White Paper

The Economic Case for Microwave as a Preferred Alternative to Leased Lines for 3G and 4G Mobile Backhaul

Abstract

This paper explores current and future mobile backhaul requirements and compares the ability of both microwave radios and leased lines to address those requirements. Specifically, the paper demonstrates that next generation microwave backhaul systems are superior in many ways to traditional leased line approaches, including significantly lower total cost of ownership resulting in very short payback periods as compared to leased lines.

Introduction

Microwave radio technology has played a significant part in the roll-out and expansion of cellular networks since their inceptions. Within the United States, however, T1 leased lines have been the backhaul option of choice due to relatively high availability, resulting in over 80 percent penetration of U.S. cell sites. By contrast, wired leased line infrastructure outside the U.S. has been either non-existent or prohibitively expensive, driving cell site microwave backhaul penetration as high as 75% in some geographies.

Today, new 3G mobile access technologies (and, soon, 4G) are dramatically increasing network capacity while mobile data subscribers are simultaneously driving dramatic increases in wireless WAN data traffic. This has financial repercussions, as noted in this article from **http://ZDnet.co.uk**[1]:

> *Speaking on Thursday at a Next Generation Mobile Networks (NGMN) meeting at the CeBIT technology fair in Germany, senior executives said flat-rate mobile-data tariffs meant usage was set to increase at a far greater rate than operator revenues. Therefore, they said, they would have to drive down the cost of providing mobile data connectivity if they were to continue to make money.*
>
> *"We will see a complete decoupling of traffic and revenues," warned the chief executive of T-Mobile International, Hamid Akhavan. "It is only a matter of time before we lose all profitability on mobile data. In the past, user experience has been driven by the average traffic on a cell site. Today it has to do with how much peak traffic you can carry in a cell."*

Backhaul, of course, is one of a few primary mobile data connectivity cost drivers. At the same time, backhaul has become the primary network bottleneck for most mobile operators. So operators are faced with investing even more in a network component that is already a major cost driver. Such circumstances, combined with the geometric characteristics of capacity and traffic growth, serve to highlight the comparatively poor scalability of leased line approaches to backhaul. As a result, microwave technology is now widely considered as a solution to this bottleneck.

Scalability is only one metric operators are considering when contemplating backhaul network improvement. Others include field upgradeability, reliability, network management and total cost of ownership (TCO). On all counts, the latest generation microwave technology is delivering outstanding performance against these metrics while significantly reducing service provider operating expenses (OpEx). Next generation microwave is quickly emerging as a compelling economic and performance alternative for mobile network backhaul in every geography.

Evolving Mobile Network Requirements

Several trends are driving dramatic month-over-month increases in the amount of traffic carried over cellular networks. The first is the widespread availability and promotion of mobile broadband services at prices that are allowing mass market penetration of WAN-connected laptops. The second is the explosion in the use of smartphones, exemplified by the Apple iPhone, which are consuming data at near-laptop rates. The third is the growth of rich media and Web 2.0 content, both of which subscribers are demanding over the WWAN. Add to these trends continued worldwide subscriber growth, and the migration of subscribers from 2G to 3G networks, and the result is that backhaul requirements of today's most advanced networks bear little resemblance to those of only a few years ago.

Backhaul Capacity Requirements

Historically, 2G sites in North America typically were served well by two to four T1 lines supporting from 3 to 6 Mbps – primarily of voice traffic. While this backhaul throughput level is sufficient for most voice-driven 2G base station sites in North America and elsewhere, the much higher air interface capacity of 3G technologies such as EVDO and HSPA can drive per site backhaul requirements to DS3 levels of 45 Mbps. In fact,

[1] ZDNet.co.uk, "Operators want fewer new mobile masts," March 6, 2008.

Deutsche Bank estimates that by the end of 2011, typical business district base station sites will require 50 Mbps of backhaul capacity.

The air interface capacities of 4G access technologies such as LTE and WiMAX are higher still, with six peak subscriber download speeds measured in the tens of megabits per second. The rollout of 4G networks, in combination with the layering of multiple wireless access technologies, will equate to maximum backhaul requirements in excess of 300 Mbps at the busiest sites.

Peak capacities aside, Visant Strategies estimates that by 2012 between 24% and 32% of base station sites in Western Europe and North America and will support backhaul capacity in excess of 45 Mbps, with as much as 9% of all sites requiring more than 155 Mbps.

The preceding discussion addresses only the last mile backhaul requirements. Backhaul aggregation sites between the base station and base station controller (BSC), as well as backhaul from BSC to MSC will , require far greater capacity-carrying ability.

The Role of IP/Ethernet

The growth of mobile data is indicative of another major trend – and consequent requirement – in mobile networks. That is, the need for the network to simultaneously support traditional TDM circuits along with high capacity Ethernet for newer IP-based services. Thus, as mobile operators upgrade backhaul capacity, they must ensure that the new backhaul platform is able to adjust continuously to a changing mix of TDM and Ethernet traffic. The transition to an all-IP mobile network is expected to take a decade or more; the most cost-effective way to bridge that gap is to invest in backhaul approaches that evolve with the network, thereby avoiding field replacements, or “forklift upgrades”, every few years.

Although this latter requirement for variable TDM/Ethernet support is not the subject of this discussion, the ability of next generation microwave backhaul systems to meet it has been well established. The latest microwave technology provides native TDM and native Ethernet in a single platform, delivering the required scalability, low latency and manageability necessary to meet the needs of both current and emerging services.

Leased Line Limitations

The poor economic argument for using leased copper lines for mobile backhaul in advanced cellular networks is well accepted and understood. Simply put, leased lines are not scalable. Adding more lines at a geometric rate is not only extraordinarily expensive but also time consuming. The wait time for new service provisioning can stretch for weeks and even months depending on service availability in the area. By contrast, after only a single day required for installation, a microwave link can be provisioned to add more capacity within minutes via remote software upgrade with no truck roll required.

Questionable reliability is another limitation of traditional leased line connections. Leased lines frequently fail to meet the 99.999% availability figure required not just by service providers but by other large users of backhaul capacity, such as utilities and state and local governments. In comparison, microwave systems are routinely engineered to deliver carrier-class availability at the 99.999% level and above.

With regard to network evolution, leased circuits are typically designed to deliver TDM connections such as T1/E1, DS3/E3 and OC3/STM1, but not Ethernet. However, UMTS and EVDO can use Ethernet as the primary network interface, while WiMAX uses only Ethernet. When using leased lines to backhaul Ethernet traffic, that traffic must be converted from Ethernet to TDM at each end of a connection; the required conversion equipment incurs additional cost and introduces excessive latency. This latency accumulation poses a serious challenge for operators, as latency budgets are shrinking with each new generation of technology. The obvious solution is to use native connections for both TDM and Ethernet so that both types of service can meet the requirements of their respective applications and high user expectations..

Finally, the cost of leased lines is dependent not only on capacity but often on distance, as in the case of point-to-point connections that pass through multiple central offices (COs) in the service provider’s network. Furthermore, the monthly cost of leased lines can skyrocket when those lines cross Local Access and Transport (LATA) boundaries.

Microwave, by contrast, is a one-time purchase typically equivalent to less than a year of lease costs and rarely dependent on the link distance or LATA boundaries. Once installed, microwave has the added advantage of being fully managed and able to accommodate remote upgrades, thereby significantly reducing

future expansion costs.

Transmission and OpEx

Wireless operators and private network operators alike spend vast amounts of time and resources managing their networks. Yankee Group estimates that transmission costs account for one-third of global mobile operator Operational Expenditure (OpEx) spending - excluding cost of goods and SG&A (Figure 1). In North America, backhaul routinely consumes 25% of operations costs due to the high proportion of leased lines.

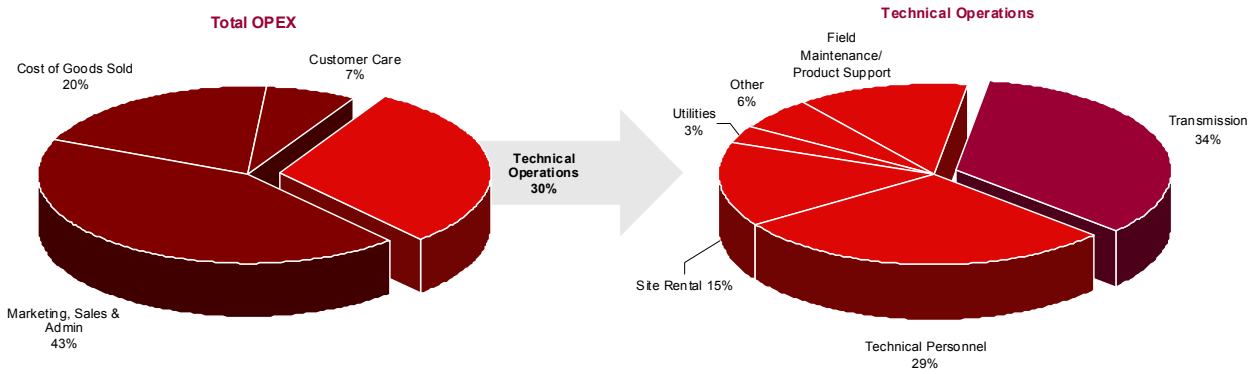


Figure 1: Transmission costs consume approximately 10% of global wireless operator OpEx

And backhaul spending will continue to grow. ABI research reports that global capital expenditures (CapEx) for backhaul transmission is expected to increase from $14B in 2007 to $23B in 2012, while OpEx is expected to rise six-fold over the same period.

Out of necessity, mobile operators are paying increased attention to rising OpEx costs associated with leased lines and are seeking ways to reduce those costs. As shown in the next section, transitioning from leased lines to microwave can help operators dramatically reduce and better manage recurring monthly operational expenses associated with transmission.

Economic Comparison: Microwave Backhaul vs. Leased Lines

An economic comparison between microwave backhaul and leased lines must begin with an understanding of backhaul network architecture and the cost elements associated with each approach.

Leased Line Network Architecture and Cost Model

There are two possible leased line architectures, each with different cost characteristics. In the *access* model, a connection is made between the point of aggregation and the network cloud or PSTN, as shown in Figure 2. A single connection is required between the aggregation point and the leased line service provider's central office (CO); the CO connects traffic to the "cloud." This model is atypical in mobile networks but common in enterprise-type applications.

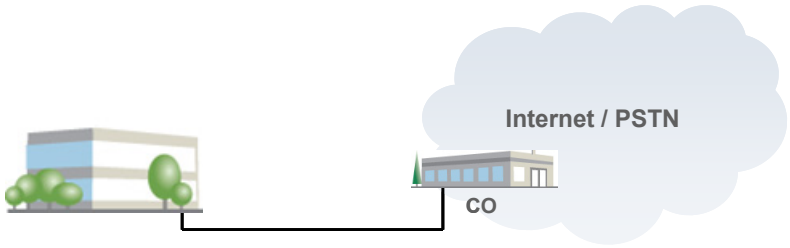


Figure 2. Access architecture

In the *point-to-point connection* model, the leased line connection traverses one or more COs in the leased line service provider's network to connect two network elements, e.g. a base station and base station controller. In this case, there are two connections, one each from the two network elements to the nearest CO, as shown in Figure 3. This configuration is the typical mobile backhaul scenario.

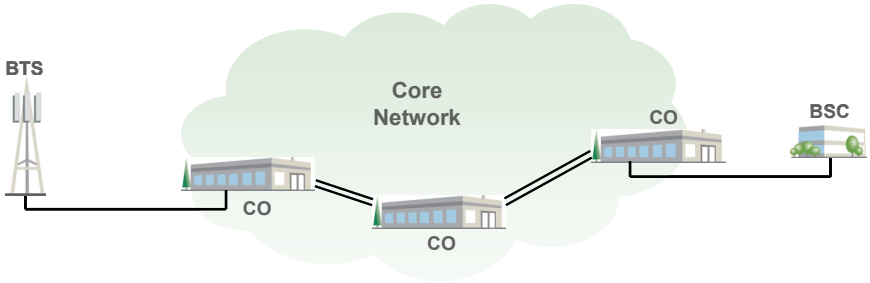


Figure 3. Point-to-point (backhaul) architecture

The cost difference between the two is clear. The access case requires a monthly lease payment for a single connection of a given capacity, whereas the point-to-point connection (backhaul) case requires monthly lease payments for *two* connections. In addition, cost is affected by the number of COs through which the connection must pass and the length of the overall connection. Finally, if the connection crosses a LATA boundary, inter-LATA tariffs can add further cost.

Microwave Backhaul Cost Model

The costs associated with a microwave radio installation include the cost of the equipment itself, start-up costs for ancillary site equipments and licenses, and a small recurring cost, as described below.

- Microwave radio equipment costs range from less than US$5,000 per link for simple bridging applications to $50,000 or more per link depending upon capacity, configuration and application.
- Antenna, cable and power costs range from US$5,000 to US$10,000 per link depending upon antenna size, radio configuration, tower height and other site characteristics.
- Installation costs for radios, ancillary equipment and cabling typically ranges from US$3,000 to US$8,000, with tower installations costing about 60% to 70% more than rooftop installations.
- In the case of licensed links, there is a one-time cost for the license and frequency coordination that typically ranges from US$1,500 to US$3,000 for a ten-year license.
- Annual maintenance is a recurring cost which can be conservatively estimated at 5% of the equipment cost, and includes both spares and an annual site visit. Exalt radios require no routine maintenance.
- Depending upon installation locations, there may be a monthly cost to lease space for the antennas, ranging from zero in the case of systems deployed on-premises to about US$700 per month for larger antennas at the most expensive third-party tower sites.

Methodology and Assumptions

In this analysis, the chosen basis for the comparison is payback period, specifically, the number of months of lease costs required to equal the investment in the microwave link. For completeness, the microwave payback is shown in Figure 4 for both leased line access and leased line point-to-point connection (backhaul) models, though the former is not applicable to cell site backhaul.

Leased line costs are estimated based on advertised rates as well as information on U.S. leased line prices provided by the Center for Communications Management Information (CCMI). Both the monthly cost and a one-time set-up fee are included. To account for the fact that leased line prices vary widely, a sensitivity analysis based on a range of lease prices is conducted, as well. As noted above, analysis is conducted for both the access and point-to-point (backhaul cases).

Microwave radio costs are based on the estimated street price for low quantity purchases of actual Exalt radio systems. Installation costs are based on an average of rooftop sites and tower sites with cable runs of 50 feet and 100 feet, respectively. For radios requiring external antennas, a 3' parabolic dish is assumed. The base case for all comparisons assumes no antenna lease costs for the microwave site. In order to capture the wide variability in such costs, a separate sensitivity analysis is conducted over the typical antenna lease cost range.

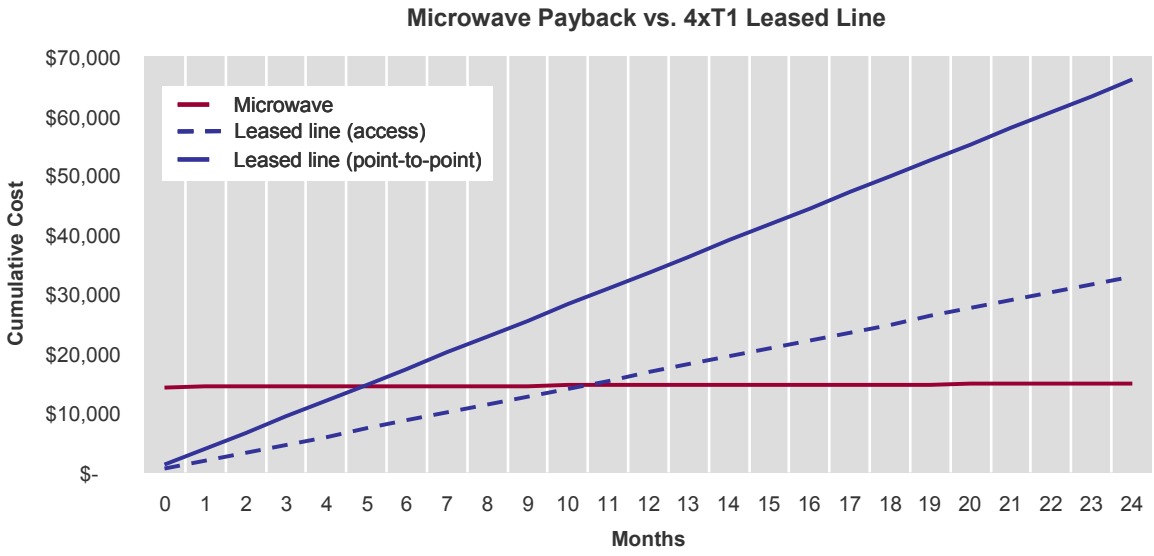
The microwave verses leased line comparison is made for four mobile backhaul scenarios:

1. A 2G base station site requiring four T1/E1 lines worth of capacity (6/8 Mbps);
2. A 2G base station site requiring twelve T1/E1 lines worth of capacity (18/24 Mbps);
3. A 3G base station site requiring one DS3 worth of capacity (45 Mbps); and
4. A future 4G base station requiring one OC3/STM1 worth of capacity (155 Mbps).

Scenario 1: Moderate traffic 2G cell site with TDM backhaul

This scenario models a 2G base station site based on technology such as GPRS or 1xRTT. In this case, four T1/E1 lines (4xT1/E1) provide sufficient capacity to accommodate the needs of the site.

Figure 4 depicts the cumulative cost for microwave, and both the access and backhaul leased line models, using the average North American price of US$337 per T1 with a set-up cost of US$625 per T1. The point at which each leased line curve crosses the microwave curve indicates the microwave payback period as compared to each leased line model.

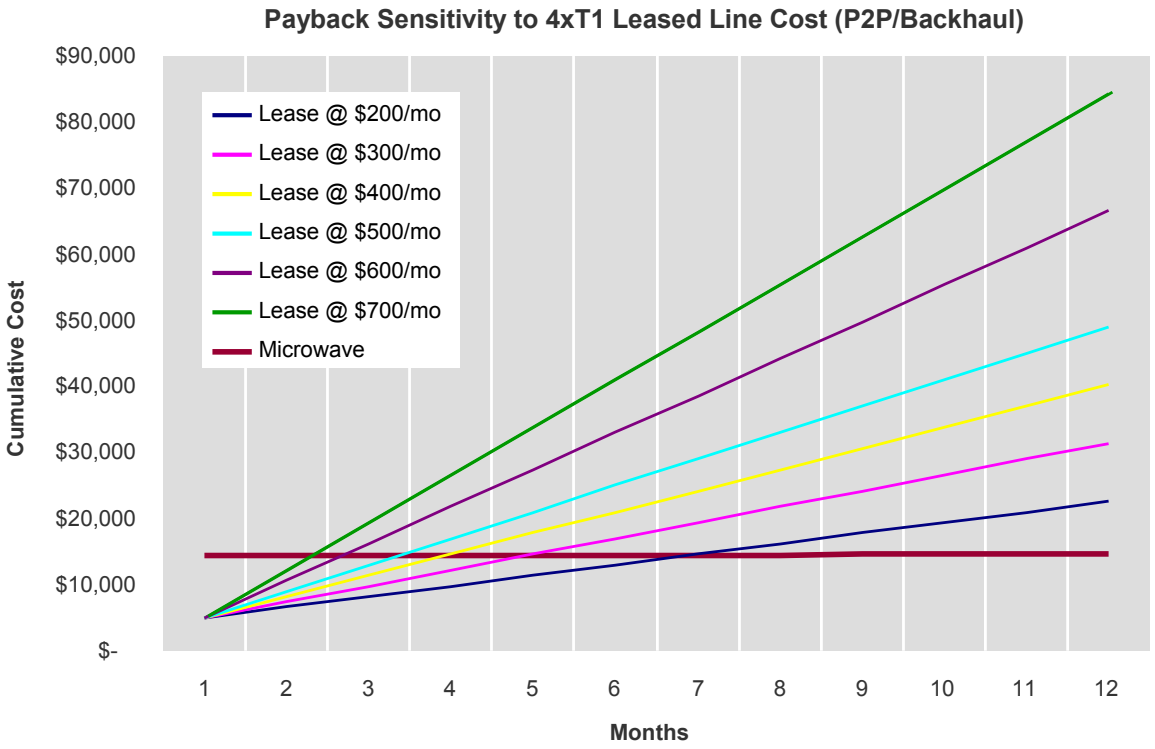


Sources: CCMI and public sources for lease line data, Exalt Communications for installed microwave cost.

Figure 4. Microwave payback and cumulative cost for microwave and leased lines for a 2G site

As seen in Figure 4, operators paying average leased line rates can achieve rapid payback on the deployment of a microwave link for base station backhaul. The payback period for microwave is indicated by the points at which the two lines cross. In this case, payback is achieved in ~5 months and ~10 months for the backhaul and access cases, respectively.

Figure 4 demonstrates microwave payback in two cases verses an average leased line price. By contrast, Figure 5 shows the period over which a microwave link of equivalent capacity would pay for itself based on a wide range of leased line costs in the point-to-point (P2P) or backhaul scenario. Thus, this and subsequent comparable figures can serve as a guide for payback periods based upon the reader's local leased line price schedules.

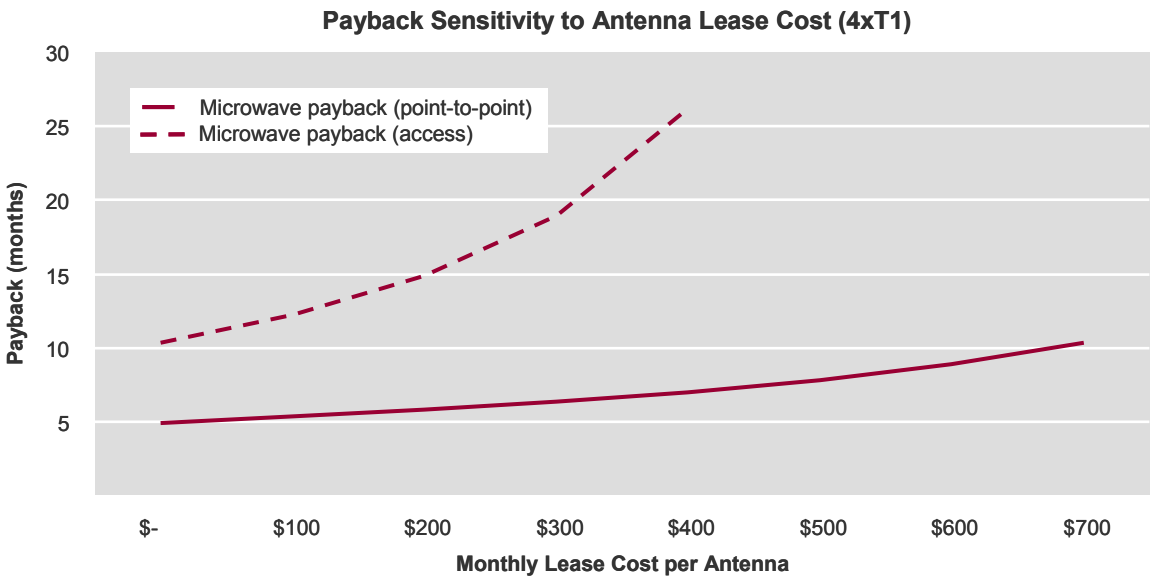


Sources: CCMI and public sources for lease line data, Exalt Communications for installed microwave cost.

Figure 5: Microwave payback sensitivity to leased line cost for a 2G site (backhaul model)

Assuming a maximum of four T1s per site, even at monthly T1 costs of US$200 microwave payback is reached in less than one year. For those operators considering longer time horizons, the typical 10-year lifespan of microwave radios makes them an attractive alternative even with sub-US$100 T1 lines.

Figure 6 illustrates the change in the microwave payback period as antenna lease costs rise from zero to US$700 for both the access and P2P/backhaul scenarios at the average T1 lease cost.



Sources: CCMI and public sources for lease line data, Exalt Communications for installed microwave cost.

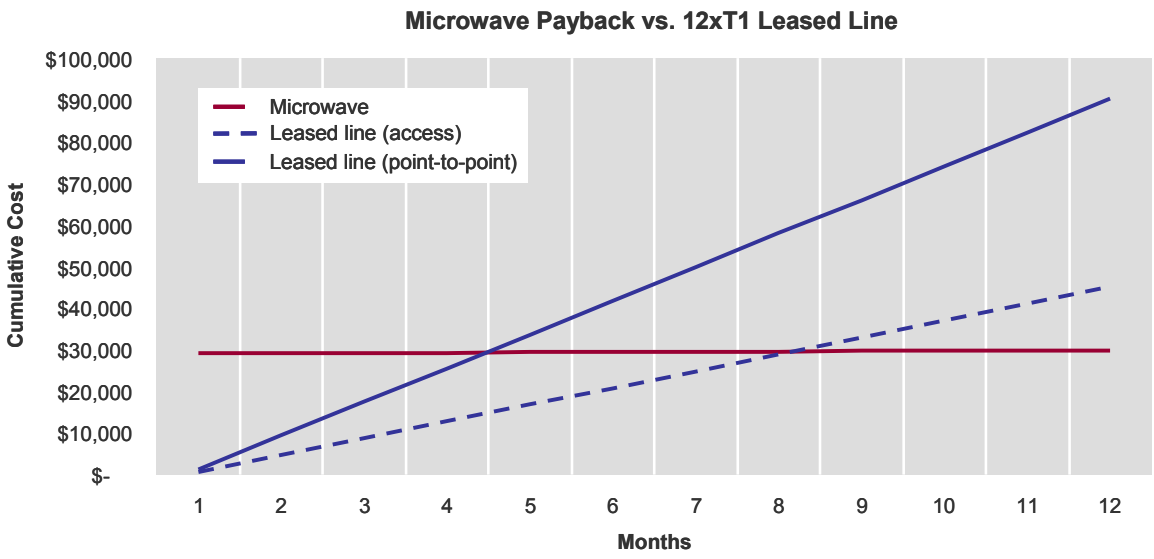
Figure 6: Microwave payback sensitivity to antenna lease cost for a 2G site

Figure 6 demonstrates that in the 4xT1 backhaul case, payback is less than one year for antenna lease costs of up to US$700 per site. In the 4xT1 access case, payback period rises more quickly with antenna lease cost, indicating that use of microwave in the low capacity access case makes the most sense when there is either a low or no associated antenna lease cost.

Scenario 2: High traffic 2G cell site with TDM backhaul

This scenario models a higher capacity 2G base station site than shown in the first scenario. In this case, twelve T1/E1 lines (12xT1/E1) are required to serve the volume of voice and data subscriber traffic.

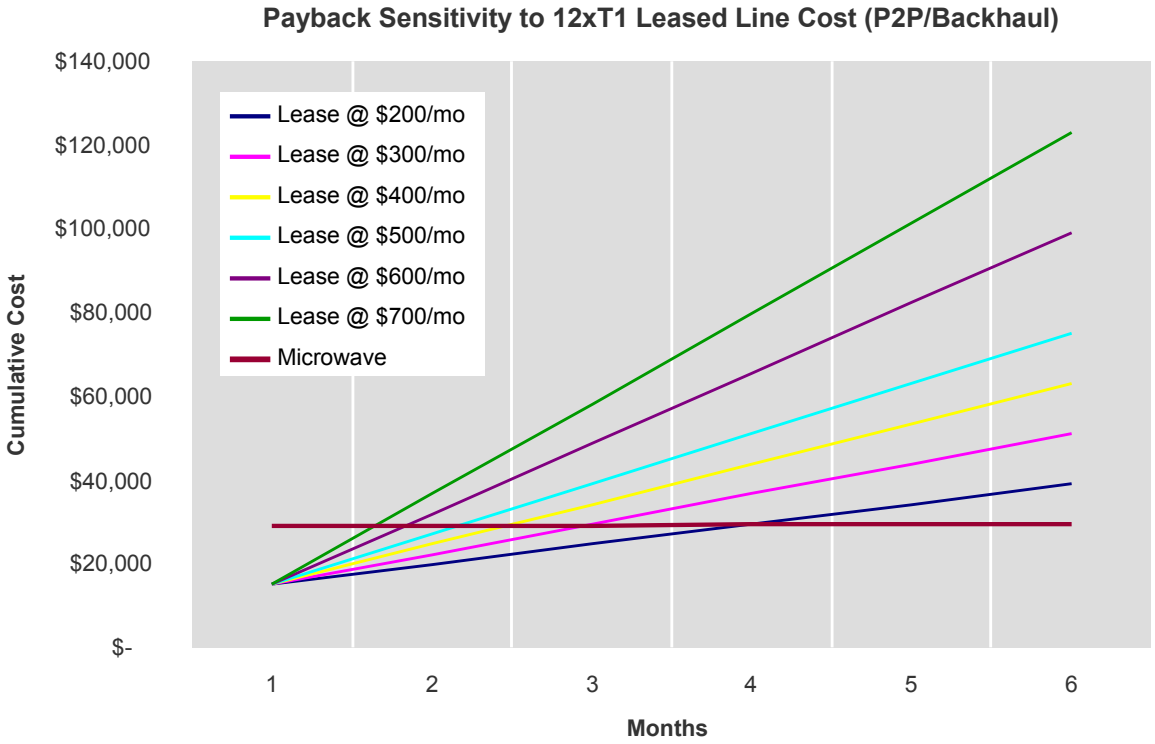
Figure 7 depicts the cumulative cost for microwave, and both the access and backhaul leased line models using the same per T1 price assumptions in the previous example.



Sources: CCMI and public sources for lease line data, Exalt Communications for installed microwave cost.

Figure 7. Microwave payback and cumulative cost for microwave and leased lines for a 2G site

As compared to Scenario 1, operators paying average leased line rates can achieve even more rapid payback with microwave. In this case, payback is achieved in ~4.5 months and ~8 months for the backhaul and access cases, respectively.



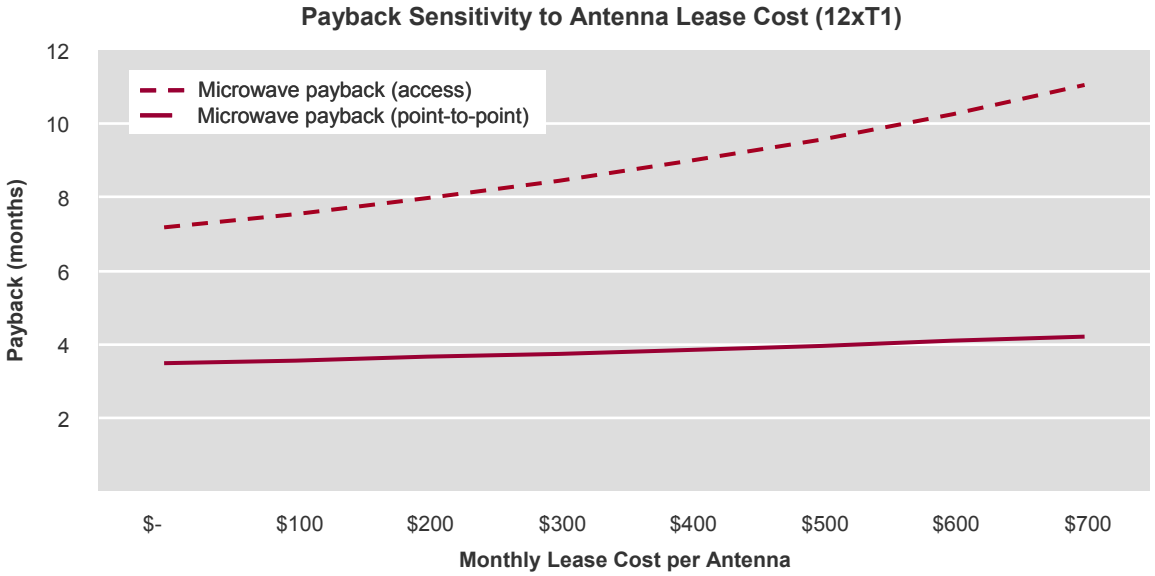
Sources: CCMI and public sources for lease line data, Exalt Communications for installed microwave cost.

Figure 8: Microwave payback sensitivity to leased line cost for a 2G site (backhaul model)

Payback sensitivity to leased line cost variation is shown in Figure 8. Under no circumstances is payback more

than 5 months.

Figure 9 illustrates the change in microwave payback period as antenna lease costs rise from zero to US$700 for both the access and P2P/backhaul scenarios at the average T1 lease cost.



Sources: CCMI and public sources for lease line data, Exalt Communications for installed microwave cost.

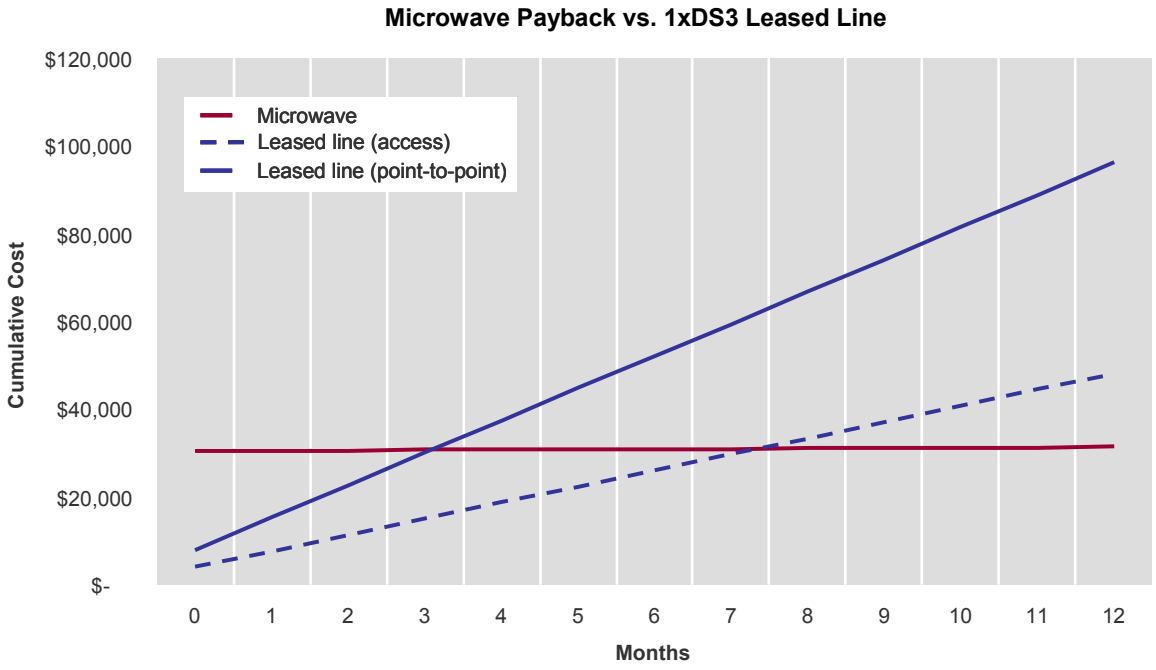
Figure 9: Microwave payback sensitivity to antenna lease cost for a 2G site

In contrast to Scenario 1, payback for both access and backhaul cases is under one year for all antenna lease cost scenarios, reflecting the dramatically improving case for microwave under all scenarios as capacity requirements increase – even to a relatively modest 18 Mbps.

Scenario 3: High traffic 3G cell site with TDM backhaul

This scenario models a 3G cell site based on technology such as HSPA or 1x-EVDO Rev A. In this case, one DS3 line (1xDS3) provides 45 Mbps of necessary throughput to accommodate a mix of voice and heavy data traffic. Typical DS3 lease rates are US$3,000 to US$4,000 per month and vary based on distance, geography and competition.

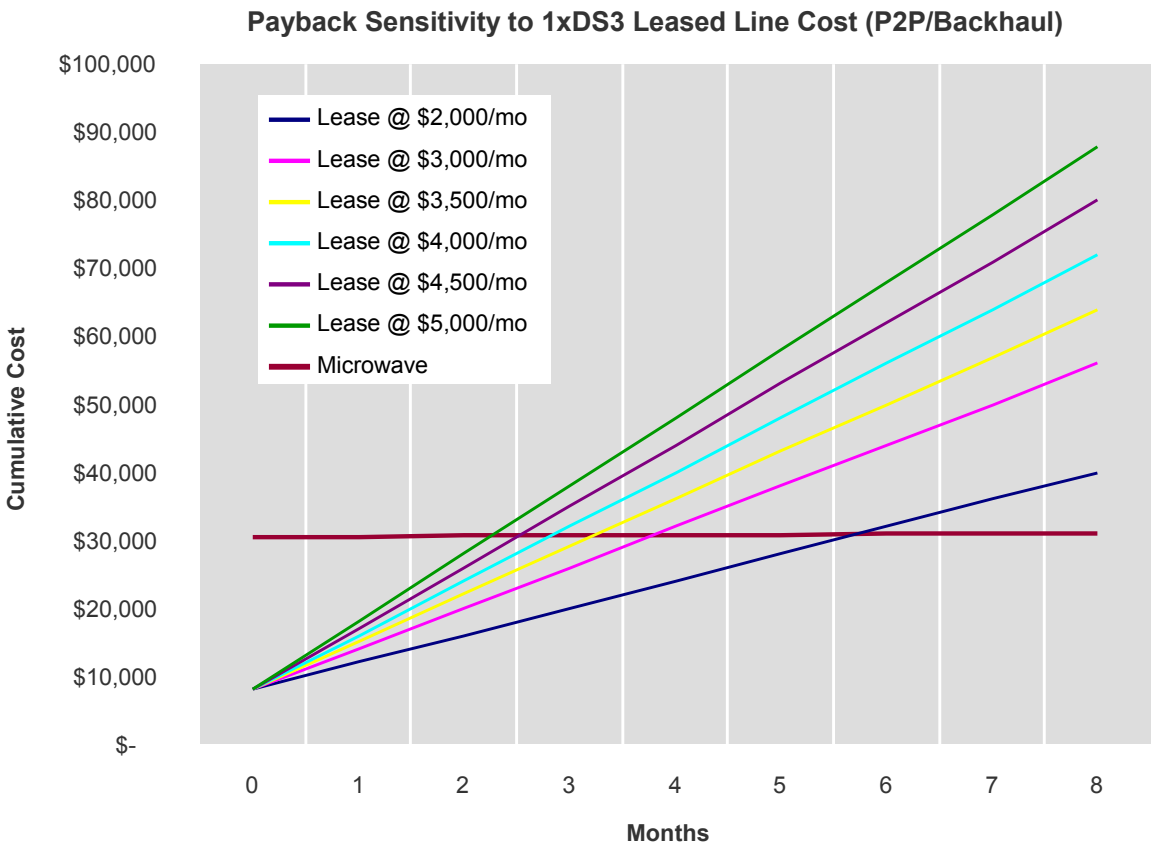
Figure 10 depicts the cumulative cost for microwave, and both the access and backhaul leased line models using the North American average DS3 price of US$3,675 and a set-up cost of US$4,000. As in previous cases, an even mix of rooftop and tower sites is assumed for the purposes of determining installation cost.



Sources: CCMI and public sources for lease line data, Exalt Communications for installed microwave cost.

Figure 10. Microwave payback and cumulative cost for microwave and leased lines for a 3G site

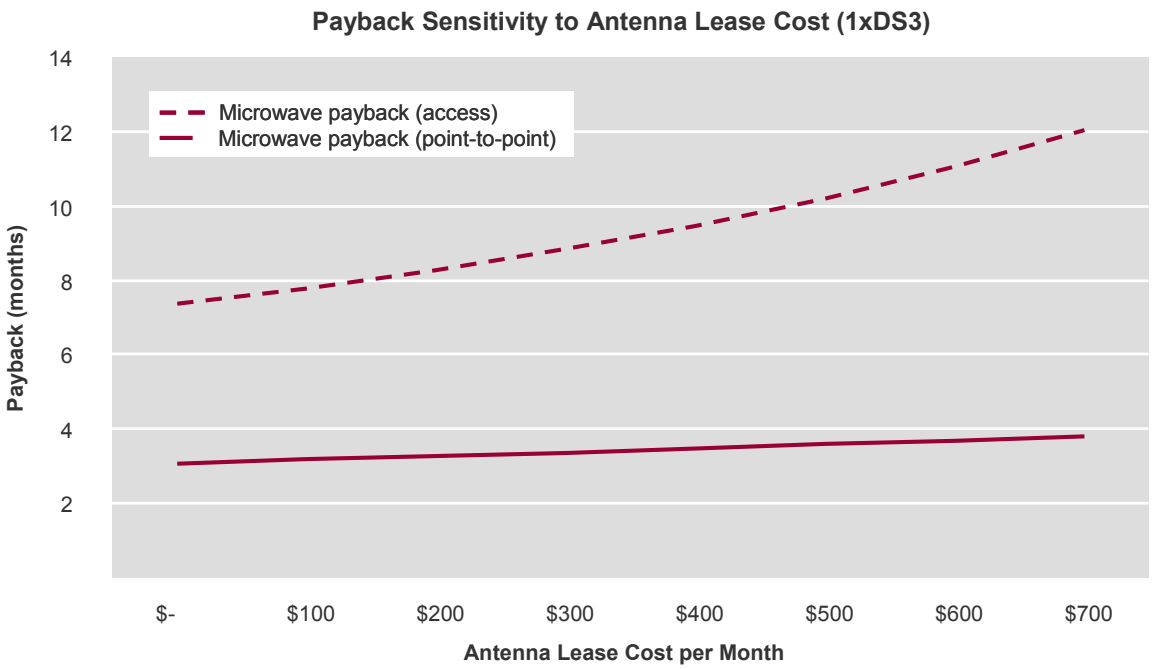
The payback period for the DS3 case is slightly shorter than for the 12xT1 case described in Scenario 2, with payback of ~3 months and ~7.5 months for the backhaul and access cases, respectively. The similarity to the previous scenario is due to the fact that twelve T1s cost nearly as much as one DS3, demonstrating the economic impracticality of deploying large numbers of T1 lines. Of course, there may be operational reasons for choosing multiple T1s. Exalt offers radio systems supporting either or both options.



Sources: CCMI and public sources for lease line data, Exalt Communications for installed microwave cost.

Figure 11: Microwave payback sensitivity to leased line cost for a 3G site (backhaul model)

Payback sensitivity to DS3 leased line price variation is shown in Figure 11. For a DS3 lease price range of US$2,500 to US$5,000 per month, the analysis yields payback periods of approximately 6 months or less in all cases.



Sources: CCMI and public sources for lease line data, Exalt Communications for installed microwave cost.

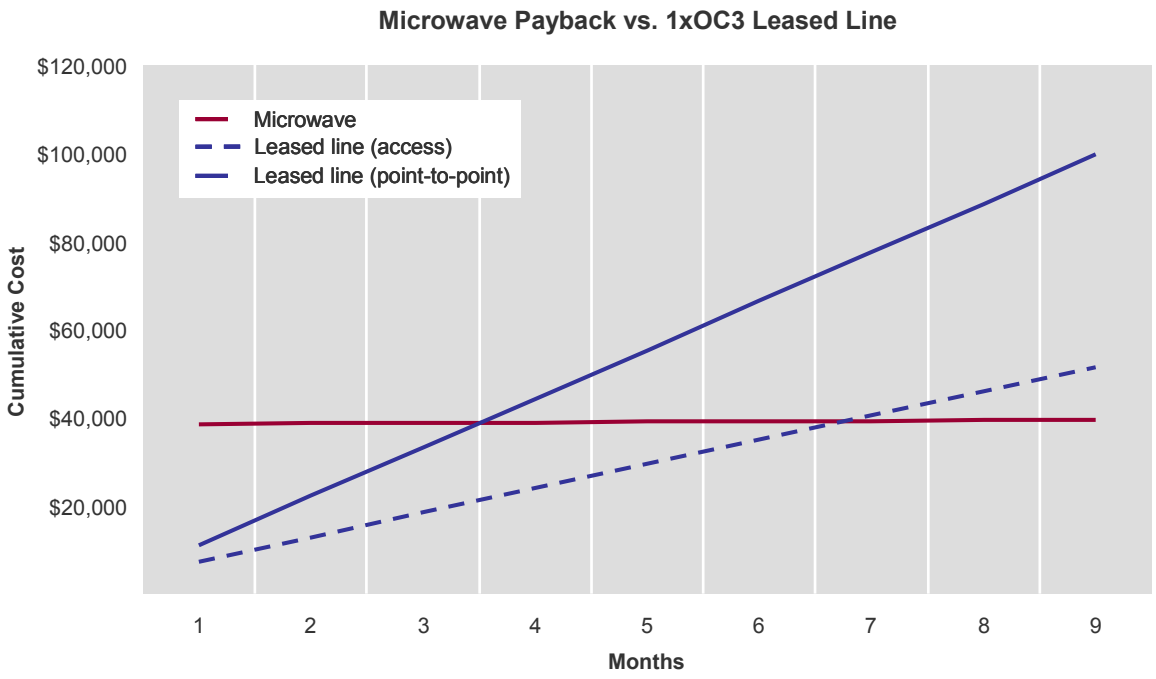
Figure 12: Microwave payback sensitivity to antenna lease cost for a 3G site

As shown in Figure 12, payback for both the access and backhaul cases at the average DS3 lease cost is under one year for all antenna lease cost scenarios, with the typical backhaul scenario yielding a microwave payback of 3 to 4 months in every case.

Scenario 4: Projected 4G cell site with TDM backhaul

This scenario models a hypothetical 4G cell site. In this case, one OC3/STM1 line (1xOC3/STM1) provides 155 Mbps full-duplex throughput, supporting the high volume of data traffic expected on such sites. Typical lease rates for OC3 circuits are US$5,000 to US$6000 per month and vary based on distance, geography and competition.

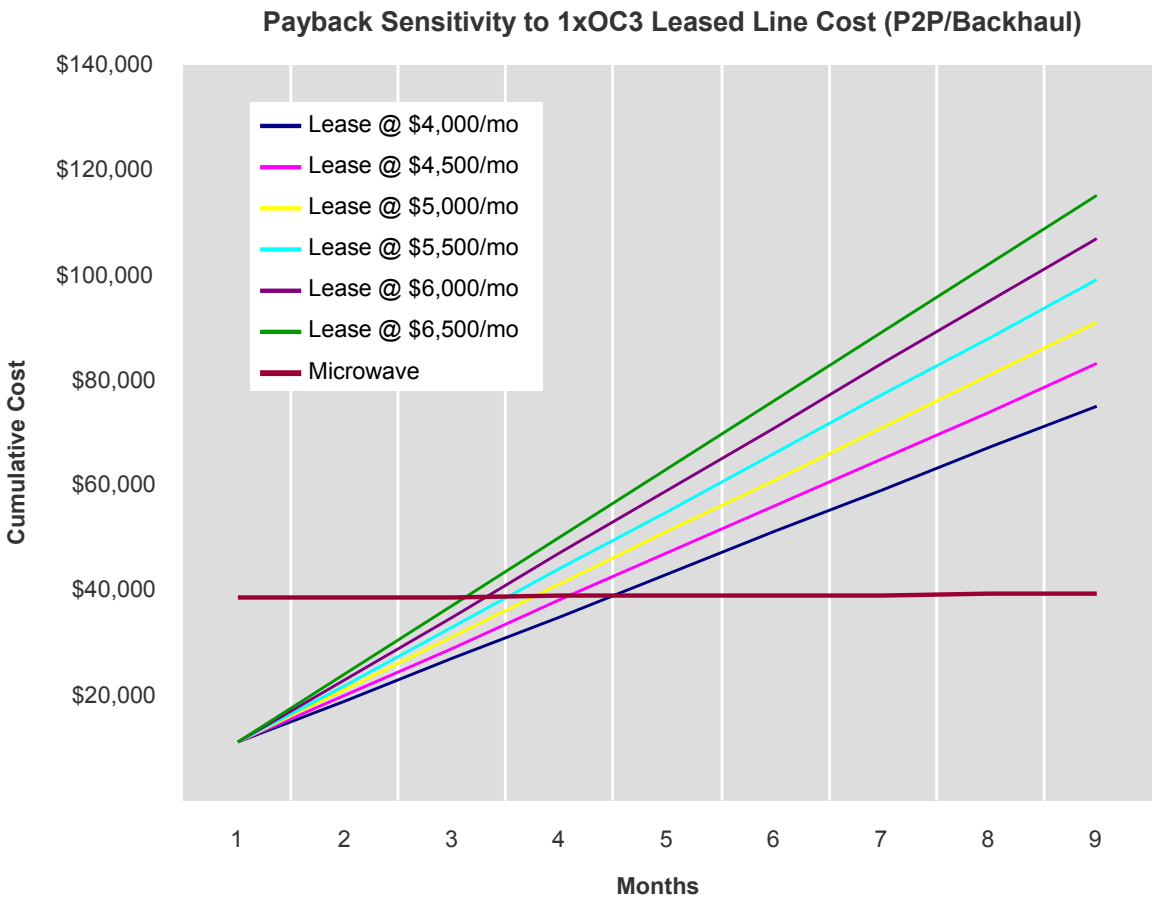
Figure 13 illustrates payback based on the North American average OC3 price of US$5,536 and a set-up cost of US$7,400. An even mix of rooftop and tower sites is assumed.



Sources: CCMI and public sources for lease line data, Exalt Communications for installed microwave cost.

Figure 13. Microwave payback and cumulative cost for microwave and leased lines for a 4G site

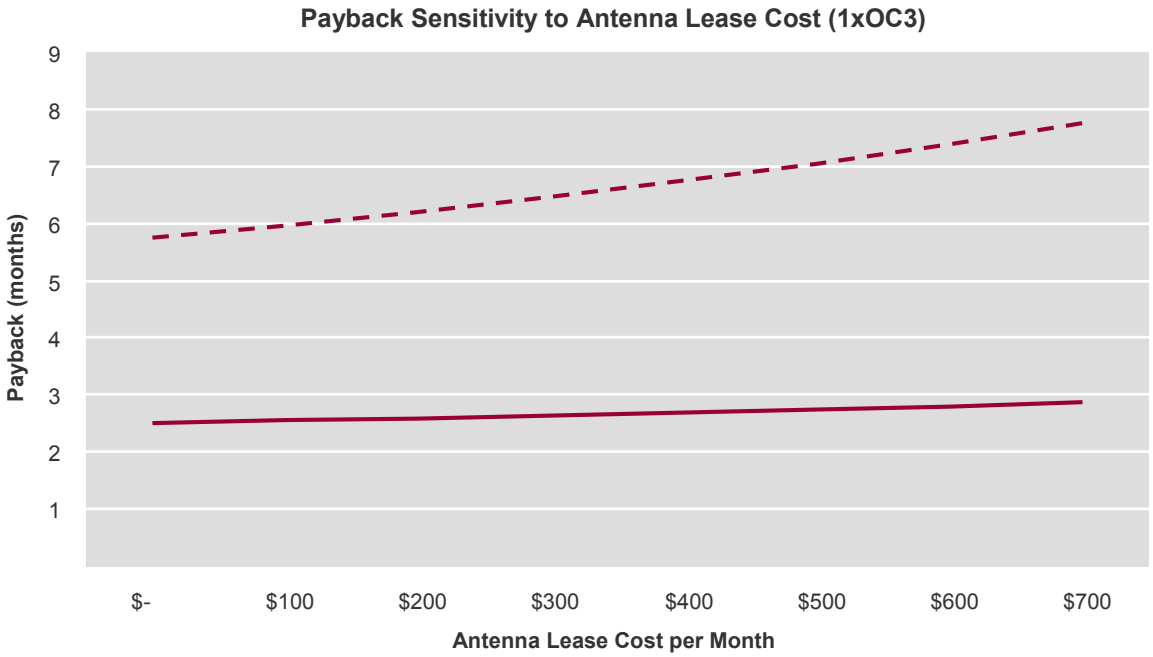
The payback period for the OC3 case shown in Figure 13 is comparable to the previous two scenarios, with payback achieved in ~3.5 months and ~6.5 months for the backhaul and access cases, respectively.



Sources: CCMI and public sources for lease line data, Exalt Communications for installed microwave cost.

Figure 14: Microwave payback sensitivity to leased line cost for a 4G site (backhaul model)

Figure 14 illustrates payback sensitivity to OC3 leased line cost variation. When OC3 lease rate is varied between US$4,500 and US$6,500 per month, payback periods are ~5 months or less in each case.



Sources: CCMI and public sources for lease line data, Exalt Communications for installed microwave cost.

Figure 15: Microwave payback sensitivity to antenna lease cost for a 4G site

As shown in Figure 15, payback for both access and backhaul cases at the average OC3 lease price is less than 8 months for all antenna lease cost scenarios, with the typical backhaul scenario yielding a microwave payback of ~3 months in every case.

All four scenarios demonstrate that a mobile operator can achieve significant savings when purchasing microwave radios rather than leasing equivalent TDM capacity. The microwave payback period for capacities ranging from 4xT1 to 1xOC3 is less than one year when no antenna lease cost is assumed, demonstrating that microwave is a far more attractive option than leasing fiber or copper lines.

When microwave antenna lease costs are factored in, the analysis indicates that for average leased line costs, only in the 4xT1 *access* scenario (which is not applicable to base station backhaul) do antenna lease costs drive payback significantly greater than one year.

Equally clear is the fact that OpEx costs associated with traditional leased line backhaul deployment are and will continue to rise at geometric rates as network operators transition from 2G to 3G to 4G (e.g., LTE) networks. In an absolute sense, OpEx costs of 4G networks will rise considerably above present 3G network levels, placing further burden on service provider balance sheets and income statements. Under such circumstances, the economic advantages of microwave technology are inescapable.

Conclusion

Demand for network capacity driven by new content, new devices and broadband services will continue to grow as radio access technologies evolve and mobile broadband usage achieves greater subscriber penetration. However, the rise in data revenues associated with the growth in subscriber traffic has already begun to flatten relative to the rise in the costs associated with delivering that data, driven by a proliferation of flat rate data plans.

Leased line backhaul expense is a significant contributor to those costs. Unless service providers that currently depend heavily on leased lines change the way they deliver backhaul capacity within their networks, their OpEx costs will soon rise above affordable limits. This analysis demonstrates that microwave is, by far, the most cost effective way to provide backhaul capacity to support current and next generation network requirements.

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More details on Exalt point-to-point microwave radio systems may be found at:
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