

**Eight Essentials to
Implementing Backhaul over
Satellite for Mobile Operators**

June 2009

Introduction:

For cellular operators one of the biggest challenges is finding the appropriate resources and technologies to backhaul voice and data traffic. As 3G and 3.5G technologies deploy, increasing data traffic challenges the capabilities of existing networks and this trend is expected to increase. In metropolitan areas many different terrestrial technologies are being implemented to deal with expanding demand including leased lines, fiber and microwave.

What does this mean for subscribers or potential customers who don't live in major metropolitan areas? Will the connectivity gap for the 2 billion people without cellular service living in rural areas continue to expand? The answer is no. In order to support increased data services and maintain Average Revenue Per User (ARPU), many cellular operators are upgrading their networks to all IP. At the same time the operators are also finding ways to extend the reach of their networks, expanding business and winning new customers.

The use of satellite technology, and more specifically, Very Small Aperture Terminal (VSAT) technology, is rapidly increasing, enabling cellular operators to backhaul voice and data traffic to remote and rural areas. This creates the ability to dramatically improve the quality of life for an enormous number of people while providing greenfield opportunities for operators to develop a new, loyal customer base.

When cellular operators evaluate VSAT technology to determine the feasibility of deploying networks in remote locations, there are some essential variables that need consideration. As a manufacturer of VSAT equipment iDirect partners with numerous satellite operators and infrastructure vendors to enable remote connectivity. This provides iDirect with insight into the challenges and requirements that cellular operators may face. With that understanding we created this document outlining eight essentials that a mobile operator should know when considering backhaul over satellite.

1. Why use VSAT when there are other technologies?

There are a number of market drivers that entice cellular operators to implement VSAT solutions for cellular backhaul. The main reason is a low cost, profitable solution is created for rural users who cannot be reached –affordably– by any standard terrestrial backhaul technologies like fiber or microwave.

It is generally accepted that the first operator to set up a service in a region usually will become the market leader and maintain customer loyalty. This also allows cellular operators to expand their business while providing existing customers with increased coverage in remote areas without experiencing expensive roaming charges.

Many governments are instituting regulatory requirements that operators must provide coverage in sparsely populated areas in order to receive additional licenses in populated urban areas. VSAT technology gives operators a way to meet these requirements and offer high-quality voice and data services in remote areas while connecting these locations seamlessly with their terrestrial network infrastructure.

2. Where does VSAT equipment work within the cellular network?

The main area where VSAT makes an impact for cellular operators is providing the link, commonly referred to as the A.bis interface, between the Base Transceiver Station (BTS) and the Base Station Controller (BSC). Instead of using a standard terrestrial fiber or microwave link between the BTS and BSC a VSAT network provides connectivity.

Using VSAT technology enables the A.bis interface to span any distance at a fixed cost. It also provides a solution unaffected by terrain restrictions or line of sight requirements and is quick and easy to deploy. For a cellular operator this provides a solution for deploying a BTS to remote areas where service is not yet offered.

A number of different satellite technologies or types of satellite networks can be used for cellular backhaul. When a cellular operator plans the strategy for a VSAT network two things should be considered: current terrestrial infrastructure and plans for future growth. Recent trends in cellular backhaul networks utilize A.bis over IP or an all-IP solution for transport. These solutions packetize the A.bis interface into an IP-Ethernet frame for the efficient transport of voice or data. These networks provide improved capabilities that are highlighted in more detail below. The majority of the large cellular infrastructure vendors including Ericsson, Huawei, and ZTE have developed all-IP network infrastructure. An all-IP network allows for the possibility of implementing an efficient IP transport network not just for the A.bis links, but for all core network links as well.

Choosing a VSAT technology that is built with IP at the core improves the scalability of the network as it directly interfaces with all-IP technology and provides the most efficient transport of voice and data services from remote locations.

3. Isn't satellite technology cost prohibitive?

In the past satellite communications may have been cost prohibitive and difficult to implement in more remote areas. Today, the technology has matured, the capabilities of the hardware have increased and the costs to deploy have been reduced.

One of the biggest challenges for cellular operators evaluating satellite technology is to understand the costs associated with using it. To determine if a satellite network is cost effective a cellular operator should look at the market opportunity, the capital expenses of deploying the network and the operating expenses of managing and maintaining the network.

In recent years the cost of deploying a satellite network has decreased significantly as the cost of hardware has decreased. Hardware platforms also have become more efficient in utilizing space segment capacity; typically the highest monthly operating expense in a satellite backhaul network. Improved efficiencies allow cellular operators to expand their networks and target much smaller populations and still earn a good return on their investment. At the same time the cost of an IP-enabled Base Transceiver Station (BTS) has fallen rapidly allowing the extension of networks to areas not previously considered.

The speed of deployment for satellite technology allows operators to quickly set up a working network and offer service. The ability to deploy quickly and start with a small network investment means operators may see immediate revenue and have the ability to scale as operations expand.

The overall cost of using satellite and specifically VSAT technology has become much more attractive for cellular operators looking to capture new opportunities.

4. Managing bandwidth costs - dedicated links versus shared links.

IP networks are the future for cellular backhaul. When it comes to satellite backhaul the same is true, but there are other factors you need to consider.

Cost issues have been an inhibitor to the widespread deployment of satellite backhaul because traditional deployments of the technology used dedicated links based on a transmission method called Single Channel Per Carrier (SCPC).

SCPC means that you dedicate a specific amount of satellite capacity to one BTS and that capacity is assigned to a single location whether it is in use or not – just like a leased line. If the network traffic for each BTS location is continuous this type of setup works well, because a limited amount of capacity is wasted. But if usage varies based on time of day then a dedicated link may be expensive. The reason it is high-priced is connectivity must be guaranteed during peak usage times, but outside of those times bandwidth that is paid for sits idle and is wasted. In areas where satellite bandwidth is in high demand this can make using dedicated links an expensive and unacceptable proposition if trying to connect multiple BTS locations using SCPC.

An increasingly popular and cost-effective alternative to SCPC is to pool backhaul traffic onto a common network, replacing the previous standard SCPC links with a shared IP Time Division Multiple Access (TDMA) network. With this type of network, bandwidth is available to be shared dynamically among many different BTS locations. TDMA allows operators to allocate satellite bandwidth according to the busy hour capacity requirements of the whole network rather than link by link. The end result is dramatically reduced bandwidth usage and lower costs.

In addition, using TDMA improves the flexibility and scalability of a network since the bandwidth pool is centrally managed. As the traffic from the remote BTS locations grows the cellular operator only needs to increase the bandwidth pool to meet the overall demand of the expanding network. No technician is required to go to the remote BTS and change any settings; it is centrally managed. This allows an operator to start small then expand their network and increase bandwidth costs when subscribers are acquired and demand increases. Contrast this with SCPC where the operator must continuously re-balance or groom the capacity of all their links to try to keep up with changing patterns of usage.

There is also a Capex evaluation when looking at SCPC versus TDMA based networks. With SCPC most of the intelligence for processing and routing traffic is built into the VSAT modem. This makes each individual modem more expensive. In a TDMA network the VSAT terminals are considerably less expensive, but normally operate in what is called a star topology. This requires a centralized hub that controls most of the management, processing and routing of information. The hub is more expensive than individual SCPC modems, but once the number of remote locations is greater than 15 or 20 sites the hardware cost of the SCPC modems exceeds the cost of the hub.

5. The evolution from TDM to all-IP for cellular backhaul.

There has been a lot of reference to IP. How is IP impacting cellular operators and their plans for expanding services?

When 2G networks were deployed sending and receiving large amounts of data were not part of the strategy. The networks were planned with a focus on voice services and any data was an afterthought.

As mobile voice services matured in developed markets, ARPU began to decline, so operators responded by launching new services. The first to gain widespread popularity was short messaging service. This quickly increased subscriber demand for data services and launched a whole new market for other data services like Internet, music downloads, photos and other applications right on the mobile handset, providing additional revenue streams for mobile operators.

The popularity of these services created a whole new set of challenges for cellular operators. 2G networks were designed for voice services so predicting an annual increase in traffic based on subscriber growth for each BTS location was a straightforward calculation. This predictability enabled operators to forecast backhaul costs and plan for these expenses as they were only a small percentage of the overall cost of providing service. Now, with the increase in data services, this predictability has disappeared and backhaul costs have skyrocketed accounting for 30-40% of total network costs for a cellular operator. Traditional networks using leased line E1/T1 for last mile connectivity do not scale economically to meet subscriber demands and are difficult to manage because of the bursting nature of wireless data services.

This is where IP is making a difference in cellular backhaul. The ability to provision, scale and manage multiple services is more efficient using IP technology. Most cellular operators are looking to either migrate existing networks to support IP technology, or are deploying next generation all-IP networks. This is being done to accommodate the increase in traffic based on data services and to provide an efficient and high quality platform for the transport of core voice services.

Most operators are very aware of the challenges outlined above, but how does that impact their decision when looking at VSAT technology? When deploying a satellite network mobile operators should look at their business strategy for expanding into new markets and whether they are going to connect these sites using an all-IP network to handle increased data services, or if they are going to connect these sites using a traditional TDM network.

Using an all-IP network allows the operators to backhaul the traffic from the remote sites using either dedicated or shared bandwidth in an efficient manner. Using a shared platform like iDirect, that is built with IP at the core, allows for an all-IP infrastructure that does not require any additional hardware to backhaul traffic from the BTS into the core of the network. Many traditional VSAT solutions designed to support TDM traffic using SCPC technology will need to include additional hardware in order to translate the TDM information into IP.

The opposite is true as well. If an operator is trying to connect remote sites into a 2G TDM network than a mediation device is needed to gain the benefits of using an IP-based satellite solution. The mediation device will translate the BTS traffic from TDM into IP in order to transport the data efficiently. Traditional SCPC solutions don't require the mediation device, but they also don't have as many of the scalability and efficiency benefits of a shared network.

In either scenario, VSAT technology provides a solution for connecting remote areas into the core network, but moving toward a technology that is based on all-IP will help future proof the network and provide increased efficiencies.

6. Quality of Service (QoS).

In the cellular industry, most operators deal with the five nines when it comes to availability and uptime. When a subscriber places a call they want to make sure that they can connect. One important aspect of satellite is that it is extremely reliable, but it requires more than just a satellite connection to guarantee the quality of the experience for voice and data services.

The quality of a voice call is extremely important and having a satellite network that is capable of preserving data integrity and prioritizing traffic is essential. This is where Quality of Service (QoS) plays a fundamental role in the transporting of voice and data traffic over satellite.

In general, backhaul does not consist of a single stream of data. Usually there are multiple streams for voice, GPRS data, EDGE data, and signaling channels to name a few. Each of these has different relative priorities and needs to be managed in a specific manner. A satellite network that offers strong QoS capabilities is required in order to manage the sophisticated traffic demands of multiple streams. If the operator is looking at exploiting other IP services in addition to backhaul at the site, for example WiMAX, the demands for prioritization are even greater.

Typical data traffic is bursty in nature so packet switched networks can be subject to congestion. iDirect's advanced QoS capabilities prioritize packet delivery based on the type of traffic while automatically allocating bandwidth instantaneously, ensuring that the integrity of the connection is maintained while reducing overall bandwidth requirements. This enables satellite operators to guarantee the mobile operator specific service level agreements for the delivery of voice traffic over congested links.

The payoff is that subscribers will get the clear channel voice connectivity they expect while having access to all of the new data applications that helps drive continued growth and revenue for the mobile operators.

7. Real-Time Traffic Management.

As we expand into more technical detail, one of the biggest challenges is properly managing the traffic on the network. We just highlighted how QoS helps to manage the types of traffic, but there are also some more fundamental challenges that it helps address.

The distance a signal must travel from earth to the satellite and back is a physical limitation that all satellite vendors face. Sending a signal this distance creates what is known as delay or latency. If not managed properly, latency can cause a voice call to have echo which provides a less than adequate experience for subscribers. When selecting a satellite solution be sure to choose a platform that minimizes the processing and queuing time for packets as they pass through the remote and hub in order to minimize the effects of latency.

Another factor that must be addressed with IP is jitter which measures the variation in latency or delay of packets as they arrive at their destination. A BTS emits packets at regular intervals for each call in

progress and those packets need to be delivered at regular intervals to keep voice quality good. If packets arrive in a different order and at different time intervals then voice quality degrades making speech choppy and difficult to understand. One way to handle a high amount of jitter is to add a jitter buffer that will store and re-sort packets and play them out at regular intervals. This solves the jitter problem but adds more delay. An iDirect system minimizes jitter without adding delay using a flexible range of timeslot sizes on the inroute transmission combined with a technique called feathering that ensures timeslots allocated to a remote are evenly spread across the time plan.

The third factor that can significantly affect quality is Packet Loss. When a packet gets dropped or can't get through the router because of network congestion it impacts the quality of the call. If there is significant packet loss, voice will be garbled and unintelligible. It is important to have a network with a very low Packet Loss Rate (PLR) in order to avoid degradation of voice quality.

iDirect's advanced Real-Time Traffic Management algorithms help avoid these pitfalls by instantaneously allocating bandwidth for real time applications, while maintaining a quality connection. The ultimate result of real time traffic management is that a satellite network operator should be able to guarantee a QoS that can be established by traffic type, origination and destination, while being able to allocate bandwidth on demand to maintain the highest quality of calls and connectivity at every BTS site.

8. How will my network scale as I grow?

Most mobile operators are not looking to only support existing customers but want to expand and grow their business. As the price of services decreases, mobile operators must be efficient in how they run their businesses, while reaching out to new markets.

When implementing a satellite network an operator should choose a system that will not only allow them to provide a quality service, but one that will allow them to scale. There are a number of satellite technologies that can be used, but most mobile operators will want to control expenses while they launch a service and begin to capture revenue.

The difference between SCPC and TDMA networks was covered in point 4, but there are other factors to be considered.

How much bandwidth does an operator need to purchase up front to launch a service?

With SCPC, a mobile operator will need to purchase the full amount of bandwidth necessary to support a new location and they don't have a good way to scale that bandwidth over time. This results in an operator paying for a large amount of unused bandwidth from day one.

With a TDMA system, an operator can scale the amount of bandwidth purchased and allocate it in much smaller increments, only increasing the amount of bandwidth as new customers are added to the network and revenue is generated. This is a very big distinction in how you deploy and scale a network. It also allows you to add new sites in more remote areas than other satellite technology because you are not over-committing based on bandwidth costs.

Another positive is that as your terrestrial infrastructure builds out, you can easily redeploy a shared solution to a new location, or leave it as a backup solution to provide guaranteed uptime in case your terrestrial network has an issue. Doing this allows you to redeploy into new markets.

When selecting a satellite operator you also should verify that they can scale as you grow. One key component of that is verifying that they have the appropriate infrastructure to support your strategy and a Network Management System that will enable them to easily deploy, manage and monitor the connectivity at every remote BTS location. If they can manage multiple satellites, topologies and bandwidth allocations they will be able to provide the mobile operator with guaranteed service level agreements and up time.

Conclusion:

- ◆ The use of shared satellite services is increasing, helping mobile operators expand into rural regions. The expansion of data services has challenged traditional cellular backhaul technologies and operators are adapting by implementing new all-IP networks to improve the efficiency and quality of voice and data traffic.
- ◆ New satellite technologies are enabling mobile operators to efficiently share bandwidth between multiple BTS locations and allowing for easier integration into the core of the network. Many new advanced features have eliminated some of the challenges that have plagued satellite adoption for backhaul, while providing a guaranteed level of service for multiple types of traffic on different mobile technologies.
- ◆ Mobile operators are finding new and affordable VSAT solutions to expand their customer base, improve service and open up opportunities for rural communities that need cellular service to grow, modernize and compete in today's economic environment.

For more information on implementing iDirect VSAT technology for cellular backhaul please visit <http://www.idirect.net/Applications/Cellular-Backhaul.aspx> or call +1.703.648.8000

VT iDirect, Inc. (iDirect), a subsidiary of VT Systems, is transforming the way the world gets and stays connected. The company's satellite-based IP communications technology enables constant connectivity for voice, video and data applications in diverse and challenging environments. These include extending private networks to remote offices; supporting mobile connectivity across land, sea and air; providing rural telephony and Internet broadband; and maintaining communications in the wake of disasters and network failures. The iDirect Intelligent Platform™ integrates advanced technology into iDirect's portfolio of hubs, routers and network management software to address the growing complexity of deploying and managing global IP networks. With more than 13 years of global satellite communications experience, iDirect serves customers in 50 countries through a diverse network of channel partners, including some of the largest satellite providers, operators and carriers in the world and seven of the World Teleport Association's Global Top Ten. Headquartered in Herndon, Virginia, iDirect has offices in Europe, Asia, Middle East, Africa and Latin America. Please visit www.idirect.net.