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STANDARDS WARS:

THE USE OF STANDARD SETTING AS A MEANS OF FACILITATING CARTELS

THIRD GENERATION WIRELESS TELECOMMUNICATIONS STANDARD SETTING©

Peter Grindley

Managing Economist

LECG Ltd

David J. Salant

Managing Director

LECG Inc

Leonard Waverman

Director, LECG Ltd

And

Professor of Economics

London Business School

Introduction

This paper describes the process by which the third generation (3G) standards for wireless telecommunications services are being defined. The standard setting decisions will affect equipment suppliers, telecommunications operators, and consumers. The development of telecommunications standards is an arcane process. Many different firms and organizations play a role. Of particular interest is the impact of standard setting in facilitating cartels for 3G systems.

Universal Mobile Telecommunications Services (UMTS) is often referred to as a third generation (or 3G) standard. Analogue cellular, or Analogue Mobile Phone Systems (AMPS), is a first generation standard and various forms of Personal Communications Services digital standards are second generation, or 2G, standards. There is no single global 2G standard, rather a set of 2G standards.

Standard setting is a global activity, with many national, regional and global organizations playing key roles. Europe has coordinated on one digital 2G standard, the " 'Global' Standard for Mobile" communications, (GSM), a time division multiple access (TDMA) standard used in both the 800 MHz and 1.8 GHz frequency bands. The European Community (EC) is developing a single 3G. However, this third generation technology uses code division multiple access (CDMA) originally developed by a US firm, Qualcomm, and so will not be fully backward compatible with GSM.

Three incompatible 2G standards have been widely deployed in the Americas: GSM; another, incompatible TDMA standard called DAMPS and Code Division Multiple Access (CDMA). The US FCC has issued one Notice of Inquiry on 3G, but there has been much less activity than in Europe. In this paper, we describe the process by which 3G standards are being defined. We also describe the interests of the various parties, as well as the potential for network tipping. When a few manufacturers are able to dominate a key standard setting body, those manufacturers can effectively tip the network, to the disadvantage of rivals. International agreements and negotiations can also play a role. We discuss the developments that are apparently leading to a converged 3G solution, where a single set of standard specifications will be agreed on. We discuss the benefits and costs of government mandated versus market determined standards in this context. The key issue for this paper is the contrast between voluntary standard setting in the US and preemptive institutional standard setting in Europe backed by Government mandated single standards. It is our fear that this standards "War" will be won by the European institutional design and government backing, with potential losses to consumers and clear losses to US producers such as Qualcomm. We show below how European standard setting can evolve into cartel behavior with denial of market access to outsiders. We also recommend how such potential behavior can be prevented.

To a large extent, spectrum can be refarmed, that is converted from 1G or 2G to 3G, such as is happening in North and South America. Most analogue cellular systems have or are being converted to digital. Another key component of the standardization process is the allocation of frequency. The International Telecommunications Union (ITU) and the EC have already allocated spectrum for this standard. Throughout the world, national communications commissions are in the process of allocating additional frequency bands for 3G services. This process is parallel with decisions being made by standard setting organizations. These decisions are all occurring at the same time, telecommunication service providers are developing business plans, and equipment suppliers are investing in R&D in developing these new standards.

The European Parliament (EP) has passed legislation mandating deployment of UMTS by 2002, and for member countries to have plans in place in 2000 allocating spectrum. In part because of all this activity, UMTS is likely to be deployed first in Europe. However, some 3G services may appear earlier than in Europe. The Federal Communications Commission does not mandate standards nor does it require the type of certification from standard setting organizations with restricted participation policies as is required by the European Community and DG XIII, the Director General for Telecommunications Policy. In particular, high data rate services are likely to appear in the US as soon they become commercially viable.

The key standard-setting agencies is the European Telecommunications Standards Institute (ETSI). The decisions in Europe could have a significant impact on the global standard setting process because of the single standard promoted by ETSI. And this standard setting process can result in market tipping. This issue has been a subject of recent communications between the US and the European Community. The EC has made ETSI the standard setting organization for all of Europe. ETSI, in turn, is largely controlled by member organizations, the service providers, network operators and equipment suppliers. So, to a large extent, ETSI's de facto role of regulating standards is controlled by the firms being regulated.

Section 2 provides an overview of first and second generation mobile systems. Section 3 is a discussion of the standards "war" for the dominant standard for 3G systems. The fourth section provides a comparison of voluntary market processes and institutional standard setting.

A. First and second generation mobile

I. The European Market

The deployment of digital mobile services first occurred in Europe. We start with the description of the process that led to digital standards and services in Europe.

1. Analogue Cellular

During the 1980s, analogue mobile telephony experienced rapid growth in Western Europe. Each country had its own system that was not compatible with that of its neighbors. This resulted in a multiplicity of standards at different frequencies. Standards adopted in different countries include TACS in the UK, RC-2000 in France, Netz B in Germany, RTMS in Italy, and NMT-450 in the rest of Europe. Incompatibility between different systems meant that subscribers had difficulties roaming and since there was a limited market for each type of equipment, economies of scale could not be realized. It was recognized that the introduction of a second generation mobile communications system would provide an opportunity to establish a pan-European system. The different analogue standards were to be replaced by digital technology and the proposed system had to meet certain criteria.[1]

1.1.1 European Second Generation: Development of GSM

In 1982, Nordic Telecom and Netherlands PPT (following a Franco-German Study) proposed to the Conférence des Administrations Européenes des Postes et Télécommunications (CEPT) that a new digital standard be developed to cope with the increasing demands on European mobile networks. In the same year the CEPT established a working party to develop a set of common standards for a pan-European cellular network. This working party was known as the Group Speciale Mobile (GSM). CEPT identified the importance of the availability of common spectrum in the development of a European system and made representations to the European Commission on this issue. This resulted in the EC issuing a directive under which European States were required to set aside spectrum in the 900MHz band for the future development of a European mobile telecoms system.

The technology that was adopted was the Global System for Mobile Communications (and this took over the acronym GSM). Innovative technologies such as CDMA were rejected because the European planners did not believe that they were mature enough to meet the planned introduction of digital 2G in 1991. In 1987 the operators from the CEPT countries signed a Memorandum of Understanding, usually referred to as the GSM MoU, in which they agreed to deploy the GSM standard at the same frequency in order to facilitate roaming.[2] In

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1 J Skourias, "Overview of the Global System for Mobile Communications". These criteria included: Good speech quality; Low terminal and service cost; Support for international roaming; Ability to support handset terminals; Support for range of new services and facilities; Spectral efficiency; ISDN compatibility.

2 The first Memorandum of Understanding was signed on 7 September 1987 by network operators from thirteen countries who committed to licensing GSM technology by 1 January 1991.

1989, CEPT transferred the GSM committee to the European Telecommunications Standards Institute (ETSI), itself formed in 1988 which completed the specifications of the system.[3, 4, 5]

From this time on, the importance of avoiding incompatibility within Europe and developing a single European standard were uppermost.

By 1989, Germany had already awarded a GSM concession, the D2 license. By the end of 1993 there were already more than 1 million GSM users in Europe. In September 1993, Mercury One-2-One introduced an up-banded version of GSM, often called DCS1800, in the 1700-1880 MHz range in the UK. The major difference between GSM 900 and DCS 1800 is the lower transmitting levels required with the latter, designed to promote smaller cell sizes. GSM 900 is similar to the digital cellular network in the US, whilst DCS 1800 resembles the US 1.9GHz capabilities.[6] It was possible to use a different technology such as CDMA for the new bandwidth but ETSI chose to mandate that new operators use the upbanded GSM technology. This was one example of equipment manufacturers in ETSI leveraging their incumbency advantages to ensure a continuation of their existing technology. PCS operators utilize dual band phones to allow roaming to GSM 900 operators.

"Since its introduction in 1992, the GSM standard has been highly successful. It has been used in 70 networks operating in Europe, the Middle East, Africa, Asia Pacific and Australasia, which have over 50 million subscribers. The GSM MoU has become a multi-national organization with 210 members from 105 countries. They meet approximately every four months to allow members to decide on the direction in which GSM should develop."[7]

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3 The GSM system has the following specifications: 128 channels, each 200kHz wide; 900Mhz band (890-915 MHz mobile transmit, 935-960 MHz base transmit); Gaussian Minimum Shift Keying as the modulation process; TDMA access technique.

4 In 1986, the EC in the Council Directive on the initial stage of the mutual recognition of type approval for telecommunications terminal equipment, 24th July 1986 mandated that:

'The Member States shall implement the mutual recognition of the results of tests of conformity and common conformity specifications for mass-produced telecommunications terminal equipment[4] in accordance with the detailed rules set out in this Directive.' (86/361/EEC)

5 This was followed up in June 1987 by a Directive[5] on the frequency bands to be received for the coordinated introduction of public pan-European cellular digital land-based mobile communications in the Community which mandated that:

'*Member States shall ensure that the 905-914 and 950-959 MHz frequency bands…are reserved exclusively for a public pan-European cellular digital mobile communications service by 1 January 1991*.'

Conformity specification means a document giving a precise and full description of the technical characteristics of the relevant terminal equipment (such as safety, technical parameters, functions and procedures and service requirements), together with a precise definition of the tests and test methods enabling the conformity of the terminal equipment with the precise technical characteristics to be verified.

6 DCS operates in 1710-1785 MHz and 1805-1880MHz

7 Source – Skouriac

II. The US Market

1. Analogue cellular

The introduction of analogue cellular systems predated digital and has been very successful worldwide. There were over 25 million subscribers in over 50 countries worldwide by 1994. The majority of these subscribers use the North American Advanced Mobile Phone Service (AMPS) standard at 800MHz. AMPS was the second cellular standard launched in the US in the 1984[8] developed by ATT/Bell Labs, and approved as a uniform standard by the Federal Communications Commission.

What is especially ironic is the current European insistence on fully, if not over-defined standards for 3G and the lack of any standards being mandated by the FCC. The original analogue cellular experience was virtually the reverse, with each European country making its own spectrum and standard decision, and the US FCC imposing AMPS on each state.

1.1.2 Migration to digital standards

In September 1988, due to a desire to increase performance capabilities of cellular system designs, the Cellular Telecommunications Industry Association (CTIA) in the US issued a set of User Performance Requirements (UPR). The UPR specified a capacity increase of a factor of 10 over analogue cellular. In response to the CTIA UPR, the Telecommunications Industry Association formulated Interim Standard 54 (IS-54), a Time Division Multiple Access (TDMA) standard (sometimes also called DAMPS), in 1989. The standard was formalized in 1991. An updated version, IS-136, is now the standard used on the networks of ATT and other PCS carriers. TDMA systems operate on both the PCS and cellular bands in the US.

GSM/DCS1800 is also a Time Division Multiple Access standard. However, the two use different coding schemes and are incompatible. In addition, Pacific Telesis and Omnipoint, among others have deployed a version of GSM, called PCS1900, in the PCS bands in the US. PCS1900 is essentially the same as GSM and DCS1800 but operates at 1850-1990 MHz. Note that the US PCS bands and the European DCS1800 bands overlap, and so Europe's DCS1800 is incompatible with the US band plan.

Early in the 1990s the TIA, responding to the CTIA UPR, adopted the IS-54 TDMA standard after considerable debate. Most discussion centered around the issue of IS-54 not meeting the UPR capacity requirement, increasing capacity by only a factor of three. Three months after the adoption of this standard Qualcomm introduced its CDMA proposal, promising capacity improvements of up to 10 to 20 times AMPS. CDMA originally reached nearly a 6-fold increase in capacity relative to AMPS, and planned upgrades to CDMA may soon achieve

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8 It was launched some two years behind the launch of another cellular standard, NMT 450.

the 10-20 fold increases originally projected. CDMA has proven to be a more efficient standard than either the US TDMA standard or GSM. There are never-ending debates about how much more efficient is CDMA. However, CDMA is the technology of choice for all third generation systems because of its efficiency.

It is worth noting that CDMA and TDMA have near complete nationwide US coverage. After the most recent re-auction of PCS licenses, GSM's coverage is fairly extensive as well. Note that this was achieved without mandating a standard, nor even nationwide roaming. Market forces in the US led to this outcome.

Crucially the US standards process is totally open with one firm one-vote rules for consensus formation. There is no obligation for firms to have US earned revenue, so that European and Asian firms participate equally. Of course the lack of mandated standards lessens the stakes, and so the fact that the TIA is open may reflect the lack of mandated standards.

The Third Generation (3G) fight is between US based CDMA and a rival standard designed largely by Ericsson and Nokia and adopted by ETSI. The Ericsson/Nokia – ETSI standard W-CDMA, the basis of the European standard - which is one of two main competing standards for 3G, has been accepted by TIA. This compares with the situation in Europe with a mandated standards process, by which cdma2000, the competing standard developed by Qualcomm, has still to be accepted by ETSI. Ericsson and Qualcomm recently signed what can be best described as a treaty. They agreed on a tri-mode standard, a combination of Ericsson's WCDMA, Qualcomm's cdma2000 and a time division duplex standard (TDD) for a separate part of the frequency band. Ericsson is to support the adoption of this tri-mode standard in Europe, and most importantly within ETSI. Ericsson though has announced its intention to develop only WCDMA compatible equipment. The rest of this paper concerns this battle between 3G standards and the ways in which they are developing.

1.1.3 The Dynamics of the Second Generation Battle between GSM, TDMA, and CDMA

The deployment of different technologies has been dependent on a range of considerations.

a) GSM

GSM was initially chosen by digital cellular users in the early days when time-to-market and service features were a priority. Equipment was in volume production earlier than other systems. One year prior to the US PCS auctions there were already over one million GSM subscribers in Europe. The service features offered were at that time more sophisticated (SMS, use of smart cards for roaming etc.) this is no longer true.[9] Sprint Spectrum chose GSM for its initial roll-out in the Washington, DC Major Trading Area. Sprint had a desire to quickly roll-out ser-

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9 GSM was at that time often selected by small operators who needed to get to market quickly before established operators roll out their networks. By moving quickly these firms are able to establish a niche market.

vice and would have suffered delays had it waited for CDMA. However, Sprint rolled out nationwide service using CDMA, and later phased in CDMA service in the DC area.

Operators who choose GSM now face some longer-term issues. Maintenance costs are reported to be higher as more base stations are required and frequency management needs to be more rigorous. In addition GSM operators are likely to face higher long run capital expenditures as GSM is relatively inefficient in the use of spectrum.

GSM carriers in North America currently providing commercial services include Aerial Communications Inc., Airadigm Communications Inc. (Einstein), BellSouth Mobility DCS, Conestoga PCS, Cook Inlet Western Wireless PV/SS PCS, L.P. (VoiceStream), DIGIPH Communications, Microcell Telecommunications Inc. (Fido), Northern Michigan, NPI Wireless, Omnipoint Communications, Inc., Pacific Bell Mobile Services, PCS One, Powertel Inc., South East Telephone, (Sprint Spectrum), Third Kentucky Cellular Group (Wireless 2000 PCS).

1.1.3.1 CDMA

CDMA has been chosen when critical IS future network capacity and long-term cost-effectiveness are crucial. As a result the standard has appealed to many large wireless operators that have cellular networks in place. Operators wanting to offer fixed telephony in the local loop may also consider this standard because of the large capacity and reduced need for frequency planning.

Generally CDMA technology provides similar geographic coverage to analogue networks but offers well over 4 to 5 times the capacity (and rising). Overall CDMA is considered likely to be the best performer in terms of capacity and long-term cost and maintenance. Service providers that have deployed CDMA are PCS PrimeCo Personal Communications (which includes Bell Atlantic, NYNEX, AirTouch, and USWest), GTE, Sprint Spectrum, and Ameritech. Despite the fact that CDMA came last to market, it has become the most common digital access technology in North America. Around two-thirds of digital service POPs are CDMA. CDMA has also gained coverage in most of Latin America, including, Mexico, Brazil, Argentina and Peru.

1.1.3.2 TDMA

TDMA was developed by what is now Lucent, but what was then AT&T. TDMA is an extension of the IS-54B standard, but it doesn’t address problems that TDMA shares with GSM (itself a TDMA technology), that is, long term capacity problems. AT&T wireless services and South-Western Bell Mobile Systems use TDMA, and TDMA has almost full nationwide coverage.

1.1.3.3 PACS (Personal Access Communications System)

An additional standard is PACS. This appeals to operators wanting to implement wireless local loop on a small scale and at low cost. This was at first selected by the FCC.

b) Market shares

Market shares in the US for all standards in Cellular and PCS combined are in Table 1 below.

Table 1: US Subscribers (Cellular and PCS) (000s) [10]

	1996	1997	1998	2000	2002	%
DAMPS/ TDMA	2,322	6,291	14,016	25,488	32,000	27%
GSM/TDMA	420	1,520	3,440	9,831	17,370	15%
CDMA	117	1,655	5,869	19,411	37,470	31%
Analog	41,184	45,846	44,175	39,270	32,160	27%
Total	44,043	55,312	67,500	94,000	119,000	100%

TDMA and CDMA numbers in this table reflect the combination of PCS and Cellular while GSM is only for PCS and Analog is only for Cellular. In Cellular the general trend is that Analog is steadily declining while TDMA and CDMA are rising steadily.

Table 2: Share of Global Wireless Infrastructure, 1998 [11]

CDMA	8%
GSM/TDMA	50%
Analog	42%

B. The Standards War: Third generation — UMTS

I. How standards work

Compatibility standards define the interface requirements allowing different products and services to work together in networks. There are different types of networks and standards. An obvious example of a network is a telecommunications system, which becomes more valuable to the users the greater the number of subscribers. Other types of “economic networks” that have similar economic features include systems products such as computers and VCRs, where core products (such as computers) are used with complementary products (software). Compati-

[10] Donaldson, Lufkin and Jenrette (DLJ), (Spring, 1998), *Wireless Communications Industry Handbook*. The last few years are estimates.

[11] Ibid.

bility standards enable core products, often from different manufacturers, to use complementary goods and services from various other producers, or be connected together in networks.[12]

The basic mechanism for standards is that the larger the network of compatible products or services, the more attractive it is to join the network. For a “direct” network such as mobile telecommunications, this means the larger the coverage area using that standard, or accessing the technology, the more chances of being able to connect with the network via “roaming”. For “indirect” network products such as computers, the benefits of standardization work through the markets for complementary goods and services. A larger installed base of core products means there are larger markets for complementary goods such as software and services, which are thus available at lower cost and greater variety. In mobile communications there are “direct” benefits of compatibility from an increased network size and area, and also “indirect” benefits from the increased network which provides a larger market for additional services and products using the network. [13]

The dynamics of standards setting are also important. The basic mechanism is that as adoption of a standard increases, the larger installed base attracts more complementary production and makes the standard cumulatively more attractive. There is typically a bandwagon or “tipping” effect, once a standard reaches a critical size of installed base after which growth becomes self sustaining. If one standard can establish a clear lead over the others it attracts increasing support and typically will sweep the market.[14] Sometimes the winning standard only becomes apparent after other standards have established their own installed bases. In that case there may be multiple or fragmented standards — one standard is the clear leader and is the focus for future growth, the other minority standards may be “orphaned” with poor support, although they may persist for several years.

Before a standard has achieved this critical size it is quite vulnerable to small changes in the installed base and in the expectations surrounding the standard. If either of these falters significantly, the standard may miss its “window of opportunity”, and is either overtaken by another standard or simply never achieves workable size. This can make the outcome of standards setting processes unpredictable, especially when mediated by the market.

More importantly, it is difficult to change a standard once it is established. An entrenched standard, with a large installed base and complementary services all using the standard, will withstand competition from newer standards, even though they may be technically and commercially more attractive. Thus standards may persist years and decades after they are obsolete.

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[12] The basic economics of standards are described in Farrell and Saloner (1986), Besen and Saloner (1990), David and Greenstein (1990), Grindley (1995).

[13] One example of such indirect network externalities would be the availability of value added services, such as Internet access and messaging. Both are more likely to be available the larger the base of consumers using that standard.

[14] Such was the case in the competition between MS/PC-DOS and CPM. See Gandal, Greenstein and Salant (1999) for a discussion and an empirical analysis.

This puts great importance on the standards setting process, in determining a standard which may have crucial significance for the conditions in the industry for a long period, as we discuss below.

The issue is how to co-ordinate the decisions of different producers and users, often with conflicting interests, to arrive at a common standard. In many cases it is left to the market to set standards by competition. Market standards have many advantages. They allow several approaches to tested in the market and compete for user acceptance. Standards are decided on the basis of economic value and consumer demand rather than purely on technical grounds. Market standards are simple to organize; complex standards bodies and procedures do not need to be set up. The process is usually relatively quick. Products are brought to the market without the delays of a formal standards process, and typically converge to the single that first achieves a critical mass.[15] A winning standard soon becomes apparent once products are on the market. Although it is sometimes argued that market standards may not select the most advanced technology available, they have passed a very important economic test of consumer acceptability which includes more considerations than purely technical ones.

For many standards government intervention may be inappropriate and standards setting may safely be left to market competition. A large part of the success of consumer products such as video cassette recorders and personal computers has been due to the efficiency and speed with which product design converged to a single leading standard established by market competition. This competition resulted in the definition of major new products acceptable to the market as a whole, and the leading standards became the basis for enormous new markets. These standards were determined after a relatively brief period of intense competition (in these cases about two to three years).[16] Other cases in which markets have successfully set standards without official intervention include compact disc and audio cassette.

However, the efficiency of the market in some respects, of converging to an acceptable design, may include costs to others, and the issue exists of what happens to the losers. The market's effectiveness in generating and eliminating alternatives may include problems. In the cases of video cassette recorders and personal computers, market convergence was achieved at the

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[15] This process was perhaps best described by Nate Rosenberg ( ). See also, Armstrong, Vickers and Harris ()[15], Cabral and Riordan ()and Salant ()

[16] In personal computers, once the IBM PC was introduced in 1981, with the DOS operating system, other standard operating systems in use on older machines (such as CPM) faded quickly from the market as they became obsolete and were defunct by about 1984. No other PC operating system was successfully established. Only Apple, with a significant installed base prior to 1981 and with quite dissimilar characteristics to the PC, held on to a minority market share. Apple standards persisted for many years, only to be in effect ousted by the PC standard in the late 1990s. In VCR, it had become clear by 1980 that the VHS standard, introduced in 1978, had effectively won the standards contest against the Beta standard, introduced a year or so earlier. However, Sony continued to promote Beta for another ten years before finally accepting defeat. There was some intervention by MITI in limiting the Japanese standards to only two, but MITI left the final choice of VCR standards to be determined purely by market competition. See Grindley (1995) for a full description of these cases.

cost of a significant number of orphaned users left with minority losing standards, a situation which persisted for several years. Contests for new standards may involve duplication of development effort and lead to costly standards wars. They may confuse consumers who are then turned off the product. Market standards may also result in fragmented standards, in which different standards manage to be adopted in different segments of the market or different geographic regions. Standards may overlap, with stranded users locked in to minority standards. As noted above, markets may settle on technically inferior standards. Finally there are questions of market power conferred by a standard.

It should also be noted that when product differentiation between competing standards is great, or the benefits of standardization are not very strong, it is possible for multiple standards to coexist for long periods. In personal computers, the PC and Apple standards coexisted for nearly two decades. The LP disk and the audio cassette coexisted for many years, as has the CD and audio-cassette.

Whereas in many products (especially consumer products) these risks may be considered acceptable and left to individual consumers to make their own decisions, in other cases there may be value in setting "anticipatory" standards before products are fully developed and before they reach the market.

There is considerable debate about the benefits of a uniform, converged standard for wireless telecommunications. It seems that the US FCC views its expanded reliance on market standards, especially for PCS, to have been a great success. There is now nationwide, or near nationwide, coverage of three digital standards, much competition has been introduced and the cost of using cellular/PCS services has fallen dramatically. European regulators would claim similar success with their single, mandated GSM standard. There is continental-wide roaming and much economics of scale and competition that has reduced equipment costs in Europe as well. Of course technological improvements have not hurt matters. In the US, there are different standards, but significantly lower roaming charges than in Europe. It could be argued that the US systems are overtaking the European ones in terms of quality and features available. However, in Europe, digital service was faster to market than in the US. We are not aware of any serious assessment of the relative benefits of the two approaches.

As noted, the second-generation GSM technology has limited capability. Further, GSM and TDMA have very limited capacity to provide for the carriage of data services, such as the Internet. The aim of third generation cellular systems is to bring mobile networks closer to the capabilities of fixed networks and provide mobile users with full interactive multimedia capabilities. The range of services that will be offered will be determined by the market over time, but might include on-line banking, shopping services, video games and video telephony.

The demand for a new generation of mobile communications technology has been driven by a number of factors including:

- The pressure to integrate fixed and mobile networks for new wideband applications
- Developments in technology and in service engineering

- Demand for multi-application hand-held terminals
- The need to ease spectral congestion
- The desire to make worldwide roaming possible

Third generation technologies are being researched worldwide, with development having started some twelve years ago. These systems are commonly referred to as UMTS (Universal Mobile Telecommunications Systems).[17] More recently these are referred to as IMT 2000. IMT 2000 is intended to operate in the 1885-2025 and 2110-2200 MHz band.

There have been several problems in the development of the third generation. These include:

a) The desire on the part of some equipment suppliers and operators to achieve backwards compatibility with the older, 2G standard. As the US and global market is currently divided among three dominant standards technologies, backwards compatibility will be favored by those who see it as more practical given the standard they use. Those who have little hope of achieving backwards compatibility will have less desire to push for its implementation. In practice CDMA operators and equipment suppliers have had the strongest desire to achieve backward compatibility and TDMA and GSM have had the least.

b) The efforts of Japan's NTT DoCoMo, the largest cellular operator in Japan with 10 million subscribers, and with significant capacity constraints to speed up the standardization process globally;

c) The ability of the European equipment manufacturers and operators to agree on a standard based on W-CDMA and TDD-CDMA;

d) The lack of recognition in Europe, and in ETSI of the US position and of the rights to key intellectual property components of the W-CDMA standard.

The US and European standard setting activities in the 3G process underscore the clash between the US market process and the Europe institutional design process. There are other reasons however to worry about the European approach given the specific ways in which ETSI allocates votes and other responsibilities among its membership. The ways in which ETSI sub groups choose work plans and design and critically the weighted voting mechanism which ETSI uses to achieve consensus. This process reinforces and facilitates any tendency to lock new non-European manufacturers out of Europe. There is a rapidly growing consensus on the international stage that the third generation mobile system will not be based on a single global standard, but on a family of standards all based on a common network platform to enable interoperability. Qualcomm and Ericsson have recently reached an agreement to combine the W-CDMA and cdma2000 technical proposals to form one 3G standard. However, no one has

[17] Internationally, they have been referred to as FPLMTS (Future Public Land Mobile Telecommunications Systems), which has been supplanted by the UMTS term.

taken any steps to even start the ETSI process of approving the Qualcomm component of this converged three mode standard.

II. ITU process

The ITU published a document in October 1997, *Framework for Modularity and Radio Commonality within IMT 2000*. This presented a model that was intended to provide the basis of third generation mobile telecoms systems. The model was to provide both operators and equipment manufacturers with a single set of elements with which all the various regional standards for third generation system must be compatible.

The goal laid out by the ITU was:

> *'to provide universal coverage and to enable terminals to be capable of seamless roaming between multiple networks. The current thinking is that user's application will negotiate to secure channels in each direction, having the required characteristics of bandwidth, delay and quality, recognizing that many multimedia applications will be highly asymmetric. The need to provide for future non-standardized services which can be created independently in a competitive, multi-operator environment, places radically new requirements on the radio interface concept. No longer will the various elements of the radio interface (e.g. channel coder, modulator, transcoder etc.) have fixed parameters; rather they will be in the form of a "toolbox" whereby the key parameters of bandwidth, transmission quality and delay can be selected, negotiated, mixed and matched by the requirements of the teleservice, according to the instantaneous capability of the radio channel.'*

This ITU recommendation is not for a fixed interface but for an adaptive model, around which the different standards can be developed. The ITU is evaluating the proposals after which it will begin intensive consultations with the parties. Further standardization work on 3G network infrastructure is scheduled for the end of 1999.

IMT 2000 is intended to operate in the 1885-2025 and 2110-2200 MHz band with the satellite component at 1980-2010 and 2170-2220 MHz. The US has allocated the 1884-1990 for PCS and Unlicensed PCS services MHz part of this spectrum for PCS. It may be possible for PCS licensees to re-farm this spectrum for 3G services, much in the same way that cellular operators have deployed 2G technologies on their cellular, first generation, frequency holdings.

III. US and CDG (The CDMA Development Group)

As described, the US market is divided among three technologies, which makes cooperation even more difficult than in other parts of the world. Hence, in the US companies are lobbying for 3G technologies that are compatible with GSM, TDMA, and IS-95 CDMA. The two biggest initiatives are the cdma2000 proposal in TR45.5 supported by the CDMA Development Group (CDG) and lmnqss and the UWC-136 proposal being supported by the UWCC GTF (Universal Wireless Communications Consortium – Global TDMA Forum). The GSM community is closely tracking the 3G activities in Europe and submitting a W-CDMA/NA proposal through the TIA. There is also a fourth proposal titled WIMS/W-CDMA (Wireless Multimedia and Messaging Services) that originated in the TR-46 group.

- **Cdma2000 (WB-cdmaOne)** This proposal is supported by Lucent, Motorola, Nortel, Samsung, Qualcomm, Sony, most recently, Lucky Goldstar and most importantly the CDMA Development Group (CDG). It is the same proposal that was and is being lobbied in Japan to the ARIB. The basis for this proposal is IS-95 and IS-41 backwards compatibility.
- **UWC-136** This initiative is supported by the TDMA community as they are particularly concerned with a migration path from IS-136 TDMA. This group is called the UWCC GTF. The UWCC's new TDMA standard seeks to meet third generation high speed requirements without wideband spectrum requirements. In addition to the US, Latin America operators are very interested in a standard such as this since many TDMA systems are in operation there now.
- **W-CDMA/NA** The GSM community in North America is submitting their own version of W-CDMA through the TIA.

Late last Fall, the US FCC issued a preliminary Notice of Inquiry (NOI) on UMTS. The UMTS NOI dealt with a wide range of issues, and represents a very preliminary stage in the licensing process.

IV. Europe and ETSI

The European Telecommunications Standards Institute (ETSI) was established in 1988, as part of the wider moves in support of a single European market. At the time there was no common European standard for mobile telecommunications, restricting the ability of consumers to roam across European borders. The European Commission viewed this as a significant barrier to the formation of the single market. A further consequence of a uniform standard would be to strengthen the telecommunications manufacturing base within Europe, creating significant Europe-wide scale economies.

Within Europe, weighted voting is common. Where it may be difficult to obtain a conclusive outcome, it is often viewed as desirable to operate with a skewed voting system, to prevent the smaller parties from restricting the options available to the larger members. Many elements of the European Union operate under a weighted voting system, to ensure that small states do not hold-up developments and to ensure the active co-operation of the larger states. Similarly, ETSI operates with a weighted voting system, with weights proportional to size for both national delegations and firms.

There are two forms of voting at ETSI. In the case of subcommittees and ETSI overall, votes are based on European turnover for companies and on GDP for countries. Members of ETSI are firms, telcos and others. Telcos get double votes based on turnover and country size (GDP). However, within subcommittees, equipment suppliers dominate since telcos rely on these firms as the latter may not have the technical expertise for new areas such as 3G. This weighted voting can be a facilitating device for collusion. In the case of 3G this has worked to exclude US-supported UMTS standards. The process within ETSI is also open to manipulation with chairs, vice-chairs, and secretaries of committees having the ability to set agendas and process to exclude rivals. In January 1998, ETSI adopted a 3G standard, W-CDMA which is specifically not backwards compatible to existing 2G CDMA systems. Crucially, W-CDMA is technically different from cdma2000 in ways that prevent existing CDMA intellectual property rights holders, largely US firms, from bootstrapping their 2G competence into 3G. The differences provide little or insignificant advantages over cdma2000, as there is no real performance basis for their adoption. The main purpose of the WCMDA standard is to make it more difficult for non-European firms having experience in making CDMA equipment to compete in Europe.

Of crucial importance is that an ETSI standard can become a European Norm (EN). For this to occur, national delegations are required to vote, again according to a weighted system. On February 11, 1998, the European Commission adopted a proposal, since ratified by the European Parliament,[18] for the coordinated introduction of the third generation of mobile telephony system. By seeking a coordinated regulatory framework for UMTS the Commission hoped to secure Europe's dominance in the development of the next generation of mobile services, but potentially to the disbenefit of non-EU members.

This proposal, as approved, stimulates the early licensing of UMTS services. Pan European roaming would require licensing to be based on the coordinated allocation of frequencies and the use of ETSI standards, both of which are requirements featured in the proposed decision.

In particular, the Act states:

"*while voluntary application of standards remains the general rule, recourse to mandatory standards may be required for interfaces and situations where necessary to ensure interoperability and facilitate roaming of mobile networks and services; whereas harmonized standards are adopted by standardization bodies, such as the European Telecommunications Standards Institute (ETSI) which facilitates regulatory action.*"

Article 6 of the Act further emphasizes the Commission's position in support of mandatory ETSI standards.

"*The Commission shall take all necessary measures where appropriate in co-operation with ETSI to promote a common and open standard for the provision of compatible UMTS services throughout Europe, in accordance with market requirements, taking into account the need to present a common standard to the International Telecommunications Union (ITU) as an option for the world-wide ITU IMT 2000 standard.*"

In May 1998, European Union telecoms ministers endorsed the draft law designed to keep the 15 nation bloc as one with regards 3G. The law, obliging member states to introduce rules for licensing 3G networks by January 2000, is aimed to ensure that 2-Gigahertz frequencies are reserved for the single ETSI backed UMTS standard.

The EU's adoption of the ETSI standard as mandatory thus has placed great pressure on the ITU to accept the European standard as one of its family of global standards. This will also

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18 "Proposal by the Commission for a Decision of the European Parliament and of the Council on the coordinated introduction of mobile and wireless communications (UMTS) in the Community", located at http://www.ispo.cec.be/infosoc/telecompolicy/en/umts.html.

have a tipping effect, which may assist European-based manufacturers to dominate equipment markets outside the EU. The fact that a US firm Qualcomm holds key rights to intellectual property and subsequent negotiations between the EC and US regulators, provided some of the impetus that led to the Qualcomm/Ericsson agreement, for a tri-mode UMTS standard.

The standardization process within ETSI is founded upon the principle of consensus but with weighted voting and a 71% rule for agreement. While it is suggested in ETSI and EU documents that proposals will only be approved where it is shown that there is near overwhelming support, the process for UMTS shows how that "consensus" can be collusive and exclusionary.[19]

Unlike the US, where there is no identifiable turnover associated with European telecommunications activity, the ETSI member is allocated just one vote (unit). Full members' votes, however, are weighted according to their telecommunications-related revenue. As a result the major US CDMA supplying firm, Qualcomm, which has no significant revenue in Europe, since its 2G standard is not accepted was accorded one vote, while Ericsson, Nokia and their European affiliates, the main proponents behind W-CDMA, have 68 and 47 votes, respectively. The Commission has considered restrictions tying membership to particular revenue levels to constitute infringements of Article 85(1).[20,21]

This system unquestionably favors dominant ETSI members, granting approximately 10 percent of ETSI members over 70 percent of the vote.[22] The weighted voting system, combined with the 71 percent supermajority required to adopt any standard, means that a tiny minority (as few as 15 members) of ETSI's approximately 450 members can effectively block any new stan-

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19 All full members and all associate members shall have the right to vote for the adoption of ETSI Guides and ETSI Standards. If the deliverable is not adopted as a result of the vote, the votes themselves are broken down into votes by full members and votes by associate members. Where at least 71% of the votes of the full members are in favor of the proposal it is then adopted for use within Europe.

20 X/Open Group at para. 34.

21 The voting system employed by ETSI explicitly favors the dominant members in an unfair manner. Larger members are permitted to make use of their scale by entering all subsidiary operators to qualify for additional, in many cases substantial, votes. For example, while BT (with no subsidiary membership) has 45 votes, the six Ericsson representative members have accumulated a total of 68 votes.

22 Evidence suggests that these members frequently vote in blocks, and that such voting enhances the dominance of manufacturers such as Ericsson and Nokia. ETSI SMG Subcommittees such as Group Alpha are controlled by equipment manufacturers like Ericsson and Nokia, for the simple reason that national telecommunications operators and administrations are not vertically integrated into manufacturing and therefore rely on equipment manufacturers to provide equipment, technical advances and the ability to simulate and test proposed alternatives. Thus, operators and administrations tend to vote with their national equipment manufacturers which, as described above, largely control the emergence of ETSI standards at the work group level. Moreover, wireless operators, whose main goal is access to new 3G spectrum, have an incentive to vote along with national administrations. Given the power of large European manufacturers within ETSI and the desire of European governments to maintain a strong employment base in this sector through a single standard, support of W-CDMA is a politically expedient stance. Operators perceive that opposition to W-CDMA could jeopardize their access to new spectrum.

dard, representing an almost complete barrier to new entrants with new technology. Conversely, this same minority can, with relatively few allies, push through a new standard.

"Associate Members", defined as those ETSI members not established in Europe, were not at the time of ETSI's January 1998 decision to adopt W-CDMA accorded the right to vote on ETSI standards.[23] As a result, non-European members were substantially under-represented in the standard-setting process. Thus, outsiders were not given the opportunity to "influence the results of the work of the group."[24]

Importantly, the requirements for membership of ETSI are themselves, ex ante, anti-competitive.[25] As a requirement of membership, a common position is required by all ETSI representatives on the ITU, on all matters that have been approved by the General Assembly. Clearly this restricts the ability of individual members to act freely and limits ETSI membership. Who would join an organization if the end result requires acceptance of a standard that one opposes.To qualify for full membership in ETSI, which triggers the right to vote on proposed ETSI standards, a company "must belong to one of the countries of Europe (CEPT) and agree to contribute to ETSI's work and to make use of the standards produced."[26,27]

When ETSI was first established in 1988 there were no incumbent manufacturers producing GSM equipment. Now however, there are incumbents and since ETSI utilizes weighted voting, incumbents can dominate choices for follow-on technologies. Table 1 shows the weighted votes in January 1998 available at the ETSI SMG (Special Mobile Group) which was deciding on 3G technology. Note that operators dominate equipment manufacturers with 703

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23 ETSI's rules were amended in March 1998 to permit associate members to vote in certain circumstances. Even under the amended rules, however, associate members' votes are essentially discarded in an instance where 71 percent approval is not achieved. In those instances, Article 14 of the ETSI Rules of Procedure provides that "an analysis of the distribution of the votes among associate members and full members shall be conducted….[and the standard] shall be adopted for use within Europe if at least 71 percent of the weighted votes cast by full members are positive." As a result, non-European members have virtually no opportunity to block a proposed standard, even if they are able to muster the support to do so, and even if, under the weighted voting schedule, they have a considerable number of votes.

24 X/Open Group at para. 32.

25 Firms such as Qualcomm Incorporated, which is neither chartered in Europe nor able to commit to use of ETSI's GSM-based standards in preference to its own CDMA technology, do not qualify for full membership. Contrary to EC law, therefore, ETSI's membership requirements, even if facially non-discriminatory, inherently discriminate against non-GSM manufacturers. Perhaps more importantly, the ETSI rules bar foreign firms from full membership, a factor noted by the Commission as central to an Article 85(1) determination.

26 ETSI website, section titled "Join ETSI", accessible at: www.etsi.org.

27 Joined Cases T-528/93, T-542/93, T-543/93 and T-546/93 Metropole Television SA and Reti Televisive Italiane SpA and Gestevision Telecinco SA and Antena 3 de Television v Commission, [1996] ECJ Celex Lexis 210, para. 95 (Commission required to examine whether a standard-setting body's "membership rules are objective and sufficiently determinate so as to enable them to be applied uniformly and in a non-discriminatory manner vis-à-vis all potential active members….")

out of 1117 votes. However, technological advances in mobile come from equipment manufacturers not telcos. Operators rely more and more on manufacturers to invent and advance. Gone are the days when vertical integration (Western Electric and AT&T for example) between operators and manufacturers was prevalent. Operators also depend on manufacturers for delivery of equipment for existing networks. Thus in standard setting organizations such as ETSI, it is manufacturers who make the theoretical and technical advances. Operators do not have the expertise to dominate standard setting. And of the 414 manufacturers votes listed in Table 1, 4 equipment manufacturers; Alcatel, Ericsson, Siemens and Nokia, control 243 votes or 60%.

Table 2 provides data on the mobile equipment market for 1996 through 1999. Ericsson and Nokia dominate the world market controlling over 60% of sales. Table 3 provides data on the importance of mobile equipment sales to equipment producers. For Ericsson, mobile services are now 70% of total for revenues. For Nokia, mobile revenues are 90% of revenues. It is crucial for these firms to ensure that they are well placed for the next generation of mobile equipment.

There are thus some indications that ETSI's process for setting standards for 3G has not been as open to alternative standards as should be needed in a period of rapid technological change, in setting a standard with major implications for the future of mobile telecommunications services across Europe and the world.

Besides the general issues discussed above, the detailed operations of ETSI are cause for concern. The structure of ETSI appears to be biased in ways that promote the interests of European incumbents, especially those with interests in GSM. For example, the ETSI Sub Technical Committee Services and Facilities (SMG 1) is responsible for specifying the requirements for GSM, based on user needs, ease of use and a close relationship with GSM-MoU and ETSI Sub Technical Committee User Interfaces, Services and Charging (NA 1). SMG 1 is however also responsible for the service aspects of the third generation Universal Mobile Telecommunications Systems (UMTS).[28]

The procedures used in the ETSI sub-committees may make it difficult for standards from outsiders to get an adequate hearing. First, the leadership of the crucial sub-committees and working groups is dominated by managers from the major European manufacturers. For example, the chairman, vice-chairman, and secretary of the Concept Group Alpha, studying the W-CDMA standard are managers from Ericsson, NEC, and Nokia respectively. Concept group delta, studying the TDMA/CDMA standard is lead by managers from Siemens, Swiss Telecom, and Mannessmann Mobilfunk.[29,30]

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[28] Alan Cox, Vodafone Ltd., and Chairman SMG 1.

[29] The Swiss vice-chairman resigned from the group in August 1997 after a divergence of opinion over TD/CDMA parameters.

[30] SMG2 Summary Report August 4-8, 1997.

Thus a few European equipment manufacturers have the incentive and the ETSI process may provide the ability for these operators to jointly set standards. That is, the ETSI processes may well be cartel facilitating devices for the coordinated development of follow-on standards.

We should be concerned with standard setting processes if these exclude rivals and raise social costs, or lower social welfare. The ETSI process, in choosing a 3G standard can act to raise rivals' costs. The W-CDMA standard basically requires a significant retrofitting to all existing CDMA installations plus a rewriting of the software code for most existing equipment. Thus current producers are severely disadvantaged in several ways. First, W-CDMA greatly reduces incentives to install second generation CDMA I-95 versus GSM. Second, W-CDMA requires these firms to reinvest in reconfiguring much of its technology, with no social gains.

ETSI also refuses to license the second generation I-95 CDMA as an existing standard. There is no reason for this exclusion. Roaming requires only **one** compatible operator in each country, not that each operator has the same standard. Interconnection allows a customer to cross a border and still receive calls. No public benefits emanate from refusing to license second generation technologies. Instead significant costs to consumers follow. I-95 CDMA would allow more efficient use of existing spectrum. More efficient spectrum use would allow additional operators, increasing competition and reducing prices. Finally, the competition between different technologies in the market place would also lead to consumer benefits of greater choice. [31]

The technical differences between W-CDMA and cdma2000 show that when a number of major choices were made, the technical drivers of the ETSI process chose the opposite. In addition W-CDMA adds certain exclusionary features – unnecessary, overly-restrictive and counter-productive in terms of performance criteria such as spectrum efficiency – that make this exclusive European standard *incompatible* both with existing second generation CDMA products, such as cdmaOne, and with the 3G version cdma2000. It is difficult to believe that neutrality of choice led to these technical decisions.

Importantly, the ETSI action has had the effect of reducing current customer interest in CDMA second generation technology, by promoting the view that second generation CDMA equipment will be stranded when 3G systems are deployed in Europe and elsewhere. Indeed, protecting European industry's second generation GSM technology from second generation CDMA competition (presumably in unprotected, non-European markets) may be not only the most immediate, but overall the *predominant* concern behind the ETSI 3G WCDMA standard.

The war is not yet over, in that Ericsson has made public that it has no intention to develop cdma2000 infrastructure. Europe mandates roaming. Roaming may be achieved by means of multi-mode handsets. However, if WCDMA gains an early lead, as seems inevitable, the chances that a cdma2000 succeeding in Europe is greatly reduced. Such a system would require more expensive handsets than WCDMA systems which could remain single mode.

[31] See J Cubbin and E Sirel; "*Competition of standards: the case of Mobile Phones*",

V. Proposals for Reform

A possible solution to cartel facilitation is as follows. First, for any 'follow-on' technology i.e., a standard developed to piggy-back on an existing technology, weighted voting should be abandoned. Since the weights are based on market share for existing manufacturing or existing services, it is too easy for several dominant players to use their existing market share to leapfrog into the next generation. It is not in society's or the consumer's interests to have innovations markets potentially biased by market share in previous technologies. To allow such potential bias could diminish innovative quantity and quality. CDMA was not invented in Europe, where GSM was the only technology mandated. Nor is CDMA allowed today.

Second, the chairs and vice-chairs of relevant ETSI sub committees should be made up from telecom companies not equipment manufacturers. The problem is that expertise is narrowly distributed. When a few equipment manufacturers dominate an existing technology, having those manufacturers employees set agendas etc. for work on new technology may inadvertently limit innovation choice.

Thus, of critical importance is the ability of voluntary standards to become mandated European norms. The EC must recognize that the ability to have a voluntary standard made mandatory places undue pressures on ETSI, pressures not normally present in standard setting. The rules of the game are changed. In ordinary standard setting firms face several competitions – in setting the standard, in getting to market, in winning the market. The ETSI process compounded by the process of establishing a norm makes acquiring the standard the key competitive activity. Hence firms expend increased resources in the standards game. Moreover, the winnings are increased – the winner establishes not a standard, but a mandatory norm. Hence the risk of collusion expands. Thus all ETSI rules should be re-examined. For example, should membership be limited to firms with a European presence or is it necessary to lift membership restrictions? An examination by DGIV of all ETSI rules and procedures is required, and a report should be made public.

Table 1: ETSI January 1998 Votes - (Members by type) [estimated by Qualcomm]

Equipment Manufacturers	Votes	Others	Votes
Alcatel	80	D-Telekom	66
Ericsson	68	KPN	45
Siemens	48	TIM	45
Nokia	47	Swisscom	45
Lucent	31	France Telecom	45
Bosch	30	BT	45
Motorola	21	Telefonica	45
Nortel	20	Telia	30
Philips	15	TDK	30

IBM	12	Austria PTT	30
Matra	10	Belgacom	30
AEG	9	Mannesman	22
Matsushita	9	Telenor	18
Fujitsu	7	Finnet	18
NEC	7	Italtel	18
		C&W	18
Total	414	GPT	18
		Telecom Ireland	18
		Portugal Telecom	18
		OTE Greece	18
		Telecom Finland	9
		Ascom	9
		E-Plus	9
		AEG	9
		Vodafone	9
		Cellnet	9
		Eutelsat	9
		Greek Telecom	9
		SFR	9
		Total	703

Table 2: Worldwide Revenues from Mobile ($m)

Company		%	1	%	1	%		%
	996	of	997	of	998e	of	999e	of Total
		Total		Total		Total		
Alcatel[32]								
Mobile infrastructure		2	9	2	1	2		2.3
	83	.65%	59	.48%	,129	.40%	,300	7%
Ericsson[33]								
Mobile systems			9		1			
	,333		,056		0,926		2,586	
Mobile phones			5		7			
	,862		,341		,073		,982	
		3	1	3	1	3		37.
	0,195	4.54%	4,397	7.21%	7,999	8.24%	0,568	51%
Lucent[34]								
Mobile		1	3	9	4	9		8.6
	,373	1.43%	,821^{+}	.88%	,254^{+}	.04%	,717^{+}	0%
Motorola[35]								
Land mobile		1	4	1	4	1		8.9
	,625*	5.67%	,926	2.73%	,720*	0.03%	,881*	0%
Nokia[36]								
Mobile systems			3		4			
	,455		,466		,779		,232	
Mobile phones			5		6			
	,973		,089		,405		,447	
% of Total		2	6	2	8	2		24.
Mobile	,859	1.78%	,427	2.11%	,555	3.76%	1,184	95%
Northern Telecom[37]								
Wireless networks		9	3	8	3	8		8.2
	,872*	.73%	,454	.93%	,890*	.26%	,509*	2%

32 Dean, A., 1998, Alcatel Alsthom, Morgan Stanley, Dean Witter. Converted from FF using 1997 year-end rates.

33 Lindberg, P.A., 1998, Ericsson/Nokia, SBC Warburg Dillon Read. Converted from Swedish Kroner using 1997 year-end rates.

34 Shah, A., 1998, *Global Telecom Equipment*, Morgan Stanley, Dean Witter.

35 *ibid*

36 Lindberg, P.A., *op cit*. Converted from Finnish Marks using 1997 year-end rates.

37 Shah, A., *op cit*.

Qualcomm[38]									
Mobile			1	1	4	2	6		7.1
		83	.98%	,733	.48%	,856	.07%	,942*	9%
Siemens[39]									
Mobile			2	8	2	1	2		2.2
		56	.22%	48+	.19%	,040+	.21%	,232+	5%
Total	**Mobile**		**1**	**3**	**1**	**4**	**1**		**100**
Revenue	**World-**	**9,515**	**00%**	**8,693**	**00%**	**7,073**	**00%**	**4,828**	**%**
wide									

\+ Denotes values estimated using a trendline of mobile revenues.

* Denotes values estimated by using a fixed percentage of total revenue. For example the percentage
of total revenue made up of mobile sales for Motorola in 1997 was 16.5%. Assuming that this proportion of total revenue is the same for all periods we estimated the mobile revenue for 1996-1999.

38 Ching, M.E., 1998, *Qualcomm*, Merrill Lynch Capital Markets.

39 Farrell, A., 1998 *Siemens AG*, Merrill Lynch Capital Markets.

Table 3: Estimates of Mobile Revenue as a % of Total Revenue

	Revenues $m					
Company	**1995**	**1996**	**1997**	**1998e**	**1999e**	**2000e**
Alcatel						
Total Revenue		27,022	31,623	27,906	30,323	
Mobile infra		783	959	1,129	1,300	
Mobile as % of Total		2.9%	3.0%	4.0%	4.3%	
Ericsson						
Total Revenue		15,695	21,185	25,588	28,771	32,030
Mobile systems		7,333	9,056	10,926	12,586	14,367
Mobile phones		2,862	5,341	7,073	7,982	8,696
Mobile as % of Total		65.0%	68.0%	70.3%	71.5%	72.0%
Lucent						
Total Revenue		23 286	26,360	29,406	33,170	37,980
Mobile	2,925	3,373	3,821	4,254	4,717	5,165
Mobile as % of Total		14.5%	14.5%	14.5%	14.2%	13.6%
Motorola						
Total Revenue	27,038	27,973	29,794	28,548	29,519	
Land mobile	4,470	4,625	4,926	4,720	4,881	
Mobile as % of Total	16.5%	16.5%	16.5%	16.5%	16.5%	
Nokia						
Total Reve-	6,7	7,2	9,6	12,	15,	17,

nue	77	39	86	552	251	838
Mobile systems	1,904	2,455	3,466	4,779	6,232	7,859
Mobile phones	2,955	3,973	5,089	6,405	7,447	8,192
Mobile as % of Total	71.7%	88.8%	88.3%	89.1%	89.7%	90.0%
Northern Telecom						
Total Revenue	10,672	12,847	15,449	17,401	20,168	23,012
Wireless networks	2,386	2,872	3,454	3,890	4,509	5,145
Mobile as % of Total	22.4%	22.4%	22.4%	22.4%	22.4%	22.4%
Qualcomm						
Total Revenue		814	2,096	3,309	4,568	5,816
Mobile		583	1,733	2,856		
Mobile as % of Total		71.6%	82.7%	86.3%		
Siemens						
Total Revenue			59,667	64,504	69,903	
Mobile	464	656	848	1,040	1,232	1,424
Mobile as % of Total			1.4%	1.6%	1.8%	

Source: Authors Estimates

VI. The Status of the European UMTS Allocation Process

The UK Government has taken the lead within Europe in beginning a consultation process towards the licensing of UMTS services in the UK. Throughout the process the UK has emphasized that it will require licensees to implement ETSI standards. This sends a powerful signal to the EU, in favor of ratification of the ETSI standards, and makes it difficult for competing standards to enter the EU market.

Other countries in Europe, following the EC mandate, have begun their UMTS licensing process. Finland has already selected four operators. All were required to submit technical business plans, and all but one chose W-CDMA. The other, who chose cdma2000, was not a winner. This may, in part, be due to the fact that cdma2000 did not comply with the ETSI standard. Thus, despite the Qualcomm/Ericsson agreement to the contrary, a standard is already being adopted in Europe.

Other EC countries that have already issued rule making notices for UMTS allocations include France, Germany, and the Netherlands. Like the UK, Germany and the Netherlands are now planning to conduct spectrum auctions for UMTS licenses. They are doing so despite the fact the ETSI has yet to respond to the Qualcomm/Ericsson agreement, which, at this time can only mean that cdma2000 will not be permitted. Given that some of these countries, especially the UK and the Netherlands want to hold auctions within a year or so, the likelihood that the Qualcomm/Ericsson agreement will have much impact is slight.

The licensing process in the UK has been influenced by the moves at the EU level to impose the ETSI standards as mandatory. In August, 1997, the UK became the first country in Europe to take concrete steps towards the introduction of third-generation mobile telecommunications systems with the release by the DTI of consultation material (Multimedia Communications on the Move). In particular, the DTI proposes to award five licenses by the end of 1999 in preparation for the start of services by 2002. These licenses, which will run for an initial period of 15 years, will be allocated through an auction process.

In the document, “Multimedia Communications on the Move,” it is clearly stated that it is the Government’s intention to implement UMTS in strict adherence to the emerging ETSI standards. The DTI requires that all third generation operators will enter into national roaming agreements.

The UK government is restricted as to its decisions over spectrum allocation. Given the basic premise that a third generation digital mobile system should be a global system the UK has to agree with other countries how much bandwidth should be set aside for the new system and where in the spectrum it should be positioned. The UK needs, therefore, to stay within the boundaries of the ERC’s spectrum allocation decision.

The effect of Qualcomm/Ericsson agreement might be greater if the individual countries of the EC, such as the UK, allowed prospective licensees to specify technology and gain ETSI approval after the licensing process is complete. The fact that it is often the case that firm seeking licenses will likely be required to specify a technology prior to submitting applications or bids, and that ETSI has taken no steps to approve cdma2000 suggests that WCDMA will be the only standard deployed in the EC.

C. Standards setting procedures

I. Why standards are needed

1. Consumer benefits

Standards have a number of benefits to the consumer. These are externalities in that consumer benefits are greater, the larger the total installed base of the standard. Some of the most important benefits are the following.

1) *Connectivity* — Standards increase the "connectivity" or "accessibility" of the network. For a telecommunications network the subscriber gains value by being able to use the network from more locations, over more service providers, via roaming, increasing the convenience of the system. [40]

2) *Complementary markets* — Standards enlarge the market for complementary products and services using the network and so increase the availability and variety these services, and makes them cheaper to produce. Also competition between complementary producers lowers the price. Savings include maintenance services.

3) *Economies of scale* — They are likely reduce the production costs of the network itself, by increasing scale economies (up to minimum efficient scale of production) and reducing duplication.

4) *Competition* — Standards may increase the competition in network services, by reducing switching costs for subscribers to change from one service to another, and making it easier for new services to enter. This reduces prices.

5) *Innovation* — Each of these benefits has a dynamic aspect, in that the larger the market for core and complementary goods and services, the more innovation is attracted into the market.

For a worldwide standard such as 3G, which is intended to include the capability for a wide range of broadband services, the effect of the size of the potential market for developing new complementary services (such as video, Internet applications, interactive shopping, and others) is particularly important.

Benefits may also be affected by the openness of the standard. A standard may be dependent on intellectual property, the owner of which may reasonably expect to share in the rents from using the standard. If a proprietary standard is expensive to adopt, then some of the benefits to the consumer are reduced. If the rents are too high, the adoption of the standard may be limited, and the externality benefits are lower. There is a balance to be drawn, between

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[40] There may also be quality improvements that are standards related, in that calls can be transmitted on the same network standard, with fewer interfaces.

rewarding the IP holder, and encouraging the widest adoption of the standard. The widest adoption of the standard is likely if it is "open", in the sense of being widely licensed at a low cost.[41]

There are costs of standardization, which can offset the benefits. Initially there are costs for development, co-ordination, and dissemination of a standard. These may be considerable, if substantial sums have been invested in developing and establishing a standard which eventually is unsuccessful.

For users the key potential cost are loss of variety. Whether these are sufficient to outweigh the benefits of network size with a standardized service is debatable in mobile telecommunications. The main potential costs of standardization are associated with problems from non-optimal standardization, noted below.

II. Potential problems with standards

Problems with standards may arise due to the fact that once a standard is established it may be very difficult to change or replace, and because the standards setting process is to some extent unpredictable. The attractiveness of a standard depends on the size of the installed base; it may be hard to replace or modify an entrenched standard. This can make is difficult for a superior technology to enter the market. Network effects may carry over from one generation of technology to the next, and define the future path of development of the market.

Such problems are often the results of how the standards are set in the first place. Some of the most important are:

1) *Fragmentation* — The market may split into several small poorly supported standards. Each may have just enough of a niche to survive but not enough installed base to achieve full network benefits. The market as a whole is held back by not having a single fully supported standard, or at least a few well supported ones.

2) *Orphaning* — Users of minority standards (the losers in standards contests) may be "orphaned" or stranded with a poorly supported standard. There may be few complements available, but the users are locked in by their investments. In some cases the problem may be alleviated by the development of converters.[42]

3) *Premature standardization* — A standard may be established around a design before the basic technological development of the product has reached its full potential. This may hold back development of the product and restrict market growth.

4) *Obsolescence* — Even a standard which was very advanced when it first appeared may persist long after it becomes technically obsolete, and hold up further development of the product. Also known as "standards inertia."

41 There are many examples where an open standard has won a standards contest against "proprietary" or closed standards.

42 See Gandal, Greenstein and Salant, "Adoptions and Orphans", 1999.

5) *Over-standardization* — The inverse of fragmentation is the possibly excessive reduction in product variety due to the standard. The trade-offs between fragmentation and loss of variety are rarely clear. Standards may reduce the number of types of core product offered, but may also increase the number and variety of complementary goods. The net effects on variety for the whole system are indeterminate. Also, any cost of lower variety must be set against the network benefits of a single standard.

Often problems such as these have occurred as the result of historical accidents, where markets developed before compatibility became important or before it was realized that lack of compatibility involved costs. This was the case for some well known instances of persistent obsolete standards and incompatibility, such as the typewriter keyboard, incompatible railway gauges, electricity voltages, and national telephone systems. Generally, much of strategy and policy is aimed at avoiding the problems. For example, it is the attempts by users, co-producers and manufacturers to avoid stranding which makes expectations so important. Also a realization of the effects of fragmentation often leads firms to collaborate rather than compete for the new standard. Where problems persist there may be a role for policy to oversee the standardization process. (For a review of the economics literature on standards policy and strategy, see Appendix 1).

A related and crucial issue is the real potential for anti-competitive acts in the process of standard setting. Since network effects are large and the benefits from moving from one generation to another are also large, there are clear gains to incumbents from establishing a standard that benefits themselves, and thus examining the process of standard setting is crucial.

III. Processes for standardization – markets or standards bodies

In theory the above problems can occur whatever process is used to determine a standard. The question is what process should be followed in setting standards so as to minimize these and other problems. A basic question is whether, from the point of view of the industry and the consumer, standards should be set by market forces (*de facto*), or by official standards authorities and committees (*de jure*).[43] An added important issue is the role of governments in mandating standards versus having standards set voluntarily.

1. Standards bodies (with or without government intervention)

From a public policy viewpoint the problems described earlier with market processes may justify the use of committees to help co-ordinate standards.[44] Such committees may be purely voluntary, without any government intervention, or may involve some degree of public control. A committee may be able to agree an effective standard before hard-to-reverse investments are

43 For an outline of standards strategy and policy issues, see David (1987), Farrell and Saloner (1986), Farrell (1990), Greenstein (1993), Grindley (1995).

44 Problems with market standards and justification for policy intervention are discussed in Rosenberg (1976), Dybvig and Spatt (1983), David (1986, 1987), and David and Greenstein (1990).

made in competing standards. It may also be able to achieve a consensus to unify existing fragmented standards.

The committee may also be able to co-ordinate the replacement of entrenched standards by new standards, if the technology has become obsolete. In a pure market situation, individual consumers may be unwilling to switch to new standards unless everyone switches at the same time, so that obsolete standards may persist long after the technology on which they are based has outlived its shelf life (standards inertia).

However, the process does not always work as well as intended. There are inherent difficulties of using committees and official standards bodies to make decisions for new technology. The variables are fast changing, and the outcomes are crucial to the firms' commercial interests, so that consensus may be hard to achieve. In practice official standards bodies may also bring their own set of problems. The last two are central to this paper.

- *Difficulty reaching agreement* — It is hard to get agreement by committee. Even if reached it may not be upheld unless backed up by market forces. Vital commercial interests are involved and standards may be too important to the future of the firms to be settled purely by committee negotiations.
- *Technical bias* — Official standards bodies tend to concentrate on technical rather than commercial aspects and so use too narrow criteria. The authority may be remote from the market and not have sufficient information to consider market demand. This may be less of an issue if the committee represents a consensus of member firms, in which case commercial interests are unlikely to be ignored.
- *Influencing the decision* — Introducing a standards body with mandatory authority changes the focus of competition from the product itself to influencing the standards authority. It may be unclear what criteria are being used in the decision, and the merits of the product may get overlooked. The authority can not have all the information to make the commercial judgments.
- *External policy agenda* — In addition, the authority may bring in its own policy agenda beyond setting an efficient standard. It is often hard to resist the temptation to use standards to promote industrial policy. This is limits consumer choice and may end by damaging the acceptability of the standard.
- *Timing* — The committee process often operates to a fixed timetable, which may not be flexible enough to decide on a standard at the appropriate time, as the technology is emerging. In some cases, with fast moving technologies, the decisions are too slow for the market. In other cases the committee may try to set a standard before the technology is ready, and risks setting an obsolete standard. The standard may be bypassed by newer technology.
- *Market power* — Ownership of a dominant standard is likely to be a strong source of market power, especially if adoption is mandated. If the standard is established by industry agreement in a standards committee, rather than by competition in the market place, there may

conceivably be antitrust concerns. This depends on the circumstances and the processes followed.

- ***Collusion*** — A standards setting body is inherently anti-competitive since competitors are reaching agreement. The agreement is in many cases such that the public benefits exceed the costs, but not in every case. US and EU law are quite clear as to the types of processes and agreements which are anti-competitive. We highlight problems at ETSI.
- ***Strategic use of standards*** — The line dividing competitive and beneficial standard setting processes from those that are anti-competitive and socially costly is whether the firms involved have a strategic result or end in mind rather than an objective of simply finding the best technical solution to a problem. This line may in fact not be easy to decipher. One key is the level of personnel involved in the standard setting, are they technical experts or senior managers?[45] Other indices would be the openness of the process, the level of concurrence, the procedures needed to introduce competing standards, the chairmanship of committees, the relations between manufacturers and policy makers, and others. Further, the ability effectively to mandate adoption of the standards gives the standards body great power to set conditions in the market place. This may be linked to the treatment of intellectual property (IP); agreement to out-license technology on reasonable terms may be a condition for its inclusion in a standard, alternatively a standard may be dependent on IP that is only out-licensed under conditions that allow an IP holder to control the use of the standard by competitors.

2. Manufacturers

In some cases the leading manufacturer, or manufacturers, may so dominate an industry that it is inconceivable that a standard would be set without their approval. In that case standards are not set by market competition between potential standards, but by the decision of the leader. Standards bodies may be involved in this process, e.g., to ensure the representation of the views of other members of the industry and consumers, or to facilitate the introduction of a new standard. To a large extent this was the case in US telecommunications prior to the break up of ATT. Microsoft has dominated desktop operating systems. Both have set standards for their industries at times.

IV. Changing roles of standards setting bodies

Standards development organizations (SDO) set standards outside the normal market process. Standards are achieved by negotiation and selection using committees representing manufacturers, complementary producers, users and government. Standards bodies are of various types, from voluntary industry trade associations with no direct legal powers to regulatory authorities with strong mandatory capability.[46] However, whether private, quasi-public, or pub-

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45 See …**

46 A distinction is sometimes made between modes of co-ordination by voluntary committees and by political or economic hierarchies (David and Greenstein, 1990; Schmidt and Werle, 1992).

lic, they all usually co-ordinate standards by some form of consultative, consensus process and most have some other policy overtones.[47] Their purpose may be to harmonize existing standards for existing technology, or to set anticipatory standards before products are developed and launched.

There are several different levels of official involvement, ranging from government mandated standards to voluntary agreement by an industry working group. There are also hybrid policies, that combine aspects of *de facto* and *de jure* standards. For example, the authority may set ground rules for the standard (e.g., in licensing terms) but leave market forces to resolve technical details and establish the standard.

There is a trend to take advantage of the willingness of manufacturers and other interested parties to become more fully integrated in the standards process. Industry driven bodies develop technical specifications, usually in focused areas, that are then passed to the formal standards bodies for ratification. These industry groups are separate from the formal bodies, but liaise closely through joint committees.[48] This may increase the speed of standardization and the commercial applicability of the standards, since the groups are driven by market requirements rather than purely technical concerns. [49]

1. Traditional role of SDOs

The traditional role of SDOs has been the harmonization of standards in an existing industry, either within the industry or internationally. Many of these standards are not compatibility standards but quality standards such as weights and measures, in which case the externalities (due to interoperability) are small. The strategic importance of the standard chosen is likely to be low. The standards body's main objective is to reconcile the different interests of the industry members to achieve a consensus for a new standard. Since the strategic importance is limited (though not zero) the task of deciding the standard is usually left to technical committees, which report periodically to higher level committees and to the industry for decisions on which standard to adopt.

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[47] Whether or not the authority is active in negotiating standards it is likely to have other traditional functions as a facilitator for new and existing standards (Sanders (1972) and Verman (1973)). They include providing channels for information exchange and discussion, providing initial information about standards, and educating users. The authority may be responsible for formal drafting of standards, technical evaluation, documentation, and compliance testing. The authority may also try to correct market problems with existing standards. It may also co-ordinate the development of enhancements to existing standards. Most of these functions are strategically neutral in that they benefit the members as a whole without favoring particular firms.

[48] Examples include the European Digital Video Broadcasting (DVB) group, a voluntary alliance of broadcasters, manufacturers and others, focused on specific standards issues, which develops standards which may then be ratified by an official SDO such as ETSI.

[49] Standards setting may be facilitated because the groups consulted prior to formal standardization are also responsible for developing the specifications in the first instance.

The formal standards bodies generally follow a set of shared principles, aimed at the goal of consensus. [50] These include due process, fairness and transparency, consensus, and voluntarism. In the past, standards setting via formal standards bodies has been a slow process, and left to technical experts.

2. Changing needs

More recently, particularly in the area of information and communication technologies (ICT), there has been a great increase in the number of standards and the speed with which these are required. With more rapid changes in technology and especially a greater need for interoperability in the electronics, computing, and telecommunications related industries, there has been a need to speed up the standards process. In network technologies it has become increasingly important to set anticipatory interoperability standards, before the technology is fully developed. The economic stakes have risen dramatically, and standards have moved from a back room issue to one of primary strategic importance.

This has presented challenges to the SDOs . Traditionally they have looked at the past. Now they are being asked to set standards for technologies not yet developed, that will determine technology far into the future and which has major strategic importance to the firms involved. The existing structures of the formal SDOs may not be able to cope without changes. They may not be able to judge all aspects of the new technologies effectively, due to the volume of change and to the range of economic and technical concerns involved. This implies a more "flexible" approach to standards setting. For example, this may call for greater inclusion of market processes, which are likely to be quicker and allow more alternatives to be considered.

Also, the strategic importance of standards makes the basis on which decisions are made all the more important. The potential for manipulation, and questions as to the membership of the standards body and the relative influence of the members have become crucial.

3. Implications for telecommunications standards

There are several implications for telecommunications. These include the following.

One. As the economic stakes rise the difficulty of obtaining voluntary agreement in committee may rise. Some of the older means of obtaining agreement (such as the unanimity principle) have already proved unworkable if they aim for a result which is not acceptable to a significant section of the industry.

Two. The structure of the telecommunications industry has changed immensely worldwide within the past decade or so, to a more competitive structure. State run monopoly carriers have been replaced by competing private firms, who want their say in standards. The many new entrants with new technologies also need to be involved in standards setting. This is no more apparent than in Europe, where ETSI was begun in 1988, when only the UK was liberalized, but ETSI continues to operate on the original premise of formalized standards set-

50 This and much of the following discussion relies on David and Shurmer (1996)

ting even in 1998 when all telecoms services in most European countries are fully liberalized.

Three. The issues no longer apply to just a single industry, such as telecommunications. With the convergence of technologies standards set in one section of ICT, such as telecommunications, have implications over a whole range of industries, such as computer, Internet applications, broadcasting, media, and so on. These interests must be represented in the standards setting process. If they are not then the standards may be bypassed in certain areas. Also, the consumer may be disadvantaged.

It is not clear what type of standards organization and standards-setting process can best provide for these needs. They may imply wider representation of interests in an SDO, different procedures for deciding standards, different objectives for the standards body, or greater reliance on market forces. This implies some doubts about the sustainability of the current structure and procedures of the standards organizations in their current form.

V. Types of standards setting bodies for telecommunications

According to the different needs for standards, and in response to the changing demands discussed above, there are various types of standards setting procedures followed in the telecommunications area currently. While the processes are based on the traditional SDO model, they are evolving as needs change and should not be seen as fixed. New standards bodies have been created within the last decade to deal with new standards issues and new segments of the industry. Typically these operate within the existing structure of telecommunications standards organizations, but are applied to specific issues not covered, or not covered effectively enough, by existing processes.

There are four broad types of approach, as follows:

1. Mandatory government standards

Historically, telecommunications services have been mainly provided by national monopoly carriers, and standards have been set by the carrier. Standards were mandated by the government, in most countries directly by the state-owned carrier, in the US by the FCC. National standards organizations may be involved in determining the technical details of the standards which are then mandated.

International standards have been determined by consensus within international standards organizations, such as the International Telecommunications Union (ITU), the Consultative Committee on International Telephones and Telegraph (CCITT), and the International Electrical Commission (IEC). Individual national carriers and standards organizations are represented in these organizations. Other international standards organizations have been established in other fields, such as the International Standards Organization (ISO), which deals with standards in areas other than telecommunications and electro-technical fields. Some limited inter-organizational standards committees oversee standards in areas that overlap the ITU-IEC-ISO fields, such as the Joint Technical Committee 1 (JTC1) in information technology.

There are also regional standards organizations, such as the European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC).

The method of government mandated standards continued for standards for the first of the newer technologies that took telecommunications beyond fixed line telephony and after many of the national monopolies had been privatized or, in the case of the US, broken up. The standards for the analogue Advanced Mobile Phone Service (AMPS) in the US in the 1980s were determined by consultations in FCC-backed standards committees and mandated by the US Federal Government as part of the licenses.

2. *Voluntary trade associations, as now common in US*

Partly in response to the inability of formal SDOs to set standards in the time scale needed by new technologies, and partly due to the reluctance of governments, and official standards bodies, to become involved in what are essentially commercial decisions, a great number of standards are now set by voluntary private trade associations. These range from *ad hoc* coalitions, such as special interest groups and working groups focused on a specific standard for the next electronic component, to major bodies setting standards for whole new generations of technology. This is the approach commonly favored for US standards.

Once the standard is decided its adoption is in many cases a private decision by the individual firms. It may be upheld by a contractual agreement, but more typically adoption of a standard relies on the economic logic of interoperability, to ensure that the product can be marketed as being compatible with the industry approved standard. In some cases the standard is ratified by a national standards body, such as the British Standards Institute (BSI) or the American National Standards Institute (ANSI). However, unless there are compelling public policy reasons for enforcing adoption of the standard (e.g., safety or spectrum interference), adoption is usually voluntary.

The governing body that will submit US proposals for 3G standards is the Telecommunications Industry Association (TIA), which is associated with ANSI.

Setting standard via voluntary trade associations is essentially an extension of market processes. Membership of the association is usually open to all members of the industry, the firms contribute specialists to work in the technical groups, and standards are usually set quickly. The standards are backed up indirectly by market forces, since the firms developing the technology always have the option to take it to the market without a standard being agreed.

The trade association approach reduces some of the problems with markets. It reduces the possibility of standards fragmentation and of “mistakes” (i.e., backing the wrong standard). It reduces duplication of development effort and should avoid costly standards wars. It avoids confusing the market with too many standards, which could kill a new technology. It also maintains industry competition, by helping standardize the interface design, while leaving the firms free to compete on other product features.

Potential advantages of these *ad hoc* coalitions over more formal standards bodies include the speed of setting up the organization (which may take whatever form is most effective), rapid definition of a standard (relying on simplified procedures backed by market forces), flexibility and responsiveness (firms can put whatever effort in they think is appropriate). Perhaps the most important difference between this and a mandatory standards approach is that since adoption is voluntary, the element of competition is always present, at least until the standard is established in the market, so that a range of options are ever present. This also avoids the problems of confusing the standard with political aims or industrial policy that can bias the standard in ways and under-emphasize the consumer.

The basic weakness of leaving the field open to unilateral initiatives from private consortia is the potential loss of benefits of universal interoperability. Although it may reduce the problems of market standards, such as fragmentation, it does not eliminate them. As noted in the US there are three differing standards for personal communications system (PCS): DAMPS (TDMA based), GSM (TDMA-based), and CDMA. Each was brought to market of its own coalition of carriers, and users cannot roam from services using one standard to the other.[51] In New Zealand, a small country, there are two digital cellular telephone networks.

However, there may be consumer benefits from multiple standards. First, and foremost, is the gain from competition, in innovation and between technologies, as *ex ante* it is not easy to forecast which digital system will outperform others. Second, the differing US standards are each able to cover the entire US. Thus a person traveling with a mobile phone can take calls anywhere in the US. Thus roaming is not an issue. Third, most calls are from fixed link to mobile and vice versa. Hence having a single system for mobile is not essential. There is no unique standard between mobile and fixed networks, yet these networks **interconnect**. Interconnection is then crucial between competing standards, not necessarily a single standard. Individuals can call from the US to any country, yet individual national fixed link systems differ significantly. Again this need for interconnection should not be confused with the need for roaming. [52]

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51 TDMA is supported by AT&T/McCaw, Rogers Cantel, SBC Communications. CDMA is supported by Alltel, Ameritech, Bell Atlantic/NYNEX, Sprint, Airtouch/US West. GSM is also a leading standard. GSM is supported by BellSouth and others.

52 Economic theory provides some support for the notion that voluntary committees may outperform markets in setting standards. Comparing committees, markets, and "hybrid" processes, Farrell and Saloner (1988) have shown that committees may outperform the market as co-ordinating mechanisms, and hybrid systems may be better still. Their reasoning is that a committee is more likely to arrive at a common standard than an industry which only communicates by investment actions. Negotiations take place before irreversible investments are made and there is less chance of choosing fragmented standards by mistake. In their analysis, committee standards may be set later than pure market standards since firms delay agreement until the last moment, but the cost of delay is more than offset by the greater likelihood of agreement. Without negotiations firms try to preempt each other: "pure market" standards are set earlier but with greater chance of fragmentation. In the hybrid system the ability to make preemptive investments strengthens the ability of the firms to make commitments in the negotiation process and so this may be best of all. However, this model does not include any possible effects of the committee's own policy agenda influencing the standard.

Thus voluntary ad hoc standard setting permits competition in the short and long term. In the short term, consumers may be worse off (smaller networks, lower scale economies in producing equipment and phones, inability to roam); but in the longer run the consumer benefits from the competition from new technologies can overwhelm any short term loss.

3. Mandatory trade associations, as in Europe

A more proactive stance towards standards has been followed in Europe and Japan, whereby standards are decided via trade associations which are then often mandated for adoption by government. This is the approach followed by ETSI in Europe as well as by MITI in Japan for the definition of standards in new technologies such as second generation cellular telephone and is currently being applied to by the European Parliament to 3G, with severe problems for some producers and for consumers.

Membership of the association typically includes firms from the industry, representatives from national standards authorities (for regional SDOs), possibly consumer representatives, and observers. The organization is decreed by government, but membership is usually voluntary. However, membership, and participation in the standard setting process, are restricted according to the aims of the organization. Thus, as described above, participation in ETSI is effectively limited to firms with sales within Europe and national SDOs from the European states (including countries outside the European Community).

The aim of the trade association is to achieve a consensus for the standard, which may then be mandated to be adopted by the members. The aim of consensus is close to the traditional role of the SDOs, but the mandating of the standard gives it much more power than either the traditional approach or the voluntary trade association.

Note that it may not be necessary to formally mandate a standard, if there is sufficient reason to want a common standard across a region, and the majority of the adopters support the standard. As part of the standards process the participants may agree to adopt whatever standard is the outcome. This is backed up by the need for compatibility, so that minority members will generally need to follow the majority, if that includes an overwhelming proportion of the potential market. However, if the risk of a split in the standards consensus is significant, formal mandating of the standard is normally required.

However, there are a number of concerns regarding both the ways in which consensus are achieved within ETSI and with the mandatory process.

One. Although the voting procedures may achieve consensus, this may be at the cost of ignoring the views of a sizable minority of members. There is a risk that the voting rules will be designed so as to achieve the desired result, rather than a valid reflection of interests.

Two. The approach may not be appropriate for new technologies. The consensus approach may be valuable in harmonizing an existing fragmented standards situation, as has traditionally been the role of SDOs . It is less clear that this is the correct way to decide future standards for new technologies, especially those that are still under development. Voting procedures may be biased towards incumbents, as above, making it difficult for entrant technologies to obtain a hearing. Although made by "consensus" between industry experts, if the membership is limited to a certain group not all views are available and the decisions are based on insufficient information.[53] This closed approach may lead to inefficient choices of standards. Crucially, there is a clear distinction between a standard such as GSM established before manufacturers evolved in the market and a follow up standard when incumbents exist. If voting is weighted according to current market size of member firms there is a grave risk of biasing the result in favor of the leading incumbent firms.

Three. The consensus process may be so effective that not only are alternative views not registered but the process may proceed at such a pace that emerging technologies are not given the chance to prove themselves. In a market process public awareness that other possibly superior technologies are available, or likely to be developed in the same time frame as the favored standard, would normally cause consumers to wait until the merits of each became clear. By selecting and mandating a standard too early in the development process the mandatory approach may lock in the members to an obsolete or under-performing standard.

Four. The power of the mandatory approach to impose standards may ignore other means of achieving the objectives of the standard. For example, it is less likely that it might choose a "partial" or meta-standard, that would achieve the objective of interoperability (e.g., by performance specifications) without limiting the standard to a specific technology (as is the case when standards are expressed as product specifications).

Five. The mandatory approach is subject to many of the other problems with officially determined standards, noted above. Primary amongst these is the susceptibility to political manipulation, and to use standards as a means of pursuing other industrial policy. Other problems, such as technical bias, inadequate consideration of alternatives, inflexible timescale, are also evident.

4. Voluntary trade associations, with officially ratified standards

There is a fourth, hybrid, approach to standard setting that is becoming more widespread. In response to concerns surrounding the slow pace and the unresponsiveness to market demand of the traditional SDOs, industry members and other interested parties have become increasingly involved in the process. These groups typically develop technical specifications that are then passed on the formal standards bodies, who may ratify them and mandate adoption. There is no guarantee, however, that the technical specifications will be ratified as standards by the SDO. Membership is entirely voluntary, the groups are self-financed and there is little government interference.

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53 This is only a modification of the historical problem with standards mandated by official standards authorities, which have often made decisions on standards based on limited evidence from the market, and have chosen poor standards as a result. Examples of such problems include CT2 in the UK. GSM itself has been criticized for inefficient use of spectrum, not equally scarce in all jurisdictions. Other problems such as interference with hearing aids, may illustrate the results of taking a closed approach to standardization.

This approach is becoming common in the field of ICT standardization, where time-to-market is of utmost importance. The Digital Video Broadcasting (DVB) group is responsible for developing technical specifications for digital television in Europe (although it also has non-EU members). The DVB has no standard setting powers, concerning itself with the development of specifications to be handed to ETSI for formal ratification. ETSI may reject the standards. Similarly, the Digital Audiovisual Council (DAVIC)[54] operates outside the formal standards bodies.

Voluntary trade associations typically approach the development process with greater emphasis on market requirements. Rather than being driven by the capabilities of technology, the technology is harnessed to satisfy a demand side request. Specification processes begin with a statement of end-user requirements, which is then passed to the engineers for development. The output is returned to the market experts for final approval before being passed to the formal SDO. The relationship with the SDO is close, usually through some form of joint committee.

This approach produces results more quickly than the formal process, as the interested parties that are involved in the formal SDOs consultation process have actually been involved in developing the specifications. As the process places greater emphasis on the end-user requirements than is the norm within the SDO, there is less chance of the resulting standard being overturned by the market.

The consensual approach can mean that agreement is difficult to achieve and that a fudged compromise solution, that is sub-optimal, may be adopted. The absence of any hierarchical control may lead to indecision and may require intervention in the decision making process by external authorities. This occurred during the development of specifications for conditional access technology[55] within the DVB, where the European Commission intervened to force a solution. This was extremely embarrassing for the DVB as the whole point of its existence was to avoid EC intervention in the market.

Much has been learned from the experiences of the DVB and DAVIC and existing SDOs are putting this experience to good use. The UK's British Standards Institute (a traditional SDO) has introduced an arm's length, voluntary industry group, known as DISC, to provide technical specifications where required. It is hoped that the DISC group will produce relevant specifications in a speedy manner (similar to the voluntary trade association) and that the hierarchical powers of the BSI can be used to avoid external interference and fudging.

D. Criteria for social welfare

How does one evaluate the conflicting claims? Clearly the issue is which approach will maximize the benefits to society and minimize costs. The social issue can be paraphrased as: how can one have a worldwide system or systems (i.e., a third generation mobile communica-

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[54] DAVIC provides technical specifications for interactive audiovisual services.

[55] Conditional access is the technology by which non-subscribers are prevented from viewing pay TV services.

tions system) which allows both existing TDMA and existing GSM to have interfaces with the best features and at lowest cost ?

There are a number of questions in this regard.

First, what degree of standardization is needed to achieve an effective level of compatibility worldwide, compared with the cost? How much detail does one need in standard? Compatibility is of value to mobile telecommunications networks in two main respects. One is interconnection, the ability to connect calls from one service to another. The other is roaming, the ability for a user of one service to make calls using another service network. If the standard specifies all the details of the system, this is one way to ensure both compatibility and roaming. But interconnection and roaming have different costs and benefits. Can one require just roaming and leave details to operators, customers and equipment suppliers?

As discussed above, interconnection between mobile and fixed link services (the bulk of calls) is provided for all mobile systems of necessity. Direct interconnection between mobile services is also likely to be provided, and although there may be some systems and cost advantages if the two systems use the same standard interfaces, it may be unlikely that these costs are the main drivers for standardization. Roaming may be more important. Note that again a single standard is not necessary for roaming to be achieved; what is required is that compatible services operate over different geographic areas. There may be multiple services, but provided a service that is compatible with the subscribers home service operates in the area, and has a roaming agreement with the home service, then the requirement for roaming may be met.

Second, what is the optimal cost way to achieve a level of compatibility for interconnection and roaming? Compatibility may be built into the standard, or it may require the use of interfaces between systems. For roaming, a further question is whether the compatibility should be in network hardware or in customer terminals. If achieving compatibility requires costly interfacing, it may be more efficient economically to place the interface in the network. If technology is changing rapidly, so that standards are in effect expected to evolve quickly, then it may be more economic to use a simplified standard at the network level, and place more of the interface capability in the customer equipment, until the technology becomes better defined and may be introduced as standard features in the network hardware. This may reduce the chance of major investment in obsolete network technology.

Third, given the above, what are the relative costs and benefits of having a single world standard versus multiple standards, compared with the risks of too early adoption of standards? Although there may be benefits to having a single world standard for 3G, the insistence on a single standard may well mean that one is chosen before the development of the technology is clear? For 3G most of the technology may fall into this category, especially for the many services other than voice telephony which are expected to rely on the system. A process that allows different standards to coexist and compete permits new technologies to be developed and tested in the market.

This is balanced by a greater risk of fragmented standards, but as noted above the disadvantages of multiple standards in this case may not be overwhelming. It also risks stranding of users who have chosen an obsolete standard. However, this implies that the stranded standard was not acceptable in the market, and was a bad choice in the first place. There are many examples where the technology favored by the standards authority, and introduced to the market, subsequently failed or was bypassed by more attractive technologies. Thus CT2, backed by the DTI the UK as a standard for portable telephone and the basis for unsuccessful public telepoint services, proved to be a loser.[56] Similarly PACS was FCC's favored technology for analogue cellular phone, only to be superseded by AMPS.

Fourth, there is the question of users of the old standard, and possible costs to them if their system becomes obsolete or is withdrawn. Issues include whether the existing systems should run in parallel with the new, or there should be ways to achieve backwards compatibility with the existing services and enable existing users to continue to use their systems, or adopt the new technology at least total cost. Backwards compatibility may be built into the new standard, although this may limit the technical advance possible with the new system. Alternatively compatibility may be achieved using interfaces between old and new systems. As above, this may be built into the new systems, or provided by gateway technologies used in the customer equipment. Finally, the costs of compatibility with older systems may be too great (e.g., in terms of efficient use of spectrum) and the most socially cost effective way of dealing with the problem is to close the older services, and possibly assist the users with their costs of conversion to new system.

For example, the European UTRA standards make the interfaces with existing second generation CDMA extremely costly. The claim of cdma-2000 that it is an easy upgrade to existing CDMA and a reasonably low cost interface for existing GSM. The technical differences between UTRA and cdma-2000 are discussed below. Note that even if UTRA were potentially superior (and there is little *a priori* ability to judge these claims), that superiority would have to exceed the higher systems and social costs of UTRA since it imposes a very high cost on CDMA (I-95) for forward compatibility.

Fifth, the balance between social and private costs should be allowed for as part of the standards choice. Weighted voting in standards bodies such as ETSI may avoid some problems of hold-up of socially beneficial new standards, but the representation in the standards bodies is primarily from the industry. The committees and subcommittees of ETSI are mainly firms, as discussed above, whose main interests are in their commercial position. This is likely to be related to consumer interests, albeit indirectly, although the more market oriented the standard process the closer this relationship is likely to be.

The basic economic mechanism of standards leads to many complex aspects of strategy and policy. In the existing literature, the basic economics of standards are described in Kindleberger (1983), Arthur (1987, 1988), David (1987), Farrell and Saloner (1986a), Besen and Saloner (1988), and Farrell (1990). Gabel (1991) adds some important implications for strategy.

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56 Grindley (1995).

A number of theoretical studies have established the basic mechanisms of standards and network effects, and looked at specific implications for strategy and policy. Seminal studies include Katz and Shapiro (1985, 1986), who demonstrate the effectiveness of sponsorship (subsidy) of initial adopters and penetration pricing by a manufacturer in building an initial market lead, and the key role this has in influencing expectations of the eventual standards winner. Farrell and Saloner (1985, 1986c) show how "bandwagons" and the effects of inertia may ensure the success of an otherwise inferior standard, and may make it hard to change a standard, even an inferior one, once established. Farrell and Saloner (1986b) and Matutes and Regibeau (1987, 1988) show how a reduction in individual product variety due to a standard may be offset, under certain conditions, by an ensuing increase in total systems innovation by focusing previously diverse R&D efforts. The importance of expectations, by means of which an inferior product may defeat a superior one, is studied in Krugman (1991), Katz and Shapiro (1992), and elsewhere. Farrell and Saloner (1992) examine the use of connectors to achieve compatibility as an alternative to adopting the standard design. Swann (1987) demonstrates the strategic use of pre-announcements to manipulate expectations of which new standard will be successful.

In the policy area, David (1986) analyses the problems of fragmentation and the stranding of users with minority, poorly supported standards. Farrell and Saloner (1988) show that in some cases committees may outperform market forces in coordinating standards by giving firms an opportunity to chose standard by negotiation before they make irreversible investments. They also argue that hybrid policies may be even more effective, in the sense that negotiated standards may be backed up by market investments, so strengthening commitments. Rosenberg (1976), Dybvig and Spatt (1983), and David (1987) consider different aspects of policy, and the potential for using official standards to avoid problems of market standards.

A full review of recent research in the economics of standards is given in David and Greenstein (1990). A review of the main strategy and policy issues for standards, and their application to a number of major case studies of the introduction of standards, is given in Grindley (1995).[57] A review of the procedures and effectiveness of different standards setting processes in telecommunications, including an extensive literature review of the area, is given in David and Shurmer (1996).

A cautionary note on the limitations of standards is sounded by Liebowitz and Margolis (1994), who point out that not all network effects are beneficial — they may lead to congestion or a reduction in variety. Also, not all economic benefits observed with standardized products, such as declining costs and expanding markets, are due to the standard itself. Normal technological progress may be at work, with standards playing a supporting role.

There have been various case studies of technical and non-technical standards. The most famous standards case is the QWERTY typewriter keyboard (David, 1985). Studies include general case summaries (Hemenway, 1975; Kindleberger, 1983), broadcasting (Besen and Johnson,

57 Studies included are video cassette recorders, digital audio (compact disc and digital audio tape), personal computers, open systems, high definition television, and telepoint cordless telephone.

1986), quadraphonic sound systems (Postrel, 1990), AM and FM radio (Besen, 1992), AC/DC electric power supply (David, 1992), automated teller machines (ATM) (Saloner and Shepard, 1992), and microcomputer software (Cottrell, 1994). A useful collection of cases is given in Gabel (1987), which includes cases on AM stereo radio (Berg), color television (Pelkmans and Beuter), microcomputers (Hergert), petrol grades (Grant), bank charge cards (Phillips), and others.

Appendix 1: Standards and policy issues in the literature

Table 2. Class of Contribution for Administrators

Class of contribution	GDP in 10^9 ECU	Number of units
1	Up to 7	1
2	7 to 40	3
3	40 to 70	9
4	70 to 200	18
5	200 to 500	30
6	Above 500	45

The weighted vote for a full or associate member (firm) is determined by the magnitude of its European telecommunications related turnover (TTO). This is listed below.

Table 3. Class of Contribution for Members

Class of contribution	TTO in 10^9 ECU	Number of units
1	Up to 70	1
2	70 to 200	3
3	200 to 700	9
4	700 to 2000	18
5	2000 to 5000	30
6	Above 5000	45

Appendix 2

One. While the cdma2000 chip rate of 3.6864 Mcps is a multiple of the second generation CDMA chip rate (3 x 1.2288 Mcps), and therefore allows a smooth migration of CDMA systems currently being manufactured and deployed worldwide, the W-CDMA rate is incompatible with all second-generation systems hardware and appears to be arbitrary. The only reason for selecting a 4.096 Mcps rate, or even its so-called "compromise" 3.86 Mcps chip rate, is to prevent evolution from the current CDMA chip rate and gain market advantage for large European manufacturers who have a head start in developing chips employing this new rate.

Two. Because of its chip rate, W-CDMA fails one crucial aspect of the ITU's criteria for an acceptable 3G standard, i.e., the ability to permit second generation systems to evolve to accommodate new features such as very high data transmission and Internet browsing, thus reducing end costs to consumers. Not only does W-CDMA only utilize GSM-based network protocols that make it incompatible with networks used today by cdmaOne, but the WCDMA chip-rate prevents W-CDMA from operating as an overlay technology to cdmaOne. Provision for being an overlay technology greatly facilitates deployment of 3G in the United States, since US operators will be required to operate 3G systems in their existing second generation spectrum allocation. For this reason, other proposals, such as cdma2000, allow overlay.

Three. The W-CDMA rate permits fewer carriers in a given spectrum allocation than the rate included in other proposed standards; in a 20 MHz spectrum allocation, for example, cdma2000 can accommodate five carriers while W-CDMA can accommodate only four.

Four. W-CDMA, as opposed to cdma2000, will cause more interference between carriers; W-CDMA fails to provide for an adequate "guard band" between carrier signals sufficient to prevent interference with adjacent licensees, a provision included in cdma2000 for operating a 5 MHz spectrum allocations.

In short, a the higher WCMDA chip rate is more restrictive, in the sense that it functions to exclude other CDMA-based manufacturers from the market, at the expense of high-quality performance. The 3.6865 Mcps rate, by comparison, is less restrictive in that it maintains the highest quality performance and ensures compatibility with other CDMA-based systems, principally second generation cdmaOne.

Five. <u>Exclusionary SIM card requirement</u> – While virtually all digital wireless phones include a User Identity Module ("UIM") function associated with subscriber information and authentication, ETSI's W-CDMA standard mandates a specific method of fulfilling the UIM function: Subscriber Identity Module ("SIM") cards. Such a requirement is overly restrictive and exclusionary. To begin, mandating use of SIM cards directly violates the ITU's "Family of Systems" concept, which requires that any true 3G standard support *all* existing second-generation phones without interworking or, in other words, without dependence on hardware and software that inadequately adapt services of CDMA-based systems to services of GSM and vice-versa. Moreover, the "lock-in" feature of SIM cards, a UIM option used predominantly by European second-generation GSM systems, has already been investigated by the Commission under EC competition rules.[58] The Commission held that when used to "tie customers to a particular network, thus limiting competition," the SIM lock feature was contrary to EC competition rules.[59]

In addition, less restrictive alternatives exist. Elsewhere, non-card based UIM methods are widely in use, and new methods continue to be developed for future implementation. Operators should have the flexibility to choose, and therefore to maintain compatibility with second generation systems, as would be the case with a 3G standard based upon cdma2000. The only reason to have mandated SIM cards at the expense of non-card based methods in the new ETSI standard was to ensure that non-card based systems would remain incompatible with the ETSI standard.

Six. In addition to its idiosyncratic chip rate and SIM card requirements, W-CDMA includes a host of additional features that will needlessly increase the costs and difficulty of interfacing cdmaOne and cdma2000 technology with W-CDMA systems, including reliance upon asynchronous base station transmission systems, time-division multiplexed pilots, and adaptive multi-rate scheme for variable rate voice coding ("vocoding"). At the Commission's request, Qualcomm would be pleased to describe how each of these factors makes W-CDMA significantly more restrictive in terms of call quality, spectral efficiency, cost-effectiveness and compatibility with existing, second-generation technologies.

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58 See Response of Commissioner Van Miert to Written Question No. 2941/96 regarding regulation of conditional access and related technical services, 1997 OJ C 91.

59 Id.

Appendix 3

There were originally five proposals for UMTS at ETSI; W-CDMA, (OFDM), W-TDMA, ODMA., one for each of the five subcommittees of the SMG Committee established under ETSI. These were quickly narrowed down to two competing solutions:

- *Wideband Code Division Multiple Access* (W-CDMA): this started as four distinct proposals but the proponents of W-CDMA converged. This standard which excludes Qualcomm, emerged from subcommittee Alpha whose members included Ericsson, Nokia, NEC and Telia, and where the Chair and Secretary were from Ericsson and Nokia respectively and the Vice-Chair from NEC. DARK CONSPIRACY The main proponents of W-CDMA, Ericsson and Nokia, deliberately made their proposal compatible with a Japanese W-CDMA scheme developed by NTT DoCoMo. W-CDMA was backed by the GSM MoU association, reflecting the group's desire to include Japanese group NTT DoCoMo in the GSM community. This compatibility was done in secret, detailed below, but no compatibility with existing CDMA from QC was undertaken; instead W-CDMA is deliberately designed to differ significantly in key design areas so as to exclude Qualcomm's cdma-2000. These design features have little technical justification other than as exclusionary attempts to raise Qualcomm's costs.[60]
- *Time Division-Code Division Multiple Access* (TD-CDMA): This was supported by Alcatel, Motorola, Northern Telecom, Siemens and Sony. It is likely that such a hybrid approach would result in cheaper roll out for GSM network operators because GSM is based on TDMA. The hybrid is also spectrally efficient but it lacks the attraction of increasing the common market for equipment and increasing ease of roaming. TD-CDMA was backed by the UMTS forum.

Both proposals use the same part of the radio spectrum[61] and both should be able to deliver the data rate required by the ITU IMT 2000 framework of 144Kbps in fully mobile environments, 384 Kbps for pedestrian use and 2 Mbps for stationary use. In January 1998 ETSI, after failing to achieve the required 71% consensus vote,[62] decided on W-CDMA as the radio technology for the paired bands and TD-CDMA for the unpaired bands of UMTS. The specification will allow harmonization with the existing GSM systems by allowing frequency allocation in bands as small as 2.5MHz while also supporting broader allocations for full wideband fea-

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[60] Issues of the committee leadership, the accommodation of more than one standard within UMTS, and the exclusion of US proposals, are discussed further in Section 5.3.4.

[61] 1885 to 2025 MHz and 2110 to 2200 MHz as mandated for all third generation systems by the World Administrative Radio Conference of 1992.

[62] Features of the two technologies were integrated when neither attracted enough support. Under ETSI rules, a 71% majority is required to endorse technical working procedures. W-CDMA obtained 61% of the vote and TD-CDMA obtained 39%

tures. ETSI proposed its solution for inclusion in the family of solutions that the ITU will consider.

The ETSI standard of NTT DoCoMo of Japan, who themselves have pursued the W-CDMA (although it is slightly different from the ETSI variant) and have stated as their objective their need to work with ETSI for a common standard. The W-CDMA proposal is backed by the Japanese Association of Radio Industries and Businesses (ARIB).

While actively seeking compatibility with the Japanese operators, and in fact reaching a compromise decision heavily influenced by the "Japanese factor", ETSI has, so far, refused to contemplate slowing down their own development project in order to accommodate backwards compatibility with cdmaOne/2000. It remains to be seen if the Qualcomm/Ericsson agreement will have any impact.

It is crucial to note that the proposed standard of ETSI basically joins two conflicting standards and leaves the issue of a single European standard open.[63] However, one essential point is clear, the W-CDMA/TD-CDMA proposal locks out cdma-2000.

63 See *Telecommunications Online*, June 1998.