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**LTE:
Delivering the Future
of Wireless**



Contact Information

Düsseldorf

Peter Weichsel

Partner

+49-211-3890-231

peter.weichsel@booz.com

Niels Rosenhäger

Associate

+49-211-3890-167

niels.rosenhaeger@booz.com

Munich

Martin Reitenspiess

Partner

+49-89-54525-522

martin.reitenspiess@booz.com

Katharina Dittrich also contributed to this Perspective.

EXECUTIVE SUMMARY

Mobile operators face a decision: Their 3G networks will soon be overwhelmed by the amount of data traffic they're handling. And demand is growing faster and faster as customers become accustomed to "anywhere, anytime" access to the Internet. How can operators expand capacity while continuing to lower operating costs to maintain their margins and keep customers happy?

We believe that the future of mobile data services lies with Long-Term Evolution technology, or LTE. Offering vastly improved network performance at just a fraction of the cost of 3G technology, LTE has the capabilities to greatly expand network capacity and offer a large number of customers the ability to access a wide range of high-speed services such as video-on-demand, peer-to-peer file sharing, and complex Web services. At the same time, additional spectrum is becoming available that will enable operators to manage their networks more flexibly, offering greater coverage and better performance for less money.

The decision operators face is not whether to shift from 3G to LTE, but when. How operators time the transition will depend on how soon their networks will reach capacity limitations—and on when they can afford the implementation. Those looking to position themselves as technology leaders may decide to move as early as possible; others may prefer to wait until the increasing demands on their networks require them to switch.

4G ON THE HORIZON

It seems like only yesterday that the long-awaited era of 3G mobile phone technology finally arrived. Yet it is already time to move on. Increasing demand for data services will soon pressure many carriers to upgrade and expand their networks significantly. But to what? Considerable uncertainty surrounds the next step to be taken in mobile technology, and when and how to take that step.

We believe that the most likely scenario for the future of mobile services will center on Long-Term Evolution technology, or LTE. LTE's advanced technology will result in increased data speeds and much lower costs per megabyte than current 3G networks can offer. Thus, it promises to be powerful enough not just to satisfy the growing demand for mobile services but also to compete effectively with fixed-line services. And it could allow operators to launch new, revenue-generating services such as video-on-demand, peer-to-peer services, and fixed-mobile convergence products.

Deciding when to make the switch to LTE will not be easy, especially for operators still concerned about 3G's lack of initial success. Given the large amounts of money mobile operators have already spent to upgrade to 3G, the up-front costs of shifting to LTE are daunting—an estimated total of

€15 billion (US\$19.5 billion) for all of Europe. And there will always be the lingering doubt that a competing technology would be a better choice. Finally, no one knows whether the new services that are driving the growth in traffic will ever produce any profits for operators at all.

Despite these objections, we believe that operators have little choice but to upgrade to LTE. The question of when to do so, however, brings with it a host of other issues that must be resolved: How quickly will wireless traffic grow in the future? Given that projected growth, how much network capacity will carriers need, and when? How much spectrum will operators need or get, and in which bands? How can operators handle the parallel operation of three different networks—2G, 3G, and LTE? Should they upgrade their 3G networks or phase them out? And what about their 2G networks? Should they actively work to migrate customers from 2G and 3G networks in order to free up spectrum for LTE? To what extent should LTE handsets be subsidized to promote customer migration and contain costs at the same time? Finally, how will the regulatory environment evolve, especially with regard to spectrum and the benefits of the Digital Dividend, the switch from analog to digital broadcast television?

DATA TRAFFIC SURGES

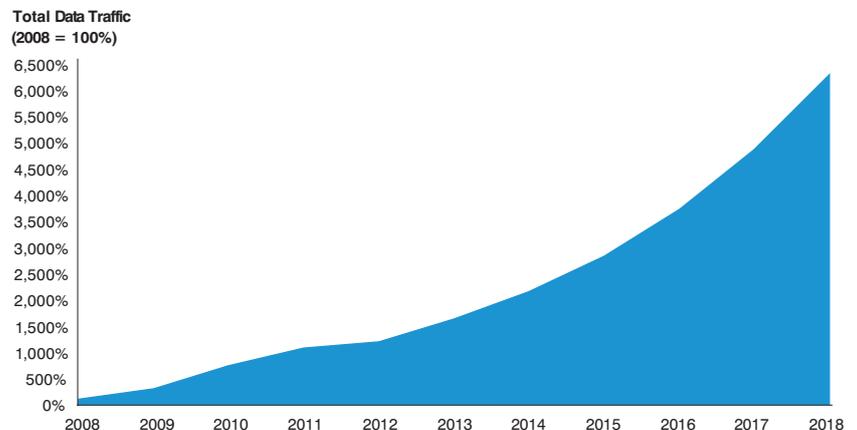
The mobile Internet has already begun to gain real traction in the marketplace. The amount of data flowing through the world's mobile networks is beginning to increase quickly, as more and more customers with big appetites for data make the switch to 3G technology. Those customers are turning to their mobile networks not just to augment their Internet usage, but as a substitute for broadband landline connections such as DSL and cable. That's in part because the cost of mobile data services in some markets has already dropped close to or below the level of DSL, for instance, and in part because 3G connection speeds have gotten fast enough to support such attractive broadband offerings as video streaming. Thanks to ever-increasing access speeds,

consumers are getting used to surfing the Web wherever they go—and the rise of all kinds of increasingly popular Web 2.0 applications will only raise their expectations further.

Many operators have already been overwhelmed with the amount of data traffic on their networks. And those who are not yet overwhelmed often underestimate just how quickly demand will grow once the millions of less technologically advanced users begin joining the mobile services pack. And every operator must ensure that its network can handle the exponentially growing traffic (*see Exhibit 1*). In the long run, the only cost-effective way to manage that traffic is with more efficient technology.

Exhibit 1
Mobile Data Traffic Will Grow Exponentially Over the Next Decade

DATA TRAFFIC FORECAST FOR TYPICAL EUROPEAN MOBILE OPERATOR (2008–18)



Source: Booz & Company

MORE FOR LESS

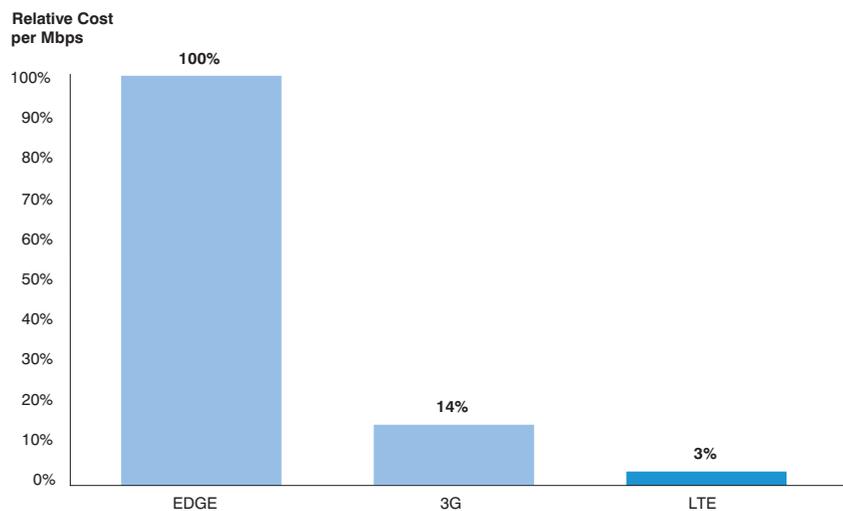
Because LTE offers much greater performance at much lower cost, it is expected to be able to accommodate that quickly growing demand for wireless data services for the foreseeable future. First analyses indicate that the cost per base station will remain essentially the same as for 3G base stations. At the same time, LTE technology has the potential to transmit data on average about four times as fast as 3G—with peak data rates of up to 100 Mbps, and even 300 Mbps with multiple-input, multiple-output antenna technology, or MIMO. Real-life average data rates will probably

be much lower—say, 5 to 10 Mbps—but that should be more than fast enough for most users and comparable to most fixed-line connections.

At those rates, LTE's cost per megabyte will be just a quarter of the cost per megabyte for 3G (see Exhibit 2). At this level, operators can continue to reduce the rates they charge customers per megabyte without significantly diluting their margins. That in turn will let them offer rates competitive with fixed broadband, allowing them to capture and keep those critical entry-level customers.

Exhibit 2
LTE Offers Significantly Lower Cost per Mbps of Capacity

RELATIVE TCO PER CAPACITY (NORMALIZED TO EDGE)



Source: Booz & Company

As the name *long-term evolution* implies, the LTE standard will evolve out of the current 3G networks in use in many parts of the world. Vendors are designing a new base station architecture so that the base stations can be upgraded to LTE simply through the addition of LTE modules. Thus, for the many operators worldwide that are already part of the GSM family of networks, LTE is a logical step—and

any alternative technology will have to fight an uphill battle against that established base.

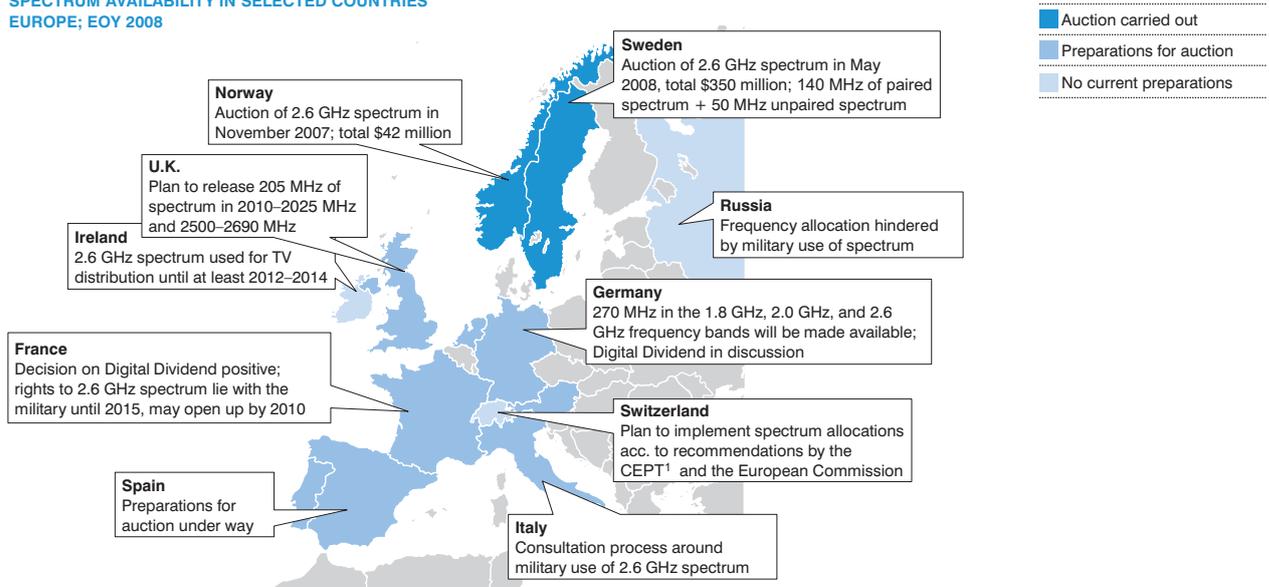
Operators will also find that the timing is right to make the switch because much of the first generation of 3G equipment will need to be upgraded soon. LTE networking equipment and handsets, already under development, will become

available in 2010, and should be rolled out in large quantities in Europe by 2012.

Meanwhile, regulatory efforts around the world are opening up large segments of the radio frequency spectrum in a number of countries (*see Exhibit 3*). That should create an excellent environment for the successful deployment of LTE, because many

Exhibit 3
Plenty of New Spectrum Will Soon Become Available in Europe

SPECTRUM AVAILABILITY IN SELECTED COUNTRIES
EUROPE; EOY 2008



1) European Conference of Postal and Telecommunications Administrations (CEPT)
Source: Booz & Company

of the new frequencies opening up will not support older GSM technologies. Furthermore, the move to switch the broadcast television signal from analog to digital will ultimately open up even more spectrum—a benefit known as the Digital Dividend—which is especially valuable for providing service deep inside buildings and in rural areas. Finally, the effort to harmonize the available spectrum

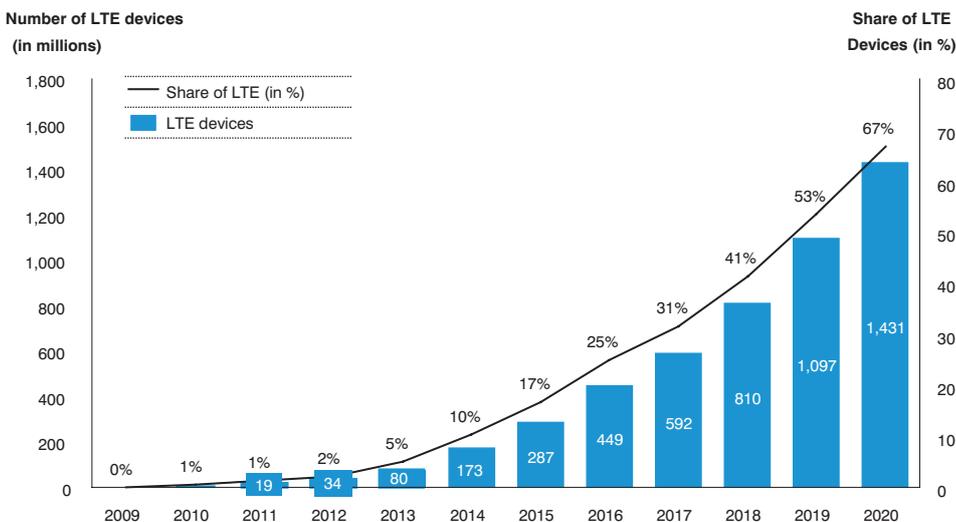
will make the introduction of new technologies such as LTE easier. The introduction of the LTE standard is expected to go smoothly—certainly smoother than the early stages of 3G’s introduction in 2003. The technology required for LTE is already more mature and more flexible than 3G technology was when it was introduced. Also unlike the early days of 3G, when the handsets available

weren’t attractive enough to entice buyers, an adequate number of attractive handsets should be available (see Exhibit 4). Moreover, the regulatory environment supporting the introduction of LTE is significantly more favorable: The big increase in the amount of available spectrum since the onset of 3G will mean less involvement on the part of regulatory bodies in the race for spectrum.

Exhibit 4
Expected Growth in Shipments of LTE Devices (2009–20)

NUMBER OF MOBILE DEVICES SHIPPED WORLDWIDE ANNUALLY
SHARE OF LTE DEVICES, NUMBER OF LTE DEVICES, 2009–2020

ESTIMATE



Source: Ovum mobile devices forecast, 2008; Booz & Company

BUILDING THE FLEXIBLE NETWORK

The many virtues of LTE, we believe, make the decision to implement it obvious. When to implement it, how, and where—those questions present several more difficult choices, and they should not be made lightly.

Like every business decision, deciding when to transition to LTE involves a strategic choice, with the goal of enhancing a company's competitive position in a highly competitive industry. Operators whose current network is close to full capacity, and who anticipate a great deal of increased traffic in the near future, should begin implementing LTE now. Because LTE offers a much more efficient network that costs much less per megabyte, early movers can gain a significant cost advantage over slower competitors. The same holds true for operators that have positioned themselves as technology leaders and intend to market their increased data speeds.

On the other hand, operators whose networks still have considerable capacity, and who don't feel the need to be on technology's cutting edge, should wait until they reach the point where significantly more capacity will be needed soon to meet demand. However, such late adopters run the risk of making the decision too late.

Similar strategic considerations apply in analyzing the regional distribution of LTE networks. Much of the opportunity presented by LTE lies in the very nature of radio transmission. With the opening up of entire ranges of spectrum, operators will be able to choose more flexibly among higher frequencies of 2,600 MHz, where more spectrum is available, and the lower bands, or less than 900 MHz, which offer greater range and improved in-house coverage. Most mobile operators will likely switch first to LTE networks in urban areas, where cells are smaller and more densely distributed. The much greater transmission efficiency of LTE will allow operators to significantly contain their transmission costs in cities, where demand is much higher.

Rolling out LTE networks outside urban areas, where demand is much lower, presents a more difficult problem. On the upside, LTE, as opposed to current 3G networks, will allow the use of frequencies of 900 MHz and below, which decreases network deployment costs substantially. Here, success will also strongly depend on the availability of cost-effective LTE handsets for the appropriate frequency bands, as well as the ability of operators to license those low frequencies.

NOT WHETHER, BUT WHEN

LTE is not a revolutionary technology, nor is it meant to be. The goal of the technology is to be able to meet the future demand of wireless broadband access, and thus satisfy customer expectations of improved data transmission performance, as well as voice transmission, without having to pay more money. It should not be thought of primarily as a vehicle for new services that will bring in significant additional revenue streams. Mobile customers have shown themselves to be unwilling to pay a premium for services such as mobile video; rather, the expected increase in traffic will be driven by applications offered by external providers, such as YouTube. Hence, incremental revenues from LTE may be hard to realize.

LTE offers a superior combination of network performance and cost savings for meeting future demand for mobile data services. In order to mitigate the risk of not keeping up with that demand, every operator must analyze in detail its current network capacity and geographic footprint, build future demand scenarios, forecast its resulting future network capacity requirements, and devise a strategy for taking advantage of newly available spectrum. Ultimately, every operator has a choice: Move now to begin the transition to LTE and capture the early cost advantage, or wait until demand rises to the point where LTE investments become necessary. The current economic crisis will no doubt motivate many operators to defer some investments; still, the decision is not whether to shift to LTE, but when.

LTE offers a superior combination of network performance and cost savings for meeting future demand for mobile data services.

About the Authors

Martin Reitenspieß is a partner with Booz & Company in Munich. He specializes in strategy, marketing, and technology in the telecommunications industry.

Peter Weichsel is a partner with Booz & Company in Düsseldorf. He specializes in technology and strategy in the telecommunications industry.

Niels Rosenhäger is an associate with Booz & Company in Düsseldorf. He specializes in technology and strategy in the telecommunications industry.

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