Accelerating the Uptake of the Next Generation of Mobile Broadband

LTE Business Models

December 9, 2008

SiGNALS Research Group

A quick introduction to Signals Research Group, LLC.

- Signals Research Group, LLC offers thought-leading field research and proprietary consulting services on the wireless telecommunications industry.
- Our flagship research product, a research newsletter entitled “Signals Ahead,” includes more than 70 corporate subscribers on five continents across the entire wireless ecosystem, as well as trade organizations, government regulatory bodies, and organizations within the financial community.
- Historically, nearly half our business each year falls outside of the Signals Ahead business area.

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The Economic Proposition of LTE

LTE Applications and Devices

The LTE Movers and Shakers

Contrary to popular belief, there isn't a discernable economic benefit of LTE relative to other advanced 3G technologies (e.g., HSPA/HSPA+).

- After normalizing for bandwidth requirements, the relative performance differences between LTE and HSPA/HSPA+ are not "day and night."
  - LTE theoretical peak data rates are achieved through MIMO and wide radio carriers
  - LTE spectral efficiency is only ~25% higher than HSPA+ (w/ MIMO and 64-QAM)
- The cost drivers in next-generation broadband wireless networks are due to factors other than the choice of technology.
  - Design criteria of the network
  - Choice of frequency band
- Many of the cost advantages associated with LTE can be realized with a CDMA-based 3G network.
  - Flat-IP core network versus hierarchical network
  - All-IP backhaul and transport (Ethernet, etc) versus leased T-1/E-1 lines

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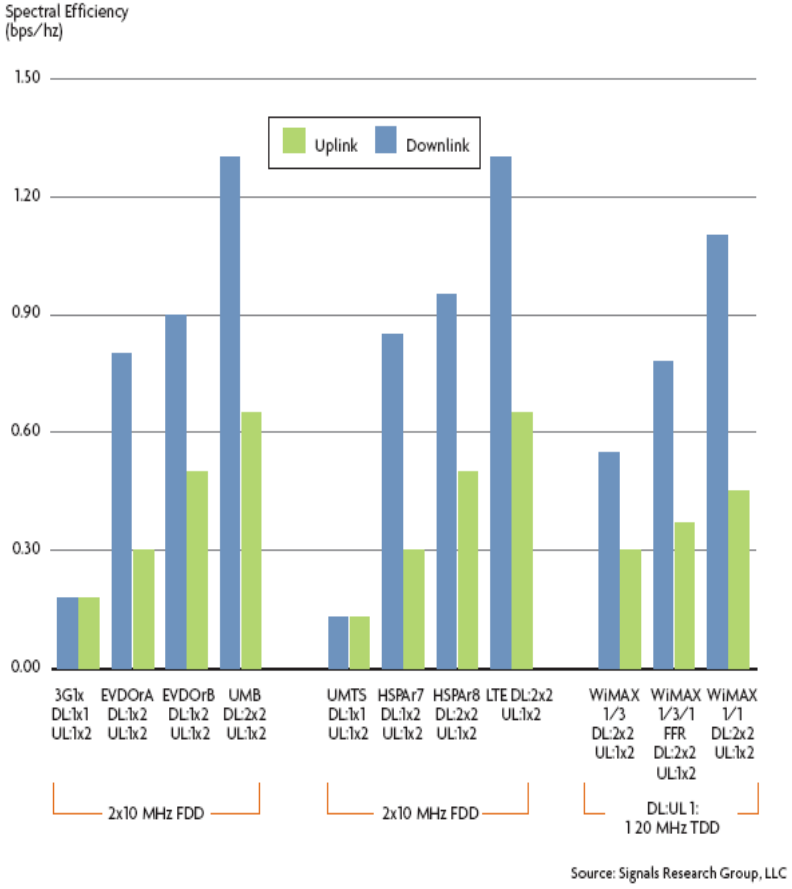
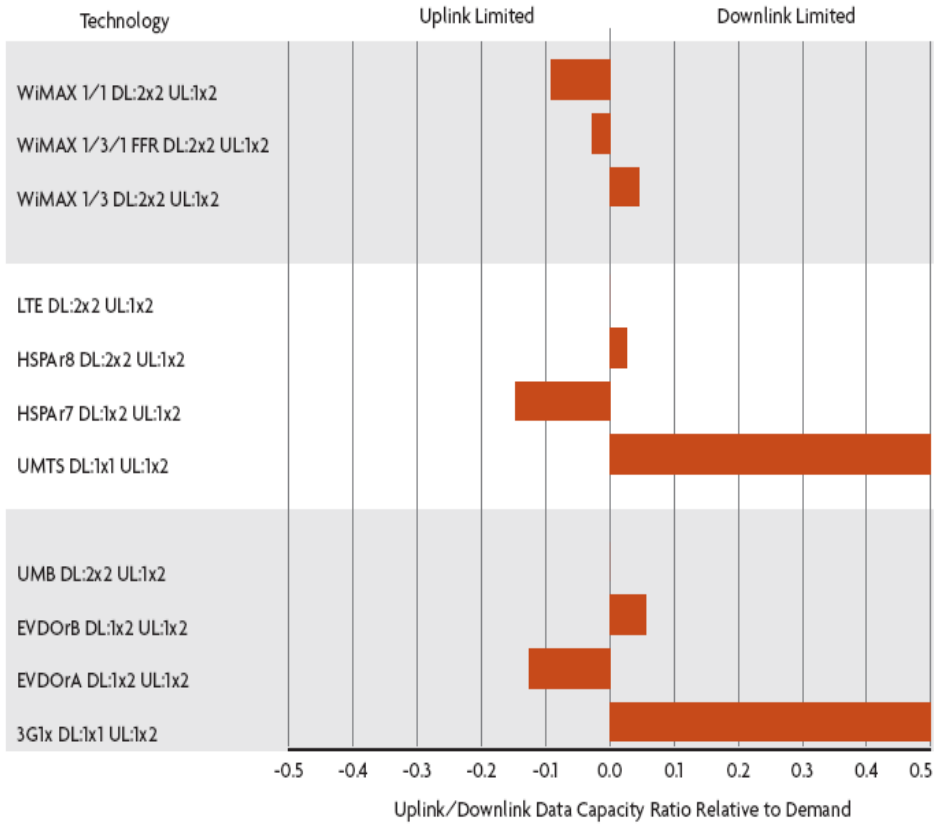
Spectral Efficiency Assumptions for Next-generation Wireless Technologies

Full Buffer Layer 2 Spectral Efficiency



Source: Signals Research Group, LLC

Uplink/Downlink Data Capacity Ratio Relative to Demand



Source: Signals Research Group, LLC

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Service Concepts: Statistical Performance Expectations

Service Concept	Voice	Data	Mobility	Antenna	Voice Probability of Coverage	Uplink Data Rate/Probability of Coverage
1	Yes	Yes	Mobile	Integrated	90%	90% @ 128kbps
2	Yes	No	Fixed	Desktop	90%	
3	No	Yes	Fixed	Desktop		80% @ 256kbps
4	Yes	Yes	Fixed	Desktop	90%	80% @ 256kbps
5	Yes	No	Fixed	Window	95%	
6	No	Yes	Fixed	Window		85% @ 256kbps
7	Yes	Yes	Fixed	Window	95%	85% @ 256kbps
8	Yes	No	Fixed	Outdoor	98%	
9	No	Yes	Fixed	Outdoor		90% @ 512kbps
10	Yes	Yes	Fixed	Outdoor	98%	90% @ 512kbps
11	Yes	Yes	All of the Above	Any of the Above	Any of the Above	Any of the Above

Source: Signals Research Group, LLC

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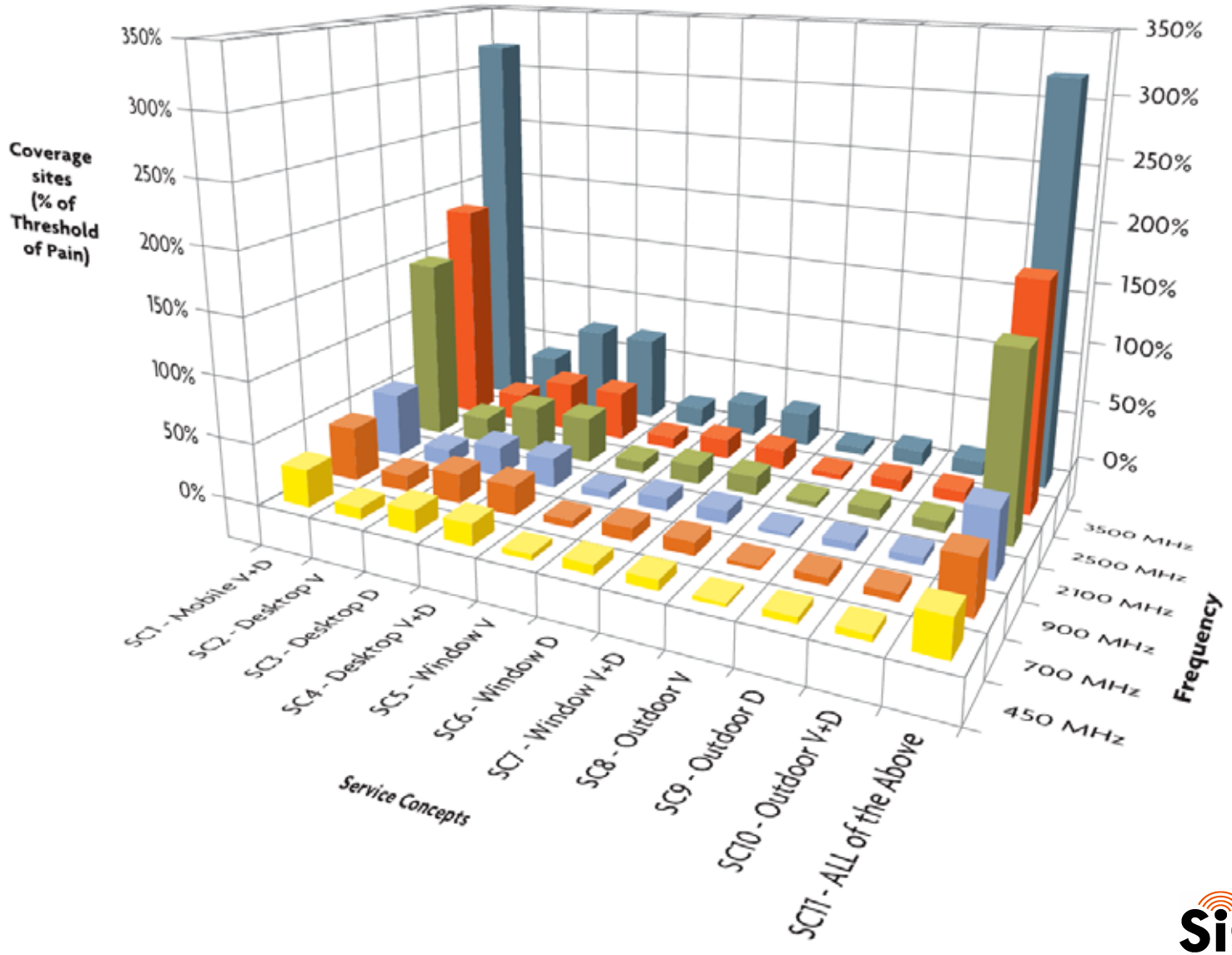
View of the World – Sites Required for Coverage



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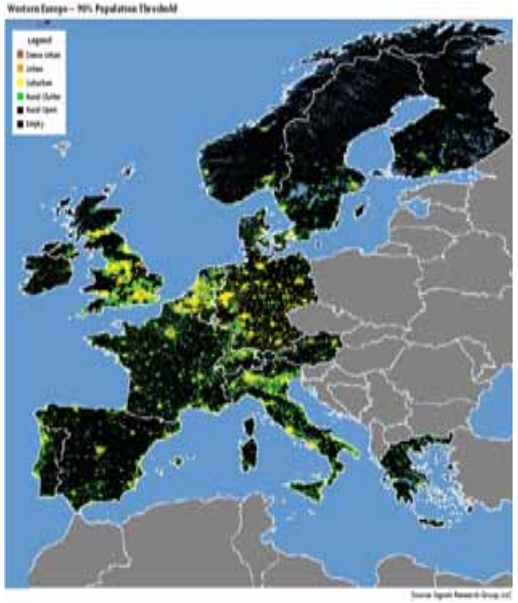
LTE Case Study – Western Europe



Our analysis of the current demographics and demand for telecommunications services in Western Europe suggests the following metrics:

- Population: 398,371,760
- Landmass: 3,698,112 square kilometers
- % of population living in dense urban, urban and suburban regions: 55.01%
- People/Household: 2.4
- Cellular subscriptions (individuals) per POP: 106.5%
- Landline subscriptions (households or businesses) per POP: 53.4%
- Broadband subscriptions (households or businesses) per POP: 23.2%
- Dial-up subscriptions (households or businesses) per POP: 11.5%
- Total cellular voice minutes per month: 5.25 billion
- Total wireline voice minutes per month: 3.82 billion

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LTE Case Study – Key Assumptions

Key Assumptions

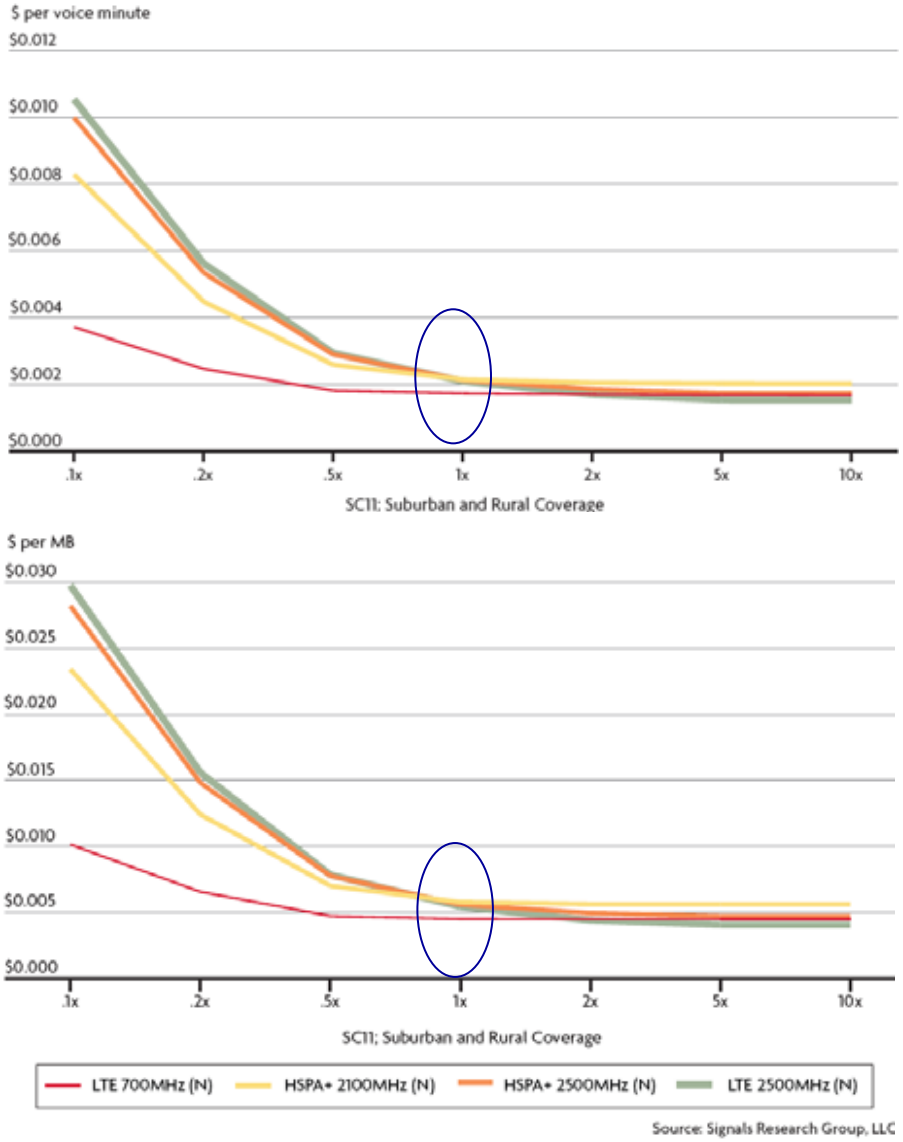
Technology	Deployment	Frequency Band	Channel Bandwidth	Total Spectrum	Core Network	Transmission	RRH
LTE	Network Overlay	700MHz	10MHz FDD	20MHz	Flat IP	Microwave/ Ethernet	Y
HSPA Evolved	Network Overlay	2100MHz	5MHz FDD	20MHz	Flat IP	Microwave/ Ethernet	Y
HSPA Evolved	Network Overlay	2500MHz	5MHz FDD	40MHz	Flat IP	Microwave/ Ethernet	Y
LTE	Network Overlay	2500MHz	10MHz FDD	40MHz	Flat IP	Microwave/ Ethernet	Y

Service Concept	11
Device Type	PC card
Quality of Coverage	128kbps with 90% PoC
Population Covered	259M (S and R)
Coverage Region	766,214 sq km

Source: Signals Research Group, LLC

- LTE and HSPA+ networks are deployed, covering the suburban and rural regions of Western Europe.
  - Choice of frequency band and the amount of spectrum varies by network strategy
- All network strategies take advantage of advanced features, such as an IP core network and Remote Radio Heads.

LTE Case Study – Results ($/Min and $/MB) as a function of demand



- At low demand levels, the network strategies involving LTE are the most attractive and the least attractive options.
  - Networks are all coverage-constrained so the advantage/disadvantage is largely a function of the choice of frequency band
- As demand [network traffic] increases the merits of LTE at 2500MHz become more attractive.
  - The economics of LTE at 2500MHz are roughly on par with the economics of HSPA+ at 2100MHz, starting at today's demand levels.

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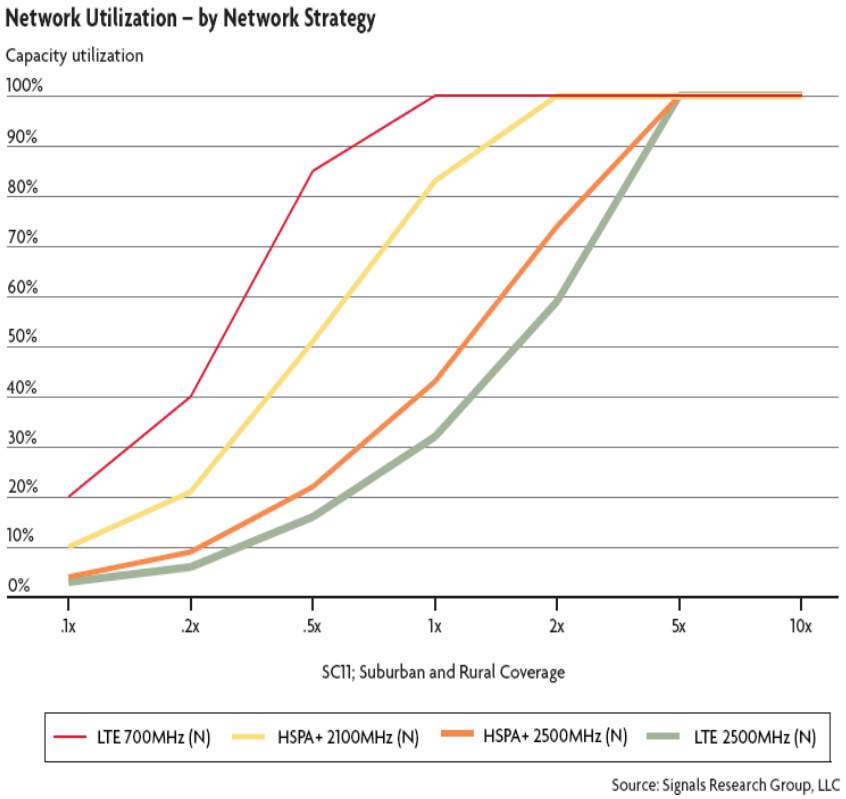
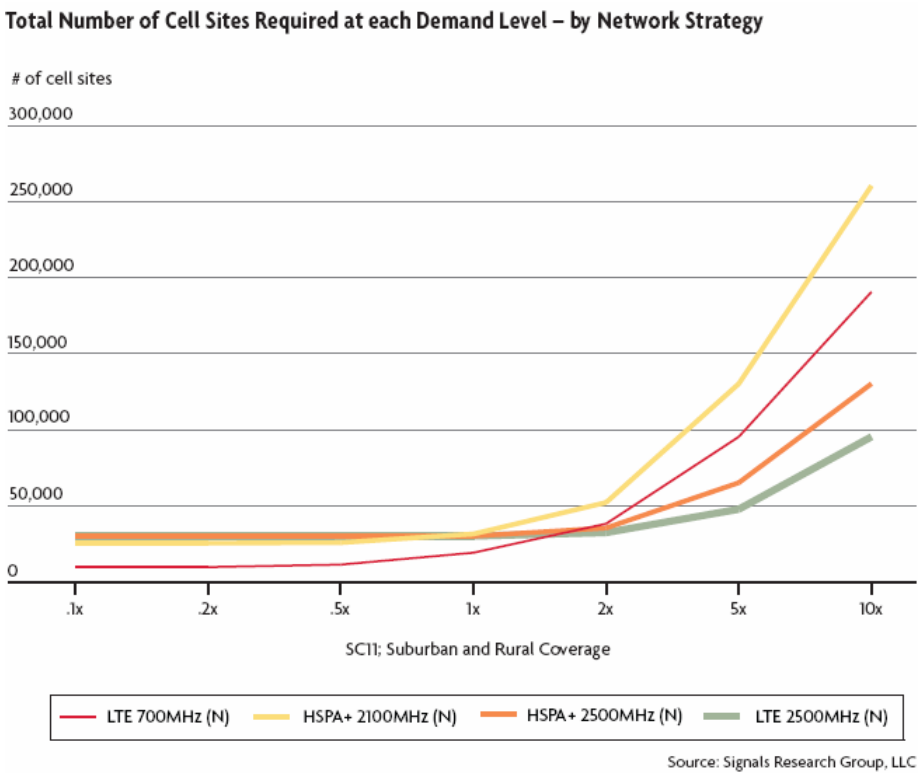
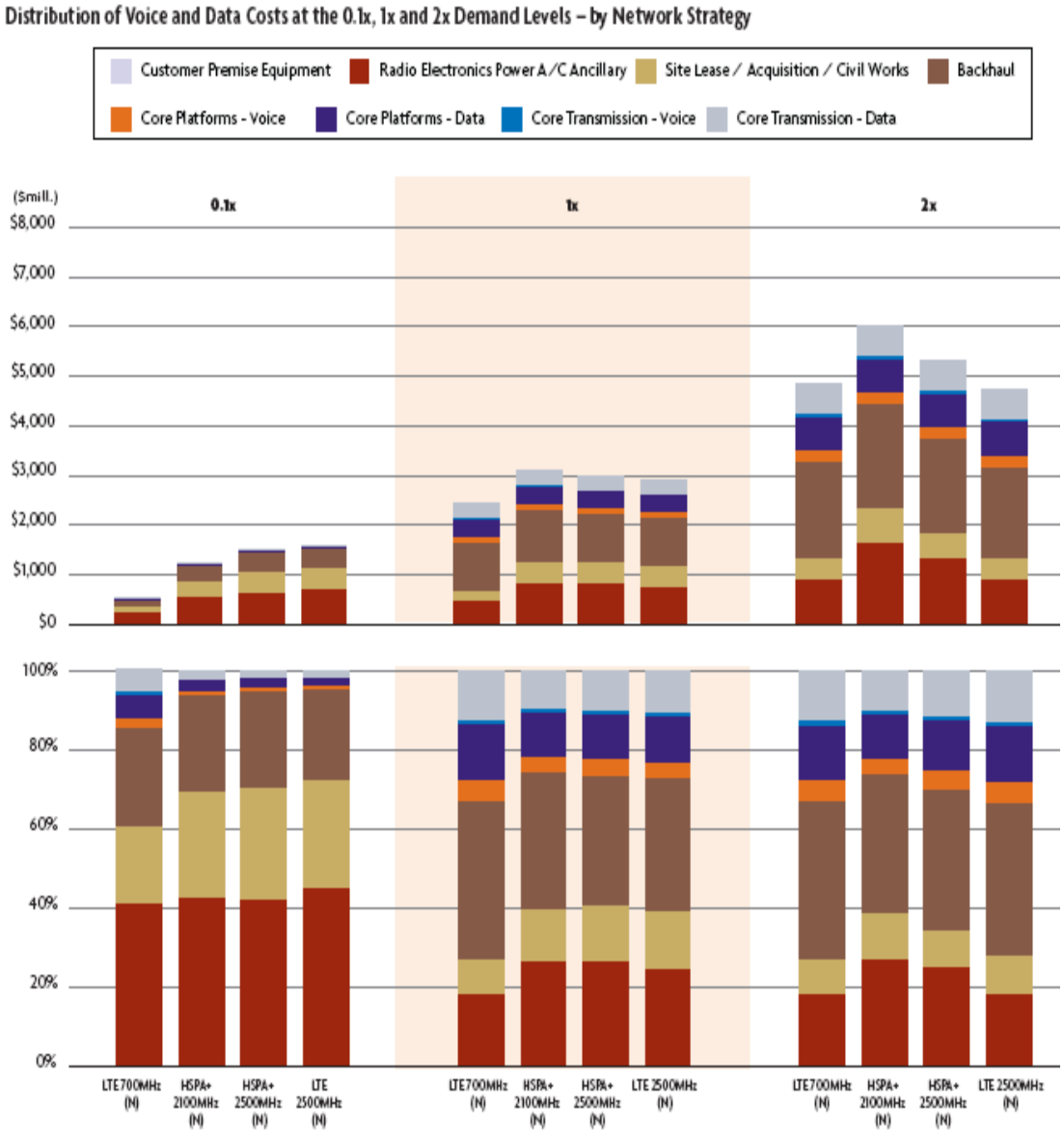
LTE Case Study – Results (Utilization and Site count) as a function of demand





- As utilization rates improve with increased demand the economics become more attractive.
- The merits of HSPA+ at 2100MHz start to become questionable with higher demand levels due to the number of capacity cell sites required.

LTE Case Study – Results (distribution of costs) as a function of demand



- At low demand levels the network economics are driven by the number of sites.
  - RAN Hardware
  - Site Lease, etc
- At higher demand levels the backhaul becomes the dominant cost driver.
  - The choice of backhaul is RAN neutral
- The core network related expenses are largely on par with the RAN-related expenses.

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A Quick Look at LTE in North America

- Following Auction 66 and Auction 73, operators are poised to deploy their respective choice of technologies.
  - Most of the incumbent operators have confirmed an intent to deploy LTE
  - At the same time these operators haven't ruled out deploying HSPA or EV-DO

- Given the high expectations for LTE and/or 700MHz, there are a number of key questions that can be posed.
  - How do FCC buildout requirements for Auction 73 impact the operator's business case?
  - How does the cost of the licenses impact the economics?
  - How do the economics vary by licensed regions (e.g., at the CMA/EA level)?
  - How sensitive are the economics to the amount of traffic on the network(s)?

Key Assumptions and Methodology Overview

- We selected an operator that was one of the bigger winners in Auction 73.
- We included the operator's total spectrum holdings (700/1700MHz) and amount paid for the spectrum by CMA/EA.
- We created "micro areas" which represent the resultant areas when CMAs and EAs are overlaid on top of each other.
- We modeled representative numbers for the cost and performance of a Greenfield LTE network with a flat IP core network and IP transport.
- We assumed the FCC network buildout requirements for 2019.
  - 70% geographic coverage by CMA/EA with various adjustments per the FCC requirements
  - Cost 231-Hata propagation models for coverage
  - Fully mobile network with 90% probability of achieving a 128kbps uplink transmission

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Key Assumptions and Methodology Overview (cont'd)

- We assumed three demand scenarios.

	Low Demand	Medium Demand	High Demand
Mobile Voice	1,500 minutes	1,500 minutes	1,500 minutes
Mobile Data	100MB	500MB	3GB
Fixed Data	5GB	15GB	50GB

- We assumed various penetration/adoption rates (e.g., wireless penetration rate = 90%).

- We "distributed" the usage between access technologies and between frequency bands. (amount of traffic on LTE is reduced due to wide availability of fiber, competition among LTE operators, and availability of other access technologies/frequency bands)

- These assumptions resulted in the following traffic per POP usage assumptions across all OFDMA networks.

(Traffic per POP)	Low Demand	Medium Demand	High Demand
Mobile Voice	203 minutes	203 minutes	203 minutes
Mobile Data	23MB	113MB	675MB
Fixed Data	170MB	509MB	1,696MB

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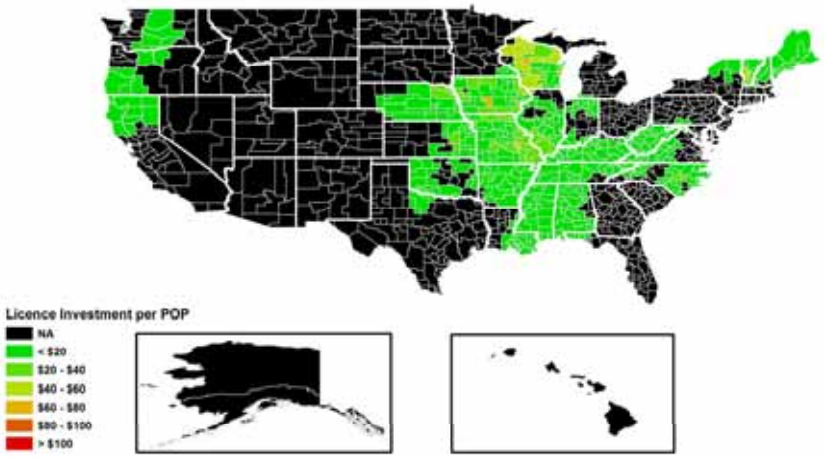
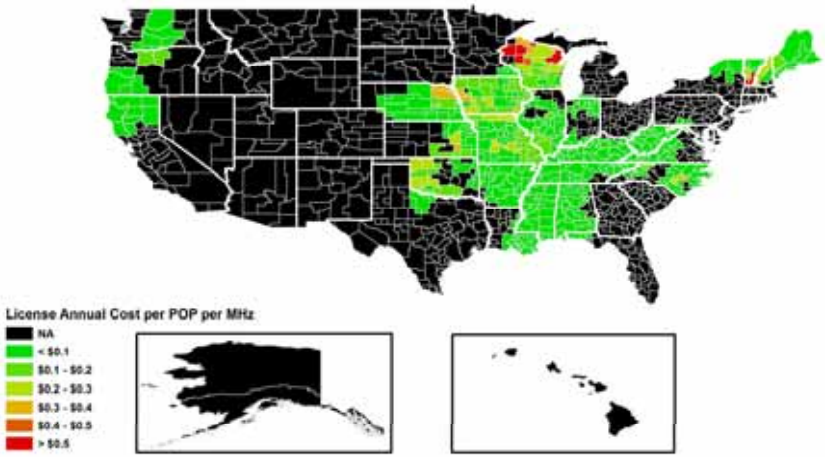
What an operator paid for its spectrum

Annual License Cost per POP



Annual License Cost per POP per MHz



- This operator spent on average $9.72 per POP ($0.57 per POP per MHz) for its spectrum.
- This equates to an annual allocated cost, which is a function of depreciation and the cost of capital, of $1.53 per POP and $0.09 per POP per MHz, respectively.
- The license cost per POP per MHz metric is more meaningful and it does a better job of indicating regions where the operator felt the spectrum was worth more on a per POP/MHz basis.

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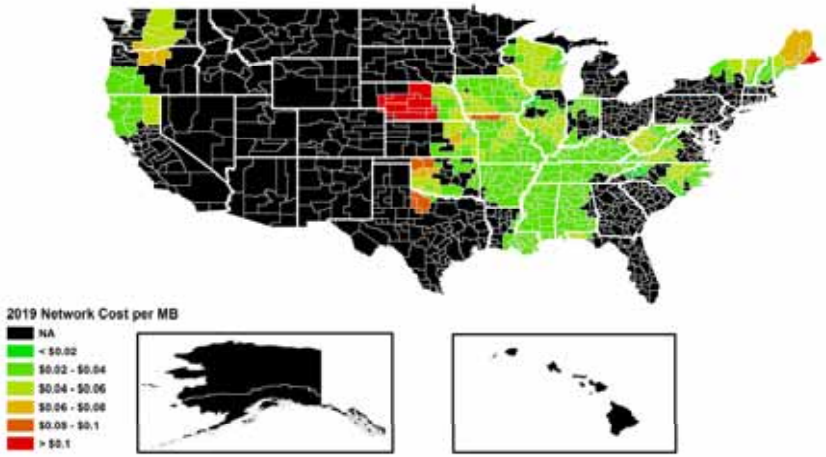
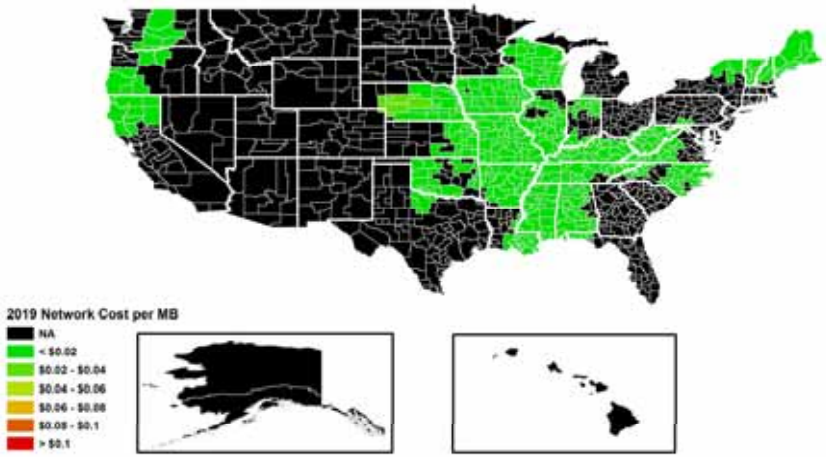
Network Cost per MB with 2019 FCC requirements (excludes license cost)

Low Traffic Assumption



High Traffic Assumption



- With low network traffic assumptions, the economics become more challenging in certain areas (largely rural).
- In these areas the operator could adopt a less aggressive strategy (e.g., nomadic coverage versus full mobility).
- With high network traffic assumptions the economics ($/MB) become more attractive in all areas.

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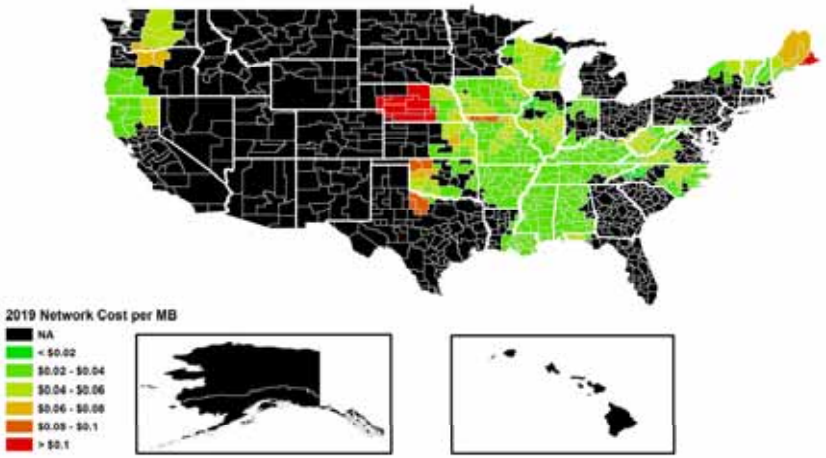
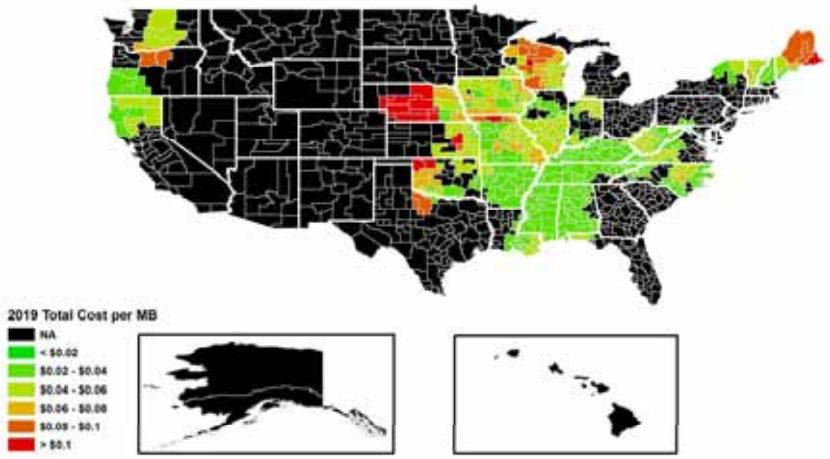
Evaluating the impact of license costs with the low demand scenario

Network Costs per MB
(excludes license costs)



Total Cost per MB
(includes license costs)



- License costs impact the economics in some regions more than other regions.
- Once license costs are included the economics become less favorable in certain regions.
  - Examples include areas of Wisconsin, Maine, Oregon/Washington, and Missouri
- The results of the high traffic scenario are less interesting and are not shown.

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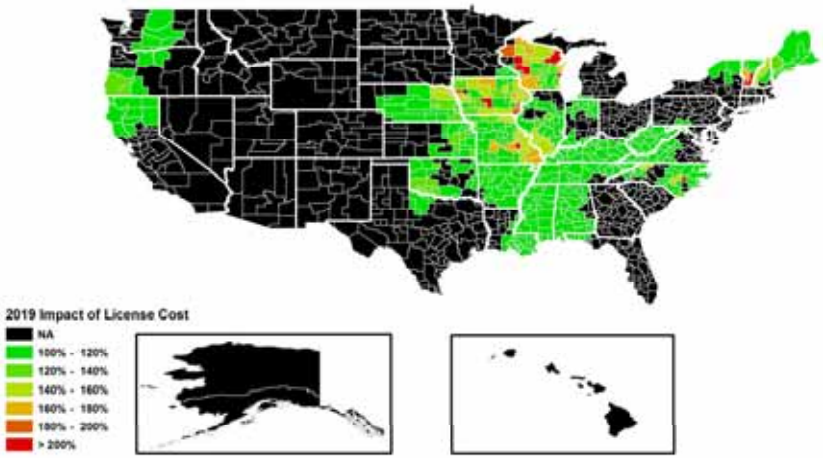
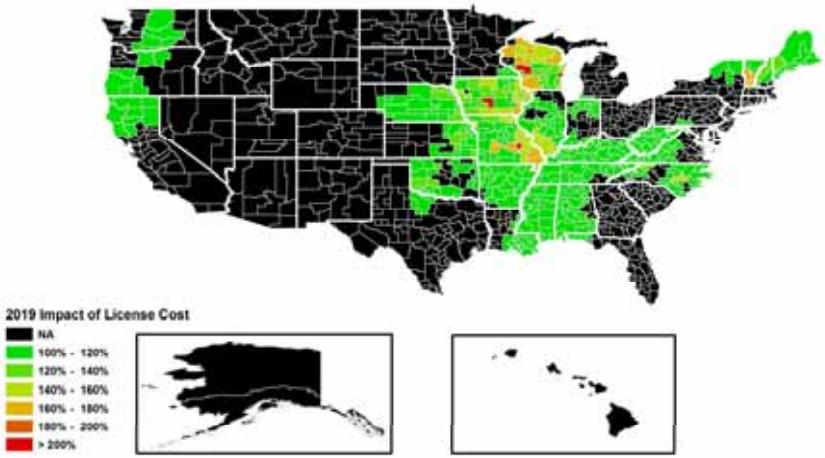
The impact of license costs with varying demand assumptions

Impact of License Cost
(Low Traffic Assumption)



Impact of License Cost
(High Traffic Assumption)



- The cost of the spectrum has a greater contribution to network economics in some regions than in others.
- With higher amounts of traffic the contribution from the spectrum costs is less meaningful.
- In most regions, network economics for a given amount of network traffic are driven by the cost of the network and not the cost of the spectrum.

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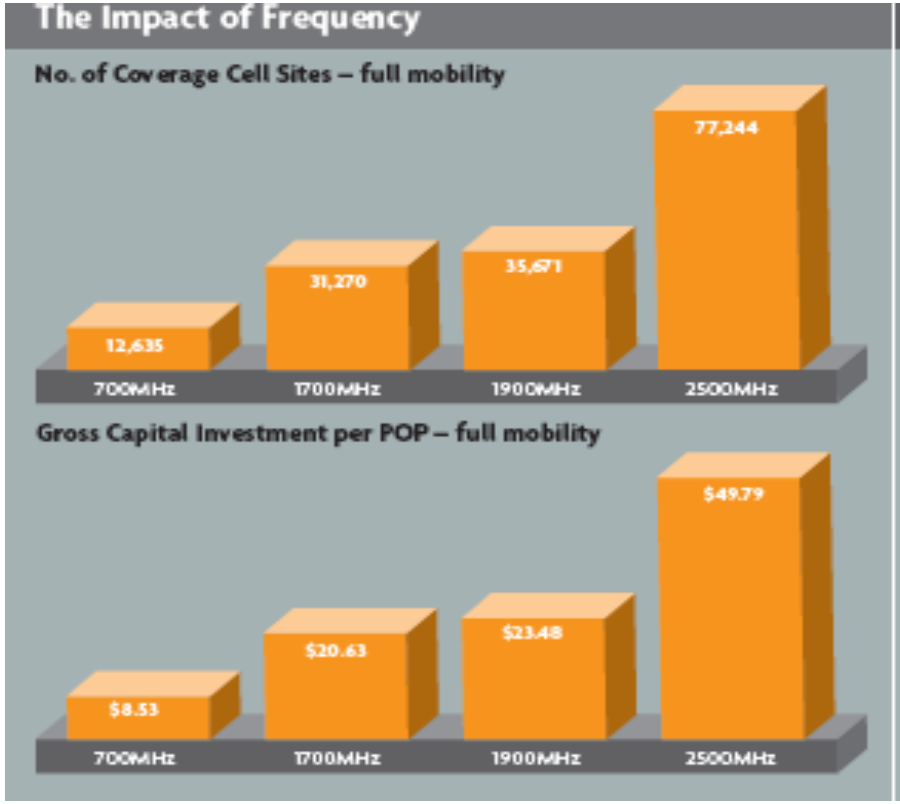
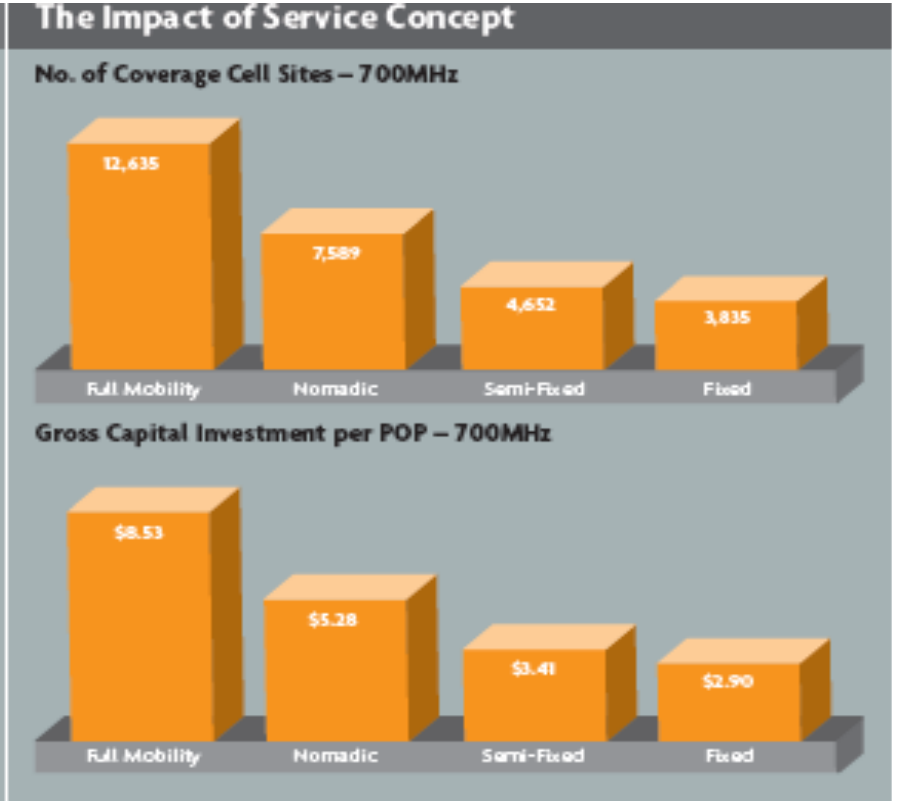
A sensitivity analysis on the impact of frequency and service concepts (analysis done for the B Block and 2019 FCC requirements)





- An operator deploying at 2500MHz (TDD) requires 6 times more cell sites to meet the FCC buildout requirements for 2019.

- By reducing the quality of coverage (e.g., nomadic versus mobile) an operator reduces its upfront investment.

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The Economic Proposition of LTE

LTE Applications and Devices

The LTE Movers and Shakers

The evolution of LTE devices

- Given the relative economics of LTE versus HSPA/HSPA+ and EV-DO, operators will leverage LTE for data-centric applications and services.
  - Voice-centric applications will continue to leverage existing 2G/3G networks
  - EV-DO on steroids
- Devices and chipsets are always the long pole in the tent when new technologies are introduced.
  - When combined with the focus on data, this suggests the initial devices will be USB dongles and comparable devices
  - Embedded modules will follow due to a longer lead time while OEMs will want to see a mature technology and wide availability of LTE coverage (just like WiMAX)
  - UMPCs and smarter smartphones will come next
- Over time LTE will support voice-centric applications and services but no immediate need and fraught with near-term risk, not to mention technology challenges.
- Operators and vendors are supporting multi-mode devices (unlike Mobile WiMAX).

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The Economic Proposition of LTE

LTE Applications and Devices

The LTE Movers and Shakers

The LTE movers and shakers

- NTT DoCoMo, Verizon Wireless and China Mobile top the list of the three operators that are most aggressive with respect to LTE.
- AT&T Mobility can leverage HSPA, although no interest in HSPA with MIMO.
- T-Mobile USA lacks the spectrum (eventually targeting to use 1900MHz), but its parent company could be an early move in Europe.
  - The domino effect is possible but not probable
- China Mobile views LTE as an evolution of TD-SCDMA. Statement is a bit of a stretch, but…
  - It demands the use of a TDD profile for LTE
  - Opens up the possibility of LTE and Mobile WiMAX competing for new markets/operators
  - Don't rule out some existing Mobile WiMAX operators converting, or more likely supporting both technologies.

Final Thoughts

- While LTE delivers improved performance over existing 3G technologies, there isn't a definitive economic advantage.
  - Operators can leverage 3G networks and achieve most of the "bang for the buck"
  - Meaningful savings can only be realized with appreciable amounts of data traffic – GBs of average monthly usage versus 100s of MBs
- HSPA/HSPA+ has a lot of legs left in it so look for continued performance improvements with the technology.
- 3GPP2 operators will be the most aggressive in moving to LTE.
  - Not because of economics but because of performance gains (and bragging rights)
- In general, 3GPP operators will be followers, but they have less of an incentive to make the switch and they will need to have spectrum.


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