TARANA High Spectral Efficiency Designs and Applications

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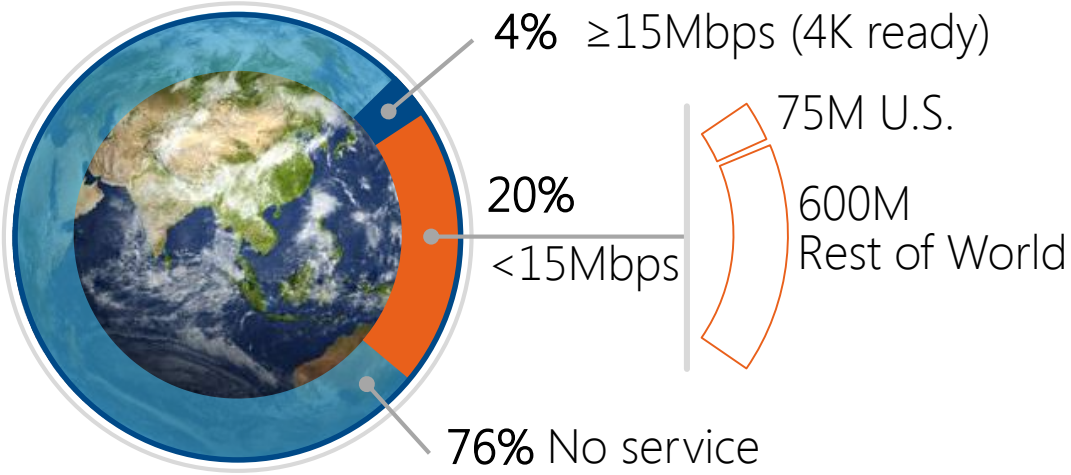
Opportunity: Un(der)served Broadband

Consumer

3.4B Households Worldwide

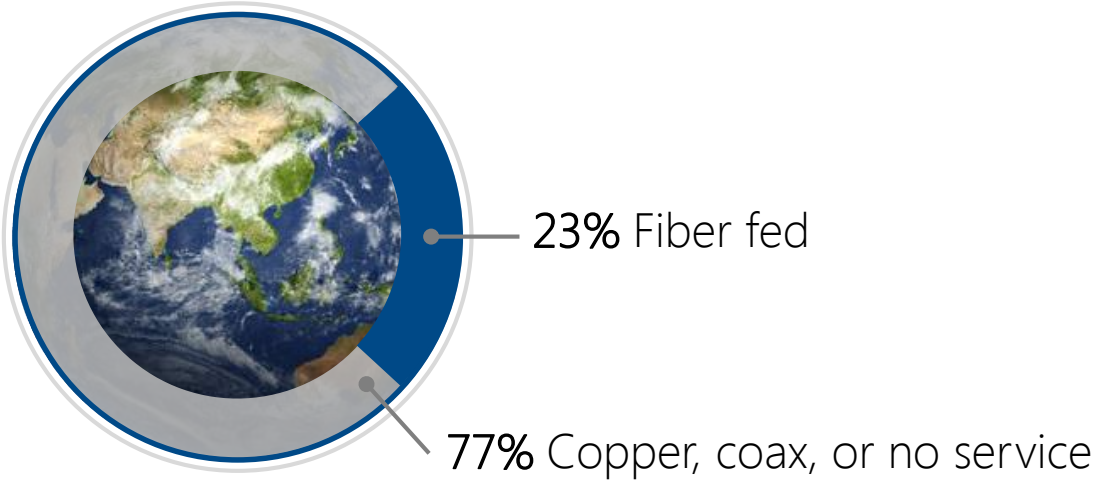
Broadband Service Penetration:



Business

150M Commercial Properties Worldwide

Business Broadband over Fiber Penetration:



Tarana's initial addressable markets:

- 2.6B unserved
- 675M underserved consumer HHs
- 115M un(der)served businesses

IoT and Mobile applications come next

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Problem: Current options not addressing demand

Fiber — High Costs

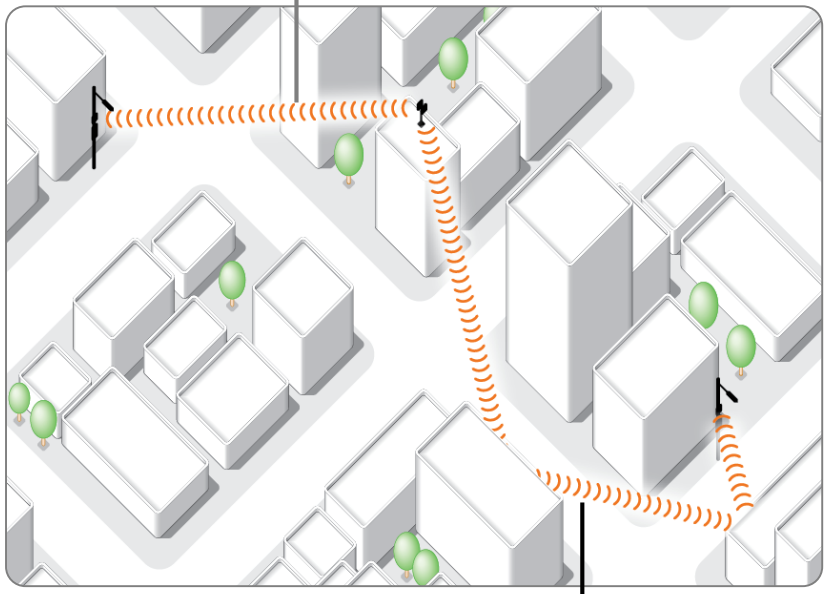
- Prohibitive costs
- Slow deployment
- Viable only for very short distances

Wireless — Poor Performance

- Obstructions
- Spectrum Scarcity
- Interference
- Motion
- Complex Installation

Last-mile wireless: why easier said than done

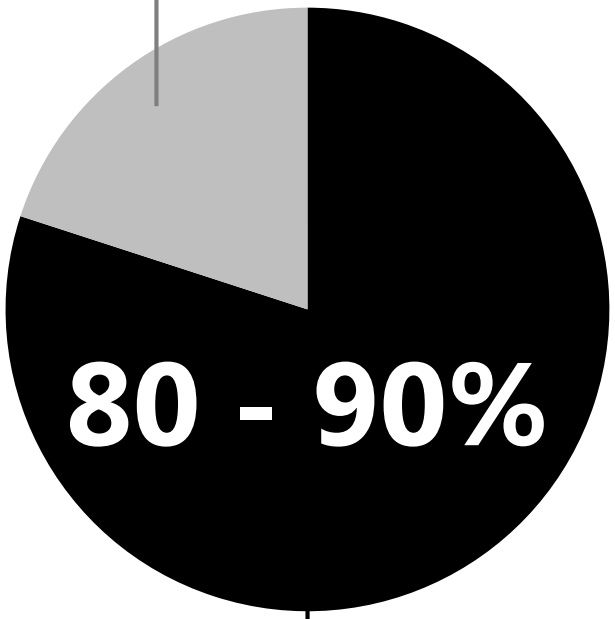
Reality: Most links have **no** clear line of sight to nearest fiber location (hence, harder to do)



Line of sight (LoS)

Non line of sight (NLoS)

Last-Mile Link Mix



Sources: Tarana's tier 1 mobile & fixed operator customers

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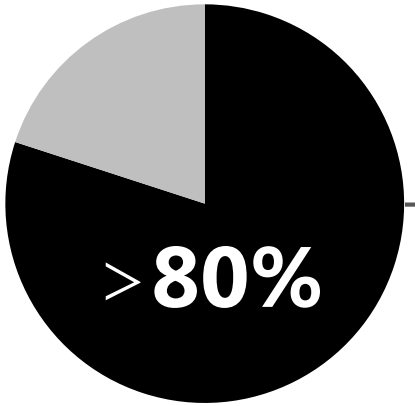
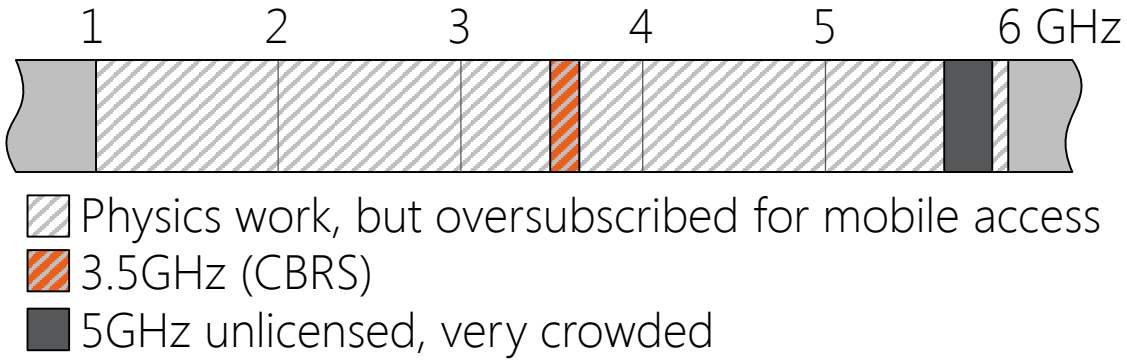
NLoS has several implications



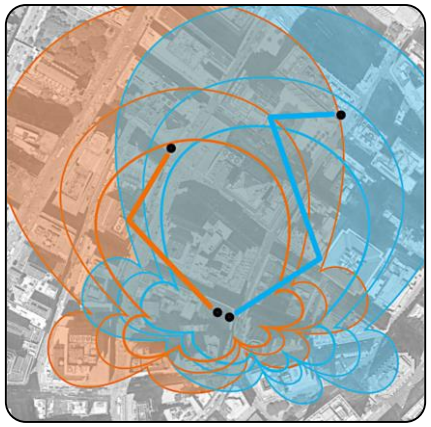
NLoS links

1. Very limited spectrum



2. Multipath

3. Co-Channel Interference



4. Wi-Fi Interference

5. Changing Conditions

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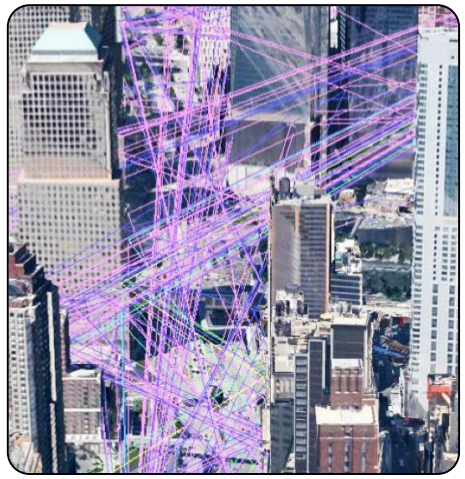
Solving NLoS challenges

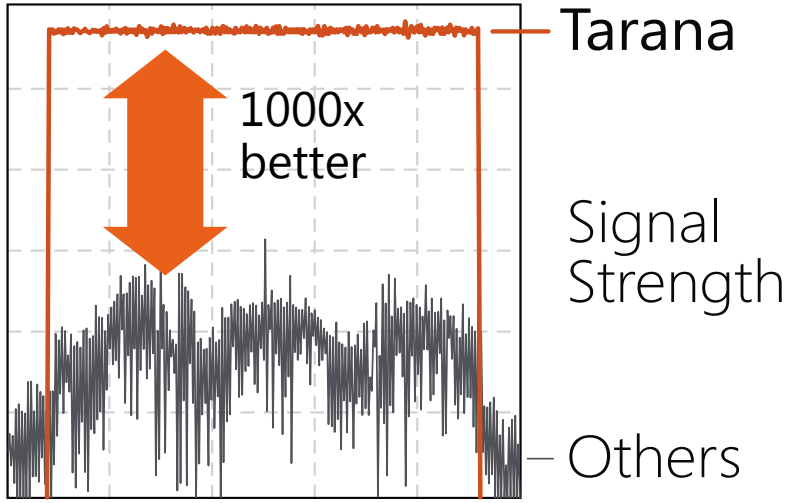
Challenge

Multipath Fading



Multipath combining

Solution



Changing Conditions

Installation Challenges

Continuous, Autonomous Adaptation

5000 times / sec

Unprecendented performance example: Flawless backhaul of LTE cell-on-boat

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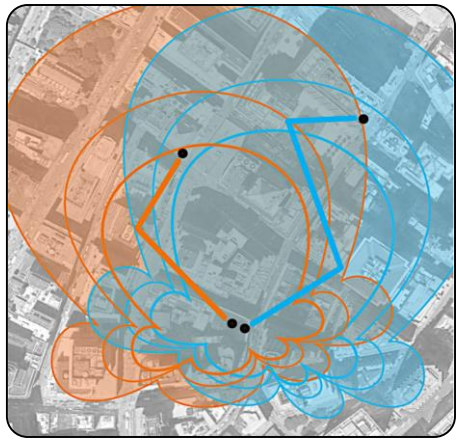
Solving interference challenges

Challenge

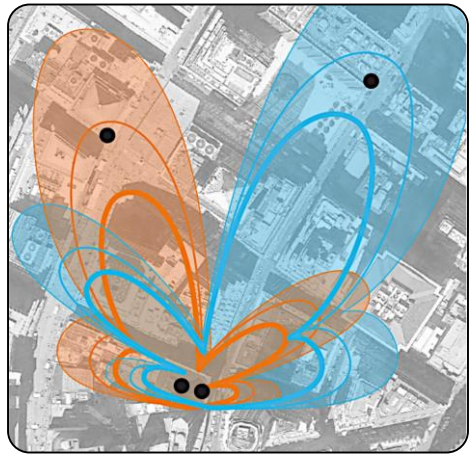
Co-Channel Interference

for licensed bands



Perfect Co-Channel Isolation

Solution



Precise digital beam- and nullforming

Wi-Fi Interference

for unlicensed bands

Unlicensed Interference Cancellation

Tarana:
Rapid nulling, free channel

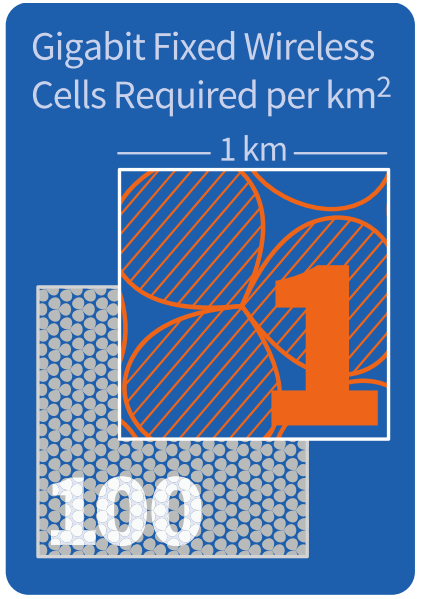
Others:
Futile channel changes

Putting it all together: Tarana Platform

Revolutionizing Wireless Performance

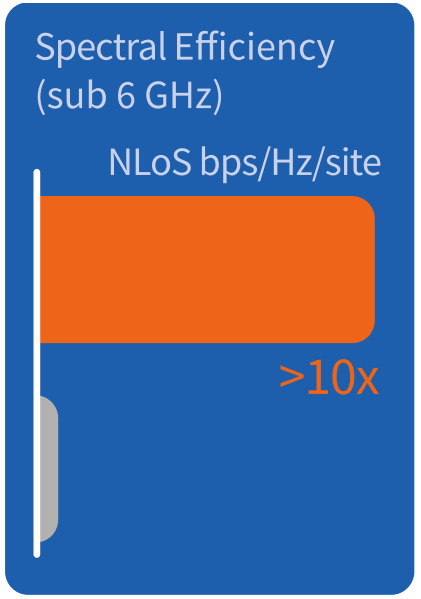
Tarana | Prior State of the Art

10x
NLoS Range



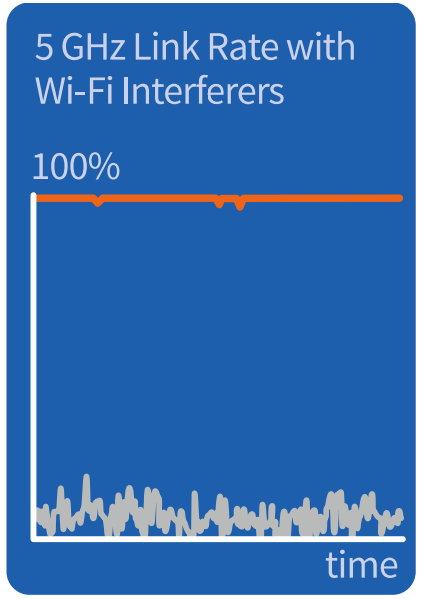
100x fewer cells
Site flexibility
Fast deployment

10x
Spectral Efficiency



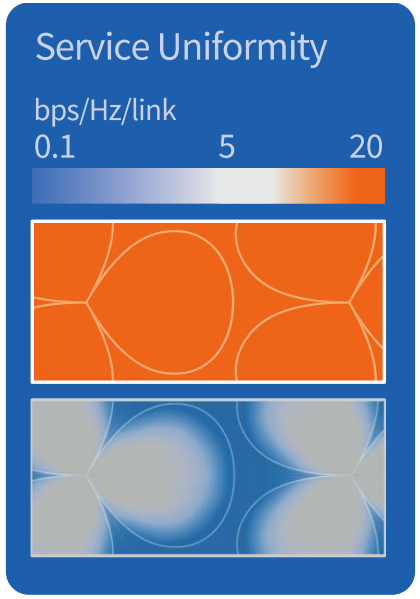
10x less spectrum

1000x
Interference Immunity



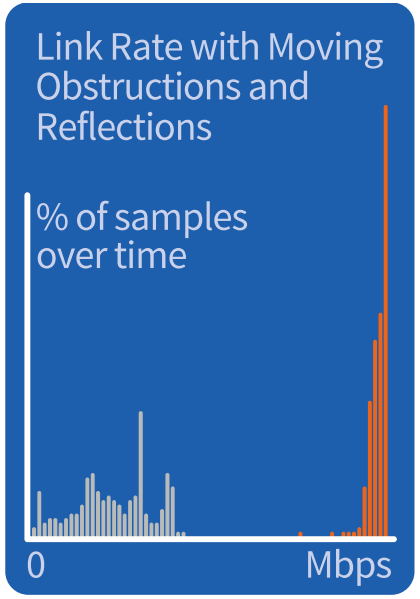
...or free spectrum

50x
Cell-edge Performance



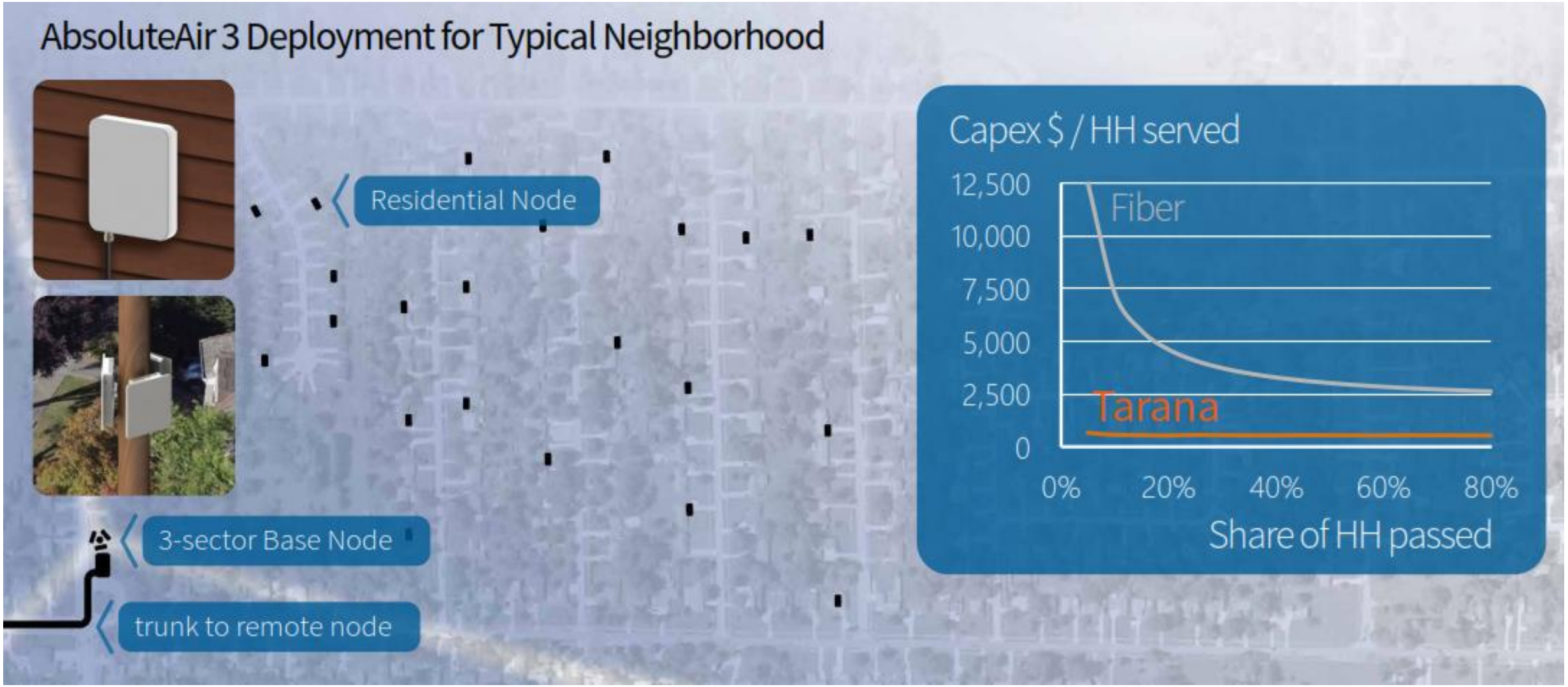
Fiber-class capacity everywhere

10x
Stability with Motion



Fiber-class reliability

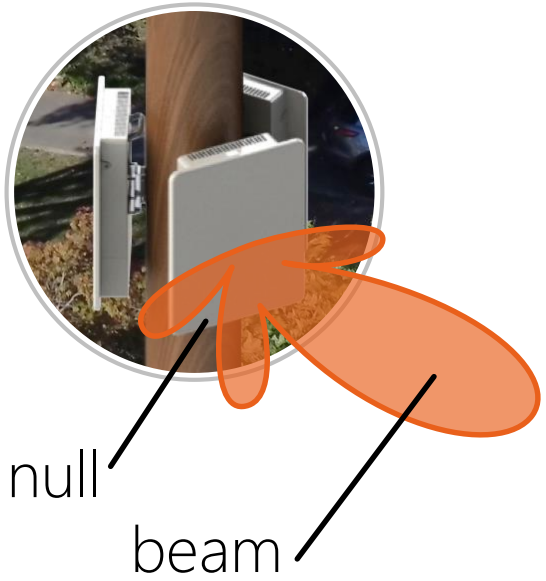
Gigabit Residential Broadband Economics



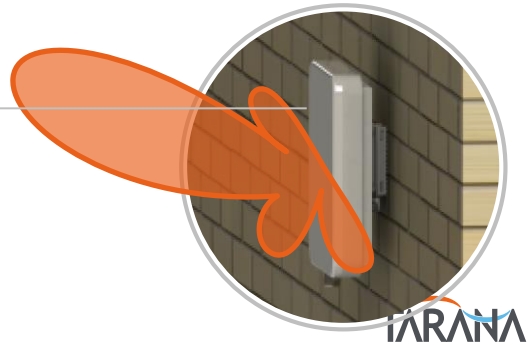
AbsoluteAir vs. Wireless Alternatives, TDD

Attribute	AbsoluteAir	4G LTE	Other 5G-NR Massive MIMO	5G mm-wave
Use-Case Focus	Fixed access	Mobile	Mobile	Fixed
Max Link Speeds Edge Link Speed	1,600 Mbps 800 Mbps	~150 Mbps < 10 Mbps	> 1,000 Mbps < 20 Mbps	Gbps
Uniform Service throughout Cell	Yes	No	No	At very short range
NLoS Range	2-5 km (Gbit)	Few km at low rate	Few km at low rate	100-300m LOS only
Spectral Efficiency in sub-10 GHz spectrum Dense Networks	~70 bps/Hz/site	4-6 bps/Hz/site	~10 to 15 bps/Hz/site	n/a
Availability	2018 - 2019	Now	2020+	2020+

Tarana Proprietary Technology Overview



Unique Architecture Elements	Performance Benefits
Distributed massive MIMO (DMM)	Large numbers of radios increase precision of all algorithms; even balance between base and remote nodes makes complex techniques feasible
Precise digital beam- and null-forming on both Tx and Rx	The foundation of all that follows: extremely well-controlled distribution and reception of radio energy only where productive
Closed-loop beamforming adaptation	Collaboration between base and remote nodes further improves digital beamforming accuracy
3D equalization	Applying signal processing across time, frequency, and spatial domains yields perfect channel even with the most complex diffraction, reflection, and motion effects
Autonomous, adaptive co-channel interference cancellation	Huge spectral efficiency gains through dense co-channel link operation
Spatial Multiplexing	Spectrum multiplier (24 streams, per base station site)
Continuous unlicensed interference cancellation	Yields licensed-class reliability in unlicensed spectrum



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Field Validation

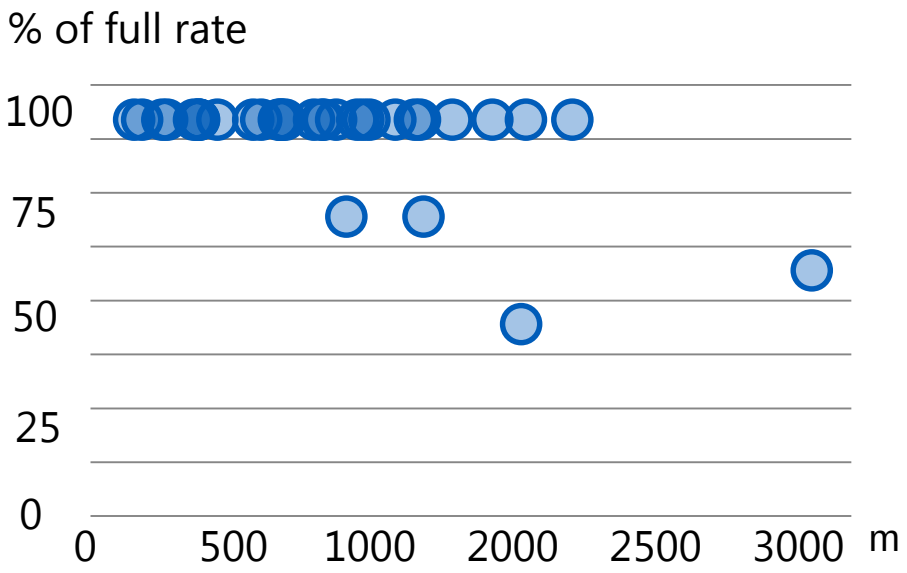
NLoS Performance

With Tier-1 US carrier

33 Severe NLoS 3.65 GHz links in Manhattan
Nearly all at maximum modulation (256 QAM)

CN at 186 m AGL, single EN mounted on SUV at roof level (locations tested separately)

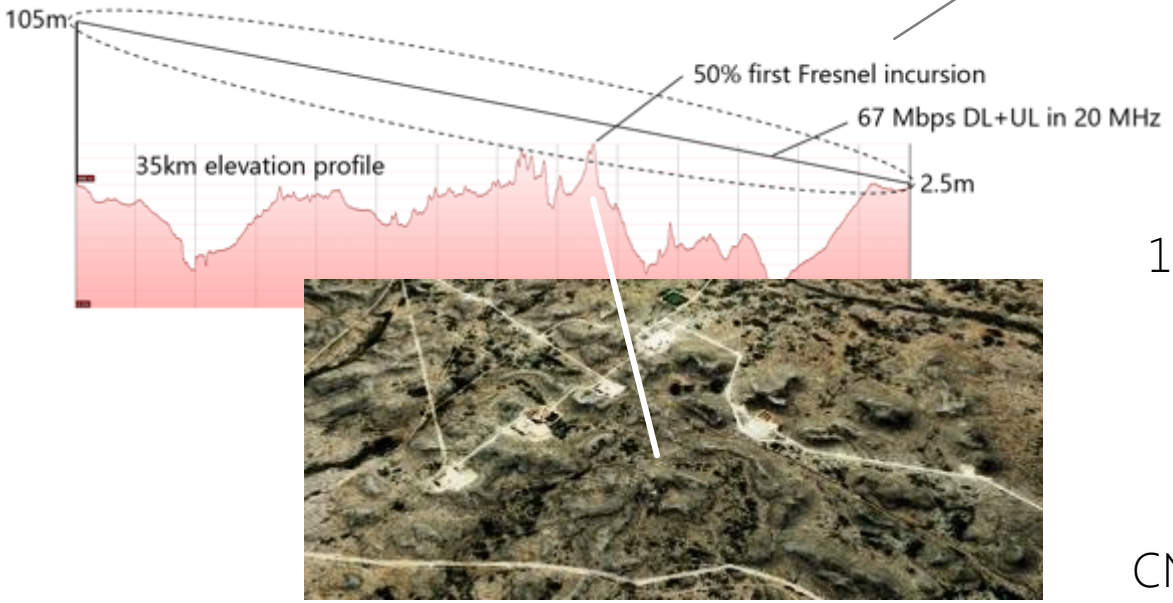
Links closed autonomously by the time the SUV was parked in each location, without physical re-alignment

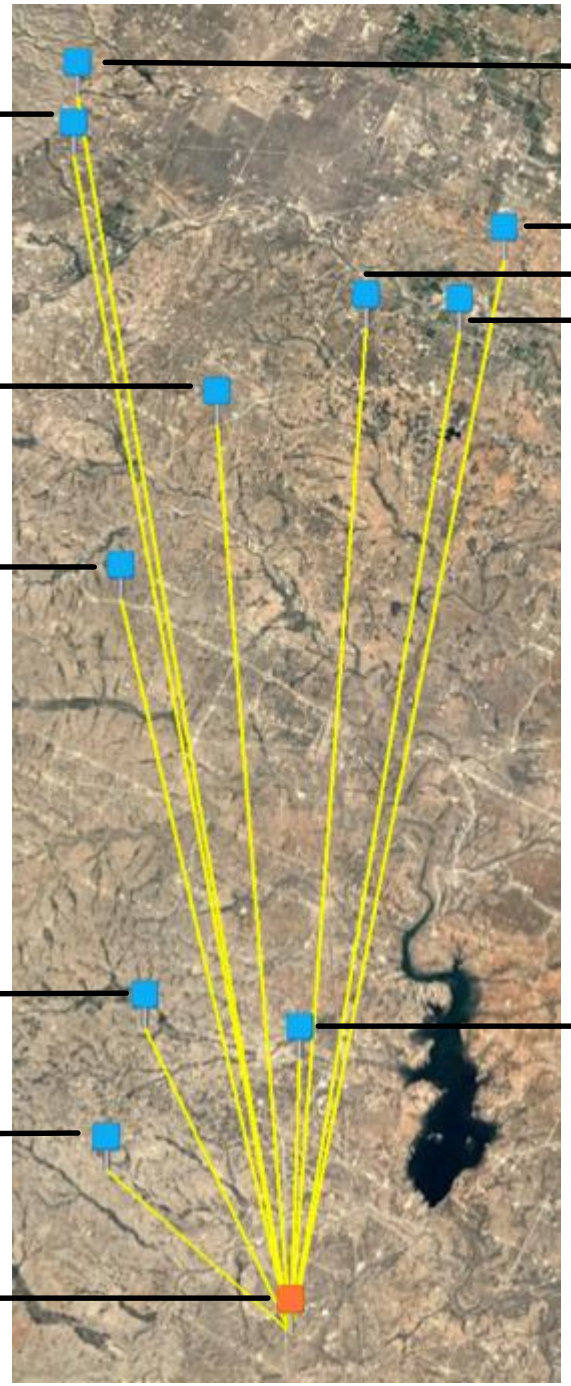


Long-Distance nLoS

- Application: remote-site connectivity in oil and gas operations in a 20 MHz channel
- Requirements for rapid, low-skilled deployment and high reliability in challenging terrain
- Tests conducted independently by tier 1 global oil producer in Texas field

Example Link:

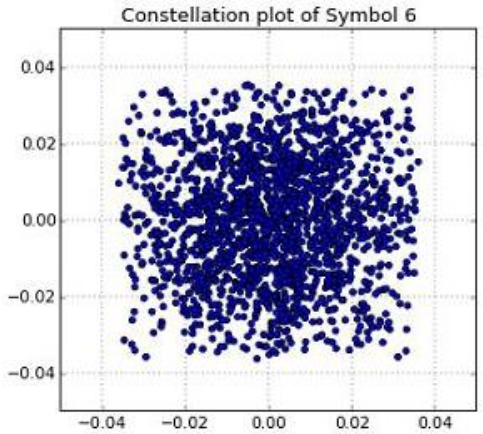




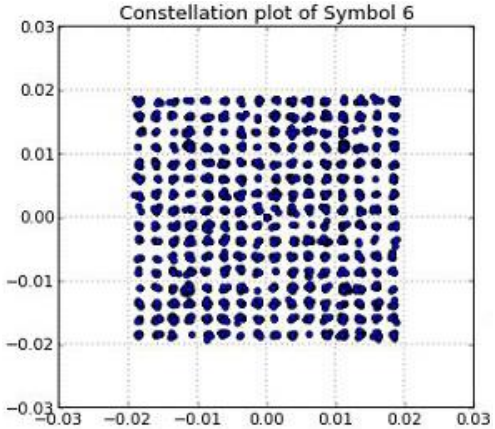
Unlicensed link deployment with interference cancellation

- 5.8 GHz 20 MHz link achieving with spectral efficiency of 10 bps/Hz
- End node co-located with Wi-Fi 802.11ac access point and multiple clients on the same UNII-3 channel

Before

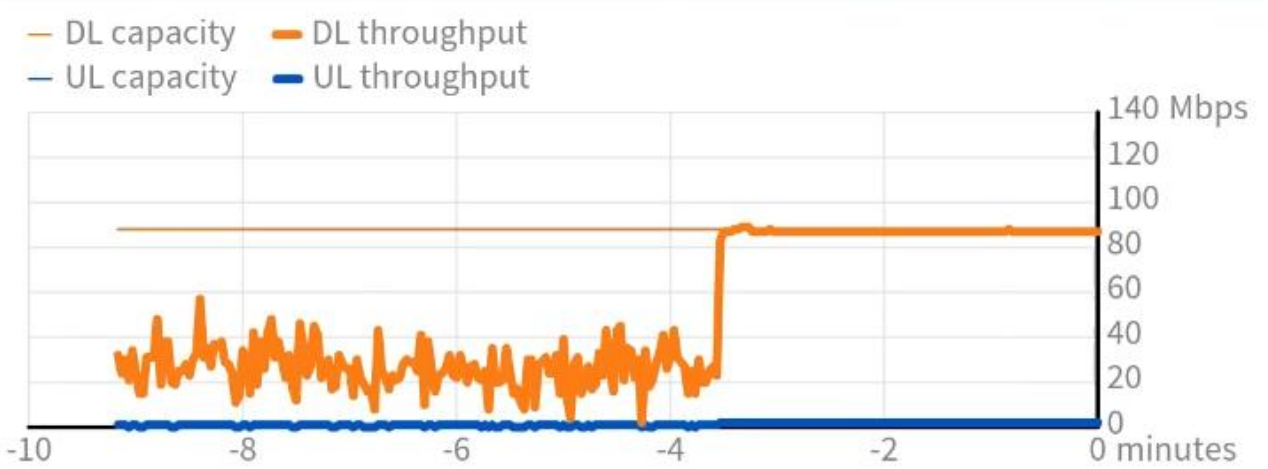


After

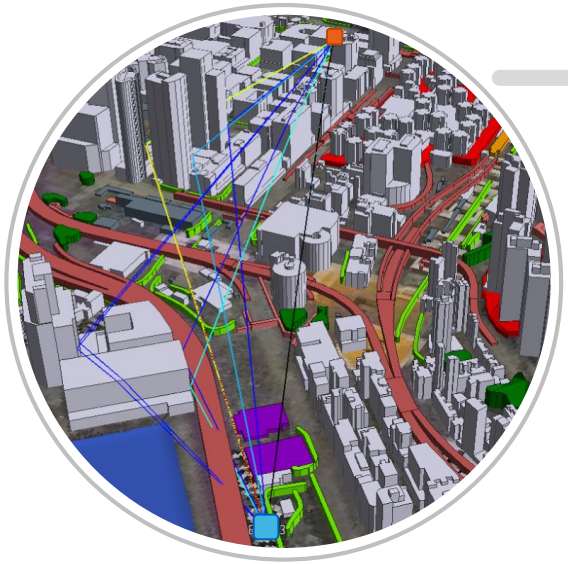


Before

After

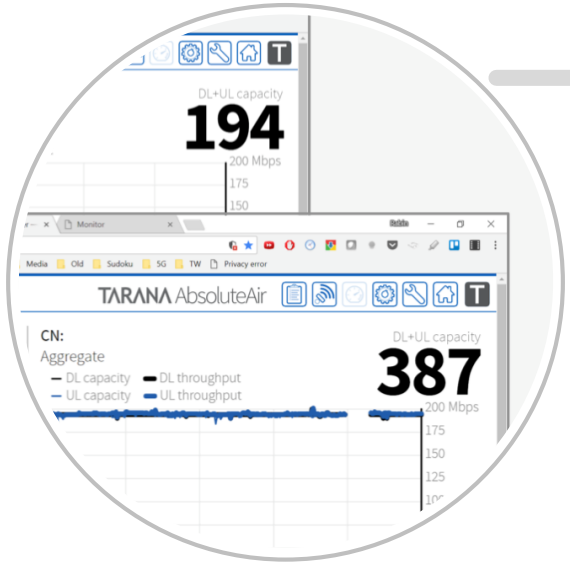


Hong Kong Trials (with leading Telco Operator)



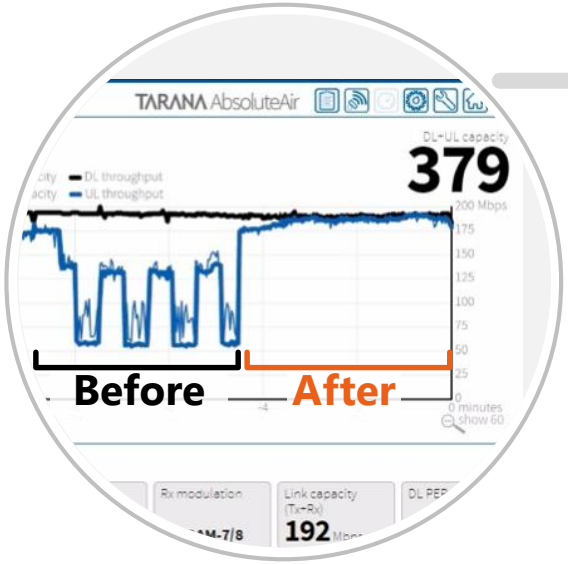
NLoS

8 fully-obstructed links tested in challenging, dynamic HK environment, with remotes at street level, from 200 to 1,200 m.
All closed within 5 minutes of setup, all at high speeds.



PtMP

Two 20 MHz co-channel links operated from one CN, in high-density rooftop-to-rooftop setting. Aggregate capacity was very stable and equaled 2x individual link capacity, as expected.



Interference

Strong nearby 5 GHz interferer pointed at CN in PtMP configuration. Capacity fluctuated down to 50 Mbps, but returned to maximum rate and full stability with proprietary interference cancellation techniques.

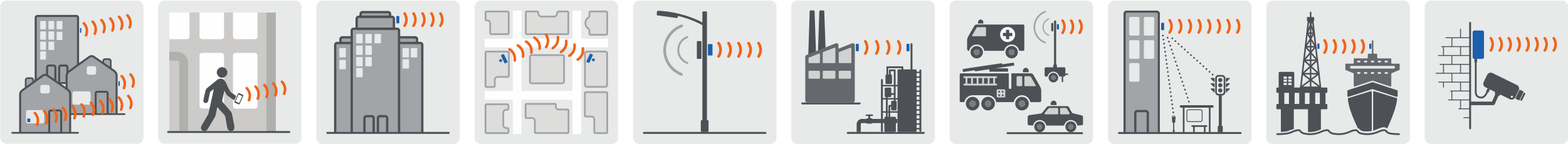
Over Water

Tested 3G, 4G, and JDSU traffic over multiple days through 11.6 km link over water (from Victoria to Caritas) — maintained reliable 340 Mbps link (in 40 MHz), weathering tides and monsoon rains.

TARANA WIRELESS, INC. FOR PUBLIC USE

A wide variety of network applications

Application	Residential broadband + IoT backhaul Smart cities w/ high bandwidth demand Vehicular connectivity Special-purpose networks (marine, security, industrial) Enterprise connectivity Radio Backhaul Mobile broadband (next)	Unique ability to support fixed and mobile wireless applications with the same infrastructure Broad utility of spectrally-efficient, easy-to-deploy, high-capacity links immune to interference, obstructions, and motion
Economy	Both developed- and developing-world ARPU	Access to single homes in developed worlds Access to multitenant buildings in developing world, with aggregate ARPU comparable to single developed-world homes
Operator Share	Low to high	Given unique range and capacity extensions, network economics are very good in either sparse or dense deployments
User Density	Rural to dense urban	



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Leading a wireless broadband revolution

Let's make it happen together!

Contact: eric@taranawireless.com