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Order Code RS20993
August 16, 2001

CRS Report for Congress

# Wireless Technology and Spectrum Demand: Third Generation (3G) and Beyond

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## Summary

Advances in wireless telecommunications technology are converging with Internet technology to foster new generations of applications and services. Presently, the United States and other countries are moving to a third generation (3G) of mobile telephony. The defining feature of 3G technology is that its various transmission speeds are significantly faster than prevailing technology. Most of the new wireless services being introduced or on the drawing boards make heavy demands on bandwidth capacity. Industry experts have observed that more efficient uses of bandwidth must be developed to meet future demand.

The U.S. Congress and federal government departments and agencies are examining the impact that 3G technology will have on bandwidth demand and spectrum allocation. Following up on actions at an international conference last year, the National Telecommunications and Information Administration (NTIA), part of the Department of Commerce, and the Federal Communications Commission (FCC) prepared studies examining the possibility of reallocating to 3G bandwidth now used for other purposes. The ramifications of this reallocation have prompted Congress to review the policies and laws that guide the management of bandwidth. Recent hearings have aired many issues regarding wireless technology and spectrum allocation. This report will be updated.

## Wireless Technology: Development and Demand

Spectrum bandwidth is a finite resource. Commercial wireless communications currently rely on bandwidth within a narrow range, a "sweet spot."[1] American competitiveness in this key technology is constrained by the limited amount of useful bandwidth that is available. This constraint is both specific, in the inherent finiteness of

[1] Martin Cooper, Chairman and CEO, ArrayComm, Inc., San Jose, CA, describes the "sweet spot" as 2000 megahertz (MHZ) of bandwidth in approximately the 700-2700 MHZ range.

spectrum, and relative, in comparison to the amount of spectrum available for commercial use in other countries.

Wireless communications services have grown significantly worldwide, and explosively in some countries. Demand for wireless telephony in the United States has almost tripled since 1995; there are over 110 million subscribers in 2001.[2] In approximately the same time frame, use of the Internet expanded dramatically from an arcane tool for specialized research to a popularized, user-friendly service providing near instant access to information and entertainment. Internet services delivered by telephone or cable connections were quickly followed by wireless delivery to portable computers, personal digital assistants (PDAs), telematics systems in cars, or mobile telephones. As wireless technologies evolve, they are converging with Internet technologies. Wireless Internet is widely expected to redefine how computers are used—one industry expert refers to the advent of "holistic computing."[3] Business and consumer demand for new, advanced wireless services is considered by many to be a potential engine for future growth in the American and global economies.

Third-generation and future developments in wireless technology will be able to support many services for business and consumer markets, such as: enhanced Internet links, mobile intranet/extranet, mobile commerce (m-commerce)—including the ability to make payments—"always on" capabilities, and high-quality streaming video. Some m-commerce services use location-finder technology. For example, to find a nearby movie theater, the phone would radio your location to a service provider, the Internet interface would list features and times for the closest theaters on your handset's screen and then map the shortest route to your choice. In the United States, location-finder technology is also being introduced through the nationwide Enhanced 911 (E911) program. This will enable mobile phone users to dial 911 from a wireless telephone and have their location transmitted to the closest public safety assistance point. As the E911 network grows, the location finder feature could become an important application of 3G in the United States. Such capabilities, however, have significant privacy issues associated with them.

**Technology development.** Mobile communications became generally available to businesses and consumers in the 1980s. This "first generation" technology, still in use, is analog, the prevailing telecommunications technology of the time. Second generation (2G) wireless devices are characterized by digitized delivery systems that provide qualitatively better delivery of voice and small amounts of data, such as caller ID.

The next major advance in mobile technology is referred to as the "third generation" — "3G"— because it represents significant advances over the analog and digital services that characterize current cellular phone technology. The dramatic increase in communications speed is the most important technical feature of 3G.[4] Higher transmission

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[2] Michael K Powell, Chairman, Federal Communications Commission (FCC), comment at FCC Public Hearing, August 8, 2001.

[3] Frank Zammataro, Vice President, w-Technologies, Inc., New York, "From Mobile Computing to Holistic Computing," [http://www.w-trade.com].

[4] The Federal Communications Commission (FCC) identifies key service attributes and capabilities (continued...)

speeds are essential for robust Internet connections. Projected speeds of 2 megabits per second have been realized in laboratory conditions but many industry observers have noted that real-world transmission speeds where 3G is in service are well below 384 kilobits per second.

Many hypothesize that 3G will be an interim technology and that new developments in wireless and Internet technologies will advance to another level within several years. An example of this is the revival of time division duplex (TDD) transmission technology. Analysts in Europe predict that TDD will replace current standards for delivering 3G, improving both bandwidth capacity and the quality of Internet service delivery.[5]

**The Role of Technology in Spectrum Management.** In order to deploy 3G and other new technologies, telecommunications carriers and their suppliers are seeking effective strategies to move to new standards, upgrade infrastructure, and develop software for new services. This migration path includes decisions about using spectrum.

Radio frequency (RF) spectrum is used for all wireless communications. It is managed by the FCC for commercial use and, for federal government use, by the National Telecommunications and Information Administration (NTIA). International use is facilitated by numerous bilateral and multilateral agreements covering most aspects of usage, including mobile telephony. Spectrum is typically measured in cycles per second, or hertz.[6] Currently, spectrum below 3000 megahertz (MHZ) is used for commercial, military and navigational purposes. Commercial uses for mobile telephony above 3000 MHZ (3 GHz) are not considered feasible with existing terrestrial wireless technology.[7]

Spectrum is segmented into bands. Developments in technology have in the past facilitated the more efficient use of bandwidth within a given portion of the spectrum. New technologies, such as Software-Defined Radio (SDR) and "smart" antennae for terrestrial wireless, are being explored and implemented to increase the efficiency of the spectrum frequencies they use.

Efficiencies in wireless technology can be achieved in every aspect of the system, what is called a "value chain." For example, SDR chips improve efficiency in the handset, smart antennae increase the efficiency of transmission towers, compression technologies send more data in less bandwidth, and TDD techniques use bandwidth more effectively.

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[4] (...continued)
of 3G as the following: capability to support circuit and packet data at high bit rates; interoperability and roaming; common billing and user profiles; capability to determine and report geographic position of mobiles; support of multimedia services; and capabilities such as "bandwidth on demand." 3G speeds are: 144 kilobits per second at vehicular traffic speeds; 384 kilobits for pedestrian traffic; 2 megabits or higher for indoor traffic, [http://www.fcc.gov/3G].

[5] *The Financial Times*, "Comeback for an Older Technology," November 15, 2000.

[6] One million hertz = 1megahertz (MHZ); 1 billion hertz = 1 gigahertz (GHz).

[7] The FCC, for example, is limiting its consideration of bandwidth available for 3G to frequencies below 3 GHz.

## Public Policy and 3G

**International Agreements on 3G.** International agreements that coordinate and enable global telecommunications are negotiated under the aegis of the International Telecommunication Union (ITU), a specialized agency of the United Nations. At ITU conferences in 1992 and 2000, resolutions were passed regarding the use of spectrum for the International Mobile Telecommunications-2000 (IMT-2000) initiative. IMT-2000 is "the ITU vision of global mobile access . . . intended to provide telecommunications services on a worldwide scale regardless of location, network, or terminal used."[8] The applications for IMT-2000 will come from 3G technology, although 3G is potentially more far-reaching than the current ITU concept.

Delegates to the ITU World Radio Conference in 2000 (WRC-2000) agreed that harmonized worldwide bands for IMT-2000 were desirable in order to achieve global roaming and economies of scale. Resolutions voted by WRC-2000 delegates encouraged nations to make available some part of one or more of the three spectrum bands identified in committee (806-960 MHZ, 1710-1885 MHZ, and 2500-2690 MHZ) for use as harmonized spectrum.

**Harmonized Spectrum.** The applications of wireless technology are tied to spectrum. Infrastructure, such as towers, relay stations, and handsets, must be able to provide communications along pre-designated frequencies. The value of harmonization is to provide common bands of spectrum dedicated to 3G technology worldwide. This makes it easier for carriers to cover large geographical areas and for the telecommunications industry to develop 3G hardware and software. Many industry observers, however, believe that WRC-2000 did not evaluate the practical considerations of achieving global roaming capabilities and economies of scale through harmonization. They argue that countries like China and Brazil are using spectrum to develop 3G technology in bandwidths not covered by the WRC-2000 resolution, and that global roaming exists today without the benefit of harmonized spectrum. Market demand is perceived by many as sufficiently large to provide desirable levels of scale and scope. In planning the American migration from existing wireless to 3G, some experts believe that spectrum in other frequency bands would be the optimal choice.

## Policy Issues in the United States

In a memorandum dated October 13, 2000 to Executive Departments and Agencies, President Clinton followed up on the WRC-2000 delegation's actions by directing the Secretary of Commerce to work with the FCC, in coordination with the NTIA, to prepare studies on allocating bandwidth for harmonized spectrum. President Clinton set July 2001 as the date by which the FCC should have identified spectrum to be used to meet the WRC-2000 objectives, and September 30, 2002 as the deadline to auction licenses for this spectrum. The memo also directed the Secretaries of State, Defense, the Treasury, Transportation and other departments or agencies using spectrum identified by WRC-2000 for third-generation wireless services to cooperate in the effort.

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[8] Resolution 223, "Final Acts of WRC-2000", ITU, Geneva, Switzerland, [http://www.itu.int/publications].

In March 2001, the NTIA and the FCC issued reports, respectively, on 1710-1850 MHZ and 2500-2690 MHZ use.[9]

**FCC.** On June 26, 2001, the Chairman of the FCC wrote the Secretary of Commerce suggesting that more time be allowed for the effort to identify appropriate spectrum and that the deadline for the proposed auction be extended. In response, the Secretary directed the Acting Director of the NTIA to work with the FCC to develop a new plan for the selection of 3G spectrum, with the cooperation of the National Security Council and the Department of Defense (DOD), among others.

On August 9, 2001, at a public hearing, the FCC adopted a notice of proposed rulemaking, seeking comment on the reallocation of four spectrum blocks, not previously discussed, for advanced wireless services. At the same meeting, the Chairman pledged to take action by the end of the month regarding the possible reallocation of the 2500-2690 MHZ spectrum frequency. This bandwidth is used primarily by Fixed Service operators for Multipoint Distribution Service (MDS), Multichannel Multipoint Distribution Service (MMDS) and Instructional TV Fixed Service (ITFS).

Some of the important policy decisions by the FCC that touch on the development of wireless technology are: imposing caps of 45 MHZ of bandwidth for any carrier in any market, in order to promote efficient use of spectrum; deciding to allow competing wireless technologies to coexist rather than imposing a standard; and auctioning spectrum without specifying the level of technology. As a matter of policy, in accordance with current statute, the FCC maintains that potential revenue should not be used as the main argument for auctioning spectrum.

**NTIA.** The March 2001 NTIA report addressed the issue of reallocating spectrum now used primarily by the DOD. In its report, cited above, the NTIA divided the band into two segments: the 1710-1755 MHZ band that is already expected to be made available for commercial use in 2004, and the 1755-1850 MHZ band occupied by the DOD and 13 other government agencies.

For the 1755-1850 MHZ band, the report provided several policy options and concluded that full-band sharing is not feasible, nor is it possible for the band to be completely vacated within the established time lines. The NTIA therefore examined three other sharing and segmentation options and found two solutions that it felt could be the basis of discussions and negotiations with the DOD. These were "Out-of-Band Pairing" and "Out-of-Band Pairing and Federal Migration from Band."

**DOD.** The present position of the DOD is that sharing of any sort is not a secure solution and that migration to another frequency band is the only possibility. Full migration could take many years because satellites in orbit cannot be reprogrammed to operate on another frequency. Satellites programmed for new frequencies would replace existing

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[9] "The Potential for Accommodating Third-generation Mobile Systems in the 1710-1850 MHZ Band," Final Report, March 2001, U.S. Department of Commerce, NTIA, [http://www.ntia.doc.gov/reports]; and "Spectrum Study of the 2500-2690 MHZ Band," Final Report, March 30, 2001, FCC, [http://www.fcc.gov/3G].

satellites as they complete their life spans. Two National Defense Authorization Acts[10] mandate that costs be reimbursed and that comparable spectrum be identified.

The issue of comparable spectrum is frequently raised by representatives of the DOD. They underline that discussions of its migration to another band presuppose that other bandwidth is available.[11] To date, no comparable bandwidth has been proposed.

**Congress.** Hearings on laws and policies governing 3G, spectrum allocation, and spectrum frequency management were held by the House Committee on Energy and Commerce, Subcommittee on Telecommunications and the Internet, on July 24, 2001. The topic was addressed, on July 31, 2001, by the Senate Committee on Commerce, Science, and Transportation, Subcommittee on Communications. Although possible legislation was mentioned in both chambers, at this date no bills have been introduced.

At the Senate Committee on Commerce hearing, July 31, 2001, it was noted that the General Accounting Office (GAO) has indicated in a draft report that studies on using military spectrum do not contain enough information to make allocation decisions. The final GAO report will likely be released toward the end of the summer.

## Issues for Congress

The continued growth in demand for bandwidth has prompted Congress to review the policies and laws that guide the management of this resource. Among the questions being posed are:

- Bandwidth used by the DOD is part of the spectrum potentially identified for international harmonization of 3G, yet the DOD believes moving to another band will be costly and difficult, and may not be possible. What role, if any, might Congress have in adjudicating the issue?
- What are the trade-offs between military and commercial needs, and how can they be reconciled?
- What law, policies and rulings for spectrum allocation would best meet the sometimes conflicting objectives of protecting consumers, fostering new technology, encouraging efficiency, bolstering international competitiveness, and promoting competition, fairness, and access in domestic markets?
- To what extent does the United States support efforts for international cooperation in developing 3G technology?
- Are there actions Congress could take to encourage more efficient use of spectrum?

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[10] P.L. 105-261 and P.L. 106-65.

[11] "Investigation of the Feasibility of Accommodating the International Mobile Telecommunications (IMT) 2000 Within the 1755-1850 MHZ Band," 9 February 2001, Department of Defense; and testimony of Dr. Linton Wells, II, Acting Assistant Secretary of Defense before the House Committee on Energy and Commerce, Subcommittee on the Internet, July 24, 2001, and before the Senate Committee on Commerce, Science, and Transportation, Subcommittee on Communications, July 31, 2001.