White Paper

WiMAX Advanced to Harmonize With TD-LTE in the 2.3, 2.5 & 3.5GHz Bands

Opportunities & Challenges for WiMAX 2

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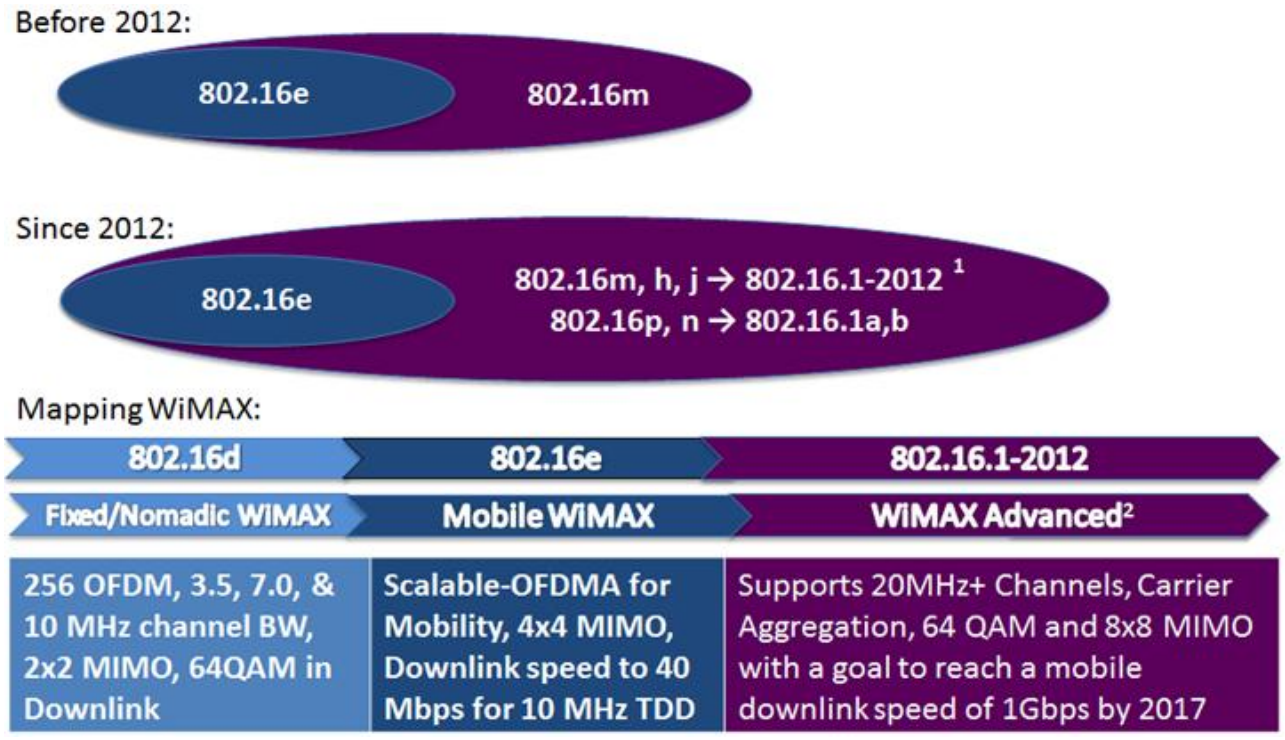
Executive Summary

The WiMAX operator community currently faces a host of challenges, ranging from difficulties in procuring cost-effective devices to securing funding for network development in the face of uncertainty regarding the future of WiMAX technology. At the request of its operator members, the WiMAX Forum initiated the WiMAX 2.1 initiative to adopt a clear technical roadmap for WiMAX Advanced and convergence with TD-LTE. Over the past year, the WiMAX Forum has been implementing the WiMAX 2.1 action plan by working with its leading operators and ecosystem vendors to develop a smooth technology roadmap and a cost-effective transition business case to WiMAX Advanced for both network and subscriber equipment.

With the support of more than 140 members, the WiMAX Forum officially approved WiMAX Advanced as an extension to its technical network evolution roadmap during its most recent board meeting in August 2013. **Figure 1** illustrates the technology roadmap and the evolution of the IEEE 802.16 standard mapped to WiMAX Advanced. This roadmap is based on the 802.16m amendment to the standard approved by the IEEE in May 2011. WiMAX Advanced is based on IEEE 802.16.1-2012 and is described in WiMAX Forum standards WiMAX 2.0, 2.1 and 2.2.

Figure 1: WiMAX IEEE 802.16 Evolution Mapped to WiMAX Advanced



[1] Continuous contribution by IEEE including by not limited to 802.16.1, such as 802.16.1a-2013.
[2] WiMAX Advanced includes WiMAX Forum Standards WiMAX 2.0, 2.1 and 2.2.

Source: Heavy Reading, WiMAX Forum and IEEE

The ITU approved both LTE Advanced and WiMAX Advanced as IMT-Advanced technologies in 2012. WiMAX Advanced runs parallel to LTE Advanced, and the WiMAX Advanced roadmap leverages the unique advantages of TDD spectrum and scalable OFDMA to allow operators to support 20MHz+ wider channels on their existing all-IP mobile broadband data networks.

WiMAX Advanced also utilizes key technologies such as carrier aggregation, 64QAM, and 8x8 MIMO with a goal to reach a mobile downlink speed of 1Gbit/s. It is also provides a path to convergence with LTE TDD where operators may benefit from the larger economies of scale associated with a larger ecosystem of TD-LTE devices. Some of the Broadband Wireless Access (BWA) service providers using WiMAX technologies are now seeking to leverage their vast TDD spectrum positions and harmonize their networks with TD-LTE.

Although there is significant interest in TD-LTE technology, most of these WiMAX operators do not have the capital or spectrum to allow them to make this transition at their own pace without disrupting their existing services and subscribers. Instead, they are hoping to enhance their operations by leveraging WiMAX Advanced technology to support new TD-LTE devices under the integrated LTE ecosystem that can complement the already affordable WiMAX devices over the long term. With WiMAX Advanced, operators can more easily support multiple radio access technologies in a heterogeneous network through the harmonization of WiMAX and LTE TDD. The key value of WiMAX Advanced is for operators to leverage the mobility of new TD-LTE devices in the integrated LTE ecosystem.

This white paper provides an update on WiMAX Advanced as discussed in several recent meetings, including the WiMAX Forum Board meeting in Washington, D.C., and the WiMAX Africa conference in November 2013. These meetings provided an interactive working forum for operators to network, share key lessons and gain concrete knowledge that will help them build profitable businesses around WiMAX Advanced. Many of the operators attending WiMAX Africa 2013 expressed the need for vendor support to retain as many elements as possible from their current deployments including their tower sites, RAN, backhaul, core networks, provisioning and billing systems. Some of these operators are also seeking regulatory reforms that would remove technology restrictions on spectrum licenses that prevent mobility and would allow them to support TD-LTE devices on a WiMAX Advanced network. These meetings also allowed participants to discuss how operators can leverage new WiMAX Advanced technologies to improve network performance and harmonize WiMAX with TD-LTE.

This white paper also serves as an update to the *Heavy Reading* Briefing Paper (www.WiMAXforum.org/LiteratureRetrieve.aspx?ID=177981) published in November 2012 that demonstrated how operators could future-proof their RAN, backhaul, packet core and customer premises equipment (CPE) while providing continuity of service for their subscribers.

WiMAX Advanced in 2.3, 2.5 & 3.5GHz Bands

Mobile WiMAX was the first 4G technology supporting all IP, OFDMA wireless broadband networks, and WiMAX deployments sparked broadband competition in many countries worldwide. Although there is no uniform global licensed spectrum for WiMAX, the WiMAX Forum published three licensed spectrum profiles – 2.3 GHz, 2.5 GHz and 3.5 GHz – in an effort to drive standardization and decrease cost. WiMAX profiles define channel size (3.5 MHz, 5 MHz, 7 MHz and 10 MHz), duplexing schemes (TDD or FDD) and other necessary attributes in order to have interoperating products. The current fixed profiles are defined for both TDD and FDD profiles, but at this point all of the mobile profiles are only for unpaired TDD spectrum.

More than 477 operators deployed WiMAX networks in 150 countries and provide wireless broadband services for more than 25 million subscribers, and covering a population of approximately 1 billion around the world. **Figure 2** provides a representative list by region of those WiMAX operators currently using 2.3, 2.5 and 3.5GHz spectrum to provide BWA in more than 40 countries. WiMAX still represents the most widely deployed, standards-based 4G network solution positioned to meet the rapidly growing demand for wireless broadband services generated by new devices and applications. Although the number of WiMAX deployments remains greater than any other 4G technology, many of these WiMAX networks are relatively small, serving targeted communities, businesses and institutions.

Mobile WiMAX networks were launched in developed countries such as the U.S. and Japan well before HSPA+ and LTE technologies were available, and they supported sophisticated dual-mode 3G/4G smartphones and other mobile broadband devices. Some of the largest Mobile WiMAX operations are in mature markets such as the U.S., Japan and South Korea, where the 2.3 and 2.5/2.6GHz bands were used to support the first 4G services offered by Sprint/Clearwire, KDDI/UQ Communications, KT and SK Telecom. Others have developed in fast-growing Asian markets such as Malaysia, Taiwan and Philippines.

WiMAX operators in these mature markets have developed a unique business case to deliver differentiated all-IP mobile broadband services to meet the needs of data centric customers better than most legacy 3G operations. UQ Communications is the first of these operators to begin leveraging its newly awarded 2.6GHz spectrum to enhance network performance by upgrading its existing network from WiMAX to WiMAX Advanced.

But other WiMAX operators in mature markets are planning to use their new spectrum to deploy TD-LTE networks in parallel to their existing WiMAX networks, to future-proof their networks and take advantage of a larger device ecosystem. Now that its acquisition by SoftBank has been concluded, Sprint is accelerating the deployment of a new TD-LTE network while maintaining the existing Clearwire WiMAX network which still serves millions of subscribers. With an average of 120 MHz of 2.5GHz TDD spectrum nationwide and access to new capital from SoftBank, Sprint can afford to use some of its Clearwire spectrum to manage this transition where mobile WiMAX and TD-LTE will co-exist over a period of two years or more. WiMAX technologies are also being used to offer essential fixed and nomadic broadband wireless Internet services using licensed TDD spectrum in the 2.3, 2.5 and 3.5GHz bands in a wide range of developing countries, emerging markets and sparsely populated rural areas throughout Africa, the Middle East, Eastern Europe and Latin America.

Figure 2: WiMAX Operators Licensed in 2.3, 2.5/2.6 & 3.5GHz Spectrum Bands by Region

REGION	COUNTRY	OPERATOR	SPECTRUM BAND	TECHNOLOGY
Europe	U.K.	UK Broadband	3.5 GHz	WiMAX to TD-LTE
	Ireland	Imagine Communications	3.5 GHz	WiMAX to TD-LTE
	France	Bolloré Telecom	3.5 GHz	WiMAX to TD-LTE
	Belgium	b.lite Telecom BVBA	3.5 GHz	WiMAX to TD-LTE
	Italy	AFT-Linkem	3.5 GHz	WiMAX to TD-LTE
	Germany	Deutsche Breitband Dienste	3.5 GHz	WiMAX to TD-LTE
	Spain	Neo-Sky, Iberbanda/Telefónica	3.5 GHz	WiMAX to TD-LTE
Eastern Europe, Russia/CIS	Bulgaria	Max Telecom	3.5 GHz	WiMAX
	Poland	Netia, Milmex	3.5 GHz	WiMAX to TD-LTE
	Russia	TransTeleCom, Enforta, Freshtel	3.5 GHz	WiMAX to TD-LTE
	Azerbaijan	Azqtel (Sazz)	3.5 GHz	WiMAX to TD-LTE
Middle East/Africa	Saudi Arabia	Mobily	3.5 GHz	WiMAX to TD-LTE
	Bahrain	Mena Telecom	3.5 GHz	WiMAX to TD-LTE
	Jordan	Umniah	3.5 GHz	WiMAX to TD-LTE
	Iran	MobinNet	3.5 GHz	WiMAX
	Pakistan	Wateen, Augere, Wi-Tribe	3.5 GHz	WiMAX
	Cameroon	MTN	3.5 GHz	WiMAX
	Ghana	U2 Online	2.3 GHz	WiMAX
	Kenya	Safaricom, AccessKenya	3.5 GHz	WiMAX
	Nigeria	SwiftNetworks, ADIV , MTN	3.5 GHz	WiMAX/TD-LTE
	Namibia	Telikom	3.5 GHz	WiMAX
	South Africa	Neotel, Easttel	3.5 GHz	WiMAX/TD-LTE
	Zimbabwe	uMAX	2.5 GHz	WiMAX
Asia/ Pacific	Australia	Vivid Wireless/Optus	3.5 GHz	WiMAX/TD-LTE
	New Zealand	Sentech, iBurst	2.6 GHz	WiMAX to TD-LTE
	Japan	UQ Communications	2.6 GHz	WiMAX/WiMAX 2
	South Korea	KT, SKT	2.3/2.4 GHz	WiMAX/WiBro
	India	BSNL	2.4 GHz	WiMAX
	Bangladesh	Banglalion and Augere	2.5 GHz	WiMAX to TD-LTE
	Sri Lanka	Sky TV	2.5 GHz	WiMAX to TD-LTE
	Malaysia	YTL Communications, P1	2.3 and 2.6 GHz	WiMAX/WiMAX 2
	Indonesia	PT Internux	2.3 GHz	WiMAX to TD-LTE
	Philippines	Smart, Globe Telecom	2.5 GHz	WiMAX to TD-LTE
	Taiwan	FarEastone, Global Mobile	2.6 GHz	WiMAX to TD-LTE
North America	U.S.	Clearwire/Sprint	2.5 GHz	WiMAX to TD-LTE
	Canada	Xplorenet, Sasktel, Bell Canada	3.5 GHz	WiMAX to TD-LTE
	Mexico	Axtel, Telmex	3.5 GHz	WiMAX to TD-LTE
	Bahamas	BTC	3.5 GHz	WiMAX to TD-LTE
Latin America/ Caribbean	Argentina	Claro, DirecTV	3.5 GHz	WiMAX to TD-LTE
	Chile	Entel	3.5 GHz	WiMAX to TD-LTE
	Jamaica	Digicel	3.5 GHz	WiMAX
	Mexico	Telmex, Axtel	3.5 GHz	WiMAX to TD-LTE
	Venezuela	OMNIVISION (Movilmax)	2.5 GHz	WiMAX to TD-LTE
	Peru	Entel/Nextel International	2.6 GHz	WiMAX

Source: Heavy Reading, WiMAX Forum and IEEE

The WiMAX Forum estimates more than 300 operators are using WiMAX technology to provide BWA services in the 3.5/3.6GHz spectrum bands. In Pakistan, Wateen, WiTribe and Mobilink currently use WiMAX technology in the 3.5GHz band to serve 460,000 broadband wireless subscribers. MobinNet is a private 3.5GHz WiMAX operator currently providing wireless broadband service nationwide in Iran with over 600,000 Internet subscribers. In addition, there are more than 30 WiMAX networks providing fixed and nomadic wireless broadband in African countries. The fixed/nomadic BWA business model still has traction in these emerging markets, but some existing 3.5GHz WiMAX operators are not financially viable and need a plan to access to a broader ecosystem of devices and operate more easily within the new LTE environment.

LTE FDD & TDD Deployments Growing Rapidly

The most recent GSA report indicates that 213 LTE networks have been commercially launched in 81 countries, with the largest nationwide deployments concentrated in three countries North America and the Asia/Pacific region. In many of these mature markets, competitive and market forces have combined to accelerate deployment, aggressive marketing and rapid adoption of 4G LTE, which reached 126 million subscribers by October 2013.

Although 3GPP has specified more than 30 LTE FDD bands, most of these initial LTE deployments have used paired FDD spectrum in the 700, 1800, 2000, and 2600MHz bands to provide a coverage layer with limited spectrum for capacity to handle traffic growth. Mobile broadband demand is at an all-time high, with some operators reporting a doubling of data traffic during each of the last five years. With increasing adoption of sophisticated smartphones and tablet devices, more and more users are turning to mobile broadband (MBB) as their primary means for Internet access, content, applications, communications and messaging. In particular, video streaming, content downloading, gaming and other high-bandwidth, data-intensive multimedia applications are accelerating mobile data traffic growth.

Some 4G LTE operators are already reaching a point of network saturation as more smart devices are penetrating the market, preventing users from satiating their hunger for advanced services and applications. As such, mobile broadband operators are just beginning to take steps to handle this scale of wireless data traffic growth in the range of 30-fold over the next few years and 1,000-fold over the next 10 years. There is a growing recognition that only the combination of new small cell technologies and large blocks of new TDD spectrum will allow operators to address this 1,000X challenge.

Figure 3: WiMAX Spectrum in LTE TDD Bands Specified by 3GPP

BAND	BAND "IDENTIFIER"	FREQUENCIES (MHZ)	TOTAL AVAILABLE SPECTRUM
33 34	TDD 2000 Europe	1900-1920 2010-2025	20 MHz 15 MHz
35 36	TDD 1900	1850-1910 1930-1990	60 MHz 60 MHz
37	PCS Center Gap	1910-1930	20 MHz
38	IMT Extension Center Gap	2570-2620	50 MHz
39	China TDD (current TD-SCDMA band)	1880-1920	40 MHz
40	2.3 TDD (Malaysia, China & India)	2300-2400	100 MHz
41	U.S. TD-LTE	2496-2690	194 MHz
42	3.5/3.6 GHz	3400-3600	200 MHz
43	3.7 GHz	3600-3800	100 MHz
44	ATP 700	703-803	100 MHz

Source: Heavy Reading and 3GPP

As indicated in **Figure 3**, the 2.3, 2.5 and 3.5GHz WiMAX spectrum bands are now among the LTE TDD spectrum bands specified by 3GPP as LTE TDD Bands 38, 40, 41, 42 and 43. Driven by a limited supply of appropriate FDD spectrum, the 3GPP LTE standard now supports 12 unpaired TDD spectrum bands that have so far been specified by 3GPP for LTE by region. The unpaired LTE TDD spectrum bands are attractive since they use higher frequencies, support flexible uplink/downlink bandwidth allocations and generally offer larger capacity, some with 100MHz contiguous spectrum blocks.

The GSA has identified 23 LTE TDD networks launched commercially in 18 countries, with nearly all using Band 40 2.3GHz or Band 41 2.5/2.6GHz spectrum. This includes Sprint, now controlled by SoftBank, which is deploying a TD-LTE network throughout the U.S. SoftBank/WCP is deploying an Advanced eXtended Global Platform (AXGP) nationwide mobile broadband network compatible with TD-LTE throughout Japan. In India, Bharti Airtel is the first BWA licensee to launch its TD-LTE services in the 2.3GHz band, and several other operators are expected to launch commercial TD-LTE services soon, including Reliance Jio. China Mobile is also expected to transition from large scale pre-commercial trials to full commercial TD-LTE services driving large volumes of devices in 2014.

The following are among those operators seeking to evolve their existing WiMAX networks to LTE TDD to access a larger ecosystem of devices and for better user experience.

- UK Broadband conducted a TD-LTE pilot in 2012 and launched commercial service using 3.5/3.6GHz spectrum in June 2012.
- Bolloré Telecom from France plans to convert its nationwide WiMAX network to TD-LTE using its 3.5GHz spectrum in Band 42 focusing on the top 15 urban areas reaching 24 million people and most of the smartphone users in France.
- Imagine Group in Ireland has 220 MHz in Band 42/43, originally offering WiMAX in all strategic parts of the country; plans to launch TD-LTE in 2013.
- Clearwire is one of the largest WiMAX operator worldwide, and after its merger with Sprint under SoftBank control most of its extensive 2.5GHz spectrum will be used for TD-LTE service, with 2,000 base stations to be deployed during 2013.
- Xplornet Communications of Canada is testing the migration from WiMAX to TD-LTE network with 25 MHz in the 3.5GHz band.
- Entel in Chile plans to deploy TD-LTE in the 3.5GHz band, offering fixed broadband access and VoIP.
- AFT-Linkem, a WiMAX operator with 130,000 subscribers in 13 regions of Italy, is conducting a trial of TD-LTE in the 3.5GHz band.
- Neo Sky in Spain is studying the introduction of a 3.5GHz TD-LTE system.
- Enforta, a Russian WiMAX operator, plans to test TD-LTE in the 3.5GHz band.
- Bulgarian operator Max Telecom has selected NSN to deploy the Evolved Packet Core and LTE-FDD radio base stations supporting the launch of a LTE-FDD mobile broadband network which operate in the 1800MHz range in parallel to its existing WiMAX network beginning in 4Q13.

- Menatelecom, a WiMAX operator in Bahrain, is currently deploying a 3.5GHz TD-LTE nationwide network, with a commercial service launch planned in 2013.
- Mobily in Saudi Arabia is working with Huawei and Samsung to migrate its existing WiMAX network to be the first WiMAX/TD-LTE multimode in the 2.5GHz Band 41. With 2,400 LTE towers in more than 30 cities, Mobily will support 2 million mobile broadband subscribers and also plans to deploy TD-LTE with 3.5GHz spectrum in the future.
- Swift in Nigeria is deploying West Africa's first WiMAX/TD-LTE dual-mode network.
- uMax in Zimbabwe completed the deployment of a wireless broadband network in the 2.5GHz band based on Telrad Mobile WiMAX equipment.
- Smart launched LTE FDD services in August 2012 using both the 2.1GHz and 1.8GHz bands and is conducting TD-LTE trials in conjunction with Huawei.
- BSNL of India recently returned the non-standard 2.4GHz spectrum it was awarded by the government in 17 of the total 22 circles to deploy WiMAX networks for BWA, and is now planning its transition to TD-LTE technology.
- Banglalion Communications and Augere Wireless (Qubee) in Bangladesh have started planning to upgrade their WiMAX networks to soft-launch TD-LTE service by year end 2013. Banglalion is the largest 4G WiMAX operator in Bangladesh, with a BWA license nationwide for 35 MHz spectrum in the 2.5GHz band.
- Axiata Dialog Broadband Networks (DBN) recently acquired pay TV operator Sky TV and Radio Network (Pvt.) Ltd., to gain control of an additional block of 2.3GHz band spectrum to expand Sri Lanka's first TD-LTE fixed wireless broadband services launched in December 2012, using 15 MHz of 2.3GHz spectrum.
- PT Internux of Indonesia is planning to transition the PT First Media WiMAX network with 30 MHz of 2.3GHz spectrum to launch "BOLT" branded MiFi services based a large-scale "Super 4G" TD-LTE network in the Jakarta metropolitan area. BOLT will initially be launched on 1,500 TD-LTE sites supporting home routers, pocket Wi-Fi routers, USB dongles, tablets and several SSDR dual-mode smartphones.
- SingTel Optus acquired WiMAX operator Vividwireless Group from Seven Group Holdings in part to gain access to up to 98MHz of spectrum in the 2.3GHz band, and plans to use this spectrum to build a new 4G network using LTE TDD technology. This new TD-LTE network will be integrated with Optus' 1800MHz 4G network to double the speed of wireless broadband services delivered to households and businesses in metropolitan Australia.

SoftBank has made a strong commitment to expanding the TD-LTE market in Japan and worldwide. SoftBank has leveraged its 30 MHz of 2.5GHz spectrum to deploy a nationwide TD-LTE compatible, Advanced eXtended Global Platform (AXGP) mobile broadband network with 38,000 base stations deployed throughout Japan. Softbank is now offering 4G-branded AXGP service on the same 2.5GHz spectrum in Band 41 that is used by Sprint for WiMAX. The recent Softbank acquisition of Sprint and the accelerated rollout of TD-LTE should also help to accelerate the convergence of WiMAX and TD-LTE networks.

Softbank recently conducted a field test drive demo of the world's first trial network supporting TD-LTE Advanced technology in the 3.4-3.6GHz Band 42. SoftBank's TD-LTE demonstration network used small-cell base stations with cutting-edge LTE Advanced technologies such as carrier aggregation, interference cancellation, MIMO and beam-forming antennas to achieve a maximum down-load speed of 1.2 Gbit/s. SoftBank clearly demonstrated that all these resources will be required to achieve the 1,000-fold growth in mobile broadband data traffic expected over the next 10 years. This field test was designed to show how mobile operators can use TD-LTE Advanced technology, small cells, smart antennas and 200 MHz of spectrum in the 3.4-3.6GHz band to achieve peak data rates of 1 Gbit/s to meet 4G IMT Advanced targets for as identified by the International Telecommunication Union.

SoftBank is also advising fixed WiMAX operators to deploy WiMAX Advanced networks in the major cities of each country supporting both fixed WiMAX and mobile TD-LTE utilizing their existing licenses. SoftBank has also advised existing WiMAX operators to leverage the growing ecosystem of Dual SIM Dual Radio (DSDR) smartphones to offer subscribers a unique combination of nationwide LTE coverage and high capacity TD-LTE in urban hot zones. Rather than selling their spectrum, SoftBank believes that DSDR should be a primary strategy for WiMAX operators in the 2.3, 2.5 and 3.5GHz band.

WiMAX Advanced in 2.3/2.6GHz Bands 40 & 41

A few larger WiMAX operators have begun planning the evolution of their existing networks to WiMAX Advanced in part to support TD-LTE devices in 2.3/2.6GHz Bands 40 and 41. The following profiles highlight the WiMAX Advanced and TD-LTE strategies of UQ Communications, YTL Communications and Packet One Networks.

UQ Communications – First WiMAX 2+ Network Operator in Japan

Since 2009, KDDI's joint venture UQ Communications has been developing its existing WiMAX network which uses 30 MHz of unpaired TDD spectrum in the 2.6GHz Band 41. UQ currently serves 4.27 million consumer and business subscribers, including both mobile and nomadic users using embedded laptops, dongles, MiFi mobile hotspots, and dual-mode smartphones. As the number of Wi-Fi enabled smartphones increases, the more users have interest in UQ's mobile MiFi devices. UQ is also developing a significant market for M2M and smart utility meter-reading applications beyond its business and consumer subscribers.

In Japan, the 2.5/2.6GHz frequency band is allocated to the BWA service, and neither UQ Communications nor Softbank's joint venture Wireless City Planning (WCP) is authorized to provide "LTE services" using this spectrum. WCP used its 30 MHz of 2.5GHz spectrum to deploy a nationwide mobile broadband network based on the TD-LTE compatible AXGP (Advanced eXtended Global Platform). Both UQ and WCP applied for additional spectrum, and in July 2013, Japan's Ministry of Internal Affairs and Communications (MIC) awarded an additional block of 20 MHz TDD spectrum to UQ Communications adjacent to its current 30 MHz spectrum in the 2.6GHz band, based on its better utilization plans for frequency assets inside buildings and larger number of customers.

UQ conducted the world's first field trial of WiMAX 2 in Tokyo in July 2011 in cooperation with Samsung Electronics. WiMAX 2 is based on the IEEE 802.16m standard approved by the WiMAX Forum in May 2011 which the ITU has approved as an IMT-Advanced technology. WiMAX Forum approved its new WiMAX 2.1 which includes "additional elements" compatible to TD-LTE. UQ's application for the additional spectrum leveraged WiMAX 2.1 to achieved downlink transmission speeds of over 100 Mbit/s. The most important drivers cited by UQ Communications for the adoption of WiMAX 2.1 technology in its next generation mobile broadband network using its 2.6GHz spectrum are summarized in **Figure 4**.

Figure 4: Key Drivers for WiMAX 2.1 Solutions Using 2.6GHz Spectrum in Band 41

Ultra-High-Speed Mobile Internet: WiMAX 2+ technology provides 1 Gbit/s+ downlink speed in the future
Efficient Spectrum Usage: WiMAX 2+ technology maximizes the number of users that can be accommodated in available spectrum
TD-LTE Compatible: WiMAX 2+ technology utilizes compatible devices and network systems to support a larger ecosystem
High-Speed Mobility and Low Latency: Available on 350 km/h transportation
Compatible With WiMAX 802.16e Devices: Users can use both WiMAX and WiMAX 2+

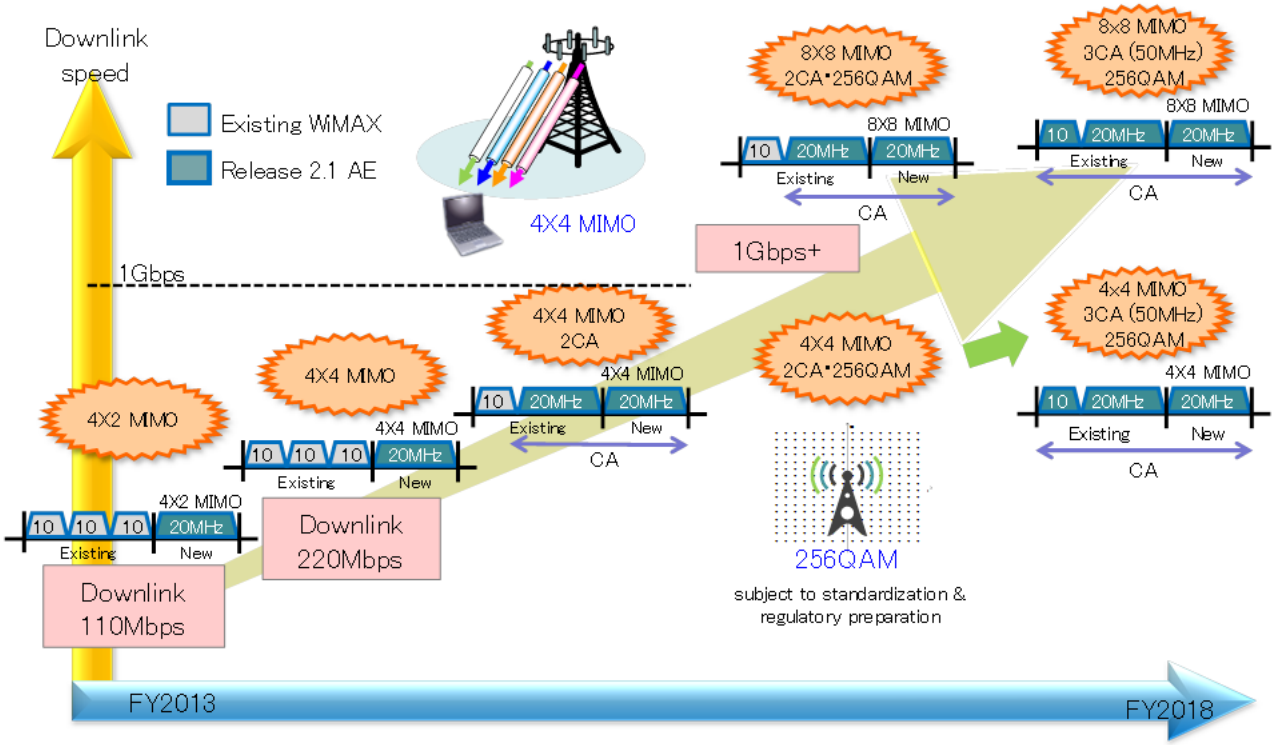
Source: UQ Communications

As a result of this spectrum award, UQ has now turned up its WiMAX 2.1 network and launched new services branded as "WiMAX 2+" in October 2013. The WiMAX 2+ service is a compatible with TD-LTE, and the maximum download speed seamlessly reaches 110 Mbit/s. UQ has introduced a new flat rate plan for both WiMAX and WiMAX 2+ for up to two years. The new Huawei WiMAX 2+ capable "Wi-Fi WALKER WiMAX 2+ HWD14" mobile router is now on sale. The Wi-Fi WALKER HWD14 is the first triple-mode 4G router on the market providing WiMAX, WiMAX 2+ and LTE capabilities in a single device. The new Wi-Fi WALKER will provide advanced WiMAX 2+ broadband service capabilities for UQ customers anywhere in UQ's or KDDI's service seamless 4G LTE area in Japan.

UQ faced several challenges and opportunities as the first operator to launch WiMAX 2+ (TD-LTE compatible) services in October 2013. The biggest challenge is turning up 20,000+ base station sites in two years. Although UQ will reuse its existing WiMAX sites, upgrading them to WiMAX 2+ compatible at that fast pace is challenging. WiMAX 2+ coverage is initially limited to central Tokyo will be expanded to greater Tokyo, Osaka and Nagoya metropolitan areas by March 2014, and to all major cities in the nation by March 2015.

UQ's strategy and timeline for introducing WiMAX 2+ to converge WiMAX and TD-LTE technologies is summarized in **Figure 5**. Looking ahead, UQ plans to aggressively adopt technologies such as Carrier Aggregation, 256QAM, and 8x8 MIMO with a goal to reach a mobile downlink speed of 1 Gbit/s in 2017.

Figure 5: UQ's Strategy & Timeline for Introducing WiMAX 2+



Source: UQ Communications

UQ will see what technology becomes the world standard and will align with operators around the globe to leverage the advances in WiMAX 2+ in the expanded 2.6GHz band to achieve >110 Mbit/s, 220 Mbit/s and ultimately 1 Gbit/s downlink speeds comparable to LTE Advanced.

YTL Communications & Packet One Networks – 2.3GHz WiMAX Licensees in Malaysia

YTL Communications and Packet One Networks (P1) together serve more than 1 million broadband wireless subscribers in Malaysia. P1 is a subsidiary of Green Packet and was the first mover and broadband wireless market leader in Malaysia using approximately 2,000 WiMAX base stations to achieve about 45 percent household broadband wireless coverage in West Malaysia. SK Telecom acquired a 25 percent stake in P1 during its second year of service, and invested to accelerate the growth of the fixed and nomadic broadband subscriber base in West Malaysia. As a result, P1 has secured approximately 500,000 fixed/nomadic WiMAX subscribers. Even so, 70 percent are home subscribers using a fixed wireless modem. P1's stated goal is to bridge the digital divide by making access to the Internet universal, ubiquitous and affordable for every Malaysian.

YTL Communications is the latest entrant into the Malaysian wireless broadband market. YTL acquired Airzed Broadband Sdn Bhd, the original Malaysian WiMAX license in 2007. The initial licensee was backed by billionaire Tan Sri Francis Yeoh and YTL Corp., one of the largest listed companies in Malaysia, with a combined market cap of about $11.9 billion. YTL launched its WiMAX service in November 2010 and has invested more than $800 million to deploy nearly 4,000 WiMAX macro base stations nationwide and nearly 500 small cell base stations supplied by Samsung and Juni for enhancing network coverage. YTL has achieved 85 percent population coverage of Peninsular Malaysia to date. YTL has netted over 500,000 mobile broadband subscribers since it launched its WiMAX network and services under the "Yes" brand in Malaysia.

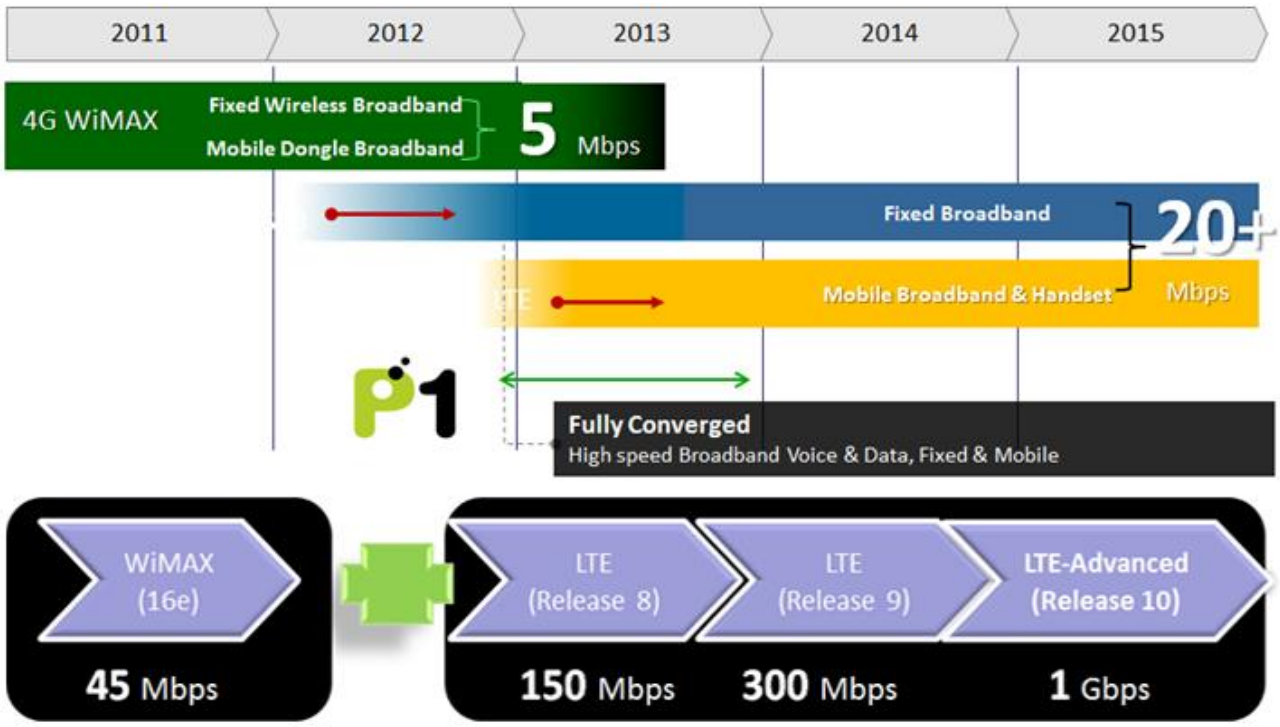
YTL offers a wide range of Yes 4G access devices including the Yes Huddle (4G Personal Mobile Router), Yes Go (4G USB dongle) and Yes Zoom (4G Wi-Fi router). YTL and Samsung introduced the Yes Buzz, Malaysia's first all-in-one, SIM-less 4G cloud feature phone in Malaysia, which allows Yes 4G network users to send SMS messages, make mobile voice and video calls and conduct seamless videoconferencing in real time. YTL has also introduced the world's first 4G Samsung Chromebook and the Eclipse dual-mode smartphone that supports 4G WiMAX and 2G/3G with SIM card. YTL is currently implementing the 1BestariNet project initiated by the Malaysian Ministry of Education, under which 10,000 primary and secondary public schools in Malaysia will be equipped with high-speed 4G Internet access and a virtual learning platform, providing high-speed Internet connectivity and access to a world-class integrated learning solution.

Having fulfilled their build-out requirements in West Peninsular Malaysia, both P1 and YTL have been granted permission to provide WiMAX service in East Malaysia. As such, YTL is actively extending its network and has been offering Yes 4G in Sabah, East Malaysia since 3Q13. P1 has also started a small scale WiMAX deployment and has launched commercial services in Sabah, East Malaysia. P1and YTL have also been granted an additional block of 20 MHz of 2.6GHz TDD spectrum that can be used for either WiMAX or LTE services. Both of Malaysia's broadband wireless licensees already have 30 MHz of 2.3GHz TDD spectrum initially licensed to deploy a wireless broad-band network based on WiMAX technology. However, in Malaysia TDD spectrum is not technology-specific and could be used

for either WiMAX or TD-LTE in the future. This would offer the WiMAX operators the opportunity to leverage the economies of scale, roaming and network sharing opportunities by joining the larger TD-LTE ecosystem.

P1 was the first Malaysian operator to announce plans to harness the combined powers of WiMAX and LTE technologies, and is still attempting to raise the necessary funding to implement this transition. P1 has announced plans to deploy a TD-LTE network using its 2.6GHz spectrum in parallel with its existing 2.3GHz WiMAX network starting in the first half of 2014. P1 has initiated a combined multi-mode WiMAX and LTE network trial with ZTE, but has not begun to implement this transition. P1 has also signed a technology cooperation agreement with China Mobile, and has joined the Global TD-LTE Initiative (GTI) aiming to spearhead TD-LTE technology in Malaysia and southeast Asia. The strategy and timeline for the introduction of TD-LTE technologies into P1's existing WiMAX network are summarized in **Figure 6**.

Figure 6: P1's Strategy & Timeline for Introducing TD-LTE in Existing WiMAX Network



Source: Packet One Networks

YTL has yet to decide whether to continue with WiMAX or deploy TD-LTE using its 2.6GHz TDD spectrum. YTL and UQ Communications are leading the WiMAX Forum effort to further develop WiMAX Advanced to allow operators to support multiple BWA technologies, including TD-LTE. Several companies are now working on chipsets that will enable dual-mode devices to support hybrid WiMAX/TD-LTE rollouts, and with China Mobile driving the TD-LTE ecosystem, a large number of ecosystem devices – including modems, routers and handsets – could come into the market in the next few years, driving prices down. The increasing availability

and choice of TD-LTE devices over the coming will compare with limited options for WiMAX, giving TD-LTE a rising competitive advantage. The advantage of this approach is that operators may not need to approach their regulator to have their spectrum re-assigned to TD-LTE.

Both YTL and P1 have joined the GTI in an effort to find common ground between the WiMAX and TD-LTE ecosystems. YTL Communications has signed a memorandum of understanding (MoU) with UQ Communications to increase collaboration. Under the MoU, UQ and YTL plan to work together on business and technical aspects with the aim of creating a stronger WiMAX ecosystem. YTL and UQ believe that WiMAX operators should be allowed by regulators to bypass additional regulatory approval to support TD-LTE devices in a WiMAX Advanced network.

Operators can decide which devices will be used on its network, and once a device is approved conforming with local regulations, operators may use the device. If the industry can create a single WiMAX/TD-LTE vendor ecosystem, this will help operators reduce procurement costs for implementing WiMAX 2+ networks compatible with TD-LTE in the 2.6, 2.3 and 3.5GHz bands.

WiMAX Advanced in 3.5/3.6GHz Band 42 & 43

Wateen Telecom – 3.5GHz WiMAX Operator in Pakistan

Wateen Telecom is the Abu Dhabi Group's latest communication investment in Pakistan after the successful launch of Warid Telecom post-paid GSM network. Headquartered in Lahore, Wateen's nationwide spectrum holdings in the 3.5-3.6GHz band include five geographic regions with 42 MHz of spectrum and nine geographic regions with 21 MHz of spectrum.

Wateen Telecom has successfully deployed a nationwide WiMAX network with coverage in 19 cities, covering more than 20 percent of Pakistan's 164 million inhabitants. Since the network's commercial launch in December of 2007, Wateen Telecom currently serves 185,000 subscribers. Wateen is close to achieving EBITDA break even on existing operations, while addressing the challenge of subsidizing expensive 3.5GHz WiMAX devices and limited performance of WiMAX USB modems in indoor environments.

Wateen is working to consolidate its assets with another 3.5GHz WiMAX operator in Pakistan to aggregate spectrum and drive economies of scale. Wateen is also planning the evolution of its network and the introduction of TD-LTE into its current 3.5GHz WiMAX infrastructure and device portfolio. This transition is being planned as a layer of TD-LTE on top of its existing WiMAX network in high data demand urban areas, driving the following requirements:

- Preserving interoperability with its existing WiMAX network and subscribers
- Stable, certified, standardized TD-LTE infrastructure equipment in 3.5 GHz
- A single cabinet to host both WiMAX and TD-LTE radio transceiver units would be a desirable feature to save operation and maintenance cost
- A converged backhaul and core should be feasible to manage operational cost and network complexity
- The ecosystem should evolve such that customers bring their own devices with built-in LTE capabilities in portable devices (mobile/tablets/laptops)
- The ecosystem should allow customers to buy attractively priced "off-the-shelf" CPE not subsidized by the operator
- Suitable TD-LTE indoor desktop CPE pricing for the Pakistan broadband market would be below US$45 by 2016

MobinNet Telecommunication Company – The Only Nationwide 3.5GHz WiMAX Operator

MobinNet Telecom is a privately held company and the largest wireless broadband operator that has successfully and solely deployed a nationwide multivendor WiMAX network covering all provinces and 123 of Iran's major cities containing more than 60 percent of total 75 million population using 52 MHz of 3.5GHz spectrum. Of the two WiMAX operators in Iran, MobinNet is the newest entrant to the Iranian broadband market and is now the market share leader.

Since the network's commercial launch in December of 2010, MobinNet has achieved a dominant 54 percent share of the emerging WiMAX market, currently

serving more than 600,000 Internet subscribers and intranet business/enterprise customers. Headquartered in Tehran, MobinNet achieved EBITDA break even in 2012 and is about to achieve net income break even on existing operations. MobinNet has developed Layer 2/3 VPNs and Intranet services, and has achieved good penetration in the enterprise segment which contributes over 15 percent of total revenue.

MobinNet fully launched its multi-vendor network platform in 2012, including Huawei, ZTE and Samsung. MobinNet is the only WiMAX operator that has three vendors in its access layer and at the same time supports many types of terminals of different providers. These efforts involve complicated system integration and interoperability tests to make sure that this multi-vendor platform works. This has increased the level of competition among the vendors, and has consequently decreased capex.

MobinNet has kept pace with its rapidly growing broadband traffic and demand for Internet speed, even with the limited coverage of its 3.5GHz spectrum and limited performance WiMAX pocket modems (MiFi) in indoor environments. The main challenge facing MobinNet as a 3.5GHz WiMAX operator in Iran is supplying/subsidizing expensive 3.5GHz WiMAX terminal devices with a reasonable price.

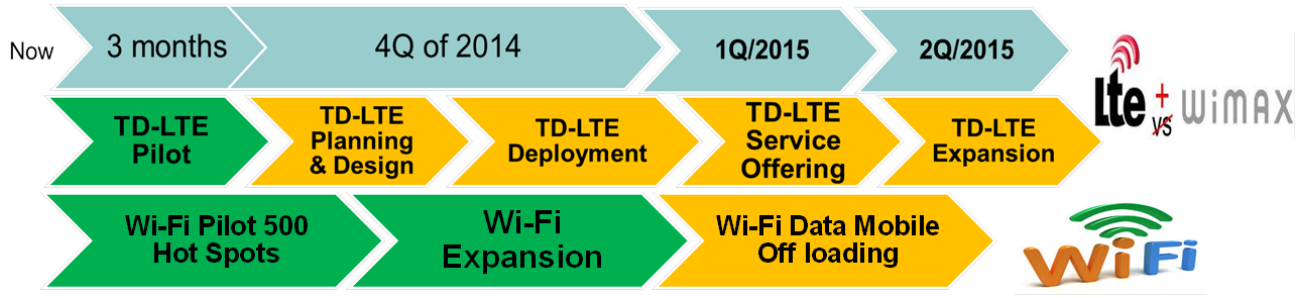
MobinNet is also complementing its existing WiMAX network with over 500 Wi-Fi access points as a pilot for a large community venue. Wi-Fi is considered a value-added service to boost customer loyalty, and is viewed as a viable option for the delivery of high-speed Internet services on mobile devices without the high cost of WiMAX modems. MobinNet also believes WiMAX operators can leverage 3.5GHz spectrum to support mobile operators deploying small cells in the new LTE HetNet environment. The operator believes 3.5 GHz is not only a great choice for small cell access but is also good option for their backhaul. MobinNet has successfully used its 3.5GHz WiMAX network as a backhaul network of Wi-Fi hotspots. This service (WiMAX + Wi-Fi) is called WiMO. WiMO is available in hundreds of hotspots in Tehran, the capital of Iran.

MobinNet is also contemplating the introduction of TD-LTE into its current infrastructure and device portfolio. The current strategy is to keep WiMAX in smaller cities and to deploy a layer of TD-LTE on top of its existing WiMAX network in high data demand urban areas to ease the transition from WiMAX to LTE in main cities. Fortunately, after two years of negotiations with the regulator, MobinNet was able to secure 20MHz of 2.6GHz TDD spectrum from the regulator for a TD-LTE pilot and plans to pilot 2.6GHz TD-LTE in some nominal sites including micro and pico cells.

Using existing IP backhaul, IP/MPLS backbone and core capabilities will ensure a smooth TD-LTE transition from WiMAX to TD-LTE. If MobinNet decides to expand its network, the multimode and multi band base stations will be prioritized. More importantly, such equipment will encourage MobinNet to negotiate with other operators for network sharing and hence spending less investment. No major upgrade is needed in its transmission networks, but some software and hardware upgrades are needed in its core and access networks. The most expensive and challenging part of this transition is terminals/CPEs.

The strategy and timeline for introducing of TD-LTE and Wi-Fi technologies into its existing WiMAX network sited by MobinNet are summarized in **Figure 7**. MobinNet believes that 2014 and 2015 are the years for WiMAX/TD-LTE convergence. The key driver for timeline is the availability of multimode devices with reasonable prices. If they were readily available today, 2013 would be the year of convergence.

Figure 7: MobinNet WiMAX to LTE Transition Strategy & Timeline



Source: MobinNet Telecom Co. (MTC)

Vendor Ecosystem for 2.3, 2.5 & 3.5GHz Bands

Meeting participants participated in the WiMAX Forum Conference in Washington, D.C., and/or the GTI 3.5GHz Interest Group Workshop in Tokyo to discuss the latest developments related to wireless broadband network evolution, network capacity and performance improvement by leveraging advanced TDD technologies in the 2.3, 2.5 and 3.5GHz spectrum bands. In support of operator initiatives, the mobile WiMAX and LTE TDD ecosystems are beginning to mature and converge across the infrastructure, chipset and device domains.

A growing vendor ecosystem is supporting the convergence of WiMAX to TD-LTE networks, including Samsung, Telrad, Huawei, Airspan, Hitachi and NSN. Most of these vendors are also prepared to play a prominent role in deployment of WiMAX Advanced networks. The following profiles summarize the vendor strategies for WiMAX/LTE convergence.

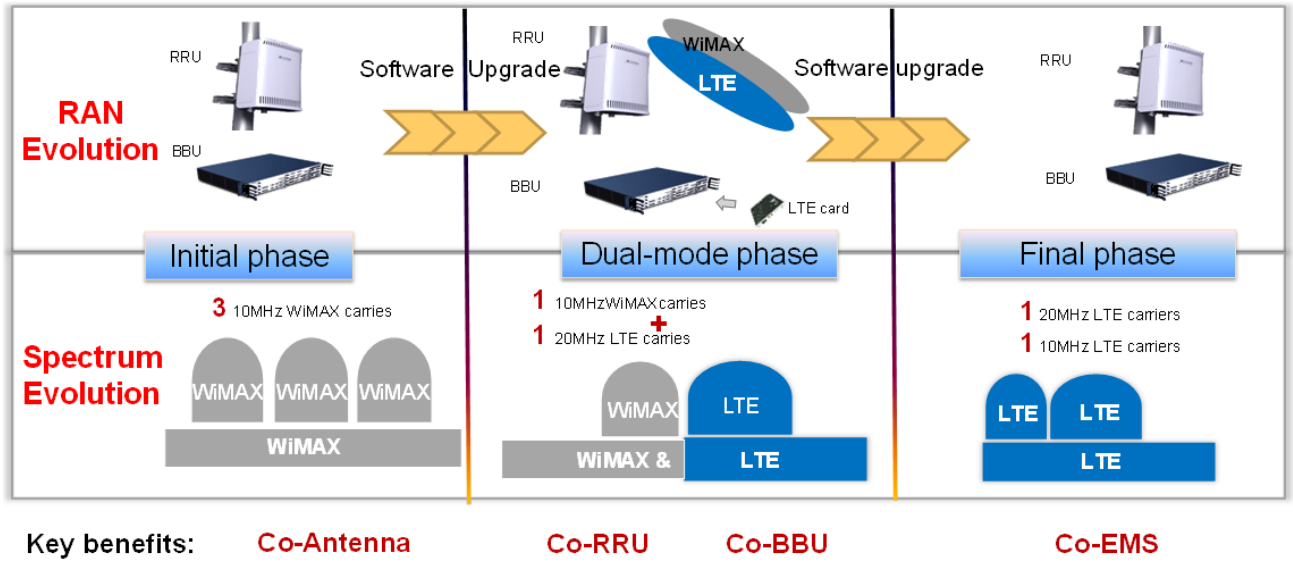
Samsung has been collaborating with the WiMAX Forum to develop WiMAX Advanced and drive ecosystem development, and is working closely with several leading WiMAX operators including UQ and YTL as they implement WiMAX Advanced to orchestrate a cost effective convergence with LTE-TDD. Samsung's solution supports WiMAX network evolution to WiMAX Advanced compatible with TD-LTE to protect the operator investment. Samsung is supporting the WiMAX Forum's continued innovation around the WiMAX standard, and believes WiMAX Advanced is a positive development that will be welcomed by operators and vendors worldwide. Furthermore, Samsung's commercial LTE-TDD deployment experience and common-platform diverse product portfolio (LTE-FDD, LTE-TDD, WiMAX, CDMA, GSM) are key in supporting operator transition to LTE-TDD at a controlled pace, without disrupting end user experiences. Samsung has been committed to LTE-TDD network deployments and commercialization since its launch of the world's first LTE-TDD network with Mobily in Saudi Arabia, followed by a series of large-scale commercial LTE-TDD network deployments in North America and Asia. Most recently, Samsung has been selected as one of the network vendors to support Sprint's commercial 2.5GHz LTE-TDD network.

Telrad Networks is a leading provider of telecom solutions that in 2013 acquired Alvarion's BWA division, with an extensive portfolio of infrastructure solutions and a large international installed base of 3.5GHz WiMAX networks. Most of the 3.5GHz operators that make up 70 percent of the Telrad WiMAX installed base are planning a transition to TD-LTE. Building on Alvarion's role as a founding member of the WiMAX Forum, Telrad supports the technological innovation promoted by the WiMAX Forum and sees WiMAX Advanced as a continuous effort to evolve and address the future needs of the BWA markets. Telrad is one of the lead contributors to the development of WiMAX Advanced to support the convergence of WiMAX and TD-LTE and offers a WiMAX/TD-LTE SDR radio along with a distributed Evolved Packet Core (EPC) optimized solution for data-centric mobile and fixed services to enable fixed/mobile convergence on LTE. This extended roadmap will enable existing and new WiMAX operators to leverage a greater ecosystem of devices and ensure a stable foundation for future deployments. Telrad Networks offers a smooth transition to TD-LTE for its customer base using initial WiMAX 802.16d TDD and FDD networks, as well as 802.16e using unique multi-technology CPEs. Telrad completed successful transitions in various networks in Latin America and Africa.

Huawei has extensive experience deploying TD-LTE networks in the 2.3. 2.5 and 3.5GHz spectrum bands, and has emphasized the smooth evolution from WiMAX to TD-LTE networks to protect the operator's investment and existing subscriber

base. With its large base of WiMAX operator customers, **Figure 8** presents Huawei's solution for the smooth evolution from WiMAX to TD-LTE to protect the operator investment. Huawei is working with Mobily to deploy the first dual-mode network to rapidly migrate users from WiMAX to TD-LTE in Saudi Arabia. Huawei is also working with UKB on the world's first 3.5GHz LTE TDD commercial network and with Menatelecom has already demonstrated World's first nationwide 3.5GHz TD-LTE network in Bahrain. Huawei is also the supplier for the "Wi-Fi WALKER" WiMAX 2+ capable mobile router now being sold by UQ/KDDI. The Wi-Fi WALKER HWD14 is the first triple-mode 4G router on the market providing WiMAX, WiMAX 2+ and LTE TDD and LTE FDD capabilities in a single device.

Figure 8: Smooth Evolution From WiMAX to LTE to Protect Investment



Source: Huawei

Airspan Networks is focused on making 4G OFDM/OFDMA small-cell solutions smarter, scalable, cost-effective and future-proof. With an extensive portfolio of outdoor/indoor LTE small-cell solutions, Airspan is heavily invested in technologies for interference management in aggressive frequency reuse scenarios and offers a unique small cell with integrated non-line-of-sight and line-of-sight backhaul. Airspan has also developed a high-performance, low-cost, small-cell solution for 3.5GHz operators wanting to deploy LTE Advanced services using carrier aggregation. As a leading equipment vendor for the 4G ecosystem, Airspan Networks supports the WiMAX Forum's effort to continually evolve WiMAX and ensure it remains an attractive option for carriers and vertical applications.

Hitachi is a Japanese telecom solutions provider that recognizes the importance of 3.5GHz spectrum as the first band offering global assignments of more than 40MHz. Hitachi believes TD-LTE is the best solution for optimizing the mobile data capacity of the 3.5GHz band, given its ability to support asymmetric upload/download allocations based on system configuration. Hitachi also recognizes the value of using 3.5GHz spectrum with small cells with active antennas, 3D-MIMO and beam-forming to minimize the effect of macrocell interference.

The availability of terminals and devices capable of supporting WiMAX Advanced in the 2.3, 2.5 and 3.5GHz bands is critical, so operators and vendors are starting to work together to increase the global production of new converged devices under the LTE ecosystem that can complement the already affordable WiMAX devices over the long term. The following profiles of selected semiconductor and device vendors leading the market for solutions with that can support WiMAX Advanced technology for multimode WiMAX and TD-LTE devices:

GCT Semiconductor is a world leader in highly integrated LTE and WiMAX semiconductor single-chip solutions for 4G wireless communications. GCT collaborated with YTL Communications, the leading 4G mobile Internet provider in Malaysia, to launch the Eclipse, an integrated WiMAX/HSPA+ 4G smartphone enabled by GCT's WiMAX single-chip solution. GCT Semiconductor is a leading fabless designer and supplier of advanced, 4G mobile LTE and WiMAX Semiconductors, and has developed some of the most advanced 4G solutions including highly Integrated single chips for WiMAX 2.0 and WiMAX/TDD-LTE/FDD-LTE multimode to support the WiMAX Advanced technology roadmap.

Sequans Communications is a publicly traded, leading chipmaker dedicated to enabling mass-market 4G LTE and WiMAX chips to original design manufacturers (ODMs) and original equipment manufacturers (OEMs) worldwide. As the creator of the world's first dual 4G WiMAX + LTE single-chip solution, Sequans supports the WiMAX Forum's WiMAX Advanced initiative. Sequans has developed an extensive line of ODM products supporting WiMAX devices, including a dual-mode WiMAX/LTE solution to help mobile operators and device makers accomplish a smooth and cost-effective transition from WiMAX to LTE. Sequans has been instrumental for any WiMAX operators at 2.3GHz -2.6GHz and 3.5GHz transitioning from WiMAX to LTE or from WiMAX to WiMAX 2+, or willing to have "UE ready" for any future migration or transition plan. Various CPE devices are commercially available through Gemtek, the leading ODM whose are deployed by WiMAX operators in South America, Europe and Asia. Many trials are being conducted and additional ODMs are now starting to offer dual-mode products based on Sequans' dual-mode WiMAX – LTE chipset. in the Japanese market KDDI/UQ are now selling the "Wi-Fi WALKER" WiMAX 2+ capable mobile router that Huawei has developed with Sequans chipset.

Gemtek is a first-tier Taiwan-based network equipment supplier that has a broad line of dual-mode WiMAX/TD-LTE dongles, indoor and outdoor CPE available for the 2.3-2.6GHz bands. Gemtek has developed a WiMAX small cell solution with a high price/performance ratio, easy installation and comprehensive features of for a variety of applications. Building on the success of its WiMAX embedded module, CPE and USB modem product line, Gemtek's WiMAX femtocell and small cells systems have already passed several field trials. Gemtek is also collaborating with Sequans Communications to develop new TD-LTE desktop CPE devices for large-scale operator trials in India and for subsequent commercial deployments. The combination of its WiMAX and TD-LTE experience positions Gemtek well to participate in the deployment of WiMAX Advanced technology and for multimode WiMAX and TD-LTE devices.

Conclusion

UQ has taken a bold step forward and has started implementation of WiMAX Advanced in Japan by launching its WiMAX 2+ branded service in October. With recently awarded 20MHz of contiguous 2.6GHz TDD spectrum, UQ has laid out a plan to offer 1Gbit/s+ service by 2017 leveraging carrier aggregation, 8x8 MIMO and 256QAM, while maintaining backward compatibility service for its existing 4.27 million WiMAX customers. The success of this transition will serve as a model for existing WiMAX operators to grow with international standards. The advantages of UQ's new hybrid WiMAX 2+ service are clear:

- Data throughput advantage in rollout of Gbit/s service
- Better utilization of spectrum and higher efficiency
- TDD LTE and WiMAX interoperation and better device ecosystem
- High-speed environment utilization – up to 350 km/h
- Backward compatibility to existing WiMAX (802.16e) services

South Korea's Ministry of Science, ICT and Future Planning (MSIP) outlined the policy for WiBro (WiMAX) operators to upgrade to TD-LTE on October 4, 2013. In addition to its technical merits, the policy was based on the future of the existing 1+ million WiBro subscribers transitioning to WiMAX Advanced. The MSIP provided support for WiMAX Advanced, so existing WiBro services, which are serving special purposes in such fields as national defense, can exist in a niche market, while expanding to overseas markets by means of network establishment and technological development.

The South Korean government also has its sights set on the potential global demand for TD-LTE, and recognizes the convergence of WiMAX and TD-LTE could drive local operators to boost their competitiveness in the 4G market. In this context, a national plan for the development of the TD-LTE segment will be developed within this year, which will cover the R&D of key TD-LTE technologies, research on next-generation equipment, such as 5G, and terminals, and the development of application service models. We have yet to see the operators KT or SK Telecom take any steps based on this new policy.

The XGP Forum was founded with the goal to define a specification to be adopted by 3GPP and making it possible for "PHS and AXGP operators" to share a common device ecosystem with TD-LTE compatible mobile broadband networks. The GTI is now collaborating closely with the XGP Forum and WiMAX Forum, and we have now seen tremendous progress from both WiMAX and PHS operators, equipment/service providers with the understanding that these technologies will be harmonized into one in the future 4G TDD architecture.

Global harmonization of WiMAX and TD-LTE is also critical to fully exploit the value of TDD spectrum and support a common ecosystem for chipsets and terminals. The GTI 3.5GHz Interest Group has reached a consensus that the main evolutionary choice for WiMAX operators should be TD-LTE. But in many emerging markets, the 3.5GHz band has been primarily licensed for fixed BWA, and it is still not clear how these operators will obtain regulatory approval to support TD-LTE services in a WiMAX Advanced network. The next step will be for the GTI and its TDD operator and vendor ecosystem to begin working collaboratively with the WiMAX Forum to streamline the regulatory arena, especially in emerging markets, and smooth the convergence of WiMAX to TD-LTE Advanced to protect operator investments.