Reducing 5G Deployment Costs Using Holographic Beam Forming Repeaters from Pivotal Commware

By Pivotal Commware

The 5G trade media has criticized millimeter wave (mmWave) buildouts as too expensive, requiring "hundreds of thousands of new cell sites, each one plugged into a super-fast backhaul connection and topped with thousands of dollars of new transmission equipment."[1] Analysts like MoffettNathanson have questioned the ROI of deploying mmWave networks at scale.[2] These are fair criticisms. But deploying fewer base stations augmented by network repeater technology based on Holographic Beam Forming® (HBF) tells a different story. This paper shows how two HBF repeater products – Pivotal Echo 5G™ and Pivot 5G™ – deployed in conjunction with base stations, i.e., gNBs, reach more subscribers at less cost than deploying gNBs alone.

Importantly, this analysis focuses on *indoor* mmWave coverage, where 100% of fixed traffic and about 80% of mobile traffic occurs. Most of the applications best served by mmWave's ultra low latency and high capacity, like AR/VR telepresence (Figure 1), will primarily occur indoors.

Figure 1

[1] "Here's Why It Might Be Time to Worry About mmWave 5G," by Mike Dano, *Light Reading*, January 9, 2020.
[2] "Fixed Wireless Broadband: A Peek Behind the Curtain of Verizon's 5G Rollout, by Moffett Nathanson, March 20, 2019.

Why mmWave?

Critics of mmWave often say that sub-6 GHz bands require fewer gNBs and offer better coverage than mmWave bands. This may be true initially, but limited spectrum at sub-6 GHz will eventually require more gNBs. mmWave will start dense, but as data demand increases, sub-6 GHz will require densification too. So why start with mmWave? Because mmWave offers a leap forward in user experience from the beginning. Users won't pay more for 5G unless they notice a significant difference from 4G.

Limited propagation is generally perceived as a weakness of mmWave, but with precision beamforming repeaters like the Pivot 5G, limited propagation becomes a strength. In the absence of precision beamforming, repeaters generate interference, solving one problem only to create several others. By contrast, beamformers avoid interference by directing and shaping mmWave signals deterministically. The outdoor, pole-mounted Pivot 5G network repeater does this so well that, as an adjunct to and minimizer of gNBs, it helps operators reach more 5G subscribers at less cost and commensurately with subscriber demand.

mmWave not only offers more capacity than sub-6 GHz for the same density, but also does so with much smaller antennas. This fact matters to those who live near them and the municipalities that issue permits. When considering lowest cost, size, weight and power consumption, nothing surpasses Holographic Beam Forming technology used by Pivot 5G and Echo 5G.

Another benefit of mmWave capacity is its ability to combine access and transport traffic. This feature is built into the 5G NR standard and allows a gNB to, for example, not only access subscribers directly through a RAN beam but also through a repeater or a series of repeaters.

gNB Costs

Deploying fiber-connected, mmWave gNBs is expensive, both initially and on an ongoing basis. mmWave signals flow, or propagate, in straight lines and are easily absorbed by buildings and other obstacles. As a result, ubiquitous coverage requires gNBs on nearly every corner, particularly in urban areas where line-of-sight is restricted. Pivotal Commware recognizes that costs can vary widely. For this analysis, it estimates the average siting cost for each gNB, including fiber installation and a pro-rata share of new poles as required, plus gNB hardware, at $65,000. Yearly power consumption averages $2,100. Another cost, often significant but highly variable, is lost revenue associated with waiting for permits to install often ungainly gNBs and to trench fiber. We leave this cost aside. Bottomline, network operators want to deploy as few gNBs as possible to meet specific coverage and subscriber acquisition objectives.

Simulation

This analysis explores 5G 28 GHz mmWave network implementation strategies using a 3GPP-defined propagation model and 15cm resolution GIS data associated with one square kilometer of a typical suburb[3]. High resolution is necessary to simulate mmWave line-of-sight propagation.

Figure 2 below shows the one square kilometer suburb from above. Seven gNBs, each circled in red, provide a measure of outdoor and indoor mmWave coverage[4] to subscriber homes in blue. Figures 3 and 4 describe outdoor/indoor coverage in terms of area and subscriber units, i.e., homes, respectively. For economic reasons, operators typically won't deploy more than seven gNBs in a one-square-kilometer area. Therefore, the graphs show growing economic pain beyond the seventh gNB. At the seventh gNB, outdoor and indoor coverage are far less than the ideal 80%. This paper will leave aside outdoor coverage to focus on the new money that wireless operators can now access economically indoors via fixed wireless access (FWA). Up to and including the seventh gNB will establish our baseline.

[3] GIS data for this one square kilometer area supplied at 15cm resolution by Nearmap. Analysis assumes standard window glass, either single or double paned.
[4] Indoor coverage is defined as 15 feet inside or beyond.

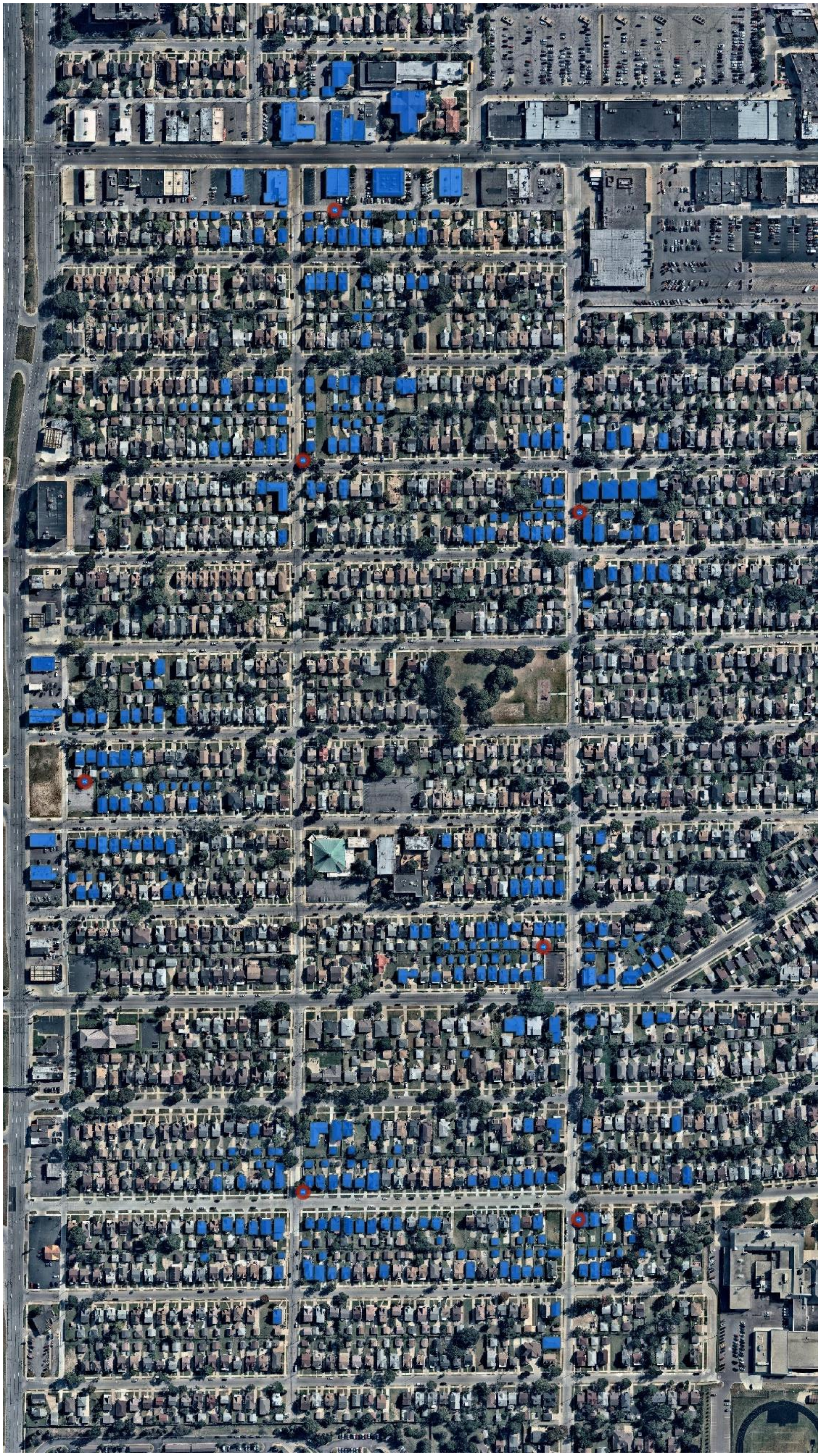

Figure 2 – One square kilometer of an American suburb populated by seven gNBs. Blue buildings indicate acceptable coverage.

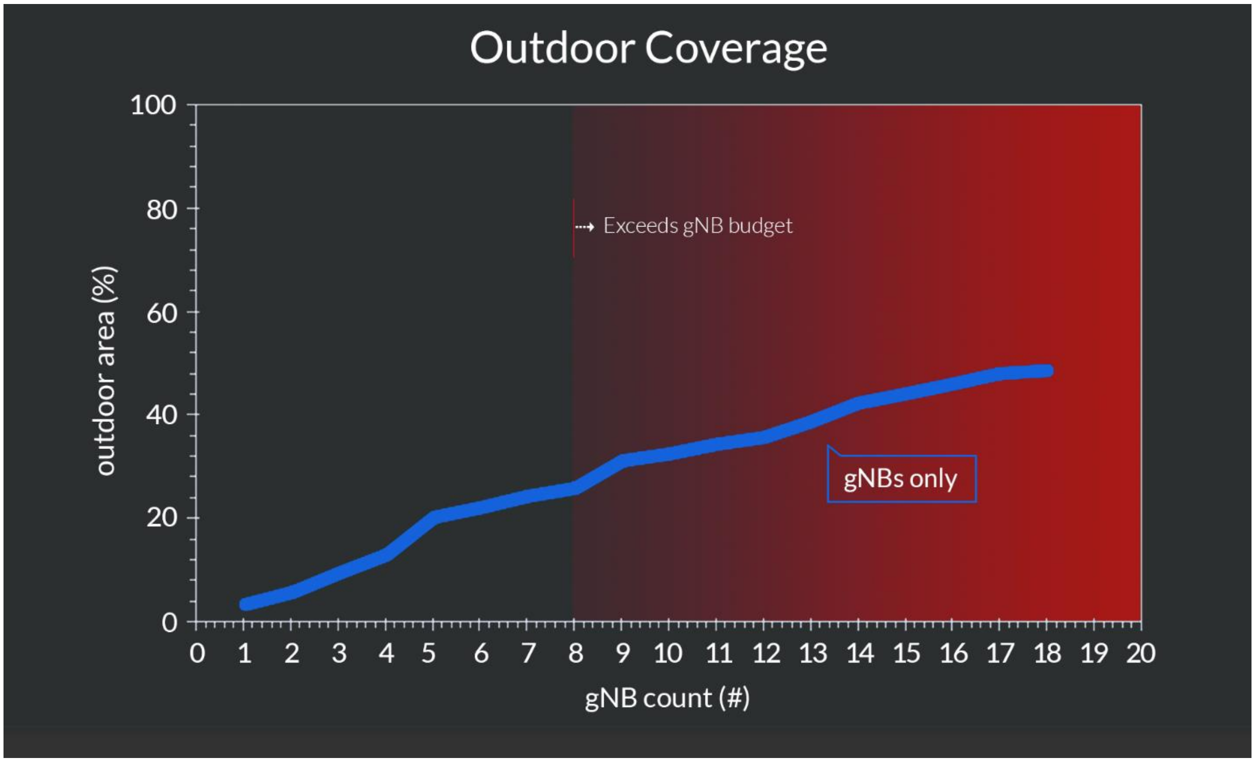

Figure 3

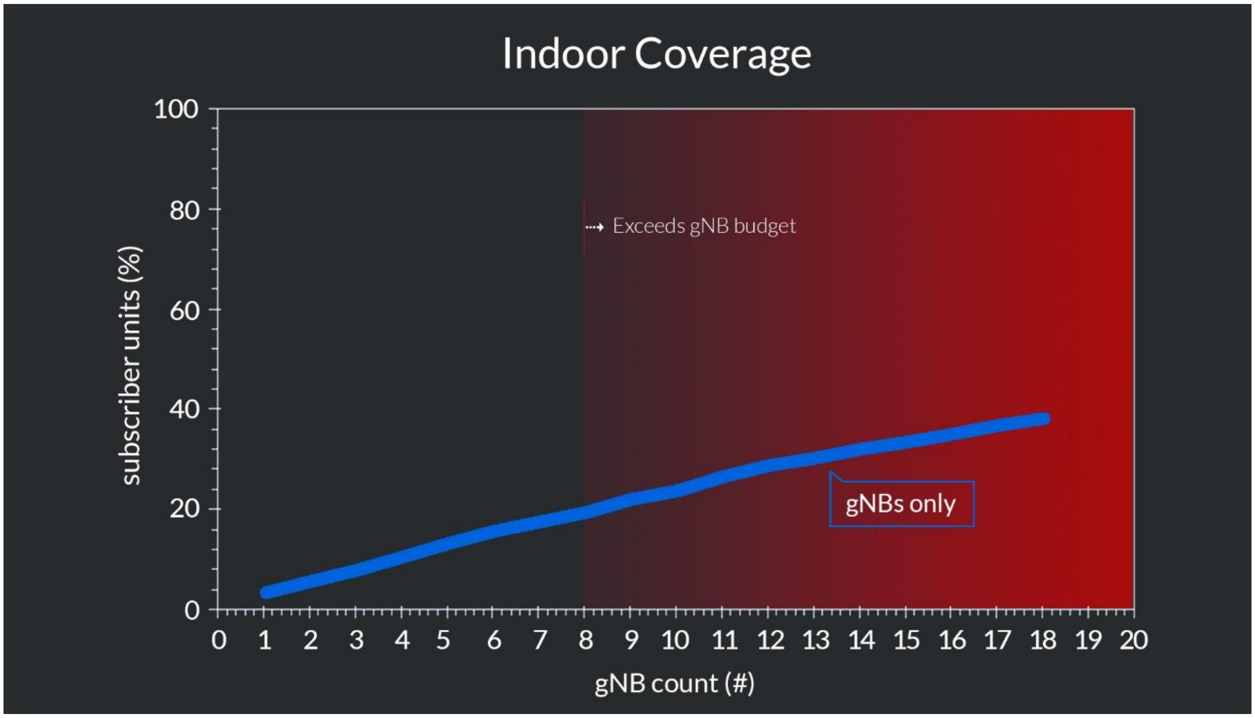

Figure 4

Introducing Echo 5G

Figures 5 and 6 show how attaching Echo 5G subscriber repeaters to the yellow buildings boost indoor subscriber coverage at the seventh gNB from 18% to 55% at an incremental Echo 5G cost of $300 per subscriber.

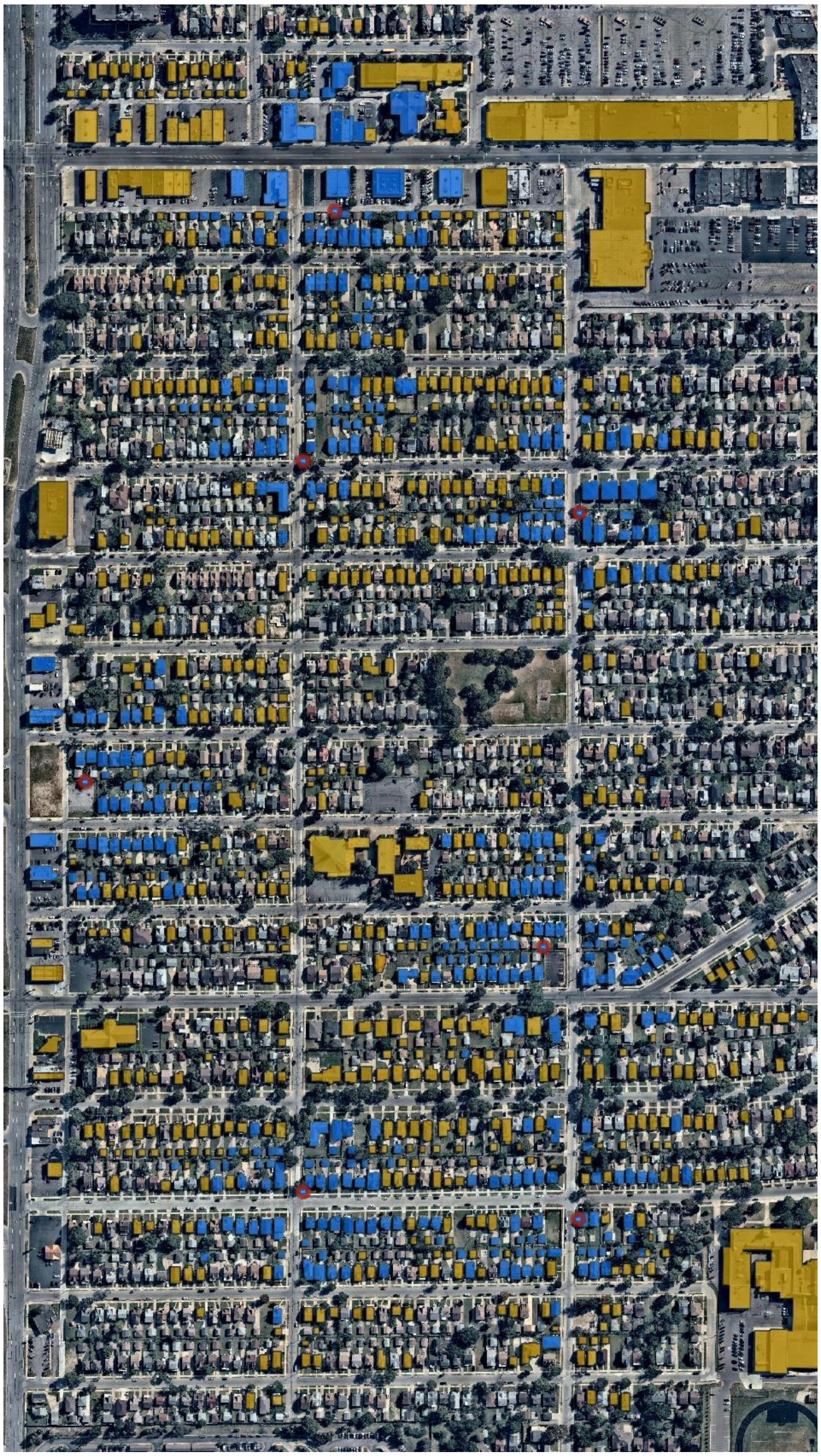

Figure 5 – One square kilometer of an American suburb populated by seven gNBs. Blue subscriber buildings indicate acceptable coverage provided by gNBs alone. Yellow buildings indicate additional subscribers covered by Echo 5Gs.

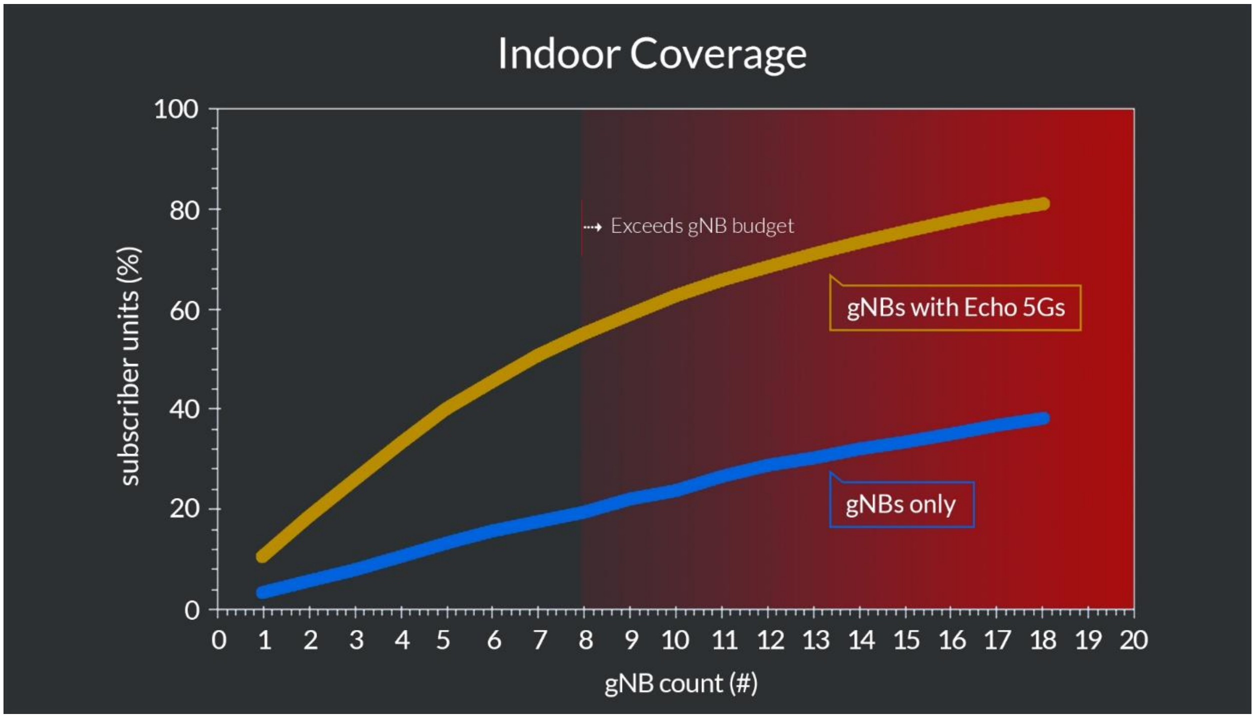

Figure 6

How does the Echo 5G improve coverage from 18% to 55%? The Echo 5G shown in Figure 7 is a self-installable, on-the-window, precision beamforming repeater designed to counteract the mmWave penetration, reflection, and structural shadowing losses so it can gently flood an interior with mmWave signal. Essentially, the Echo 5G acts as an mmWave portal between indoor and outdoor worlds. If the yellow building units in Figure 5 did not have Echo 5Gs, then they would suffer from some combination of penetration, reflection or structural shadowing and not receive an adequate indoor mmWave signal.

Figure 7 – Echo 5G

Introducing Pivot 5G

Figure 8 shows the Pivot 5G, an outdoor network repeater that addresses mmWave coverage challenges by capturing and redirecting mmWave signals from the gNB around obstacles like buildings. By extending the range of gNBs, Pivot 5G, by virtue of its small size, easy permitting, low power consumption and no requirement for fiber, reduces gNBs CAPEX, ongoing OPEX, siting costs and deployment time by minimizing the number of gNBs. Using Pivot 5Gs, network coverage can grow organically along with revenue.

Figure 8 – Pivot 5G

Figure 9 offers another birds-eye view of the neighborhood to show additional FWA subscriber homes in green acquired by Pivot 5Gs (designated with a "P'") after the seventh gNB shown in previous graphs. Figure 10 shows indoor coverage rising to 80% coverage using Pivots instead of gNBs. Not shown is the fact that by the 30th and last Pivot, 360 Echo-equipped subscribers were added. If we assume an incremental cost of $300/Echo and $5,000/Pivot, then the combined incremental cost per subscriber is ((360 x $300) + (30 x $5,000))/360 = $717. But's let not forget the 533 subscribers added by Echos to reach 55% coverage in Figure 6, where the incremental cost per subscriber was $300. This makes Pivotal's total incremental cost per subscriber, not counting the baseline of seven gNBs, ((533 x $300) + (360 x $717))/(533 + 360) = **$468.** This compares to $1,822 to achieve the same coverage from 21 more gNBs alone. Pivotal Commware's next paper will publish this incremental cost per subscriber and other expensive gNB details.

Figure 9 – One square kilometer of an American suburb populated by seven gNBs. Blue subscriber buildings indicate acceptable coverage provided by gNBs alone. Yellow buildings indicate additional subscribers covered by Echo 5Gs. Green buildings indicate still more subscribers covered by Echo 5Gs and pole-mounted Pivot 5Gs designated by "P".

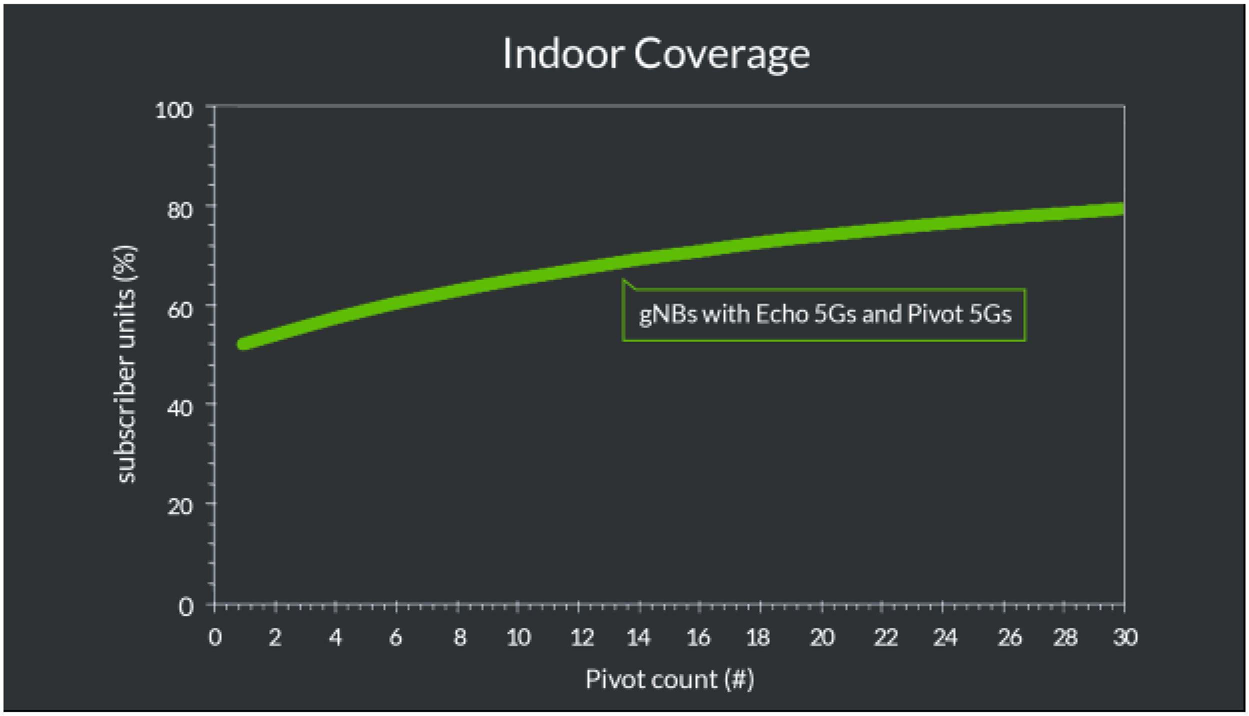

Figure 10

Summary

Using 15cm resolution GIS data associated with a typical suburb, this paper has demonstrated that 5G mmWave network operators can achieve 80% indoor coverage in one square kilometer using seven gNBs, 30 Pivot 5G repeaters and 360 Echo 5G repeaters instead of 28 gNBs alone. Beyond the seven gNBs that an operator would have deployed in any case for mobility, the incremental cost/subscriber of using Echos and Pivots instead of gNBs to achieve 80% is $468. This analysis places greater than $100 billion of new FWA money within reach of U.S. mobile network operators who have nationwide mmWave spectrum.

Due to mmWave propagation characteristics, repeaters will be required to guide mmWave signals around obstacles outdoors and to penetrate indoors, but only Pivotal Commware provides the lowest C-SWaP (cost, size, weight and power consumption) technology to accomplish this. Holographic Beam Forming uniquely provides Gigabit+ service to subscribers using the smallest and lightest unit that they can install on their windows and power from an indoor wall outlet. Pivot 5G uses the same technology to help network operators lower their cost per subscriber by acquiring more subscribers using fewer gNBs.