

3G Wireless Market Brief

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What is 3G?

Wireless communications and the Internet are the two great technology waves that are driving global demand for new telecommunications services and systems at the threshold of the 21st century.

Clearly, the Internet is driving a variety of data-related services and applications both for personal and business use. At the same time, wireless communication is gaining acceptance as a flexible, low-cost and widely-available access technology with increasing data handling capabilities.

The International Telecommunications Union (ITU) has recognized the need to establish a flexible standard for the wireless access to the global telecommunications infrastructure that will serve mobile and fixed users in both public and private networks.

3G refers to the third generation wireless technology that is intended to deliver a full range of voice, data and Internet access services over a multiplicity of vehicular, pedestrian, and fixed wireless applications.

The ITU's International Mobile Telecommunications-2000 (IMT-2000) is the broad reference for third generation systems that use radio spectrum in the 2 GHz band (1.8 – 2.2 GHz) IMT-2000 aims to unify diverse systems used around the world today into a flexible radio structure capable of offering a wide range of services in various radio environments, with service quality on par with wireline networks.

The goal for 3G systems is to provide universal coverage and to enable terminals to be capable of seamless roaming between multiple networks. The concept of a small light-weight and convenient "pocket communicator" is a fundamental part of IMT-2000 that is intended to provide voice, data and video communications between people and/or machines "anywhere, anytime."

Market conditions and drivers vary so widely in different regions, however, that the ITU has moved from the concept of IMT-2000 as a single global standard to one that

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accommodates a family of systems. The goal is now to establish global roaming among the various 3G technologies.

Evolution to 3G

Global standards for 3G systems are still being developed so widespread 3G operation is still a few years away.

The ITU's five standards are divided among several access technologies that include: CDMA (spread spectrum), TDMA (time division duplex, or TDD) and GSM (frequency division duplex, or FDD).

Of direct concern are the wideband CDMA-based standards - cdma2000 (advocated by CDMA proponents) and wideband CDMA (W-CDMA) favored by GSM fans. The difference is in the timing and whether the data is synchronous or not. The cdma2000 has a chip rate of 3.6864 Mbps and supports synchronous operation. W-CDMA has a chip rate of 3.84 Mbps and supports asynchronous and synchronous operations. The TDMA wideband standard is UWC-136, advocated by the Universal Wireless Communications Consortium, but has not received much attention by operators.

The evolution paths from the first two generations of cellular standards (1G and 2G) to the 3G family of IMT-2000 standards is show in Exhibit 1.

Regional choice of 3G is based on a number of factors such as customer requirements, investment in existing 2G infrastructure, and the desire to support local industry. Various 3G development plans include:

- Japan – wideband CDMA (W-CDMA) and cdma2000
- Korea – Global CDMA I (similar to cdma2000) and Global CDMA II (similar to W-CDMA)
- The Americas – cdma2000 for migration from cdmaOne, UMTS for migration from GSM1900, and UWC-136 for migration from IS-136 TDMA
- Europe – UMTS with UTRA (UMTS Terrestrial Radio Access) for migration from GSM900 and GSM1800. Key drivers are the implementation of advanced services

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that meet the EU's concept of an "information society" and to introduce increased competition among service providers.

Present 2G systems, such as GSM and cdmaOne (CDMA) have been very successful in delivering narrowband¹ services such as voice and low-speed data. 2G systems operate typically at data speeds of 9.6 Kbps and are moving up to 14.4 Kbps.

2.5G deployments involve upgrading 2G networks with bandwidth handling enhancements. General packet radio service (GPRS) for GSM and IS-136 enable data rates increases of up to 171 Kbps. Enhanced data rates for global evolution (EDGE) for GSM and 1xRTT for cdmaOne promise data speeds up to 384 Kbps.

3G systems deployed with additional radio spectrum will offer more advanced wideband² services and higher data rates up to 2 Mbps that until now were only associated with wireline access.

3G will offer a new range of services with a consistent look and feel across a wide range of operating environments from full mobility to the office and home.

3G has taken "global roaming" as a key requirement, creating an increased market for internationally mobile users and potential for increased commonality of handsets and terminals creating associated economies of scale.

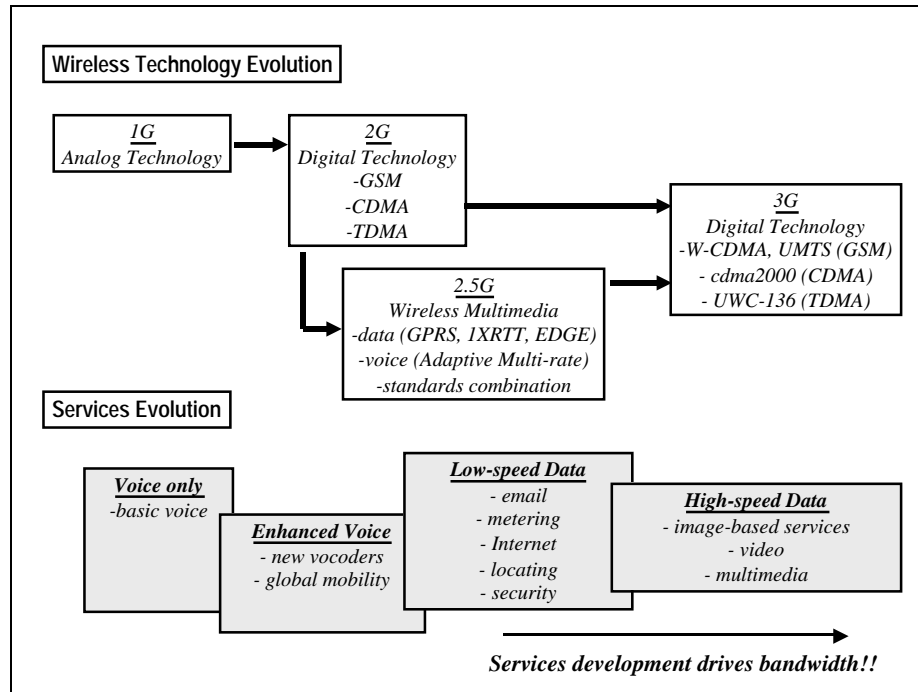
3G is seen as offering a ubiquitous, seamless wireless data capability that is positioned to intercept the ever-expanding data traffic of the wireline telephone networks.

¹ Narrowband refers to bandwidth used to carry voice (analog - 4 KHz; digital -64 Kbps) and data (9.6 Kbps to 1.5 Mbps)

² Wideband refers to bandwidth used for voice and higher-rate data at speeds of 1.5 to 2 Mbps and higher.

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Exhibit 1
Evolution to 3G



Source: ITU; Various cellular suppliers

Paths to 3G

The path for CDMA carriers to reach cdma2000 is the clearest. The initial step from today's IS-95 networks is 1XRTT (Radio Transmission Technology), called Phase I 3G by CDMA proponents and 2.5G by everyone else. 1XRTT uses 1.25 MHz of bandwidth and offers packet data and voice access speeds up to 144 Kbps. Unlike its competitors 1XRTT approximately doubles to network capacity. Most upgrades to 1XRTT will require only inexpensive channel cards and software enhancements. 3XRTT is the next step to full 3G. 3XRTT requires 5 MHz of bandwidth and enables 384 Kbps for mobile packet data voice and video, and 2 Mbps for fixed uses.

For GSM carriers, the path to 3G is relatively predictable. General packer radio service (GPRS) is considered to be 2.5G and is being widely tested. With a 115 Kbps data rate, GPRS is a pure data-over-voice network overlay. 3G for GSM is W-CDMA which provides 384 Kbps with full mobility and requires 5 MHz of bandwidth versus 200 KHz for narrowband GSM. Most GSM carriers are expected to go to GPRS then to W-CDMA

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which requires a change of the air interface. Universal Mobile Telecommunications System (UTMS) is the European version of 3G for GSM. UMTS supports full interworking with existing GSM systems and will reuse investment in GPRS. UTMS will support data rates of up to 2 Mbps and new multimedia applications over new wideband air interface based on CDMA techniques that delivers more RF spectrum than current GSM systems.

There is an interim step between GPRS and W-CDMA called enhanced data rates for global evolution or EDGE where TDMA and GSM converge. Many GSM carriers may leapfrog EDGE which provides the same 384 Kbps as W-CDMA. AT&T Wireless which is a big TDMA user plans to go to EGDE then likely to W-CDMA.

TDMA's evolution to 3G is uncertain. EDGE is TDMA's 2.5G-like step and W-CDMA is assumed where TDMA operators will end up in 3G applications. UWC-136, based on the IS-136 standard, is not seen as a 3G contender.

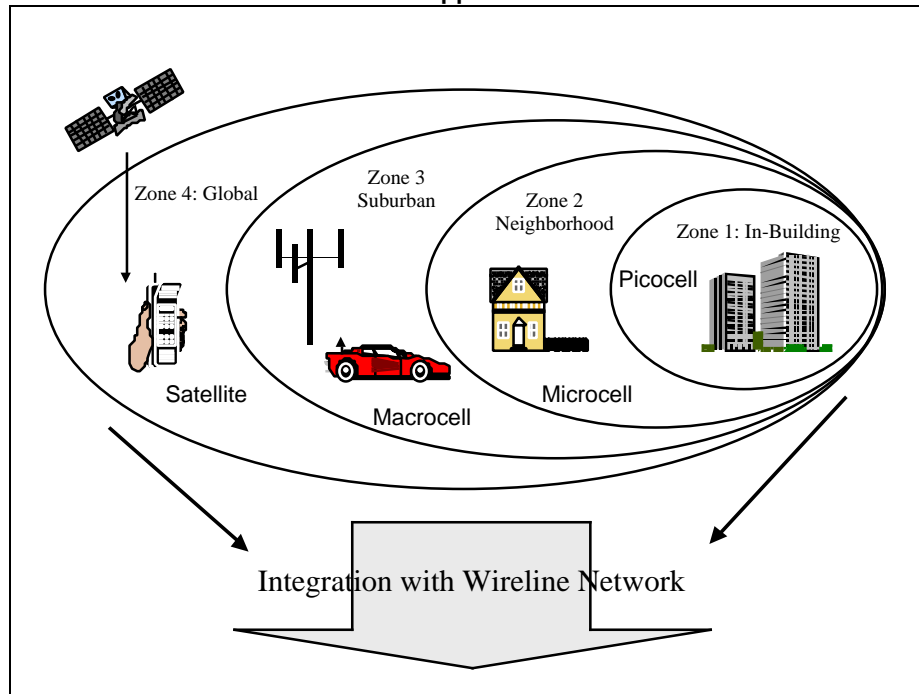
Applications

IMT-2000 is defining 3G requirements that include:

- Small, low-cost pocket terminals.
- Worldwide roaming.
- A single system for residential, office, cellular, and satellite environments.
- High-speed data determined by cell site deployment shown in Exhibit 2:
 - Picocell (In-building): 2 Mbps
 - Microcell (Outdoor to indoor/neighborhood or pedestrian): 384 Kbps
 - Macrocell (Vehicular): 144 Kbps

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Exhibit 2
IMT-2000 3G Hierarchical Cell Site Applications



Source: UMTS Forum

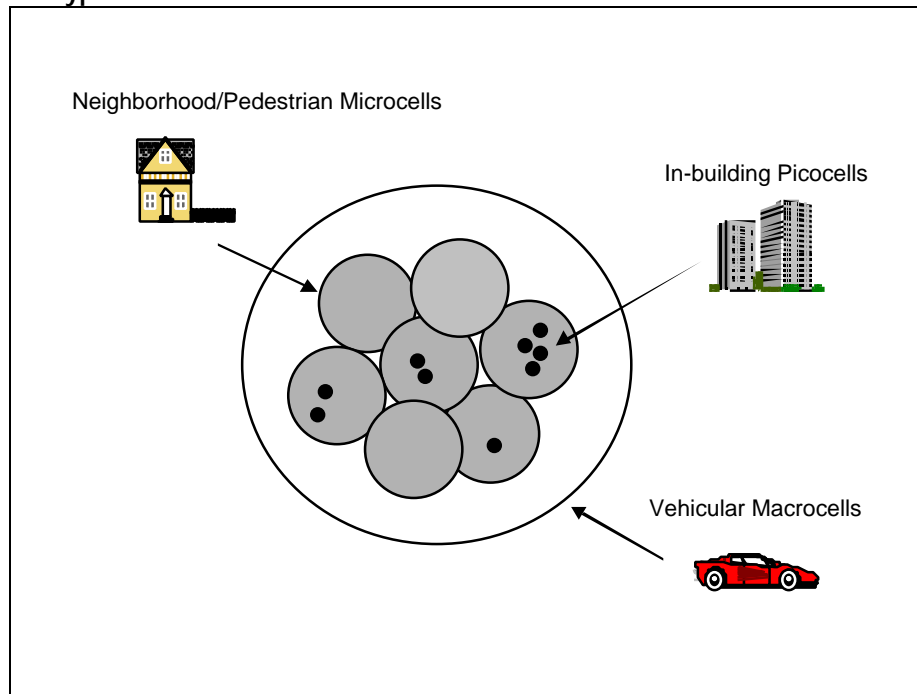
Given the limited amount of available new spectrum, the use of hierarchical cell structures based on the use of macrocells, microcells and picocells has been proposed. In the hierarchical model cells are deployed as follows:

- Macrocells carry the fast-moving wide-area vehicular traffic that would need voice and low speed data services such as e-mail or messaging. Macrocells would have a range of a mile or more. Antennas are mounted on towers above rooftops and trees.
- Microcells carry higher-data rate pedestrian traffic that utilizes handheld communicators and laptop computers in a limited mobile environment. Microcells have a range of about 1,000 feet and are designed to serve a neighborhood or a business block. Antennas are mounted on rooftops or the side of a building.
- Picocells are deployed to cover "hot spots" to relieve capacity bottlenecks such as at airports, in office buildings or at convention centers where user density is particularly high, and where mobility is less of a consideration than access. Picocells have a

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range of a few hundred feet. Antennas are typically mounted inside a building under the roof.

Exhibit 3
3G Typical Cell Structures



Source: Nortel Networks

The type of services that can be supported by 3G include:

- Voice, audio, text, still image, dynamic video
- Interactive services such as conversations, messages, and restore and storage
- Distribution services such as point-to-multipoint broadcasts
- Mobility information services such as locality
- Data services dependent on the radio connection:
 - Fixed wireless access for broadband connections
 - Wireless packet service for Internet access
 - Wireless circuit service for voice and low-speed data connections.

A number of user benefits anticipated under the IMT-2000 standards include:

- Seamless global roaming.
- High speed data services (up to 2 Mbps)

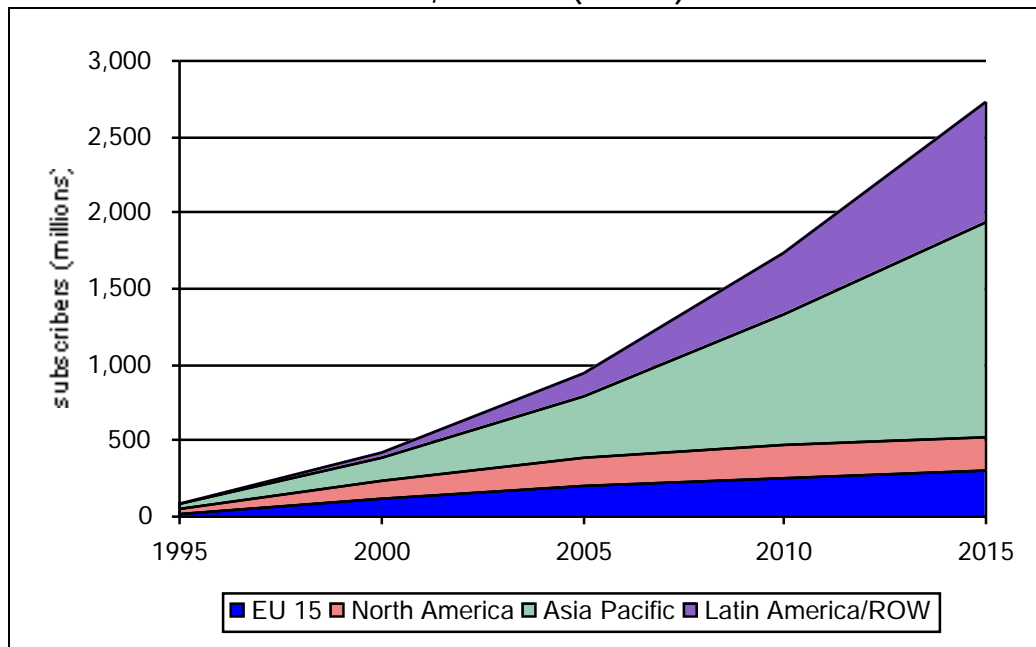
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- Multimedia services (voice, video, data)
- New innovative applications.
- Telematics (metering, e.g., vending machines, utility meters).
- Increased integration between fixed and mobile telephony services.
- Increased choice of services.

Global Wireless Market Outlook

The outlook for wireless subscriber growth around the world over the next 15 years is quite dramatic. Exhibit 4 shows that from a base of over 400 million in 2000, the overall subscriber base is projected to grow at a 14% average compounded rate to more than 2.7 billion users by 2015.

Exhibit 4
Global Wireless Subscriber Growth, 1995-2015 (millions)



Source: UMTS Forum, Report #1

The greatest growth is expected from the developing countries in Asia Pacific region such as China. The subscriber base in Asia Pacific will reach 1.4 billion subscribers by 2015, a 17% average annual growth rate. In Latin America and through the rest of the

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developing world, the subscriber growth rate will average 25% a year, reaching 800 million users by 2015.

Subscriber growth in developed regions of Western Europe and North America is less than 1/2 of the global growth rate over the same period. Slower growth is a result of wireless services already reaching a large part of the potential subscriber base. By 2015, the EU 15 region is projected to have a subscriber base of 300 million, a 7% per annum growth. By comparison, North American subscriber base, growing at only 4% a year, will reach 230 million subscribers by 2015.

Infrastructure Impact

- **Network**

3G systems will eventually be built on common modular, high-availability platforms, creating a distributed peer-to-peer network solution where functions may be located to best address the needs of a particular service provider. This capability will enable features such as local PSTN interconnections, optimal routing, and advanced wireless enterprise solutions for corporate customers. The platforms will be scalable, allowing operators to deploy networks where core equipment is either centralized or highly distributed, thus allowing operators to reduce their backhaul and interconnect charges.

- **Integration with 2G**

Leading wireless equipment suppliers are suggesting that 3G networks will evolve from today's 2G systems. Motorola, for instance, envision 2G systems continuing to provide high quality voice and low to medium speed data communications, while higher bandwidth capacity of 3G will be mainly used to offer multimedia and high value added services while supporting many 2G services. Many 2G network components will be upgraded. This will, enable operators to build on their 2G network investment and customer base, and will provide customers with a smooth upgrade path to 3G services. For instance, cell site equipment from a variety of manufacturers will be designed so that over time operators will be able to deploy both 2G and 3G radios on the same base stations.

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- **Data Rates**

3G data rates will be dependent on the mobility of the users. The demand for higher data rates is a key driver for 3G systems. Data rates are increasing from 9.6 Kbps in 2G systems to 384 Kbps in 2.5 G systems and up to 2 Mbps in 3G. It is expected that 3G cell sites will be deployed wherever the capacity of a 2.5G system is insufficient to provide the bandwidth required to deliver the desired new service.

- **Convergence with IP**

3G systems will eventually be built around a broadband³ core that transports voice, data and multimedia traffic over a common network. Many of the new 3G service will utilize Internet Protocol (IP) that is transported on an underlying asynchronous transfer mode (ATM) network. The Quality of Service (QoS) features provided by ATM will result in a carrier-grade mobile extension of the Internet. As well, 3G infrastructure will take advantage of Voice over IP (VoIP) technology to deliver voice cost-effectively over the Internet or corporate Intranets to wireline users.

- **Network Architecture**

There are three independent components of 3G systems architecture:

- A service platform that offers end-users the same service features regardless of the underlying access technology, thus providing what is called the “Virtual Home Environment.”
- A transport network that supports voice and data with equal efficiency, and that provides mobility management and other core functions.
- A series of access networks that includes the new 3G air interface, along with other wireless and wireline access technologies that are capable of supporting high-speed data and multimedia services.

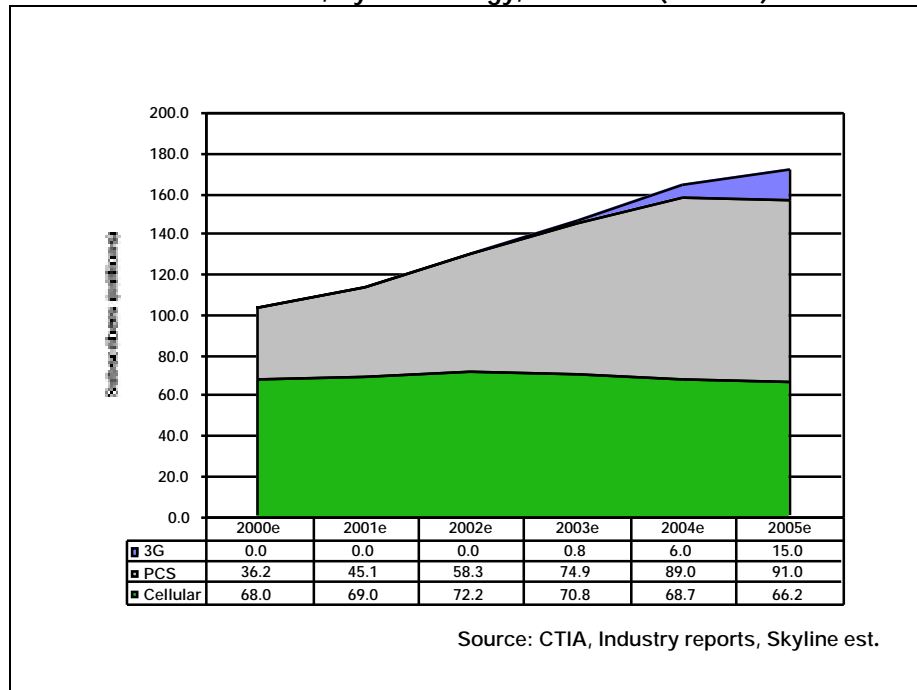
³ Broadband refers to bandwidth required to handle data speeds of 45 Mbps (DS3) or higher.

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- **Cell Site Coverage**

2G cell site radius can range up to 20 miles or longer. With 3G, the cell site radius will be much shorter. This coverage will be a function of data rate and available bandwidth, and location and traffic loading. Simulations have shown that the higher the data speed and greater bandwidth required, the smaller the cell site footprint. Motorola estimates that it will take an average of 7.7 cell sites to provide 384 Kbps coverage over the same area as a single 9.6 Kbps site. The denser the traffic area, the greater the required bandwidth, and the higher the average data speed, the smaller the 3G footprints must be. Thus the preponderance of picocells and microcells to service data hungry users. As a result, it is expected that, in the early stages, at least, 3G deployments will not be country-wide or even city-wide. Rather, 3G will exist in islands of coverage, augmented by 2G or 2.5G systems that can provide wider coverage for new services to the extent possible. As a consequence, 3G deployments will represent a subset of total cell sites installations in the early years, with estimates ranging from 16 to 23 % of the total. (See Exhibit 5)

Exhibit 5
U.S. Wireless Subscribers, By Technology, 2000-2005 (millions)



Source: Skyline Marketing Group

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- **Infrastructure Costs**

Deploying a 3G network will not be cheap. Wireless industry analysts estimate that 3G deployments will cost roughly \$70 per POP for each operator in major markets around the world shown in Exhibit 6. Recent results from 3G auctions in the UK showed that operators are aggressively bidding up the price of 3G licenses to an astounding US\$34 billion, about 10 times what the government expected. Upcoming 3G bids in Germany are projected to bring in over US\$46 billion. A similar multiplier effect is anticipated in Hong Kong as well. These high table stakes are raising concerns that operators may not be able to price high value-added services to attract a wide market. For instance, a 2 Mbps signal will occupy a lot of infrastructure resource regardless of the technology used. If an operator were to provide that data rate over a wide area from one base station, the charges to end user would have to be very high for the operator to recover its costs to provide the service. Capital costs for cell sites including antennas, coaxial cable and radios vary from \$100,000 – 200,000 for a wide area macrocell, to \$50,000-60,000 for a microcell, and \$30,000-40,000 for a high data rate picocell. High deployment costs support the notion that 3G deployments will be highly selective and targeted in the early years and more prevalent as the costs come down over time.

Exhibit 6

3G Network Deployment Costs

(Assumes Four Operators per Country For Five Top National Markets)

Country	Population at YE1999 (millions)	Cost per Capita	Total Cost (billions)
U.S.	270.3	\$280	\$75.7
Japan (3 operators)	125.9	\$210	\$26.4
Germany	82.1	\$280	\$23.0
UK	59.0	\$280	\$16.5
France	58.8	\$280	\$16.5

Source: Herschel Shosteck Associates

Note: Assumes an average \$70 per POP times 4 operators per country except where highlighted. Not all data include the cost of the licenses.

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Current 3G Activity

In Japan, NTT DoCoMo is expected to launch commercial W-CDMA service in 2001 using Ericsson and Lucent equipment. DDI/IDO is testing cdma2000 gear from Lucent. Japan is likely to be the first to market with true 3G capabilities.

With trials already underway in the UK and 3G license auctions being finalized, BT Cellnet is expected to be the first operator to offer commercial GPRS service in 2000 with equipment from Motorola. The EU deadline for licensed operators to have 3G commercially available is January 1, 2002. As such, European carriers will not be far behind their Japanese counterparts and are expected to set the pace for widespread 3G deployments around the world.

Canadian GSM carrier Microcell is testing W-CDMA with equipment from Nortel and Ericsson. Tests are expected though 2000 and likely beyond as technical and economic issues are resolved.

In the U.S., Sprint PCS, a CDMA operator, is actively working on 1XRTT with multiple vendors. Trials will begin in early 2000 and continue throughout the year with plans for commercial operation in 2001. Bell Atlantic Mobile is following a similar timeline.

Both Sprint and Bell Atlantic are also conducting trials with Lucent's cdma2000 equipment. Omnipoint Communications, a GSM operator in New York, has GPRS test systems in place from Nortel, Ericsson, and Siemens and began trials in 1Q2000. AT&T Wireless will begin GPRS internal trials in 2000 and is testing a commercial GSM/EDGE subscriber unit that operates in the U.S. spectrum. With multiple standards to contend with and associated high deployment costs, the American market likely will lag the rest of the world in 3G rollouts.