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The Critical Dimensions for 5G Fixed Access

A techno-economic analysis of millimeter wave networks

October 18, 2017

San Francisco • Singapore • Tokyo • Vancouver

Executive Summary

To assess the commercial potential of millimeter wave fixed access technologies, we developed techno-economic models to validate various business case scenarios. This is only one of multiple factors that impact commercial success, but it is important as it focuses the spotlight on critical aspects such as service plans and pricing, deployment process, equipment features and capabilities, spectrum, and ecosystem development.

Fixed wireless access in millimeter wave frequencies emerged as a principal application of 5G technology driven by the business plan of a few service providers. The process of standardizing the technology is well underway and several trials have been completed or are currently underway by leading vendors and service providers. The two leading US operators, AT&T and Verizon, competed strongly to acquire spectrum in the 28 and 39 GHz bands. Verizon has further engaged in 11 market trials to characterize the technology and assess its feasibility. All this has heightened the interest of financial investors and wireless ecosystem players in the commercial potential of millimeter wave fixed wireless access.

Validity of the business case is critically dependent on the number of connected houses per site. There exists a threshold below which the business case becomes highly sensitive to other parameters that quickly makes it unviable, especially in the presence of other competing technologies. In our case analysis, this threshold is 32 houses per cell site. The other parameters include the cost of site lease, backhaul, and customer premise equipment and installation.

The number of connected houses per cell site is directly correlated to the coverage capabilities of millimeter wave technology. Coverage is tightly coupled with the deployment scenario and the capabilities of the equipment. It is crucial to understand the true performance possibilities of this technology, and how it applies to different markets. This understanding helps to guide the feature design required to realize the successful business models.

The success of millimeter wave is largely predicated on the ability of the service provider to acquire the right site location where capital and operational costs could be amortized over a large enough client base. This and other related factors lead us to conclude that millimeter wave access is a niche application that will take longer than current industry expectation to fully materialize as a significant commercial opportunity.

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Table of Contents

Introduction

Fixed wireless access has a challenging business case. There have been many unsuccessful ventures: LMDS/LMCS in the mid-1990s and WiMAX in the 2000's are prominent examples. Unlike previous attempts, the drive for fixed wireless access is now happening from within the mobile ecosystem, driven by large service providers focusing on millimeter wave spectrum (mmWave). This raises questions on market viability by ecosystem players looking to develop products and solutions: How big is the market? Is the millimeter wave market a niche market? And, should we invest in the fixed access market?

Having experienced previous industry cycles, we at Xona Partners learned to pay close attention to the critical aspects that will allow a technology to gain traction and lead to a thriving market. To address questions related to mmWave networks, we developed techno-economic models that tightly represent the business and usage cases. Technology and business aspects are both critical in such an analysis: the technology performance and market conditions must be appropriately modelled to ensure accuracy. In this paper, we outline key factors impacting the business case, focusing on mmWave technologies under the 5G banner. Our target audience is the investor community, both financial investors and technologists looking to invest in mmWave solutions or networks.

Methodology Summary

We leveraged techno-financial models that Xona Partners have developed and optimized over multiple use cases to determine the most critical parameters that affect the business case. The models combine technical performance in select deployment scenarios with financial metrics that allow us to gauge sensitivity of the business case to different technical, commercial and market parameters.

The simulation engine allows us to cost-out the deployment for different applications. The cost model includes the end-to-end network: access, core and transport networks (Table 1). In this paper, we focus on a deployment scenario in typical suburban area in a US city (Figure 1). The deployment scenario features base stations of small form factor mounted on short poles of 10 – 20 meters in height, in residential areas (i.e. mmWave small cells).

The success benchmark in the business case we present in this paper is the number of months to breakeven. To simplify the presentation and focus on key drivers, we had to consider a subset of all operational aspect of a fixed wireless venture. We therefore left out some parameters, such as customer acquisition costs, while understanding their impact on the business case. In effect, the actual breakeven point for a commercial venture would be longer than the value we present in this paper as our analysis presents a ceiling below which actual operating parameters must remain.

Table 1: Capital and operational mmWave network expenses.

	Capital Expenditures	Operational Expenditures
Radio access	• mmWave access nodes • Site acquisition, permitting • Installation, test and commissioning • Radio planning & design • Project management • CPEs • Spares • Spectrum	• Site lease • Transport • Power • CPE installation services • Operation and maintenance • Warranties and vendor support
Core Network	• Core network elements (AAA, OAM, billing, DHCP, Firewall, OSS/BSS, etc.) • Design services	• Vendor licensing expenses • Operation and maintenance

Figure 1: Example of North American suburban area.

A Market Perspective

We focus our analysis in the 28 GHz band. By strict definition, mmWave implies frequencies between 30 – 300 GHz, however in the present industry context frequencies in the 24 and 28 GHz are also referred to as mmWave. A few operators are heading the demand, analysis and market trials of mmWave solutions, including Verizon, AT&T, NTT Docomo, SKT, and KT. The US, Korea, and Japan are the current market leaders in setting requirements and in planning for mmWave networks – they have a combined population of 500 million. Other markets, most notably Europe, China and India have been relatively absent, with a few exceptions. The US operators are focusing solely on the fixed use case, whereas the Asian operators have been additionally investigating the mobile use case. The leading fixed access application is fiber extension to provide cable, TV and data services. The geographic concentration of interest in mmWave is important for benchmarking potential economies of scale, especially that related to the cost of the subscriber device (CPE), where volumes are necessary to achieve low price.

The Performance of Millimeter Waves

mmWave has significant throughput performance with a channel size of up to 900 MHz. The challenge resides in the coverage performance. mmWaves have limited non-line-of-sight range due to high penetration loss through walls and foliage, and poor diffraction capabilities around obstacles such as rooftops (Table 2). mmWaves are also susceptible to environmental elements such as rain, snow, and sand, which are accounted for during the planning stage. Bouncing signals, signals that come from any direction, are a practical challenge: the strongest signal is not necessarily the one directly from the transmitter.

Table 2: Range performance for system operating in 28 GHz.

	Coverage range at 100 Mbps cell edge throughput		Coverage range at 1 Gbps cell edge throughput	
	LOS	NLOS	LOS	NOS
Outdoor-to-outdoor		354		219
Outdoor-to-Indoor (standard multi-pane glass)	1260	128	428	66
Outdoor-to-Indoor (IRR glass)	140	37	51	18

The combination of the above challenges leads to high performance variability, which translate into the following practical aspects:

a. mmWave modems cannot be placed anywhere. Rather, they must be window-mounted and facing the base station. Reflective window coating is a hindrance that leads to outdoor CPEs being required.

b. Few houses would be covered by a cell site in non-line of sight requiring outdoor CPE deployments to improve the range of coverage and offered throughput.

c. Outdoor CPE installations require truck rolls by installation specialists.

d. Beamforming technology is necessary to compensate for performance shortcomings, which adds cost of the base station equipment or the CPE, or both.

The Critical Elements of the Business Case

Of the many elements that impact the success of fixed wireless access deployments, profitability is generally linked to only a few key parameters. To explore the impact of some of these parameters on the business case, we take a scenario of a suburban market served by two competing service providers. mmWave systems are mounted on pole in a 4-sector configuration to serve houses 360-degrees around the pole. The chance of achieving line-of-sight connection to a mmWave modem is 50%.

Connected Houses Per Cell

The number of connected houses, or subscribers, supported by a cell site affects how quickly the service provider can break even on their infrastructure costs. This, along with the service price, affects the revenue side of the business case. But unlike the service price, which is bound by the type of service offered and competitive alternatives, the coverage performance of mmWave technology determines the number of served and connected houses. For instance, a larger cell size covers more houses and spreads costs over a larger client set. This is critical as it sets the foundation of the business case and acts as a bias or anchor around which other parameters can be optimized.

Fixed access networks are typically rolled out selectively, targeting certain areas of interest to the service provider. This is advantageous in controlling cost but also restricts one from leveraging economies of scale.

It is advantageous to the service provider to deploy high poles to extend radio coverage. However, residential areas are very sensitive to cell siting. Often, it is not possible to obtain cell site locations, and when a site is secured, the height of the pole is restricted to below 15 m. This is just above the tree line in many neighborhoods, and restricts reach to the first tier of houses around the cell site.

In our deployment scenario, the business case become valid at near 8 subscribers per sector, or 32 per cell site, based on a 4-sectored configuration. A number below that makes the business case unprofitable, as it has high sensitivity to variations in other parameters. As the number of subscribers increases, the business case becomes more robust to other cost parameters.

To showcase the sensitivity of the business case to other parameters, we set the number of subscribers to 8 per sector.

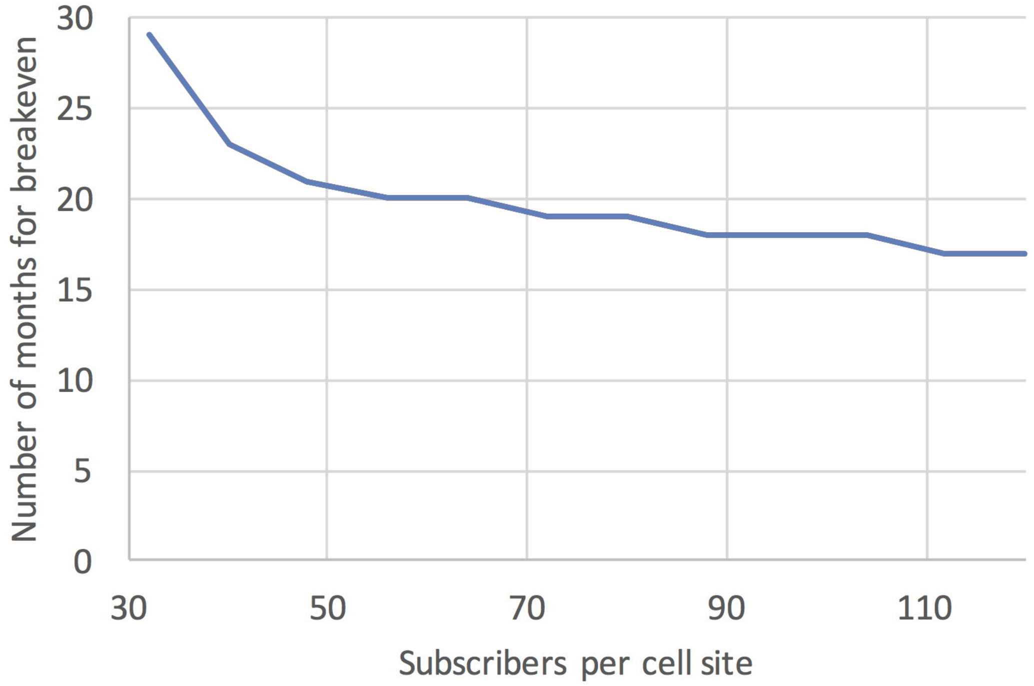

Figure 2: Impact of number of subscribers per cell on the business case.

Based on the coverage characteristics of mmWave and for practical and commercial reasons, service providers will roll out of mmWave networks in areas where they can serve a large number of subscribers, unhindered by municipal cell siting restrictions and physical coverage obstacles. The fixed wireless access use case is selective.

Cost of Transport

mmWave fixed access networks typically require fiber backhaul, as wireless become limited for multiple reasons. In our scenario, we consider mmWave technology being used for fiber extension, hence, fiber is readily available for backhaul. This has a major impact on the viability of the business model. In fact, leasing fiber backhaul for fixed wireless access is highly unlikely to yield a positive business case. Additionally, the service provider will need to control its own transport network expenses.

In our scenario, the cost of transport to the service provider cannot exceed $550/sector/month (Figure 3A). After that point, the business case would break even in 56 months. Ideally, the cost of transport should be below $300/sector/month to present a positive value proposition.

Pole Lease Expenses

mmWave fixed access base stations are deployed on poles similar to small cells. The permitting process has proved to be expensive and challenging. Site leases have also shown to be a major roadblock in this deployment scenario, where in many instances costs of $1,000/month or more are not uncommon. In the case of fixed wireless access, the business case is sensitive to this parameter considering that relatively few subscribers are served by a site, amortizing the lease expense and justifying the value proposition.

In our scenario, monthly expense for pole lease must be below $150/month (Figure 3B).

Cost of CPE

The cost of the CPE presents a challenge, because it is typically overlooked in the business case, while on the other side, the industry knows that the success of fixed wireless access is predicated on low cost CPEs. This was understood well after high cost CPEs was a driving reason behind the failed LMDS/LMCS technology. Since that time, fixed wireless access proponents either attempted at creating volume through standardization and ecosystem development (e.g. WiMAX), or adapting other massively deployed technologies for fixed wireless access, such as Wi-Fi and CDMA (WLL).

Complexity and low volumes are detrimental to achieving at a low-cost CPE. mmWave technologies typically maintain higher complexity through technologies such as beamforming, to save on other expenses such as truck rolls. It becomes critical for large markets to adopting mmWave technology in high volumes to achieve the cost objectives. In the world of telecom, the volumes range in the millions of SoCs.

In our scenario, the cost of the CPE should remain below $350/unit. The business case begins to deteriorate quickly above $550/unit (Figure 3C). With these figures in mind, we could work our way to estimating a detailed BOM cost for a CPE, including the silicon and antenna subsystems.

CPE Installation

Truck rolls are expensive: they require trained teams, equipment, and coordination to fulfill on their mandate. It is the objective of any fixed wireless access technology to eliminate or reduce to a minimum truck rolls to install CPEs. This often led to sophisticated technology incorporated at both the base station and CPE. While additional expenses at the base station could be tolerated, that at the CPE is more pressing. From this perspective, the cost of truck rolls is a complementary cost to that of the CPE.

In our scenario, where 50% of the CPEs will require truck roll, the cost per truck roll should not exceed $400/CPE (Figure 3D). In the event that more CPEs will require truck rolls, the cost per truck roll must decrease accordingly.

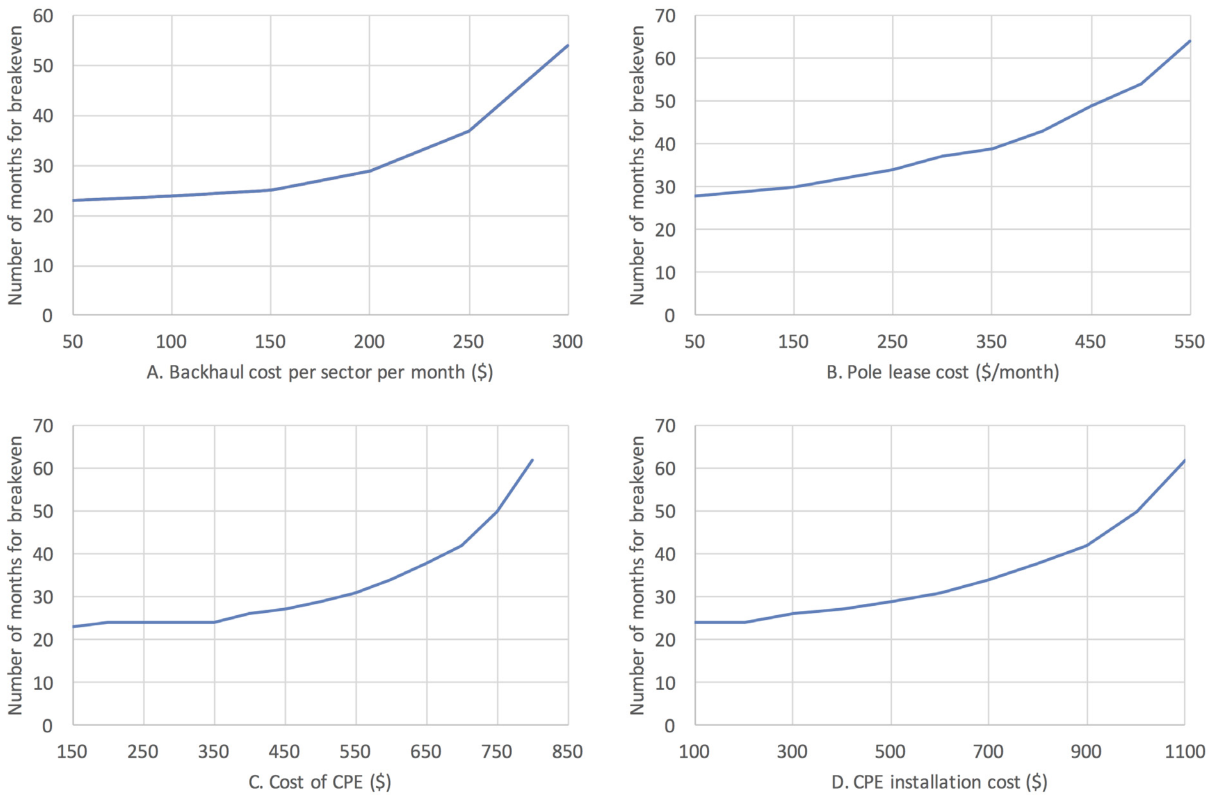

Figure 3: Sensitivity of mmWave business case to key parameters.

Key Takeaways

The selective nature of mmWave renders the technology to niche applications. Requirements for backhaul and cell siting allows a limited number of service providers to take advantage of the technology. These include both wireless and fixed access service providers with fiber assets.

Coupling these conclusions with spectrum availability – an issue that we did not address in this paper, but is of vital importance to achieve economies of scale – lead us to conclude that mmWave will remain a niche technology and will take longer than currently expected to mature and develop: we expect a limited ecosystem for access solutions and a long deployment ramp.

Acronyms

AAA	Authentication, authorization, and accounting
BOM	Bill of material
BSS	Business support systems
CPE	Customer premises equipment
DHCP	Dynamic Host Configuration Protocol
IRR	Infrared reflective
LMCS	Local multipoint communication system
LMDS	Local multipoint distribution system
LOS	Line of sight
mmWave	Millimeter wave
NLOS	Non-line of sight
OAM	Operations, Administration, and Maintenance
OSS	Operations support systems
SoC	System on chip
WLL	Wireless local loop

About Xona Partners

Xona Partners (Xona) is a boutique advisory services firm specialized in technology, media and telecommunications. Founded in 2012 by a team of seasoned startup technologists, managing directors in global ventures, and investment advisors, Xona draws on its founders' cross-functional expertise to offer multidisciplinary technology and investment advisory services. Xona works with private equity investors and technology corporations in pre-investment due diligence, post investment lifecycle management, and strategic technology management to develop new sources of revenue. For additional information, visit http://xonapartners.com/.

www.xonapartners.com advisors@xonapartners.com @xonapartners