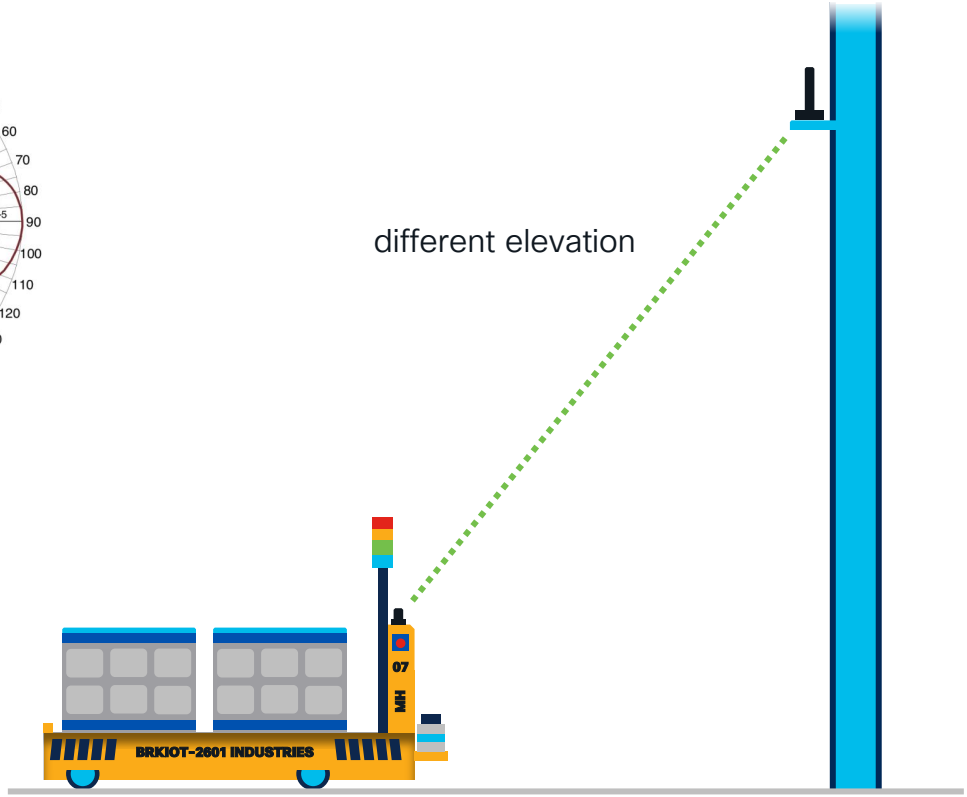
FLMESH-HW-ANT-51





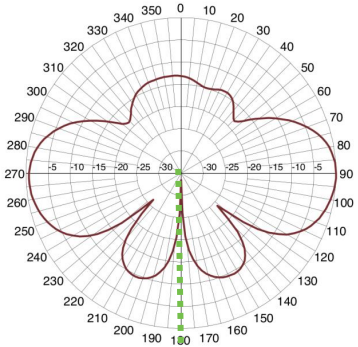
FLMESH-HW-ANT-51

different elevation

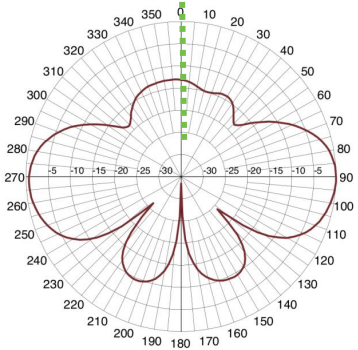


Wayside Antenna placement

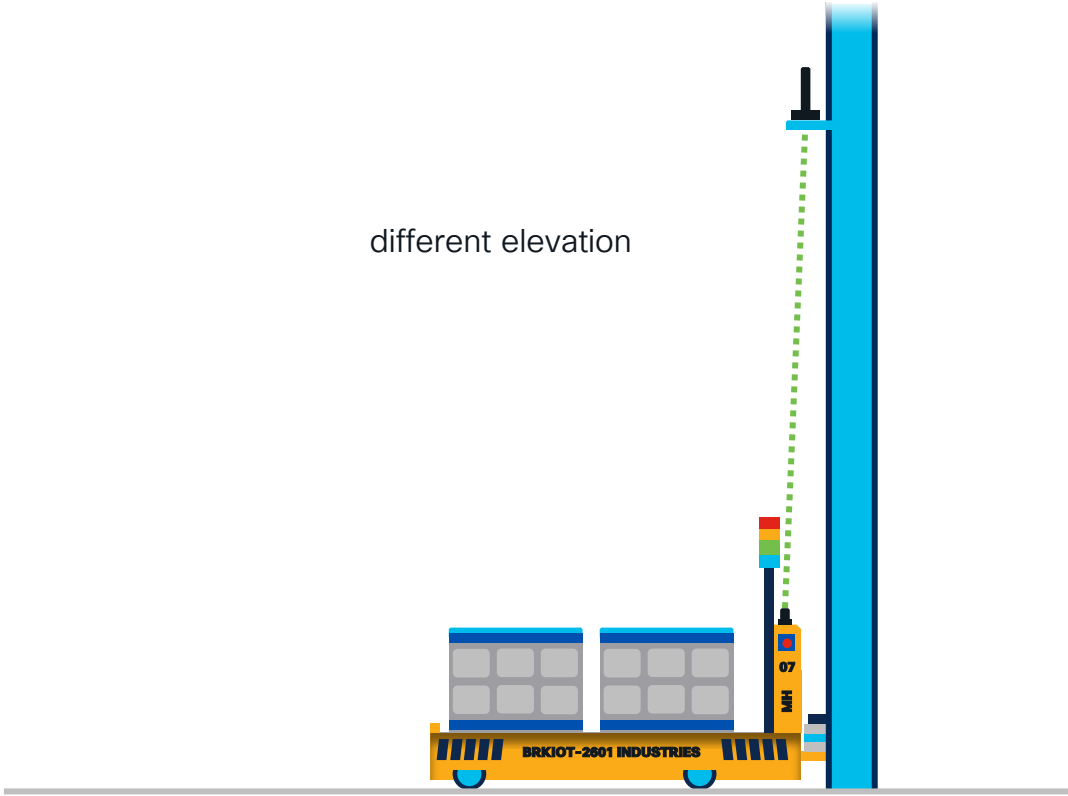
FLMESH-HW-ANT-51



FLMESH-HW-ANT-51

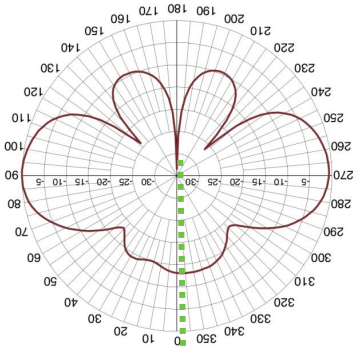


different elevation



Wayside Antenna placement

FLMESH-HW-ANT-51



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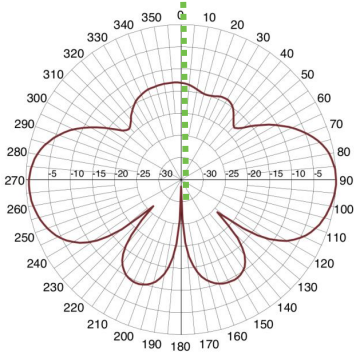
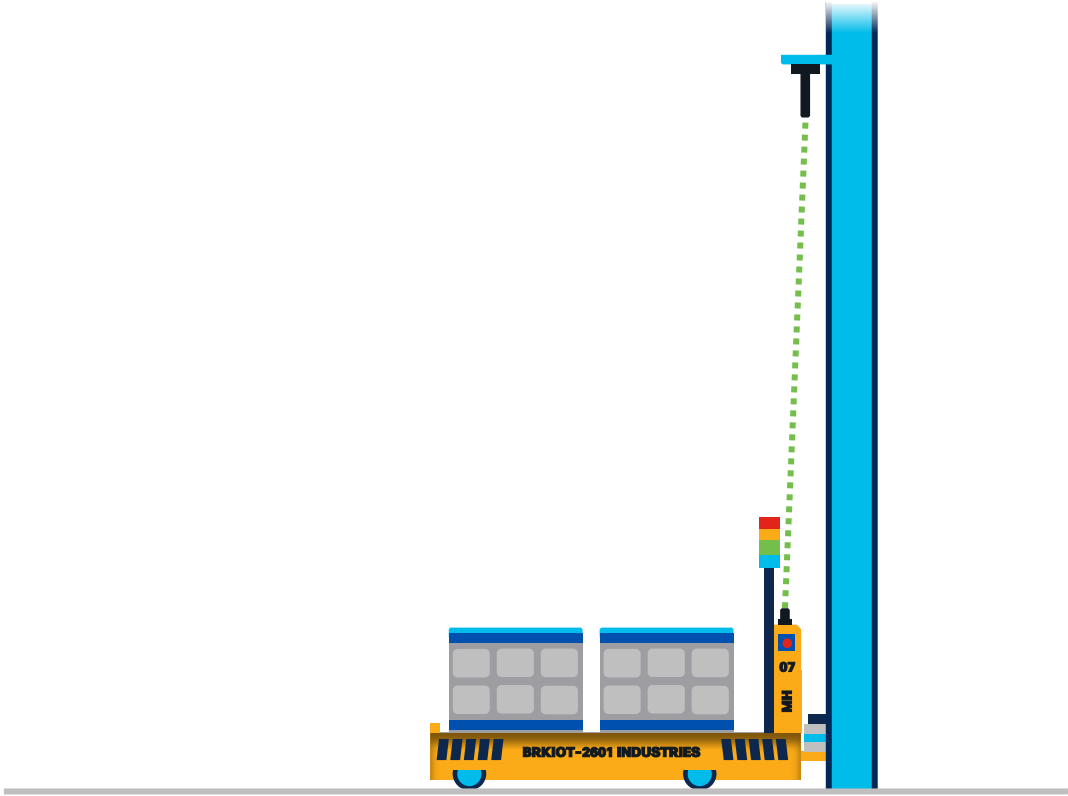
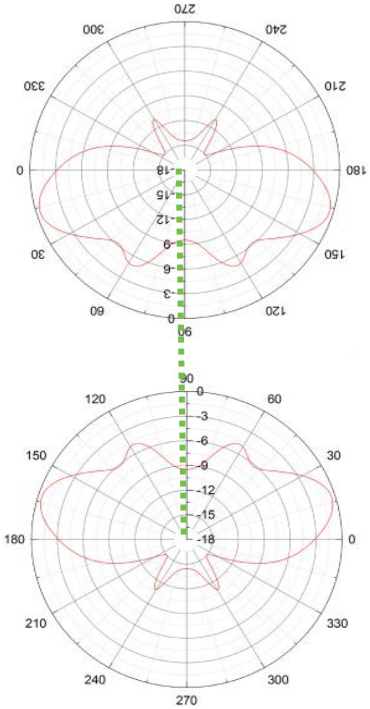


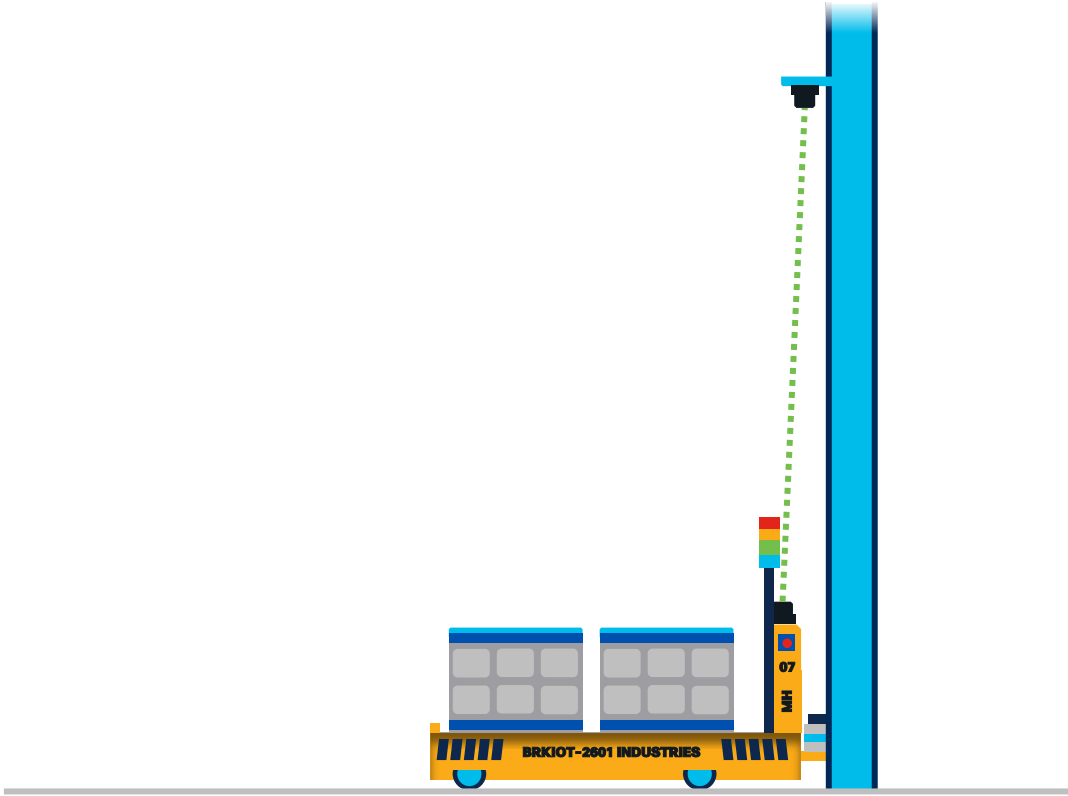


Wayside Antenna placement

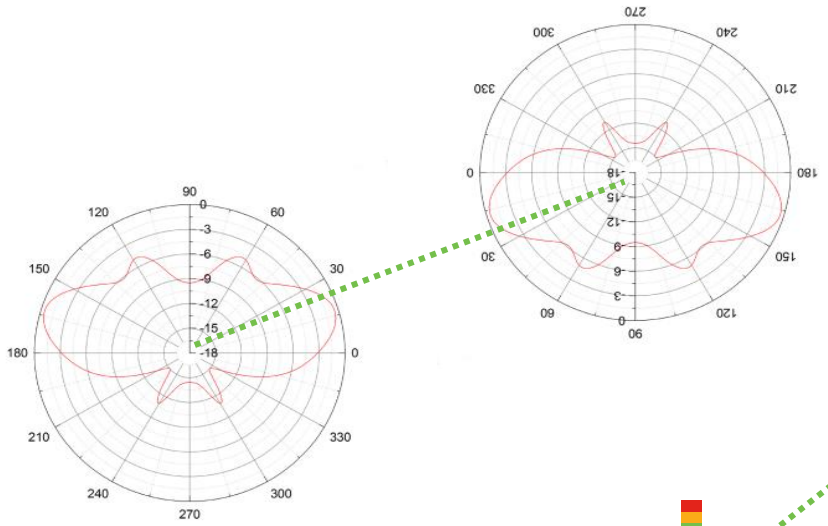
mp antenna
08-ANT-0941

mp antenna
08-ANT-0941





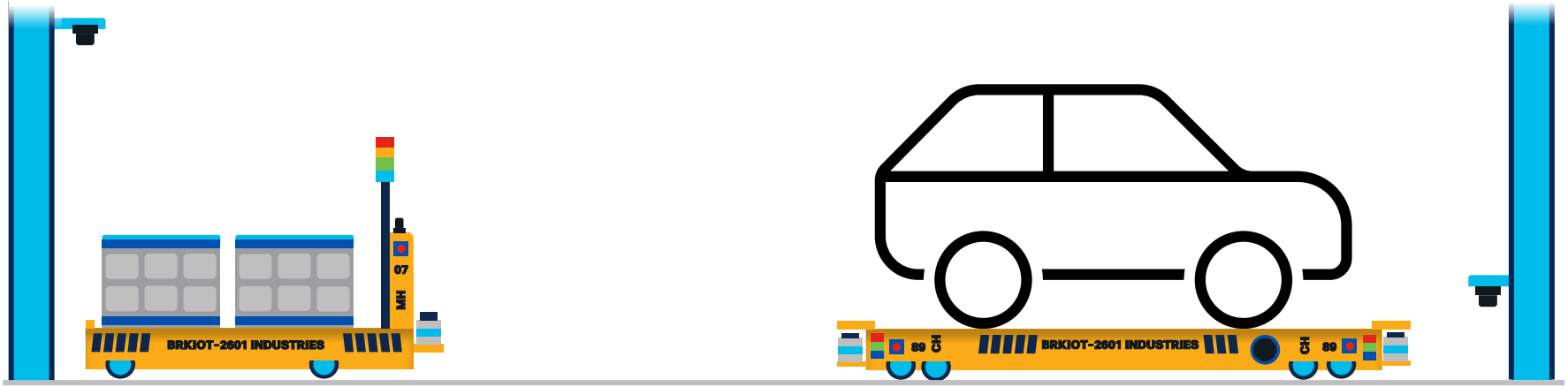
Wayside Antenna placement



mp antenna
08-ANT-0941

mp antenna
08-ANT-0941

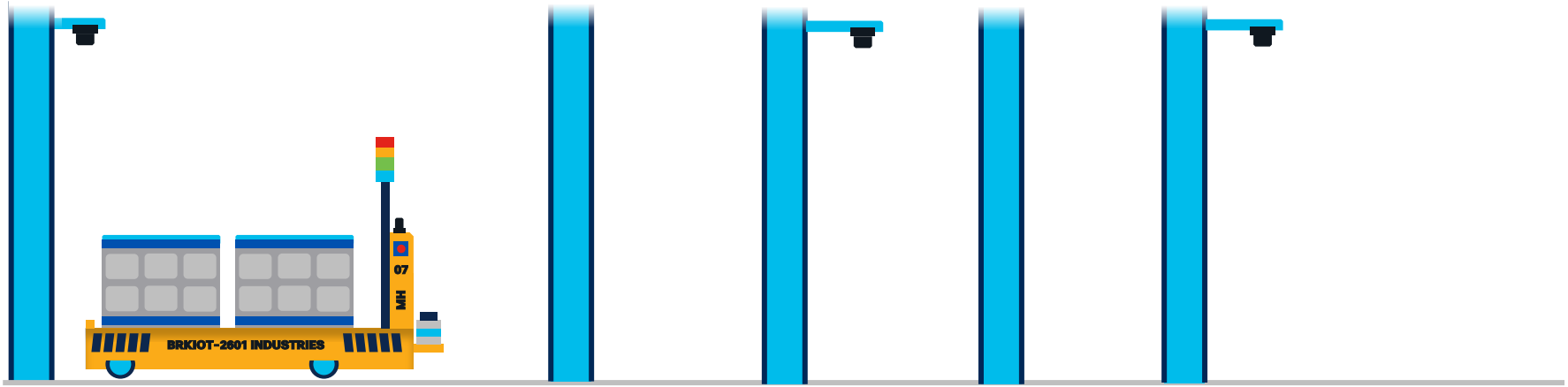
Vehicle Antenna placement



- Antenna mounted near top of vehicle
- Clear line of sight above vehicle
- Cargo no higher than antenna

- Antenna mounted on side of vehicle
- Wayside close to same elevation

Wayside Antenna spacing



- Keep the estimated signal within the operational range (-40dBm to -72 dBm)
- Use as few access points as possible
- Consider a single failure scenario

Tip #7
Tuning is top-to-bottom

Maintain Application Visibility

enip

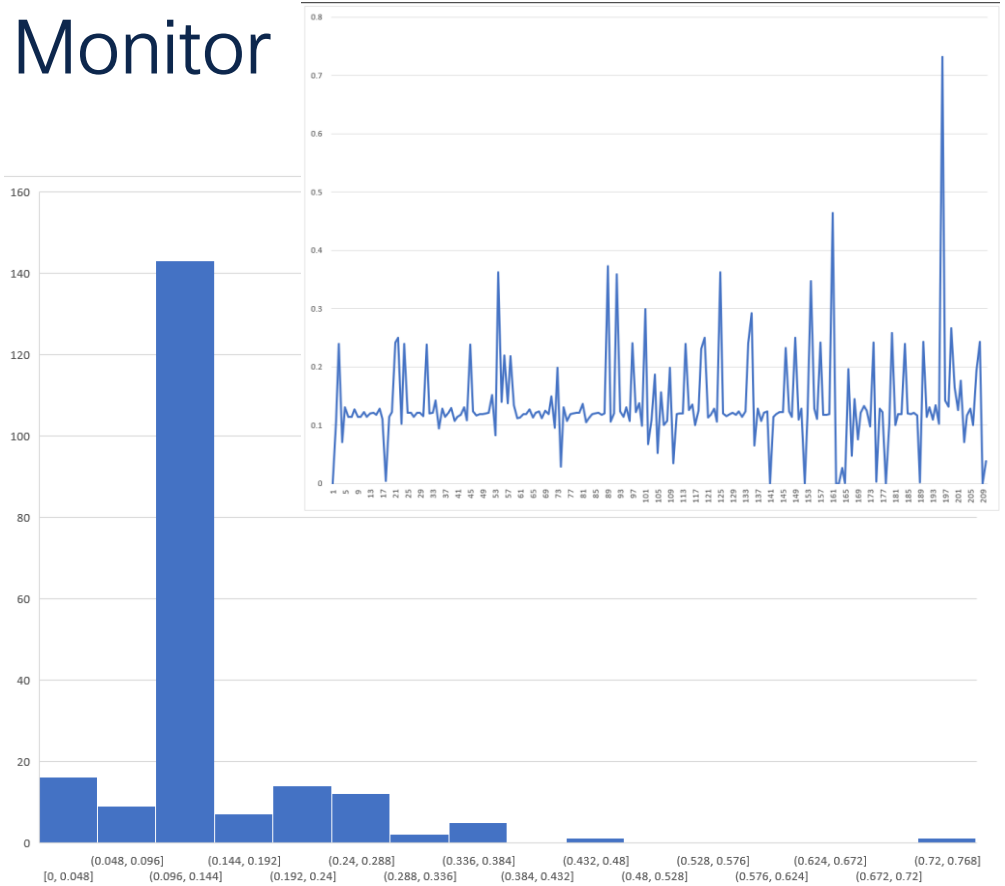
No.	Time	Protocol	Length	Differentiated Services Field	Sequence Number (raw)	Native VLAN	Encapsulation Se	Connection ID	Info
2381408	19:18:07.063	CIP I/O	240	0xbc			12137	0x000240c5	Connection: ID=0x000240C5, SEQ=0000012137
2381411	19:18:07.066	CIP I/O	240	0xbc			929682	0x00024014	Connection: ID=0x00024014, SEQ=0000929682
2381423	19:18:07.073	CIP I/O	128	0xbc			222885	0x03414bb3	Connection: ID=0x03414BB3, SEQ=0000222885
2381485	19:18:07.104	CIP I/O	240	0xbc			928684	0x000f4014	Connection: ID=0x000F4014, SEQ=0000928684
2381491	19:18:07.107	CIP I/O	240	0xbc			87889	0x00094722	Connection: ID=0x00094722, SEQ=0000087889
2381493	19:18:07.108	CIP I/O	240	0xbc			928494	0x0251696f	Connection: ID=0x0251696F, SEQ=0000928494
2381500	19:18:07.116	CIP I/O	240	0xbc			23582	0x02d1518c	Connection: ID=0x02D1518C, SEQ=0000023582, T->O
2381507	19:18:07.120	CIP I/O	128	0xbc			222838	0x001f402a	Connection: ID=0x001F402A, SEQ=0000222838
2381516	19:18:07.124	ENIP	148	0x6c	430365777				Register Session (Req), Session: 0x00000000
2381526	19:18:07.130	CIP I/O	128	0xbc			2913	0x0461655b	Connection: ID=0x0461655B, SEQ=0000002913
2381546	19:18:07.142	CIP I/O	240	0xbc			141	0x000e4999	Connection: ID=0x000E4999, SEQ=0000000141, T->O
2381550	19:18:07.146	ENIP	148	0x6c	3239757508				Register Session (Rsp), Session: 0x4000001F
2381555	19:18:07.148	CIP CM	254	0x6c	430365805				Connection Manager - Forward Open (Class (0x69)) ('
2381580	19:18:07.162	CIP CM	210	0x6c	3239757536				Success: Connection Manager - Forward Open (Class (
2381597	19:18:07.169	CIP I/O	240	0xbc			3795107	0x000c4014	Connection: ID=0x000C4014, SEQ=0003795107
2381618	19:18:07.179	CIP I/O	128	0xbc			21094	0x02c1429d	Connection: ID=0x02C1429D, SEQ=0000021094
2381626	19:18:07.183	CIP I/O	240	0xbc			12138	0x000240c5	Connection: ID=0x000240C5, SEQ=0000012138
2381628	19:18:07.186	CIP I/O	240	0xbc			929683	0x00024014	Connection: ID=0x00024014, SEQ=0000929683
2381710	19:18:07.225	CIP I/O	240	0xbc			928685	0x000f4014	Connection: ID=0x000F4014, SEQ=0000928685
2381718	19:18:07.227	CIP I/O	240	0xbc			87890	0x00094722	Connection: ID=0x00094722, SEQ=0000087890
2381719	19:18:07.228	CIP I/O	240	0xbc			87890	0x00094722	Connection: ID=0x00094722, SEQ=0000087890
2381733	19:18:07.235	CIP I/O	240	0xbc			23583	0x02d1518c	Connection: ID=0x02D1518C, SEQ=0000023583, T->O
2381770	19:18:07.262	CIP I/O	240	0xbc			142	0x000e4999	Connection: ID=0x000E4999, SEQ=0000000142, T->O
2381779	19:18:07.272	CIP I/O	128	0xbc			34	0x02e163fe	Connection: ID=0x02E163FE, SEQ=0000000034, O->T

Maintain Application Visibility

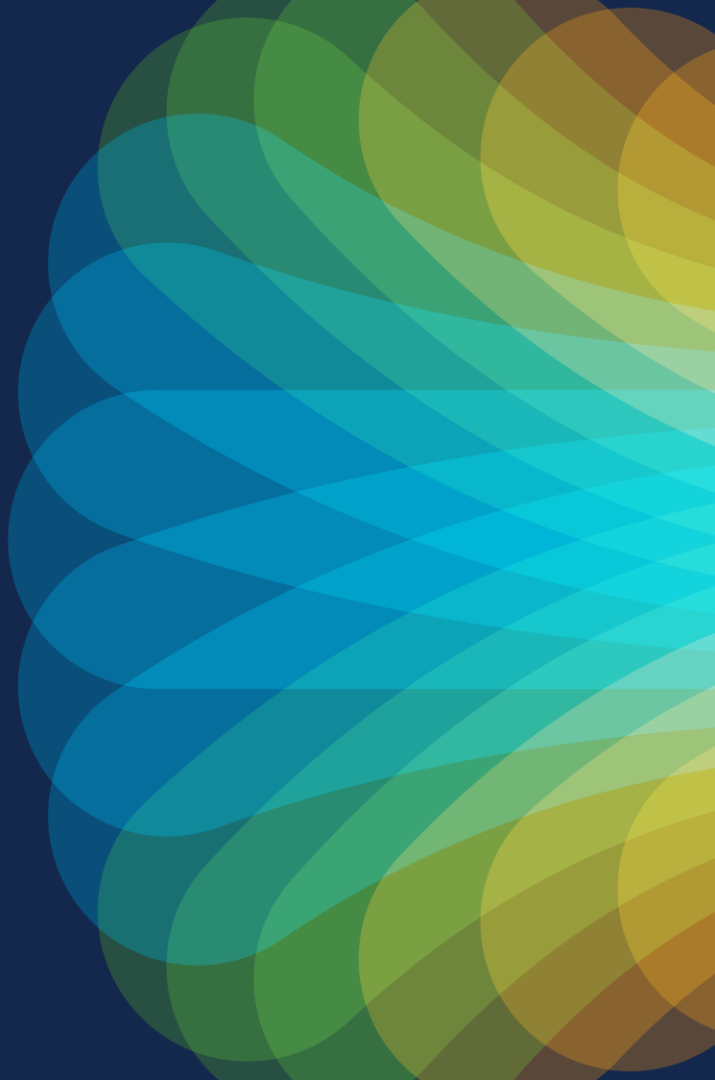
```
CIP Connection Manager
  > Service: Forward Open (Request)
  v Command Specific Data
      ...0 .... = Priority: 0
      .... 0101 = Tick time: 5
      Time-out ticks: 156
      Actual Time Out: 4992ms
      O->T Network Connection ID: 0x00000000
      T->O Network Connection ID: 0x01a16af7
      Connection Serial Number: 0x00b7
      Originator Vendor ID: Rockwell Automation/Allen-Bradley (0x0001)
      Originator Serial Number:
      Connection Timeout Multiplier: *4 (0)
      Reserved: 0x000000
      O->T RPI: 500.000ms
    > O->T Network Connection Parameters: 0x4802
      T->O RPI:  20.000ms
    > T->O Network Connection Parameters: 0x4872
    > Transport Type/Trigger: 0x81, Direction: Server, Trigger: Cyclic, Class: 1
      Connection Path Size: 26 words
```

Benchmark Points to Monitor

- Application Latency (peak)
- Maximum consecutive packet drops



Tip #8
Turning it on is just the beginning.



Data Collection and Monitoring

- RF Link Metrics
- Data Packet Captures
- Process / PLC Data

IW Monitor (Cisco URWB)

fmstats (Cisco URWB)

Arkime (formerly Moloch)

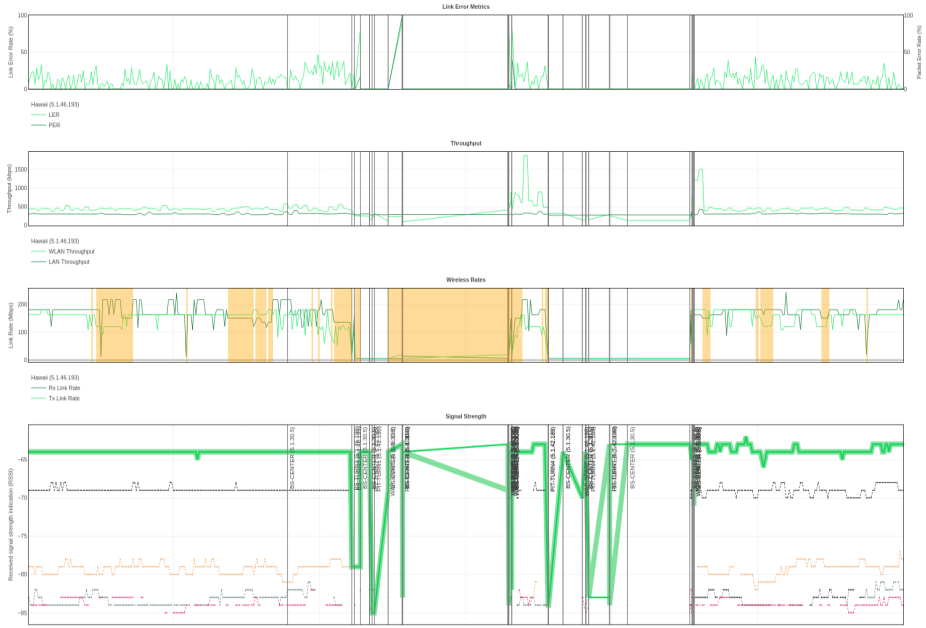
PCAPs

Historian

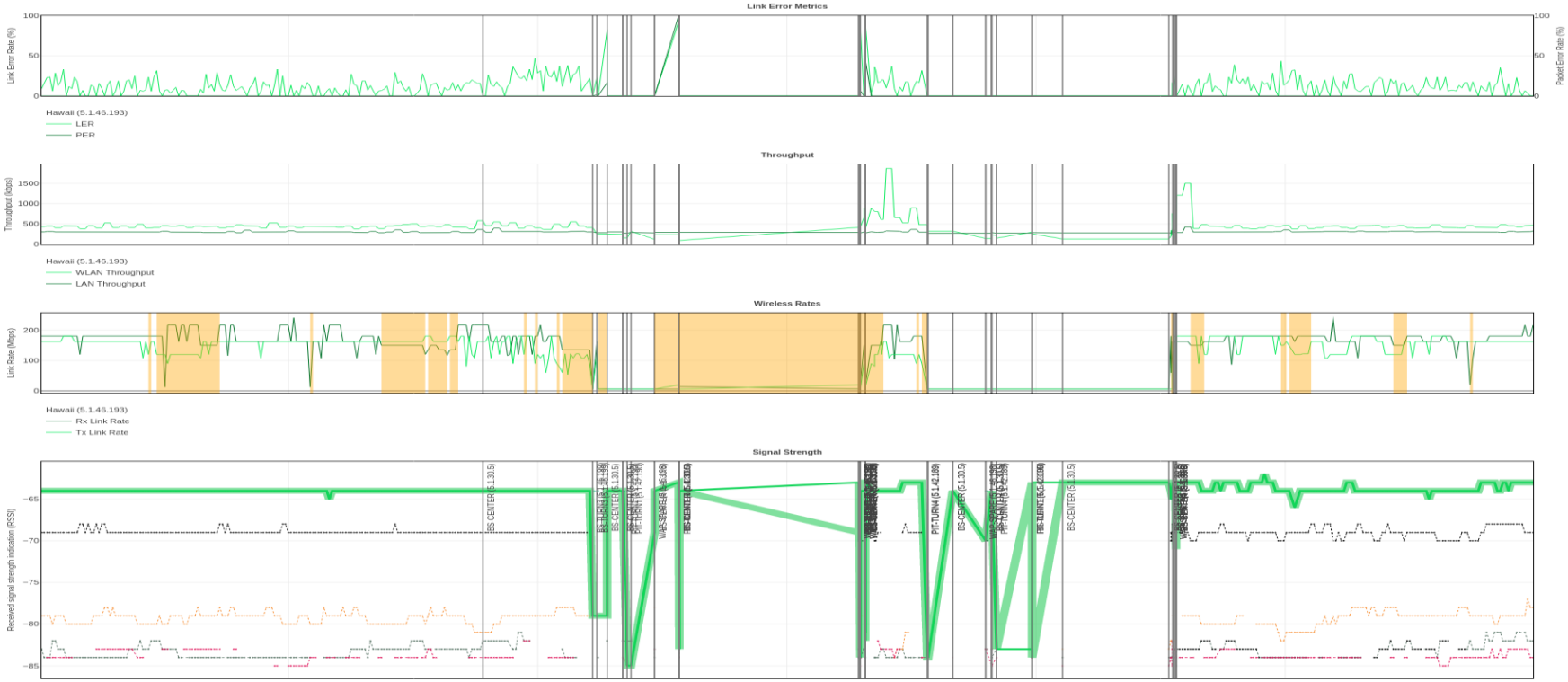
Alarms

Identifying Issues

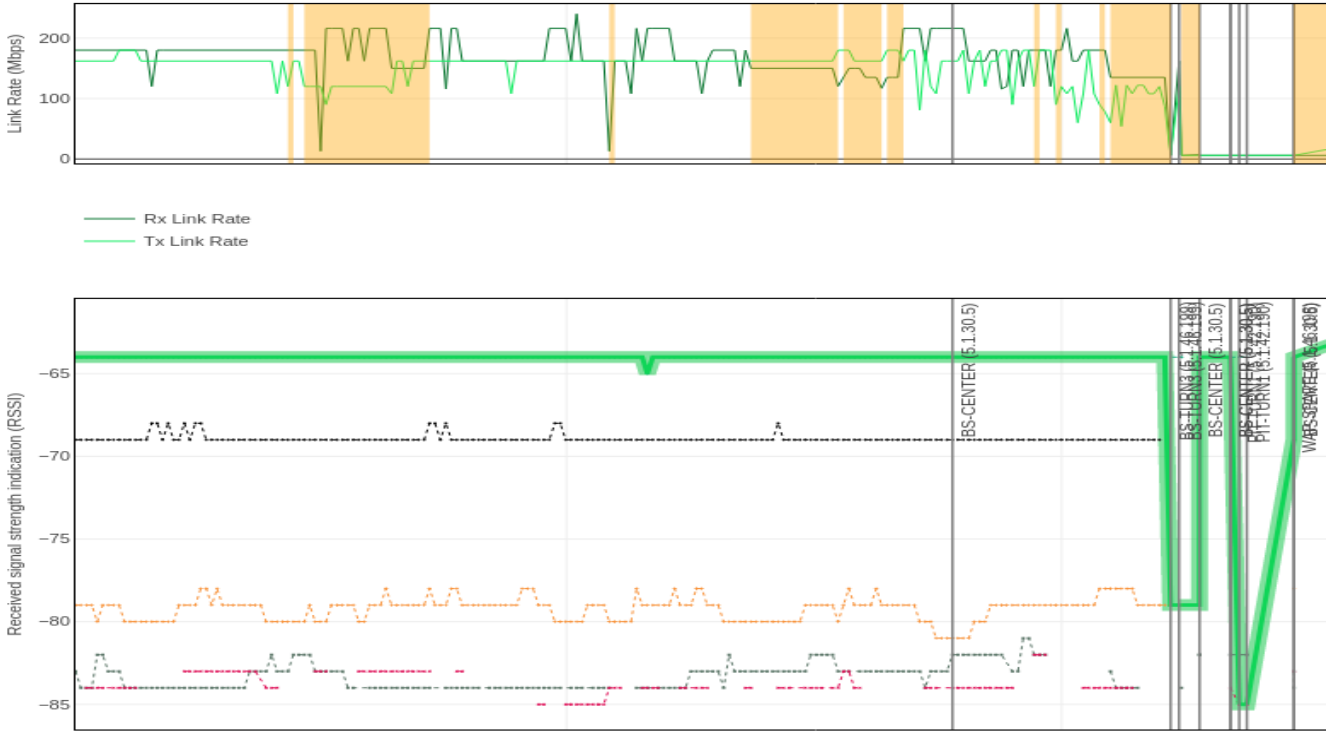
- “It’s the network.”
- Triage First – build a process to have the right data in one place



Troubleshooting RF Issues



Troubleshooting RF Issues



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Attendees who fill out a minimum of four session surveys and the overall event survey will get **Cisco Live-branded socks** (while supplies last)!

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These points help you get on the leaderboard and increase your chances of winning daily and grand prizes

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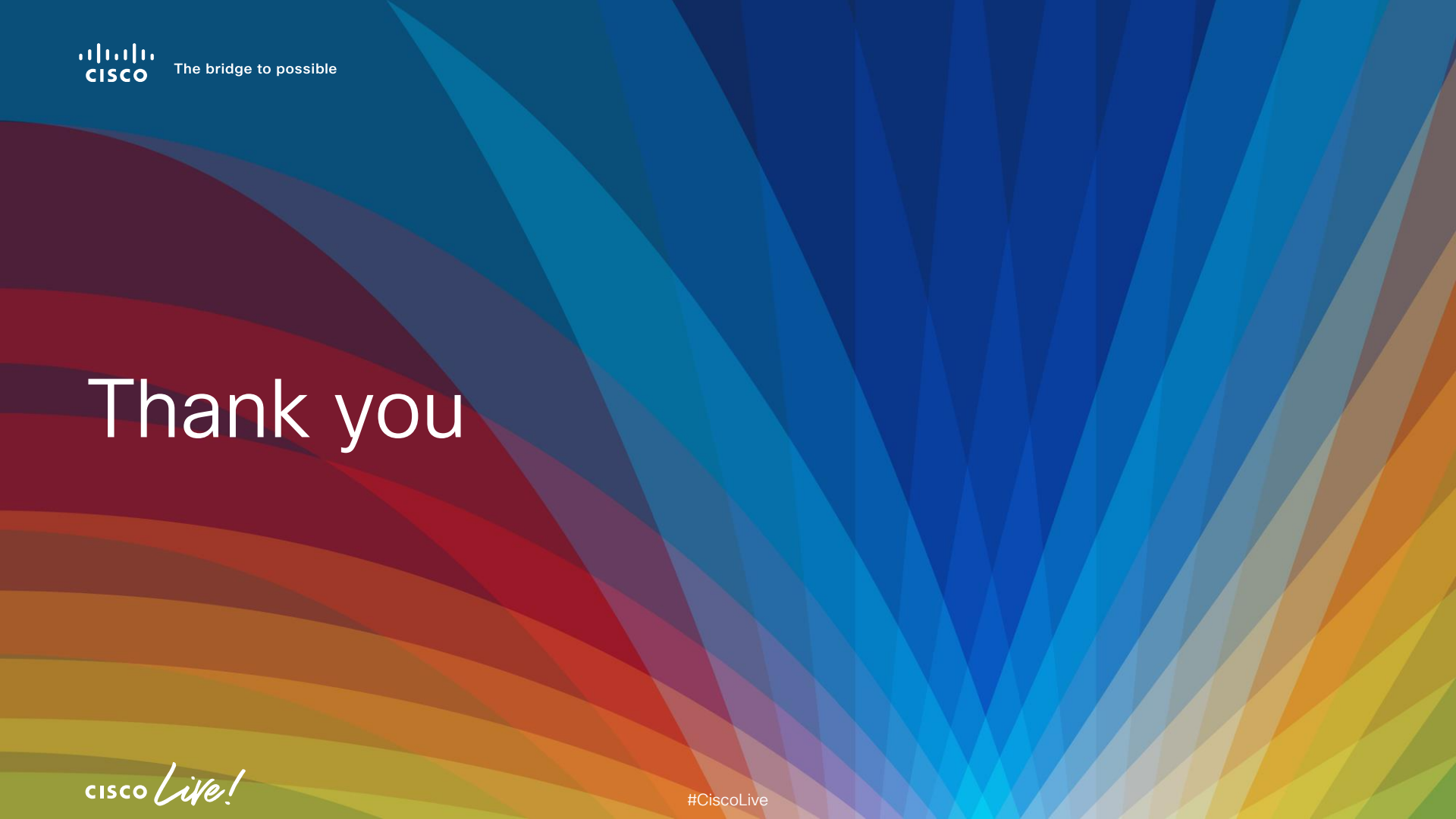
- Visit the Cisco Showcase for related demos
- Book your one-on-one Meet the Engineer meeting
- Attend the interactive education with DevNet, Capture the Flag, and Walk-in Labs
- Visit the On-Demand Library for more sessions at www.CiscoLive.com/on-demand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Challenge

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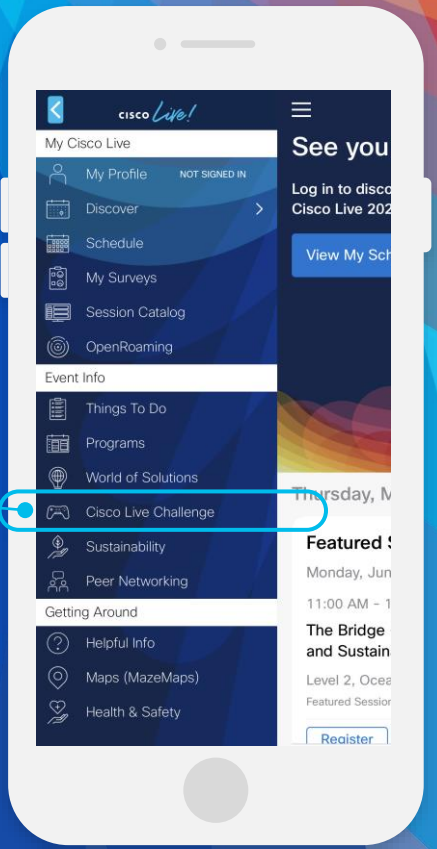
2. Click on 'Cisco Live Challenge' in the side menu.
3. Click on View Your Badges at the top.
4. Click the + at the bottom of the screen and scan the QR code:

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