



Meet Wi-Fi HaLow

The long-range
Sub-GHz Wi-Fi for IoT

Confidential



Agenda

- 01** What is Wi-Fi HaLow?
- 02** Advantages of Wi-Fi HaLow
- 03** Typical applications of Wi-Fi HaLow
- 04** How to apply Wi-Fi HaLow in IoT solutions

01

What is Wi-Fi HaLow?

An aerial photograph of a rural property. In the center is a large house with a grey roof. To the left of the house is a swimming pool with a blue cover. To the right of the house is a large barn with a red roof. The property is surrounded by green grass and trees. A road is visible on the left side of the image. A purple banner is overlaid on the left side of the image, containing the text "Where wi-fi connectivity is today...".

Where wi-fi
connectivity is today...

An aerial photograph of a residential property with a large green lawn, a swimming pool, and several buildings. Overlaid on the image are several concentric purple circles that expand outwards from a central point, representing the range of Wi-Fi HaLow coverage. The circles cover the entire property and extend into the surrounding area.

Where we could be...
with Wi-Fi HaLow

Imagine **100x the coverage**

With **900MHz Wi-Fi HaLow**

Providing **full property connectivity**

Where we could be...
with Wi-Fi HaLow

Imagine 100x the coverage

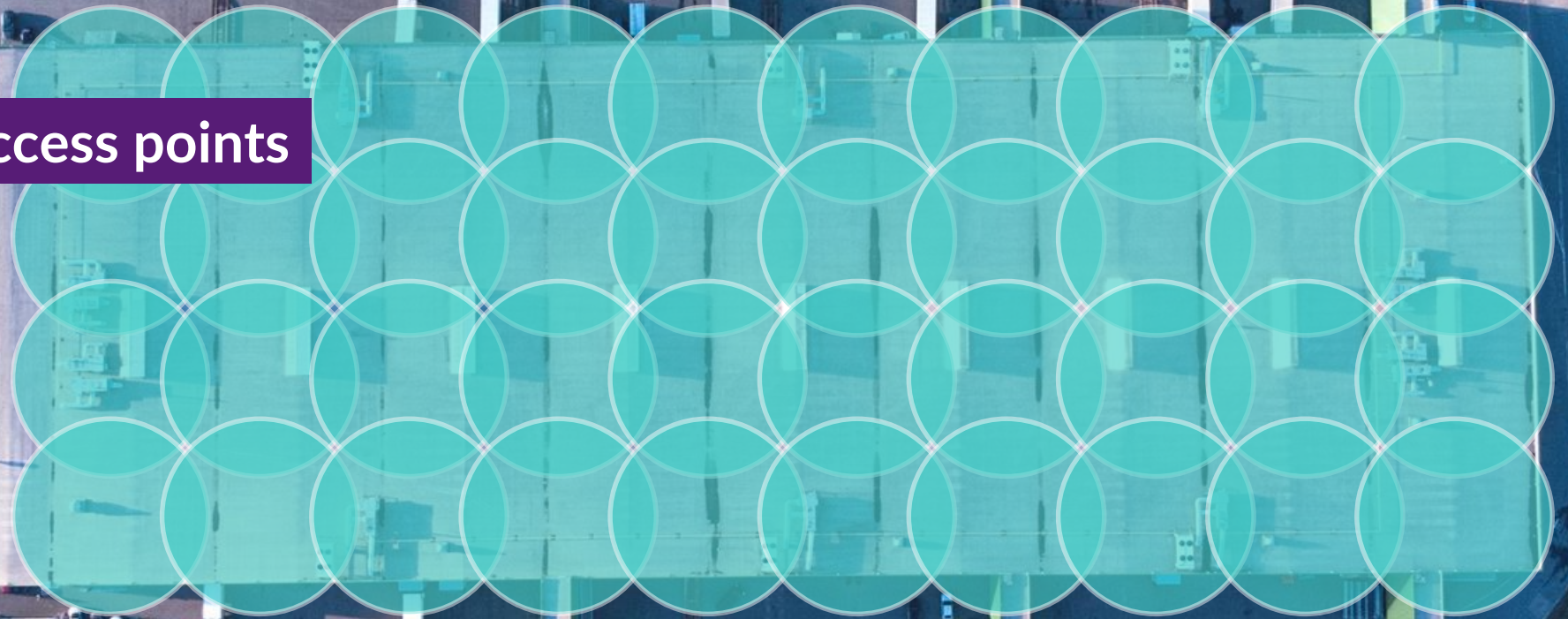
With 900MHz Wi-Fi HaLow

Providing full property connectivity



Wi-Fi HaLow for commercial use

Current 40x access points

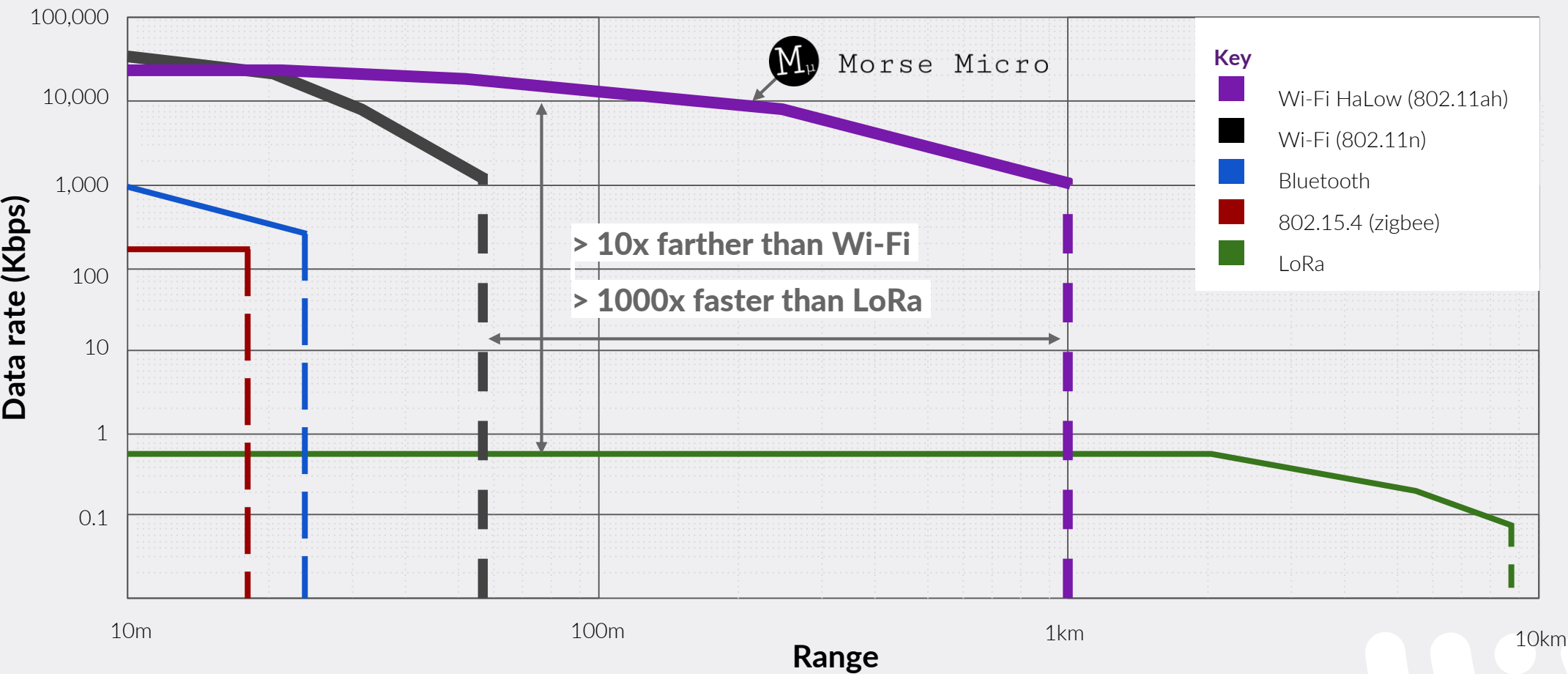


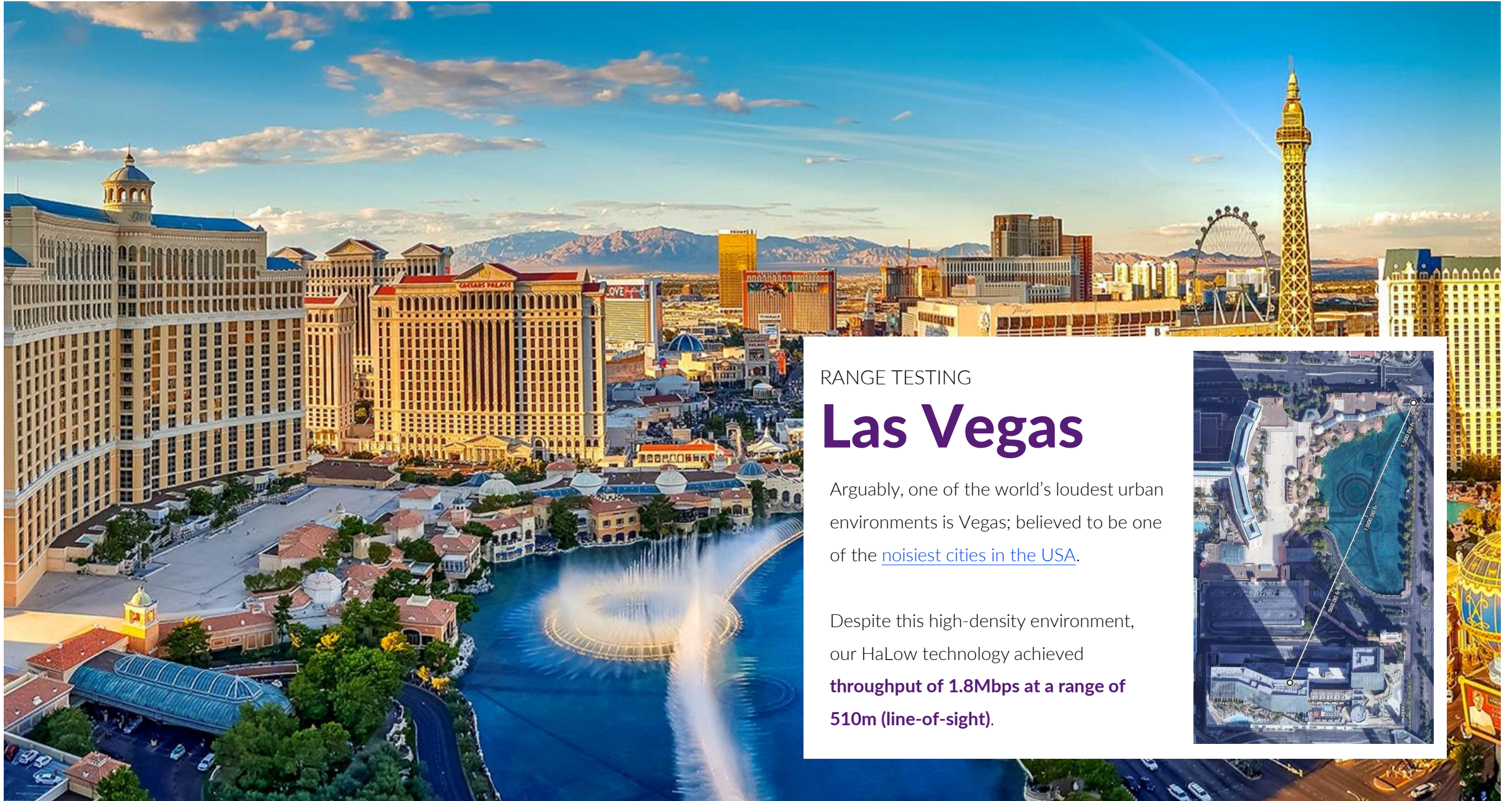
Wi-Fi HaLow for commercial use

Current 40x access points

Wi-Fi Halow 1 access point

IoT technology comparison



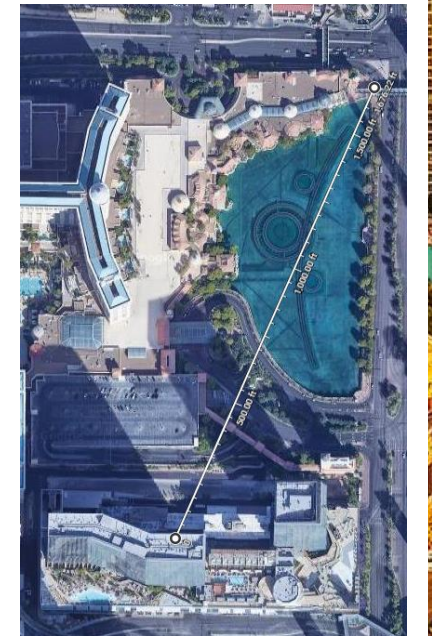


RANGE TESTING

Las Vegas

Arguably, one of the world's loudest urban environments is Vegas; believed to be one of the [noisiest cities in the USA](#).

Despite this high-density environment, our HaLow technology achieved **throughput of 1.8Mbps at a range of 510m (line-of-sight)**.



RANGE TESTING

Joshua Tree

At the other end of the noise spectrum is Joshua Tree National Park. Here HaLow consistently maintained signal, with a low packet error rate across line of sight. **Networking throughput was measured 1.2Mbps across the terrain with a max distance of 15.48km.**

```
~Interface~
~lane IEEE 802.11ah , phy 0, reg: n/a, SSID: MorseMicro
~Level~

link quality: 34% (24/70)
=====

signal level: -86 dBm (2.51 pW)
=====

~Packet Counts~
RX: 3K (129.6K KIB), drop: 0 (0.2%)
TX: 3K (4.62 MIB), retries: 465 (12.4%), failed: 4
inf

mode: Managed, connected to: 0C1BF741EB1A1DA, time: 1123m
freq: 923.0 MHz, channel: 42 (width: 2 MHz), bands: 1
beacons: 617, lost: 15, avg sig: -85 dBm, interval: 0.1s, DT
tx rate: 0.650 Mbits/s MCS 0
tx rate: 2.166 Mbits/s MCS 2 short GI
tx power: 10 dBm (1000.00 mW), power save: on
retry short/long: 7/4, rts/cts: 1000, frag: off
~Network~

64 bytes from 10.42.1.1: seq=1800 ttl=64 time=9.969 ms
64 bytes from 10.42.1.1: seq=1801 ttl=64 time=30.009 ms
64 bytes from 10.42.1.1: seq=1802 ttl=64 time=30.011 ms
64 bytes from 10.42.1.1: seq=1803 ttl=64 time=30.008 ms
64 bytes from 10.42.1.1: seq=1804 ttl=64 time=8.936 ms
64 bytes from 10.42.1.1: seq=1805 ttl=64 time=30.107 ms
64 bytes from 10.42.1.1: seq=1806 ttl=64 time=30.086 ms
64 bytes from 10.42.1.1: seq=1807 ttl=64 time=30.066 ms
64 bytes from 10.42.1.1: seq=1808 ttl=64 time=8.917 ms
64 bytes from 10.42.1.1: seq=1809 ttl=64 time=12.131 ms
64 bytes from 10.42.1.1: seq=1810 ttl=64 time=31.130 ms
64 bytes from 10.42.1.1: seq=1811 ttl=64 time=8.940 ms
64 bytes from 10.42.1.1: seq=1812 ttl=64 time=30.124 ms

[ 5] 27.00-28.00 sec 182 KBytes 1.33 Mbits/sec 115
[ 5] 28.00-29.00 sec 154 KBytes 1.26 Mbits/sec 109
[ 5] 29.00-30.00 sec 157 KBytes 1.29 Mbits/sec 111
- - - - -
[ ID] Interval Transfer Bitrate Jitter
Lost/Total Datagrams
[ 5] 0.00-30.00 sec 4.30 MBytes 1.23 Mbits/sec 0.000 ms
0/3177 (0%) sender
[ 5] 0.00-30.28 sec 4.28 MBytes 1.19 Mbits/sec 12.696 ms
76/3177 (2.4%) receiver

~perf Done.~
~[0] 0:ibash+ "MH_buildroot" 00:59 01-Jan-76~
```


What are the Sub-1 GHz Wi-Fi HaLow frequencies?

Industrial, Scientific and Medical (ISM) bands, generally license-free in most parts of the world below 1 GHz.

- 902-928 MHz In USA and Many Other Countries
- 918-923 MHz in Vietnam

Channel Assignments / Channel Bandwidths

1MHz	902. 5	903. 5	904. 5	905. 5	906. 5	907. 5	908. 5	909. 5	910. 5	911. 5	912. 5	913. 5	914. 5	915. 5	916. 5	917. 5	918. 5	919. 5	920. 5	921. 5	922. 5	923. 5	924. 5	925. 5	926. 5	927. 5
2MHz	903		905		907		909		911		913		915		917		919		921		923		925		927	
4MHz			906				910				914				918				922 (38)				926			
8MHz			908								916								924							

26 MHz available in USA + most of ITU Region 2 (Americas)

Vietnam

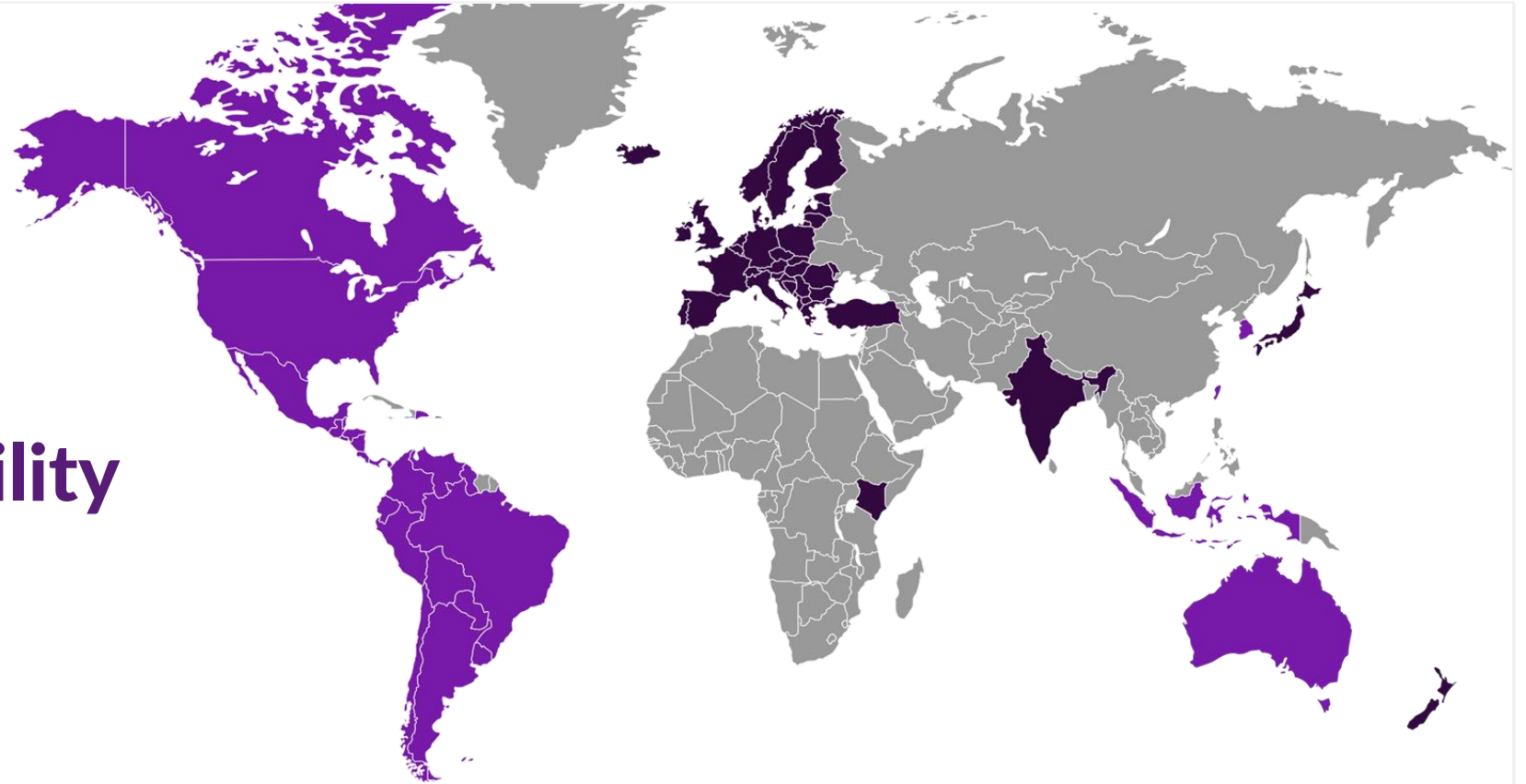
AUSTRALIA (AU)/ NEW ZEALAND (NZ)

*Subject to regulations within country of operation. Some include restrictions on channel bandwidth, duty cycle, and maximum output power



Wi-Fi HaLow spectrum availability

- Full Wi-Fi HaLow capacity available
- Partial Wi-Fi HaLow capacity available
- Unknown



Americas

- United States (902-928 MHz)
- Canada (902-928 MHz)
- Mexico (902-928 MHz)
- Brazil (902-907.5 MHz and 915-928 MHz)
- Argentina (915-928 MHz)

Europe and Africa

Many countries in Europe support the 863-868 MHz band. The 915.8-919.4 MHz band is being adopted over time as countries harmonize their spectrum with CEPT recommendations. African countries are just starting to adopt these bands.

Asia Pacific

- Australia (915-928 MHz)
- Japan (920.5-921.5 MHz and 922.5-927.5 MHz)
- Korea (917.5-923 MHz and 925-931 MHz)
- New Zealand (915-928 MHz)
- Singapore (920-925 MHz)
- Taiwan (920-925 MHz)
- Thailand (920-925 MHz)
- Vietnam (918-923 MHz)

02

Advantages of Wi-Fi HaLow

compared to Wi-Fi, Wi-Fi 6, LoRaWAN, and 5G

Benefits of Wi-Fi certified HaLow

Benefits:



Long range:
approximately 1km



Higher data rates
for long range



Penetration
through walls and
other obstacles



Optimised for
energy efficiency



Over 8,000
connected devices
per access point



Improved reliability
against noise and
variable conditions



Robust Security
WPA3, and Wi-Fi
enhanced encryption



Easy to deploy
alongside existing
Wi-Fi



Lower cost
setup and upkeep



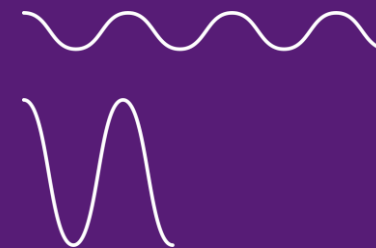
Uses open
international
standards

Why does Wi-Fi HaLow have better reach?

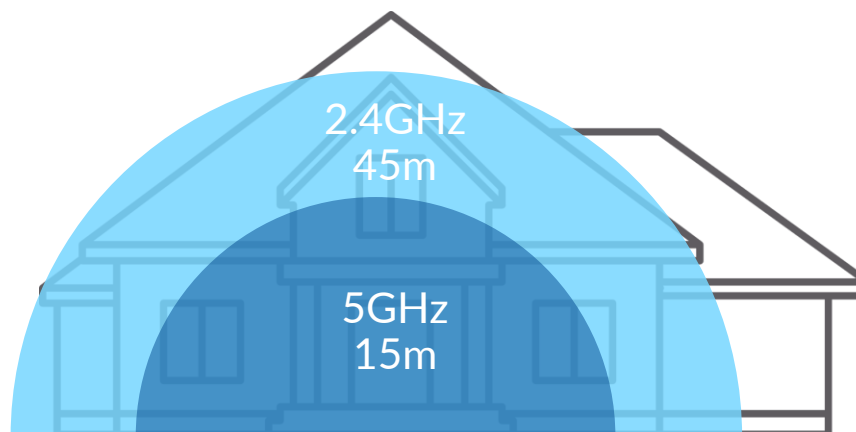
Lower frequencies
Travels farther and
better penetration



Narrower bands
Travels farther



Current Wi-Fi

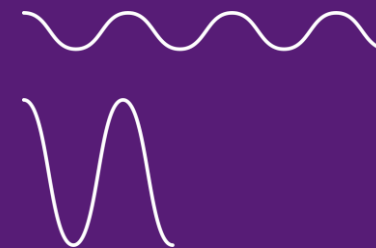


Why does Wi-Fi HaLow have better reach?

Lower frequencies
Travels farther and
better penetration



Narrower bands
Travels farther



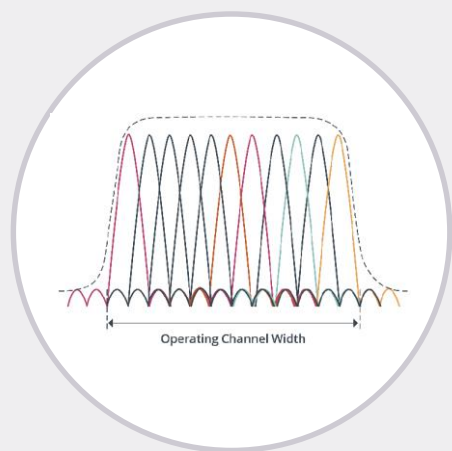
Wi-Fi HaLow

900MHz – 1km+

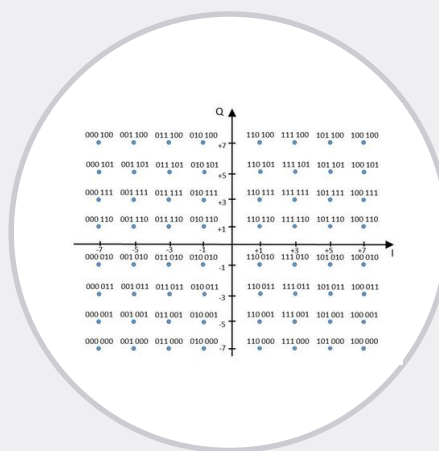


Higher data rates over long distances

Wi-Fi HaLow combines OFDM modulation scheme of preceding generations of Wi-Fi , plus encoding techniques known as “BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM” to yield much higher data rates and more robustness in the presence of noise than simple FSK or ChirpSpreadSpectrum radios.



OFDM w/Multiple
sub-carriers carrying
the message
improves robustness



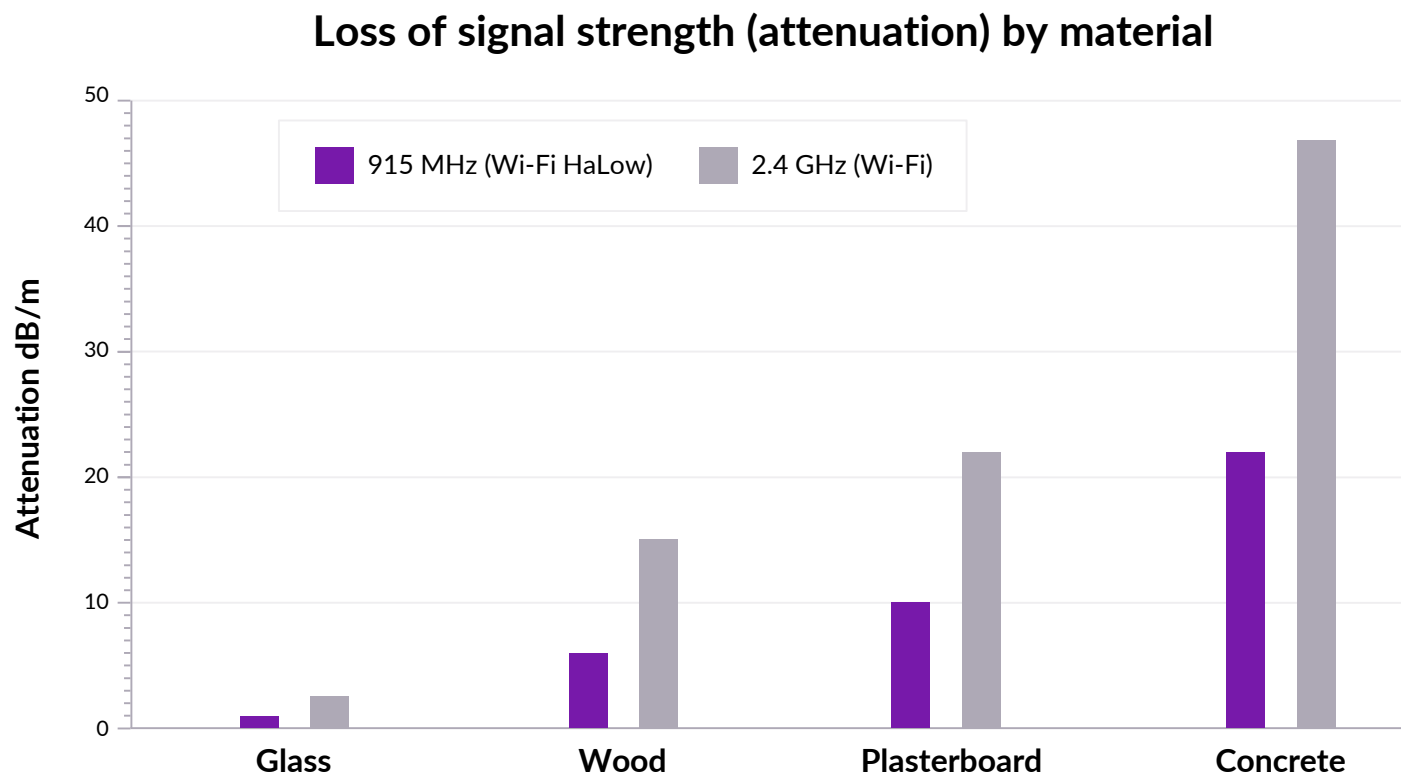
64-QAM transfers
6-bits per sample



**Higher data rates and
more robust connection**

150 kbps to 32 Mbps
(single stream, 8 MHz MCS7)

Less Attenuation = Better Penetration



Lower frequency of 915 MHz Wi-Fi HaLow penetrates through materials better than 2.4 GHz and higher frequencies

Morse Micro HaLow has layered Power Efficiency



**Active transfer
power usage**

High transmit and receive efficiency
10 to 100x more efficient up to 1km



**Idle (sleep)
power usage**

Responsive or Custom extended sleep time
>100 micro amps for 10 DTIM



Wi-Fi HaLow Enables High-Density Networks

8,191
Unique Stations

Through a single access point (AP)



Increase
efficiency by
Leveraging
TWT and RAW



Broadcast,
Multicast and
Unicast traffic



Quality of
Service (QoS)
support



BSS Coloring to
prevent overlap

Wi-Fi HaLow Improves Reliability

Morse Micro's Wi-Fi HaLow utilises all the best practices to ensure reliable connectivity

Radio

- Sub-1 Ghz stays connected at farther distances than other 2.4 Ghz and higher frequency technologies (Wi-Fi, BLE, Zigbee)
- Better penetration through walls, trees, people, moving objects as conditions change

Phy

- OFDM + built-in Forward Error Correction (FEC)
- Narrow bandwidth extends range advantage
- Special MCS10 mode used to gain 3 dB link budget

MAC

- All the benefits of traditional Wi-Fi using Listen Before Talk (LBT) to prevent collisions
- Acknowledgements (ACKs)
- Continuous monitoring of Packet Error Rates (PER), signal strengths, SNRs for Automatic Rate Controls (ARC)
- Agile support for Sub-channel operation if conditions change (eg. Drop to 4 MHz or 2 MHz within 8 MHz mode)

TCP/IP and UDP/IP

- Native IP technology can utilize time-tested techniques such as TCP (acknowledgments of received packets and order)
- Supports session-oriented connections from cloud to Station
- TLS connections to trusted platform in the cloud



Wi-Fi HaLow Has Robust Security

WPA3-Personal

- The latest wireless security standard developed by the Wi-Fi Alliance
- 128-bit AES encryption
- Protected Management Frames (PMF)

WPA3-Enterprise

- Multiple Extensible Authentication Protocol (EAP) methods, i.e. EAP TLS
- 128-bit AES encryption
- Key derivation: minimum 256-bit



Wi-Fi EasyConnect using Device Provisioning Protocol

IoT devices associated securely from a known key

Wi-Fi EasyConnect using Device Provisioning Protocol

Encrypts traffic over the airwaves.

Additional encryption capacity

Very high data rates to support extra overhead of additional layers of encryption and FOTA updates!



Wi-Fi HaLow is Easy to Deploy and Use

Wi-Fi HaLow is Wi-Fi It's easy to use

Step 1) Turn on Wi-Fi HaLow AP

Step 2) Connect Wi-Fi HaLow Stations



Same network management tools can be used as for Home, Enterprise and Industrial IoT solutions



Green-Fields overlay: No conflicts with existing Wi-Fi 4/5/6/6e/7 site plans for home, office or factory

Lower cost of IoT Devices



License-free RF bands, no subscriptions to cellular network SIM card plans or fees



Energy efficiency of Wi-Fi HaLow vs. cellular or low-throughput devices; longer battery life w/less hardware overhead



As easy as scanning a QR code

Greater coverage with fewer Access Points (APs)



Fewer Wi-Fi HaLow APs needed Vs. short-range 2.4 Ghz Wi-Fi or Zigbee, BT/BLE/Thread





Better penetration means one AP can span floors and pass through structures



No reliance on MESH

Lower Cost of Setup and Upkeep for IoT

 Lower setup expense		 Lower ongoing expenses and upkeep		
vs Wi-Fi (2.4 - 5Ghz)	vs 5G	vs CAT1/NB-IoT	vs Private 5G	vs repeaters, hubs, and meshes
HaLow AP offers 100x area, 1000x volume of traditional Wi-Fi for IoT devices = less AP's required to cover a given area	lower module cost and base station cost (for private)	no recurring costs for data plans	no recurring costs for 5G Private radio rental or spectrum purchase	reduce network complexity, increase reliability and lower operating cost



International Standards

Morse Micro's Wi-Fi HaLow uses open international standards to ensure interoperability

Ethernet – IEEE 802.3 standards for wired local area networks (LAN)

Wi-Fi – IEEE 802.11 standards for wireless local area networks (WLAN)

TCP/IP – Internet Engineering Task Force (IETF) global standards for routing internet packets

WPA3, EasyMesh, EasyConnect, EnhancedOpen – Wi-Fi Alliance standards for security and interoperability

IEEE 802.11ah is an international Wi-Fi standard which contemplates Radio, Phy, and Media Access Control (MAC), and **natively supports IP packet routing** to the cloud

03

Example applications of Wi-Fi HaLow

Example applications of Wi-Fi HaLow

Home automation

Indoor & outdoor reach from a single AP

Better penetration through walls & obstacles

No dependency on Wi-Fi mesh

IPv6 ready & WPA3 secure



Example applications of Wi-Fi HaLow

Warehouse automation

Whole building
coverage with single AP

Outdoor reach for
yard connectivity

WPA3 secure & IPv6
ready

Address up to 8,191
STAs per AP



USE CASES

Video connectivity

Ultra-low power
consumption

>100x area
coverage

8-MHz bandwidth
suitable for HD video

Better penetration
through walls



Example applications of Wi-Fi HaLow

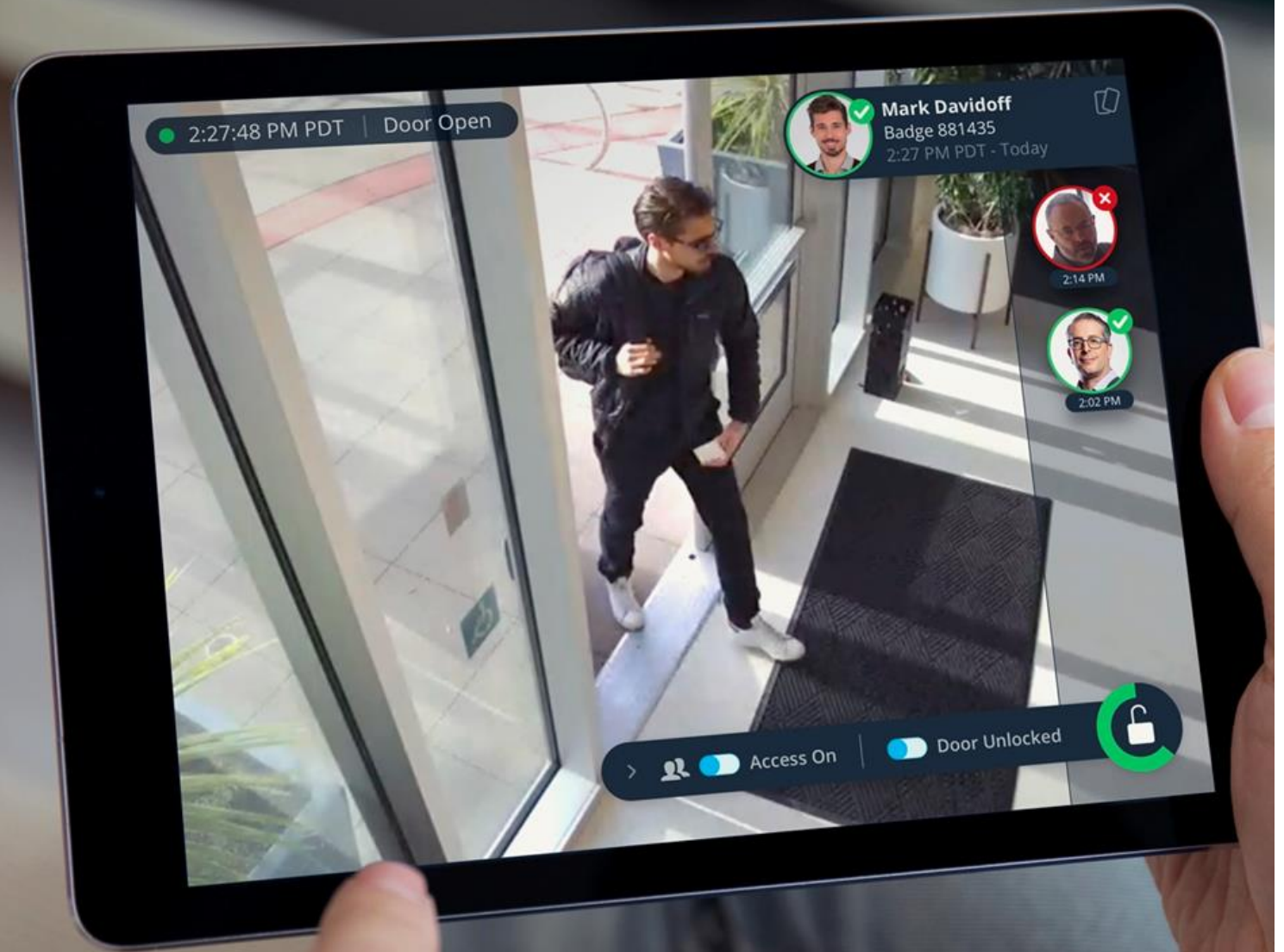
Building automation

Whole building
coverage

Simplified
infrastructure

Better penetration
through walls &
floors

WPA3 secure &
IPv6 ready



A photograph of a large industrial factory floor filled with numerous yellow robotic arms (KUKA models) working on assembly lines. The robots are positioned at various heights and angles, creating a complex, repetitive pattern of machinery. The background shows the structural elements of the factory, including pipes, beams, and overhead lighting.

Example applications of Wi-Fi HaLow


Industrial automation

Entire building
coverage

Better penetration
through walls &
objects

Native IPv6 support
& secure connections

OTA firmware
updates

An aerial photograph of a vast vineyard at sunset. The rows of grapevines are illuminated by the warm, golden light of the setting sun, creating a rhythmic pattern across the landscape. In the background, a small village with several houses and a church spire is visible, nestled among trees with some autumn-colored foliage. The sky is a soft gradient of orange and yellow.

Example applications of Wi-Fi HaLow

Rural connectivity

Extensive coverage
with single AP

Backhaul network
for other IoT

Reliable data
connectivity

Suitable for
long-range, low data
rate connectivity



USE CASES

Critical Communications

Extensive coverage
with single AP

Better penetration
through trees, noise
and obstacles

Multi-layered network
architecture to improve
connection reliability

Data rates sufficient
for voice and video
communication





Example applications of Wi-Fi HaLow

Remote and Island Connectivity

Connect HaLow Access Point to satellite for 1km+ connectivity

Cover multiple structures and homes

1km+ roaming connectivity

Over 8,000 stations supported by a single access point



Example applications of Wi-Fi HaLow

Smart City Integration

Vehicle traffic, parking
monitoring and
controls

Security cameras

Utility monitors
and controls

Information kiosks for
buses and trains

04

How to apply Wi-Fi HaLow in IoT solutions

Building the Wi-Fi HaLow Global Ecosystem

Wi-Fi HaLow's access and reach will become essential for the growth of IoT

We have begun building what will be a universal standard available everywhere

Building the Wi-Fi HaLow Global Ecosystem



Module Partners

Module ODM partners already manufacturing Wi-Fi HaLow modules based on Morse Micro's MM6108 microchip, and leveraging FCC-certified reference designs. These modules are compliant with IEEE 802.11ah and Wi-Fi HaLow. Operations in 850–950MHz bands with 1/2/4/8MHz channel width.



P/N: AW-HM581

- LGA module, 44-pins
- Dimension: 13x13x2.1 mm
- Host I/F: SDIO/SPI
- Sample: Now

P/N: AW-HM593

- Stamp module, 34-pins
- Dimension: 14x18.5x2.25 mm
- Host I/F: SDIO/SPI
- Sample: Now



P/N: MM610X-001

- Stamp module, 43-pins
- Dimension: 22x17x2.0 mm
- Host I/F: SDIO/SPI
- Sample: Now

P/N: MM610x-MF08

- LGA module
- Dimension: 14x18.5x2.25 mm



P/N: FGH100M

- LGA module, 44-pins
- Dimension: 13x13x2.2 mm
- Host I/F: SDIO/SPI
- Sample: Now



P/N: SX-SDMAH

- LGA module, 60-pins
- Dimension: 18x17x2.65 mm
- Host I/F: SDIO/SPI
- Sample: Now



Wi-Fi HaLow Applications

AsiaRF Access Points



Wi-Fi HaLow Applications

We are enabling Tier-1 OEMs to build HaLow products in the following verticals



Mesh Access
Point



Consumer video



Enterprise
security



Point-of-Sale



Enterprise
gateway



Drone



Home garage
gates



Warehouse
roller doors



RFID tags



Yellow gear
comms



Tractor / vehicle
Wi-Fi



Intercom video

Wi-Fi HaLow Applications

Chicony - Wi-Fi HaLow Camera

- Morse Micro MM6108 Wi-Fi HaLow
- Ambarella, Sigmastar and Novatek Camera SoC
- PIR support



We are also working with ISPs in the US, Philippines, Japan and Australia



UNITED STATES

Working with ISPs to bundle in video cameras to increase stickiness of the ISP service



PHILIPPINES

Trials with 800 units in the field providing internet access to small islands



JAPAN

Working with major ISPs to integrate into their home router



AUSTRALIA

Working with ISPs that are evaluating our technology

About Morse Micro

Morse Micro Team

- Wi-Fi HaLow market leader
- World-class team of 160+ Wi-Fi chip experts including extensive field support team
- Over \$140MUSD Funding

Wi-Fi HaLow Silicon

- Smallest, fastest & lowest power Wi-Fi HaLow chip in the world
- Partnering with Module Vendors to Enable FCC certified Wi-Fi CERTIFIED HaLow™ modules

**Official Wi-Fi HaLow
testbed vendor**

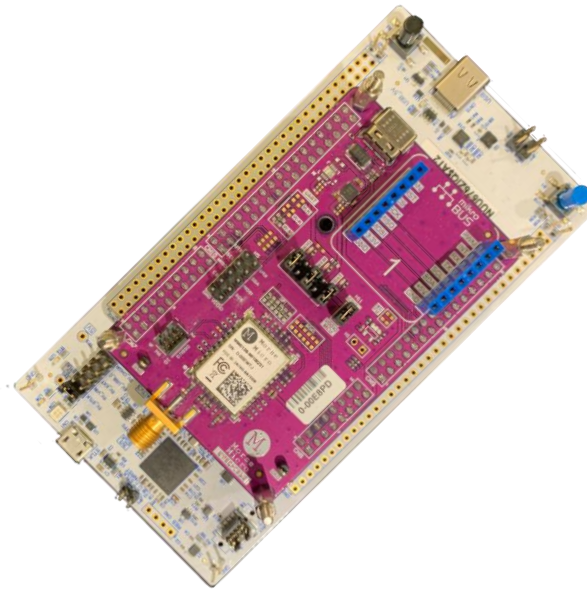


Platforms at a glance



MM6108-EKH01

Wi-Fi Halow RPi-Hat +
RPi + Enclosure



MM6108-EKH08-01

Wi-Fi HaLow Shield +
STMicro STM32WB55RG



MM6108-EKH04

Wi-Fi HaLow Router / USB
Adapter / Ethernet Adapter



Morse Micro



morsemicro.com