The coming of LTE will lead to large-scale changes within mobile operators’ networks. The most obvious and highly discussed of those changes are found at the base station. Infrastructure vendors, with an eye towards the future, have been marketing for several years the value of multi-mode solutions that can support different wireless network technologies (GSM, WCDMA and LTE) on a single platform. Base station architectures are also changing to better facilitate LTE, with increased reliance on remote radio heads and a stronger focus on small cells. Of course it goes without saying one of the big changes with all of these LTE base stations are their ability to support higher capacity levels. But when looking at the changes ongoing at operators’ networks as they prepare for LTE, the base station is just part of the story.

Networks are not a single “thing,” but rather a connection of “multiple things.” LTE base stations will not work unless they are connected to other things that will make them work. One of those things is backhaul.

As operators reengineer their networks for LTE, backhaul has become an important factor in their success. Higher base station capacity demands higher backhaul capacity. As operators consider deploying small cells to achieve the coverage and performance to support LTE service expectations, small cells mean more base stations, all of which require more backhaul connections to reach the core network. Network applications that look to capitalize on higher network capacities, such as streaming video, also demand improved latency performance. While there is no one solution for all of these backhaul issues, microwave-based solutions certainly appear capable of meeting many of them. But this will require changes within the microwave backhaul industry as well. Microwave backhaul vendors, hoping to best capture the LTE opportunity, will need to change up their solutions just like LTE has forced base station vendors to change theirs. This report looks at some of the changes LTE will drive in the microwave backhaul market.
flexibility than fiber optics. Microwave can be economically installed in many more locations than fiber. Furthermore, microwave can provide a cost savings over fixed-line solutions as the mobile operator will often own the microwave backhaul link, versus having to rent the fixed-line solution. It is benefits like these that have helped to increase mobile operator interest in microwave, especially as they start to plan their LTE networks. Microwave solutions have been much more pervasive in markets such as Europe, but are now being deployed on a global basis, including North America. However, just as LTE has impacted the way vendors design their base stations, LTE will also bring changes to the microwave backhaul market. Some changes like capacity and latency requirements will be universal for all backhaul solutions, while others such as support for new spectrum bands and form factors will be unique to microwave solutions. The following looks at market requirements for microwave backhaul solutions when it comes to supporting LTE networks.

**Universal Backhaul Features**

Universal backhaul features are those backhaul requirements needed to meet LTE network requirements no matter the actual type of connection. These features are basic “table stakes” for any LTE backhaul solution. Microwave products must support them to even be considered part of any mobile operator's network.

- **Higher Capacity and Lower Latency:** Technology has shown time and time again, consumers don’t like to wait, and faster performance can drive the adoption of new products and services. One of the major reasons mobile operators are investing in LTE is the promise of improved network speeds that can be provided over existing 2G and 3G networks. LTE can deliver download speeds of 100 Mbps or better. LTE-Advanced (LTE-A) will bring those download speeds to 1 Gbps, as Ericsson demonstrated in late June 2011. These speeds are all substantially higher than the 21 to 42 Mbps found today with dual-carrier HSPA+ or the sub-4 Mbps speeds found with CDMA EV-DO Rev. A. While the speed benefits of LTE are fairly obvious, the latency benefits are not quite as well known. In-network latency measures the amount of time it takes for a data packet to move between two points. The higher the latency, the slower the network. Applications like video and voice, both of which are important applications for LTE, can be significantly degraded by high network latency. As such LTE latency requirements can be as low as 10 milliseconds (ms). Admittedly not every backhaul connection will need to support 1 Gbps and provide approximately 10ms of latency, but microwave products are going to need to improve their performance to stay in line with mobile operator requirements. Also of significance, is the variability of the packets flowing across the network, while latency causes obvious delays, jitter (the measure commonly used to capture variability), causes issues such as pixilation in video and an unacceptable voice (VoIP) experience.

- **Multiple Backhaul Topologies:** Building a wireless network is rarely simple or easy. LTE will be no different. Backhaul topologies will change as networks migrate from 3G to 4G and operators start deploying new base station form factors in new spectrum bands. Also as each market can be different, operators very likely will have to support multiple backhaul topologies within their LTE networks. Some of the backhaul topologies expected to be seen with LTE are hub and spoke, tree, and mesh and ring. Microwave products need to be flexible to work in any of these topologies. Microwave latency performance is important here as some of these topologies could include multiple hops before the data traffic reaches a network aggregation point from where it is sent to a network aggregation point.

- **Multiple Protocols and Synchronization:** There is little argument that the explosion in traffic that is expected to traverse the backhaul network will be packet-based; however, unless the network operator is building a greenfield network, there will be some residual and perhaps even growing legacy traffic to be handled such as 2G voice (especially true when the operator has elected to deploy a dual network). Regardless of the microwave technology deployed, there must be some capabilities to handle non-packet traffic. Current solutions will support native circuit (TDM) traffic or provide a circuit emulation service (CES) or a pseudowire capability.
Unique Microwave Backhaul Features

While the common backhaul features are very important to the microwave market, it is the unique features coming out of the microwave market to meet the demands of LTE networks that have generated much of the recent coverage. The need for more small cells in LTE networks plays a big role with these unique backhaul features.

Small cells allows for closer proximity between the network base station and the end-user. This proximity can help to provide improved network coverage and capacity. For LTE networks deployed in higher frequencies like 2.5GHz and 2.6GHz, small cells will be especially important as they will help compensate for those spectrum bands propagation capabilities which can hamper in-building penetration. But small cells pose some serious issues when it comes to backhaul.

First off, small cells mean more network base stations, all of which require backhauling. Increasing the number of base stations needing to be connected to the network adds greater complexity and will require new microwave solutions to handle that complexity more effectively, and at cost points well below that of traditional microwave devices. Because of this the market has seen an increased interest in point-to-multipoint solutions along with the exploration of new spectrum bands. At the same time the actual backhaul radio needs to shrink in size, so as not to negate the benefits of the small base station size. An operator can't deploy a small base station close to the end-user if the backhaul microwave unit is too large.

**Point-to-Multipoint:** Microwave backhaul connections traditionally require two radios – one at the base station and one at the site where the base station connects back to the network. For example, with a standard point-to-point configuration, eight base stations would require 16 microwave radios – one at each end of the microwave link. With a point-to-multipoint solution, eight base stations can be connected with nine radios – one at each base station and one at an aggregation site where each base station would connect. Point-to-multipoint reduces an operator's CapEx and simplifies the overall network by reducing the number of microwave radios needed to build a backhaul network. The advantages that point-to-multipoint brings to network with increased base station counts due to small cells are fairly obvious. Cambridge Broadband Networks has been one of the early proponents of point-to-multipoint solutions for LTE networks, but other vendors have indicated point-to-multipoint solutions are something they are examining. Where point-to-multipoint is vulnerable is in the area of capacity, as all base stations in a single sector have to share the same bandwidth. The more cell sites connected at the aggregation radio, the less capacity each site has.

**New Spectrum Bands – Going High:** Microwave vendors such as Bridgewave are starting to push backhaul solutions into higher bands than normally used, such as 60GHz. 60GHz is notable for high capacity and limited signal range. This makes it a good solution for small cells in a tight environment, such as in downtowns of major cities. The short signal range is especially important in North America where the band is licensed-exempt. As any operator can use 60GHz in that region, the short signal range helps to prevent interference with other operations in that band. Not to be overlooked when it comes to 60GHz, however, is that it requires line of sight between both ends of the link to work. This can limit its deployment options in some cases.

**New Spectrum Bands – Going Low:** Another way microwave vendors are changing their products to meet the demands of LTE is to go low; develop microwave products that operate in bands below 6GHz. These lower bands have a distinct advantage over higher bands – they don’t require line of sight. Also lower bands can be used in point-to-multipoint configurations. Both of these features can help deploy small cells in a concentrated metro area. A new backhaul entrant, BLiNQ Networks, has decided to use the advantages of these lower bands as its entry point into the microwave market.

**Smaller Form Factor:** One of the big advantages of a small cell is its size, which gives it greater ease of deployment over a traditional base station. The backhaul that goes with the small cell cannot not negate that advantage, so microwave solutions targeting small cells need to be small themselves. If a small cell is to be mounted on a light pole, its backhaul has to fit on that pole as well. Aviat, Dragon-
Wave, Ericsson and Nokia Siemens Networks all introduced backhaul radios with small footprints in 2011 to address this issue directly – and other vendors are expected to have similar solutions as well.

**Integrated Backhaul Solutions:** Taking the small form factor one step further, there is also the possibility of integrated the backhaul radio directly into the small cell. Chip vendor DesignArt Networks offers a reference design that supports this. The backhaul can either be done using the same spectrum as the access radio (in band), like a relay, or be done using dedicated backhaul spectrum. Integrated backhaul can greatly simplify one of the biggest challenges with small cells, how to connect them to the core network. It also gives small cell vendors a greater stake in the overall mobile network as they are now part of the backhaul network as well. One challenge associated with integrated backhaul solutions relates to antenna designs, where the small form factor prohibits the use of traditional antennas and requires innovative designs that are small and highly directional. This presents a cost-benefit trade off: does the cell site installer need to focus the antenna (increased OpEx) or can it be remotely optimized (increased CapEx)? Another consideration with integrated backhaul is the use of in band spectrum for backhaul, as this can reduce the available capacity for access.

LTE has been the driving force behind much of the mobile network innovation of the last several years. Microwave backhaul has been no exception. As LTE networks go live and start to scale, the microwave products are in a good position to grow their share of the overall backhaul market. But microwave will only be part of the overall backhaul network. Mobile operators still show a preference for fiber-based backhaul solutions when available. Fortunately for microwave, fiber can’t cover nearly as many places as microwave. It is also important to remember even within microwave there is no one solution for all deployments. While much of the focus on microwave and LTE is on how it will change the market, there still remains a need for more established solutions that support macro cells. Also the need to provide operators with backhaul solutions that can transition their networks from their voice heritage to an all IP world remains of great importance. All said, the microwave backhaul market appears to be one of the big winners when it comes to LTE.

### Recommended Actions

**Recommended Vendor Actions**

- Huawei should consider purchasing Cambridge Broadband Networks. Huawei already has a relationship with the vendor, and Huawei is actively pursuing the small cell market. Acquiring Cambridge would fill out Huawei’s existing backhaul portfolio, which would make it a stronger backhaul vendor.

- Small cell vendors, like Nokia Siemens Networks and NEC, should consider working with DesignArt Networks or other vendors who can deliver an integrated backhaul solution. Integrating backhaul into the small cell would make their products easier to deploy by dealing with the big operator question around how to backhaul them.

- BLiNQ Networks needs to establish some operator references. As a new market entrant it is not well known. References will help raise its profile and give it market credibility which is important for the vendor to gain traction with Tier 1 vendors.

- Smaller backhaul vendors need to establish relationships with larger network infrastructure vendors such as Alcatel-Lucent, Ericsson, Huawei, Nokia Siemens Networks and ZTE. Many mobile operators don’t want to deal directly with smaller vendors, and expect their primary infrastructure vendors to manage those relationships. Plus smaller microwave vendors generally only offer part of the backhaul solution; partnering with larger infrastructure vendors allow their products to be part of a bigger overall backhaul solution.

- Microwave vendors should reexamine their position on point-to-multipoint solutions. While...
point-to-multipoint may not deliver as much capacity as a point-to-point link, point-to-multipoint should meet the capacity requirements of small cells. Also point-to-multipoint will appeal to mobile operators concerned with how to manage backhaul CapEx associated with small cells.

**Recommended User Actions**

- Mobile operators looking to deploy small cells need to engage their RAN vendors on how to backhaul them. While this doesn't mean they have to buy the backhaul solution from their RAN vendor, they should get their assistance on how to best design their backhaul network. Backhaul can make or break a small cell solution, so mobile operators should get their RAN vendors support in this area.

- If LTE is driving a network refresh with the mobile operator, that operator should make sure and include its backhaul in that refresh. Microwave products continue to make improvements, especially in terms of capacity. Increasing microwave in the overall backhaul mix can save an operator on OpEx, as it frees them from monthly payments to fixed-line operators.

- While it can make things more difficult from a vendor management perspective, there is value in a mobile operator breaking out RAN from its backhaul when it comes to selecting network vendors. Separating the two can allow the mobile operator to better capitalize on product developments coming from backhaul specialist. While these specialists most likely can’t address all of an operator’s backhaul requirements, they might very well have best of breed solutions for very specific deployment scenarios.