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16. Abstract

In 1996, the U.S. and Mexico passed legislation to deregulate their telecommunications industries. In both countries, telecommunications deregulation dramatically changed the nature of the competitive relationships between telecommunications service and equipment providers, as well as changing the nature of the market in general. These changes will affect the development and use of individual telecommunications technologies, and will also affect the nature of public-private partnerships for the research, development, and deployment of Intelligent Transportation Systems (ITS), particularly at the U.S.-Mexico border.

Regulatory changes in the telecommunications sector will affect many of the technologies that form the foundation of ITS, and will also change the nature of the market for telecommunications services and equipment. This study explores in a non-technical fashion the major provisions of both Telecommunications Acts and how each may affect the research and eventual deployment of ITS at the national and state level. This study also specifically addresses how deployment of ITS in the U.S.-Mexico border region may be affected by the interaction of two simultaneously changing telecommunications markets.

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EFFECT OF TELECOMMUNICATIONS DEREGULATION ON THE DEPLOYMENT OF INTELLIGENT TRANSPORTATION SYSTEMS IN TEXAS AND AT THE TEXAS-MEXICO BORDER

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Research Project IB-01: Improve Transportation Efficiency in the U.S.-Mexico Border Area Through the Use of ITS

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CHAPTER 1: EXECUTIVE SUMMARY

CHALLENGE

In 1996, the U.S. and Mexico passed legislation to deregulate their telecommunications industries. In both countries, telecommunications deregulation dramatically changed the nature of the competitive relationships between telecommunications service and equipment providers, as well as changing the nature of the market in general. These changes will affect the development and use of individual telecommunications technologies, and will also affect the nature of public-private partnerships for the research, development, and deployment of Intelligent Transportation Systems (ITS), particularly at the U.S.-Mexico border.

OBJECTIVES

Regulatory changes in the telecommunications sector will affect many of the technologies that form the foundation of ITS, and will also change the nature of the market for telecommunications services and equipment. This study explores in a non-technical fashion the major provisions of both Telecommunications Acts and how each may affect the research and eventual deployment of ITS at the national and state level. This study also specifically addresses how deployment of ITS in the U.S.-Mexico border region may be affected by the interaction of two simultaneously changing telecommunications markets.

WHY IS TELECOMMUNICATIONS IMPORTANT?

As a result of the 1996 Act, long-distance and local telephone service providers can, in theory if not in practice, compete in each others' markets. Service providers are now competing to capture the biggest market area and market share. This has resulted in, among other things, service "bundling," huge mergers, and many important questions regarding the use and valuation of right-of-way.

Right-of-way along state highways has become an extremely valuable resource. Many state Departments of Transportation (DOTs), by entering into "shared resource" projects with private sector telecommunications providers, are trying to leverage this resource in an attempt to gain additional capacity for state-owned networks. Crucial issues for states when considering such partnerships are whether to lease or own this network, who to choose for a partner, and how to structure the partnership. Answers to these questions often depend on how much of the state network is (or will be) devoted to ITS. Complex, high-bandwidth ITS applications are expensive to design, build, and maintain, particularly over the long-term.

The push toward industrial privatization in Mexico has now reached the telecommunications sector. Mexico's 1995 telecommunications legislation concentrated on privatizing Telmex and introducing competition to the long-distance market. Currently, there are three major long-distance service competitors to Telmex (which is partnered with SBC). Each of these competitive entities incudes a major U.S.-based service provider — AT&T/GTE, MCI, and Bell Atlantic. The involvement of these firms may open the door for the eventual deployment of advanced telecommunications-based transportation technologies in Mexico, and could conceivably make it easier to install ITS systems at the border and in Mexico's interior to reduce congestion and facilitate trade.

CONCLUSIONS

It is clear that the U.S. in general, and each of its states in particular, will be affected by the new telecommunications legislation passed in the U.S.. U.S. states along the border with Mexico will also have to address the affect of the Mexican telecommunications reorganization and assess how it will impact their trade and communications with Mexico. It is abundantly clear that many of these effects are not yet known.

The Acts' effects on the development and deployment of ITS will also be hazy for the time being, partly because the impact of ITS in general has yet to be assessed, and partly because ITS systems have yet to be deployed and used on a widespread basis — especially at the border. However, it is reasonable to assume that the increasingly interdependent relationship between telecommunications and transportation, combined with the changing competitive atmosphere of the telecommunications industries in both the U.S. and Mexico, will have a marked effect on the development, deployment, and use of ITS in the U.S. and at the U.S.-Mexico border.

Wireline and wireless telecommunications systems are the keys to building a national ITS infrastructure. Although the 1996 Act opened the telecommunications industry to competition nationwide, and the FCC has issued benchmarks, guidelines, and rules for regulatory change, each state is free to issue its own rules and guidelines for interconnection. Some state public utility commissions (PUC's) have been more aggressive than others in setting these rates and rules. State officials should consider it their responsibility to respond proactively to the changes the new telecommunications legislation will bring. They should develop strategies to take advantage of new opportunities and to ensure that they are not adversely affected by the mergers and alliances that are the apparent by-product of the legislation. They should ensure that their state's telecommunications sector is developed to support long-term economic plans.

State Utility Commissions and state DOTs are pivotal in this respect. State Utility Commissions will set the tone for how each state will address telecommunications competition by regulating how it will occur, and how much it will cost. DOTs must assess from a cost/benefit (or other) standpoint whether to lease or own the state network (or pieces of it), and attempt to decide on the nature of use and development of right-of-way. The speed at which these decisions are made is crucial to their success and usefulness.

DOTs in states located at the U.S. border with Mexico should also take into account the state's function as a major crossing point for U.S.-Mexico trade. Expediting and managing this trade, and its related transportation movements, is a telecommunications technology-intensive task heavily dependent on the commitment (both political and financial) of state DOTs to deploy ITS at border crossings. Long-range planning with Mexico is also particularly important when developing transportation-related infrastructure, of which telecommunications is an integral part.

In creating these strategies and policies for telecommunications, state agencies should seek the counsel, advice, and involvement of major service and technology providers, as well as transportation and telecommunications research organizations. By doing so, state agencies will find it easier to make the necessary changes to their operations and will be on their way toward creating a comprehensive and integrated telecommunications infrastructure conducive to meeting requirements for economic development in the future.

This study will show that certain issues will be important for federal, state and local governments, as well as the private sector, to track. When reading this study, there are a series of questions and issues to keep in mind. These issues include:

- The extent to which public-private partnerships have formed or not formed for the purpose of research and/or deployment of telecommunications based systems, such as ITS.

- The position and attitude each state takes with respect to telecommunications deregulation — which states are taking a pro-competition stance, which ones are not, and how each state is managing its responsibility to set the ground rules and interconnection fees for competition in the local market.

- The manner in which states are or are not attempting to pursue "shared resource" projects for right-of-way and for ITS with private telecommunications providers and whether or not each state's strategy (partnering or not partnering, and, if partnering, the structure of the partnership) has been successful. A related issue to watch is whether or not the window of opportunity for these projects is closing.

- The extent to which U.S. telecommunications providers' involvement in the Mexican long-distance market will or will not affect the deployment of ITS systems at the border and in the interior of Mexico.

CHAPTER 2: TELECOMMUNICATIONS AND INTELLIGENT TRANSPORTATION SYSTEMS

INTRODUCTION

In less than 150 years, the speed of transporting messages has leaped from the limits of the transportation system (10 to 50 miles per hour, including carrier pigeons and steam trains) to the speed of light (186,000 miles per second). Before the invention of the telegraph, it took days, even weeks, for messages to be exchanged. News actually did "travel," and the speed and efficiency of communication of any kind depended on the speed and efficiency of the means of transportation used. Modern telecommunications is, then, the application of technology to extend the distances and increase the speed by which humans can communicate without the necessity of travel.

The worlds of transportation and telecommunication are again beginning to converge as a consequence of advanced technology—the confluence of telecommunications and computers, in addition to analog technologies, which are steadily becoming more sophisticated. Fiber optic cables allow video monitoring of congested roadways, as well as the operation of changeable message signs to warn motorists of accidents or poor weather. Transponders, sensors, and similar devices on trucks and automobiles make use of analog radio waves to facilitate toll and tax payments, or indicate location and identity. These devices are often used in tandem with on-board computers using two-way satellite technologies to help truck drivers deliver their shipments. Modems (wireline and wireless) and PDAs (Personal Digital Assistants) facilitate the electronic transmission of data, especially over the Internet, and support the convenient use of real-time congestion information for commuters, EDI forms for businesses, and applications for telecommuters and businesspeople.

The rapid convergence and integration of new voice, video, sound, and data technologies, both analog and digital, wireline and wireless, has set off a wave of legislation designed to facilitate competition in the telecommunications industry with the hope that such competition will lead to the more widespread (and therefore less expensive) use of these technologies, as well as leading to some attempt at creating standards for software and equipment. The U.S. and Mexico have both recently overhauled their telecommunications regulations – the U.S. in February 1996 and Mexico in May 1995. These Acts have far-reaching implications for the future of a variety of technologies that form the foundation of Intelligent Transportation Systems (ITS).

Provisions in each Act will affect the direction of technological development in the telecommunications industry, and will also impact the rules governing competition and regulation between industry stakeholders. Changing competitive relationships between service, software, and hardware providers will affect the development and deployment of individual and bundled telecommunications technologies, and will also affect the nature of public-private partnerships for the research, development, and deployment of ITS. The potential for change in the telecommunications industry is vast, and of great interest to the agencies and individuals involved in transportation.

The push toward industrial privatization in Mexico, particularly in the case of petroleum and transportation, is also well underway in telecommunications. Implications for change will be similar to those in the United States. An understanding of these changes and what they mean is critical to the development of an effective telecommunications policy, not only between the United States and Mexico, but in this hemisphere in general. This understanding will also be critical to the negotiation of shared telecommunications services, and, therefore, to "seamless" transportation services, at the U.S.-Mexico border.

This study will attempt to address in a non-technical fashion some of the most important aspects of each Telecommunications Act, and will describe how technological and regulatory changes may affect the development and deployment of ITS in Texas and at the Texas-Mexico border.

INTELLIGENT TRANSPORTATION SYSTEMS (ITS)

Created in 1991 as part of the Intermodal Surface Transportation Act of 1991 (ISTEA), the Intelligent Transportation Systems (ITS) program is part of the U.S. government's effort to invest in advanced transportation technologies to improve highway travel and public transportation operations. Moving goods and people across towns, states, countries, and continents requires the transparent and relatively seamless connection of roadways, telecommunications technologies, and regulatory requirements. With this in mind, the ITS program encompasses a diverse set of objectives that include reducing congestion, increasing travel safety, increasing economic productivity, and safeguarding the environment [1]. Through the integration of advanced technologies, the ITS program strives to achieve these objectives.

To facilitate ITS research, testing and deployment, the U.S. Department of Transportation has grouped ITS technologies into major functional areas:

- **Commercial Vehicle Operations** (CVO) aims to facilitate interstate trucking by encouraging the use of electronic systems (such as computers and other advanced communications devices) as replacements for the paperwork required to comply with state and federal regulations. These ITS systems also include the use of weigh-in-motion technologies (i.e., weighing trucks at highway speeds instead of requiring trucks to stop at weigh stations), accident notification systems (particularly if hazardous materials are involved), tracking and messaging systems, and roadway monitoring systems to enhance safety.

- **Travel and Transportation Management** includes those systems designed to encourage the smooth and efficient flow of highway traffic, such as the timing of traffic control signals, real-time information about traffic and road conditions, and the removal of disabled vehicles and accidents from roadways.

- **Travel Demand Management** aims to reduce the number of trips made by single-occupancy vehicles, particularly in densely populated urban areas and during peak traffic periods, by providing information about the location, availability, and cost of mass transit services, ridesharing opportunities, and pretrip information on traffic conditions. In addition, traffic management centers, equipped with a variety of telecommunications, video, and other electronic equipment, are able to monitor local roadway traffic conditions in real time and respond quickly to congestion, emergency situations, and other events.

- **Public Transportation Operations** involve providing information to mass transit users so they may better plan their trips. These ITS operating systems also make it easier for public transportation officials to keep track of vehicle location and monitor ridership levels.

- **Electronic Payment** systems facilitate commercial and non-commercial travel by enabling travelers to pay for various fees, tolls, transit fares and/or parking through the use of "smart" cards, transponders, and similar devices.

- **Emergency Management** systems enable quick notification of authorities and prompt response in emergencies. These systems are particularly important when dealing with hazardous materials, or in situations where accidents may cause severe gridlock if not immediately cleared [1].

All of these ITS functional areas employ various telecommunications technologies. They range from basic radio signals, which can be used for travelers' information radio stations and the signals transmitted by transponders to receivers, to satellite systems, video transmissions over fiber optic lines, and sophisticated integrated systems in transportation management centers, which employ a wide variety of telecommunications technologies to facilitate traffic management.

Telecommunications technologies of various kinds play a large part in the effectiveness of ITS systems. When the regulations that govern these technologies change, it is important to assess how the ITS program and the plans for deployment of ITS technologies will be affected.

THE TELECOMMUNICATIONS INDUSTRY

Telecommunications Technologies

News of deals, partnerships, and alliances between telecommunications firms can be found every week, if not daily, in the business section of almost any major newspaper. Structural shifts in the industry are being caused by the combined effects of the 1996 Act and the rapid evolution and convergence of a variety of telecommunications technologies with advanced transportation management systems. To understand how telecommunications and transportation have converged, it would be helpful to have an understanding of the various types of telecommunications technologies that exist (for more detailed information on how telecommunications technologies work, please see Appendix E).

One of the many ways of breaking down the telecommunications industry into its component parts is to split it into four major categories: broadcasting, cable television, telephony, and computer networks. The telecommunications industry can also be further divided into wireline and wireless technologies and hardware. However, as phone companies begin to deliver video programming and/or Internet services, and cable companies provide phone service and wireless video, and all these firms are partnering with one another to offer a panoply of services from all four groups via wireline and/or wireless systems, these categorizations, although helpful on a descriptive level, are somewhat arbitrary.

Broadcasting (Video & Audio)	Cable Television (Wireline & Wireless)	Telephony (Wireline & Wireless)	Computer Networks (Wireline and Wireless)

The category of broadcasting includes video and audio programming delivered over the airwaves to televisions and radios within range of the radio signal. Therefore, broadcasting is a point to multi-point technology; that is, transmission of a signal is one way and travels from a single broadcaster to a large number of receivers. Because of the limited capacity and width of the electromagnetic spectrum available for broadcasting purposes, only a limited number of frequencies are used by broadcasters. To provide for the orderly allocation of these frequencies, the Federal Communications Commission (FCC) was granted the authority under the Telecommunications Act of 1934 to licence frequencies to broadcasters based on "public interest, convenience and necessity." [2]

Cable television has traditionally sent video programming as analog signals (similar to broadcasting signals) over coaxial cables. Similar to regular television broadcasting, cable television involves one-way transmission of a signal. But, whereas viewers of regular television broadcasts receive only what the broadcaster decides to broadcast, the cable subscriber can select programming packages so that he or she can view whatever broadcasts are desired. Currently, the average cable subscriber can view 75 or more channels of programming, but technology is rapidly moving toward the provision of more than 500 channels. With the use of wireless cable system technologies, however, programming limits imposed by coaxial cable capacity may soon become irrelevant.

Telephone technology, much like cable television, has traditionally been wireline-based, with voice conversations sent via analog signals through networks of copper wires linking individual homes and businesses. Switching technologies allow regional telephone companies to route millions of telephone calls to the proper recipients. Therefore, unlike cable and broadcasting, wireline telephones are designed for point-to-point, or interactive, communication. Telephone networks are separated into local and long-distance carriers. The regional telephone companies ("telcos") operate local networks within individual cities, and between cities and their suburbs. Long-distance telephone companies operate between cities, across the country, and internationally. Local telcos have traditionally used copper wire for their network transmissions; recently, however, many local telephone networks have upgraded to fiber optic cables. Fiber optic cables carry streams of digital information, rather than analog signals, at the speed of light (and hundreds of times faster than copper wire). Most long-distance telephone operators already use fiber optic networks [2].

Recent technological developments have pushed the telcos beyond the sphere of telephony. Fiber optic technology has enabled them to send video programming and data over phone lines. It differs from cable in that the video signal sent over the phone line goes to a single home and not to every television in the area (similar to pay-per-view). This bundling of services opens a vast new arena for partnering (or competition) between telephone companies and cable operators.

Wireless services are considered to be the future of telecommunications. They come in a variety of forms, including both analog and digital cellular telephony, private land mobile radio and enhanced specialized mobile radio, cellular digital packet data services (CDPD), personal communications services (PCS), radiopaging and two-way messaging, ARDIS (Advanced Radio Data Information Service), radio frequency and infrared WLANS (Wireless Local Area Networks), analog, digital, and specialized microwave relays, geostationary satellites, low-earth-orbit (LEO) satellites, and meteor burst technologies, to name a few (see Appendices A and B). Within the last few years, cellular telephony and other wireless communications services have outgrown their image as status symbols. No longer seen as a luxury, many individuals and government agencies regard wireless communication as a means to keep in touch with mobile employees, or to communicate information to a mobile public.

Rapid growth in the cellular sector brings both advantages and disadvantages for users. As the industry matures, its technological base is reaching beyond traditional voice services to new and untapped data and information markets, such as ITS. This rapid growth has brought falling prices (especially for data transmission) and expanded services.

Yet the competitive and crowded marketplace provides a potential user with a confusing array of choices. Options are rapidly increasing and, with them, new ways to accomplish old tasks. Also on the increase are problems arising from the rapid, and in many cases, built-in, obsolescence of many communication networks [3]. These problems will likely be exacerbated by the 1996 Act as competition in telecommunications services and hardware spurs rapid growth in the industry.

The fourth category of telecommunications technology includes computer networks and electronic information services. Accessing computer networks or the Internet simply requires a computer, a modem, and a telephone line. The user, via the modem, dials the "host" computer of the network or service, and can communicate and/or obtain information on the network. The modem translates the digital bit stream created by the sending computer into analog signals appropriate for telephone lines. Fiber optic cables, however, can carry larger streams of digitized information much faster than copper wire, which is a necessity if a user is, for example, viewing or sending graphics files, sound files, video files, or large amounts of data.

In the near future, electronic information network services and advanced television programming technologies (such as HDTV, or High-Definition Television) will, for the average user, remain in separate spheres. Eventually, a nationwide fiber optic network may carry virtually limitless television channels, home shopping, home banking, general information, video games, movies, and a vast array of commercial (business-related) activities. This "broadband communications network" will transmit information not in analog signals and waves, but in digital bits. Because of the increased capacity of fiber optic cables to carry this kind of information, the electronic world of the computer and the computer network has steadily become more important to the world of economics and commerce. As the importance of telecommunications to economic activity increases, the relationship of transportation to telecommunications will become stronger.

Telecommunications Hardware

Telecommunications hardware primarily consists of infrastructure and transmission equipment (such as copper or fiber optic cables) and customer premises equipment (such as the telephone, television, or computer). Further distinctions can be made between wireline and wireless equipment. The heart of wireline systems is the "switch, which routes messages from senders to receivers. Analog switching has given way to digital networks, resulting in better performance (relative to speed and reliability). Significantly, the conversion of analog to digital brings computers into the hardware picture, and the net result is the seamless integration of voice and data. Switching equipment and transmission equipment are directly related via the kind of cable being used — copper or fiber optic. Fiber optic cables are, however, more expensive to manufacture and install than copper lines [4].

Signals can be transmitted over landline cables as well as wireless systems. Because they are "wireless"systems, however, does not mean they use less or less expensive equipment. The infrastructure hardware for wireless systems employs both satellites and base-station switching, and for some cellular service providers, hundreds of microcell transmitters, or even satellite-based networks with worldwide reach and the capacity to transmit voice, data, and video [4].

Customer equipment can consist of telephones, televisions, radios, cable boxes, answering machines, modems, fax machines, pocket pagers, cellular phones, computers — anything the end-user must have to operate the technology. This equipment is often offered not just by major telephone companies, computer firms, or cable service providers, but by independent vendors as well. Equipment sales is a lucrative business, and the 1996 Act will have a significant effect on this area of the telecommunications industry as firms begin to diversify their core competencies and compete with one another. It may, in the future, make more sense for a company to develop proprietary systems and technologies, much like Microsoft — or it may not; there may be more incentive for firms to create hardware adaptable to a common set of system architecture standards.

Telecommunications Industry Stakeholders

Telecommunications industry stakeholders are many and varied. Briefly, they come from both the public and private sectors. In the public sector, stakeholders include (but are not limited to: the Federal Communications Commission (or FCC) on the federal level, State Public Utility Commissions and Departments of Transportation on the state level, Metropolitan Planning Organizations (MPO's) on the local level, and various university-based or government-funded research institutions involved with engineering research or public policy analysis concerning telecommunications

Private sector stakeholders include long distance companies such as AT&T, MCI, and Sprint, each of the regional Bell operating companies, the hundreds of companies that manufacture the hardware for telecommunications, the hundreds of thousands of individuals who consume telecommunications services and purchase related hardware, computer companies, and Internet access companies. Private transportation companies, shippers, customs brokers, third-party logistics providers are also included in this group.

CONCLUSION

Within the last decade, telecommunications has undergone revolutionary changes. Fiber optics have dramatically changed the nature and quality of telecommunications, and cellular telephony has moved from being an item only wealthy businesspeople and police or other emergency services personnel would use regularly to being a technology used by the masses. Fiber optics encouraged digitization of telecommunications and opened the door for multimedia applications. Cellular telephony has allowed individuals to become increasingly mobile without fear of losing touch, or losing business, and has encouraged the use of telecommunications in transportation. The computer has been a unifying technology, bringing, through digitization, the ability to transfer data and video, as well as voice, over both wireline and wireless systems at high speed. The ability to make data transfers and transmit video using telecommunications technologies that support voice has revolutionized transportation by allowing the creation of intelligent networks.

Stakeholders in the telecommunications and computer industries realize that any legislation affecting the development and marketing of these technologies, or the competitive environment in which these technologies and systems exist, will be significant in terms of financial impact and for long-term strategic planning. The impact of telecommunications is of great significance to both the private sector and the public sector. The future of telecommunications is important to public-sector stakeholders for a variety of reasons, not the least of which are issues of use and valuation of right-of-way, partnership arrangements, and whether or not to operate a private and separate telecommunications network. The next chapter will describe the most important provisions of the Telecommunications Act of 1996, and discuss several of its significant implications.

CHAPTER 3: THE TELECOMMUNICATIONS ACT OF 1996

PROVISIONS OF THE TELECOMMUNICATIONS ACT OF 1996

The 1996 Telecommunications Act will eventually affect almost every person in the United States who has a telephone (at work or at home), a television, a computer, a radio, or a job that uses any these technologies. The Act will affect businesses as well as schools. It will affect what you see, what you hear, how you see it, how you hear it, and how much you pay for it. It will affect the domestic economy and international trade. It will affect competition, industry standards, and to a certain extent, the nature and direction of certain kinds of infrastructure development and investment, transportation infrastructure and intelligent transportation systems in particular. It will also affect emerging trends, such as telecommuting and electronic commerce.

The combination of deregulation and new technology has revitalized the telecommunications market and caused many changes to occur. Long-distance providers, regional Bell companies, cable television operators, satellite operators, Internet service providers, digital wireless service providers, state Utility Commissions, and perhaps even your local power company all want to move in to each others' markets and market an entire array of services (usually linked). This chapter will explore some of the ways in which the 1996 Act may affect telecommunications.

Passed on February 8, 1996, the Telecommunications Act of 1996 (the "Act") is a far-reaching and broad piece of legislation that has already had an extensive impact on the future of telecommunications in the United States. The 1996 Act dramatically changed the ground rules for competition and regulation in virtually all sectors of the telecommunications industry, from local and long-distance telephone services, to cable television, broadcasting, and equipment manufacturing.

The first Telecommunications Act was passed in 1934, with the 1996 Act representing the first major overhaul of telecommunications legislation in 60 years. Regulatory modification was sorely needed, given the massive changes that have occurred in the telecommunications industry since 1934, particularly in the areas of wireless technology and computing, international commerce, and the global trend toward telecommunications privatization.

Since 1934, telecommunications policy has largely been set by the Federal Communications Commission (FCC), in concert with state public utility commissions ("PUCs"). In recent years, the federal courts have also become involved in telecommunications policymaking as a consequence of their effort to enforce the 1984 antitrust consent decree that dismantled the Bell System. These policymakers have consistently supported a variety of ownership and service restrictions to maintain and protect monopolies at state and federal levels.

With the 1996 Act, Congress made an effort to reassert its primacy in setting telecommunications policy and adopted "competition" as the basis for the future development of telecommunications in the United States; major steps were also taken by Congress to relax federal telecommunication regulations and ensure fair competition, especially in the long-distance telephone market.

The Act's provisions fall into five major areas:

- Telephone service
- Telecommunications Equipment Manufacturing
- Cable Television
- Radio and Television Broadcasting
- The Internet and On-line Computer Services

In each of these major areas, a variety of cross-market entry barriers are being eliminated, market/geographical concentration and merger rules relaxed, and new obligations placed on the FCC and state regulators, particularly in the area of monitoring "appropriate content" [5]. Briefly, long-distance and local telephone companies are now able to compete in each other's markets, and they can also offer video services over phone lines, competing directly with cable providers. Cable operators can now enter the telephone market, and the federal regulations governing cable rates will be gradually lifted. The Act relaxes limits on the number of television and radio stations a single company can own, and also requires television sets to be equipped with a "V-chip" to block violent programming. The bill also imposes criminal penalties for knowingly transmitting "indecent" material on the Internet [6]. Some of these provisions are currently being debated in U.S. courts, federal and local.

Many sections of the 1996 Act are self-executing, but in many cases, the FCC must first issue regulations that indicate the specifics by which many of the provisions should be carried out and the procedures and rules by which cable operators, state public utility commissions and others must operate in order to implement the regulatory changes the law demands. The Act does impose deadlines on the FCC for issuing these regulations, but it is not yet known whether the FCC will be able to meet all these deadlines [7].

Telephone Service: The Act overrules all state restrictions on competition in local and long-distance service. The Baby Bells will be able to offer long-distance services outside their regions immediately, and inside their regions once barriers to entry of other firms are removed. There will be continued subsidization of telephone service for rural and low-income subscribers under the "universal service" rules, and increased efforts to assist schools, libraries and other public institutions in acquiring more sophisticated telecommunications devices. The antitrust consent decrees are repealed, but their requirements for "equal access" to all long-distance carriers are maintained.

Telecommunications Equipment Manufacturing: The Baby Bells will be allowed to manufacture telephone equipment once the FCC approves their applications for out-of-region long-distance. There are also nondiscrimination requirements, restrictions on joint manufacturing ventures, restrictions on the role of Bellcore (the Baby Bells' research entity) in setting standards, and a requirement that the FCC create rules that would make telephone equipment accessible by people with disabilities.

Cable Television: The 1992 Cable Act, which restricted the operations of cable television, is substantially relaxed. Rate regulation requirements on all cable television services (except the "basic tier" that includes over-the-air channels and public/educational television programming) will be removed by March 1999. Telephone companies will be permitted to offer cable television services or carry video programming for other entities via "open video systems." As a consequence, pricing freedom will occur sooner for those cable television companies that face competition from local telephone companies offering "comparable" video services over telephone facilities. Cable systems in small communities can deregulate immediately. Like the regulations for television's "V-Chip," cable television operators will be required to scramble sexually explicit adult programming.

Radio and Television Broadcasting: The Act relaxes media concentration rules by now allowing single companies and single networks to own television stations that reach up to 35 percent of the nation's television-owning households (the current limit is 25 percent), and by requiring the FCC to consider changing other regulatory limits on television station ownership in individual communities. Television networks would be allowed to purchase and own cable television systems, but a network could not acquire another network. Similar to television, all restrictions on radio station ownership are repealed, but local limits are maintained (though in a more relaxed form). Television broadcasters would be allowed "spectrum flexibility" to use additional frequencies for hi-definition television and other purposes, but would have to return any unused spectrum allocated by the FCC and possibly be required to pay auction fees for the unused spectrum.

Lastly, television equipment manufacturers will be required to equip each new television with a "V-Chip" ("V" for violence) to allow parental blocking of violent, sexually explicit or "indecent" programming. Ratings boards would decide which shows receive a "violent" rating, unless the television industry decides to establish a voluntary ratings system. There is no mandate for broadcasters to broadcast/televise the signals used by the V-Chip to block programming.

The Internet and Online Computer Services: One of the most controversial sections of the Act is the subpart known as the "Communications Decency Act of 1996" (the "CDA"). The CDA imposes, among other things, criminal penalties for the "knowing" transmission of "indecent" material over the Internet, makes it a crime to create and send a computer transmission with the intent to "annoy or harass" the recipient (the "anti-flame rule") [5].

It is interesting to note that the 1996 Act does very little with respect to regulating competition and ownership of the Internet and its related hardware and software, or computers in general. This is not at all surprising given the confluence of telecommunications technologies that make it difficult to separate Internet technologies from their providers — the telephone companies. Because this media operates over telephone lines, any regulations that affect telephony will affect the Internet. Regulations that allow cable companies to provide Internet services will certainly affect the nature of the Internet, whether with respect to its cost, the other services with which it is bundled, the number of additional households that will now be able to have Internet access who never had it before, or the way we view the technology (on a television screen rather than on a computer screen).

IMPLICATIONS OF THE 1996 ACT

Service Bundling

We see the commercials on television. The long-distance telephone companies are providing customers with cellular service and Internet access in addition to standard (and advanced) telephone and messaging services. A local telecommunications provider is offering customers long-distance service, Internet access, cellular service, and paging. A cable company is offering wireless cable services that can bring 500 channels to your home and, via its coaxial cables, Internet access through your television set as well. These companies are taking advantage of the provisions in the 1996 Act that allow single communications companies to offer bundled services outside of their "core" activities at competitive prices. Home consumers and businesses are beginning to buy packages of services, or bundles, that include combinations of local, long-distance, wireless service, cable television service, Internet service, and perhaps even electricity and home monitoring services [8]. The ideal situation is for your service provider, perhaps in partnership with other service providers, to make it simpler for the consumer to use all these technologies by creating a "seamless" network for all kinds of telecommunications services and putting all service charges on one bill [9].

It is hoped that this kind of bundling, combined with the ability to cross over into a variety of telecommunications markets, will work to keep prices low and competitive for individual users. Service providers hope that bundled services will help attract "lifetime" customers by providing all the competitively-priced, technologically-advanced services a customer could want in a "one-stop-shopping" format. Service providers also hope that bundling will maximize revenues as customers use more of their services. For example, the most immediate target for the service providers is the "power user," another name for the upscale professional who can easily bill $300 or more per month in telephone, cable, Internet, cellular, and other communications charges. The profits will go to the carriers that have the maximum number of services in their bundle, and market this bundle to the users with the most money to spend. This is a profound change from the standard telecommunications scenario in which a service provider sells individual services to all its customers, to a scenario in which the provider targets certain high-end users for a package of broad services that may be discounted but is often way beyond what the average user intends to pay on a monthly basis [9].

It may also mean that the individual consumer will have to spend an immense amount of time trying to tell the difference between companies, their "bundles," what these "bundles" cost, and how much they will use each of the components — similar to the confusion consumers continue to experience when deciding on a long-distance carrier.

It is clear that competition through "bundling" will push long distance carriers, wireless carriers, cable television operators, computer companies, and others, such as hardware and software firms, to forge alliances in order to remain viable because the success of the bundling concept depends on how many users are in the market and how big the market is [8]. This often means trying to create partnerships with providers in contiguous geographical areas — to avoid interconnection costs associated with using the lines of a competitor.

It is unclear who will be the winners and losers in this environment filled with new partnerships for expanded services and expanded coverage areas. What will happen to those firms who cannot partner? What if "bundling," in the long-term, is an unsuccessful strategy that turns out only to have frustrated the average consumer?

Another issue to point out is that the large long-distance companies have been aggressively competing amongst themselves for years. They have more extensive marketing experience than the Bells, and have nationwide customer service and billing systems. The Bells, on the other hand, argue that they are closer to the customer than the long-distance competition and should succeed, at the very least, in expanding their penetration into markets they presently serve and also because, simply, they own the lines that go into almost every home and business in America [8]. This is one of the reasons the issue of interconnection fees is such a contentious one.

The Bells also argue that they have an advantage because almost 40 percent of all revenue taken in by the long-distance carriers comes from calls that originate and have their ultimate destination within a single Bell's operating territory. This fact, they say, provides them with significant advantages when expanding into the long-distance markets [10].

Bundling will not come easy. Before they will be allowed to sell long-distance services within their regions, for example, the Bells must satisfy a 14-point checklist proving to the FCC that sufficient competition exists in their local markets. Meanwhile, AT&T is already arguing with several Bells about the terms of the interconnection agreements to their local networks, suggesting that the Bells are attempting to hinder access to local markets and preserve their local monopolies. The Bells retort that they are further hobbled by federal rules that require them to maintain a three-year "arms-length" relationship with their long-distance units — meaning that a parent Bell could not supply its own long-distance unit with marketing information on customers unless it makes that information simultaneously available to other rivals, and meaning that the parent Bell cannot provide the unit with equipment discounts or marketing services. Yet, despite (or because of) these difficulties, the Bells have devised a strategy — partnering [10].

Partnering and Alliances

The notion of partnering and alliances between telecommunications service providers is the flip side of the telecommunications competition and bundling coin. If competition theoretically allows smaller companies to get into the markets that have historically been the dominion of the giant telecom corporations, competition also paradoxically encourages huge telecommunications mergers.

Bell Atlantic and NYNEX announced their $23 billion merger (the second-largest merger deal in U.S. history) in April 1996, creating a giant service area connecting 37 million phone lines in a 13-state region spanning from Maine to North Carolina — with a high percentage of these phone lines going to businesses. An estimated 20 percent of all long-distance calls placed by customers in the NYNEX region also end in the region; for Bell Atlantic the figure is estimated at 45 percent. It is also estimated that around 30 percent of the entire nation's total of $14 billion in international calls originates in their combined territory. The new combined entity will now be able to offer customers, particularly corporate clients, "one-stop" service including long-distance, local, video, and wireless with discounts to customers bundling two or more of these together. The new entity should also be better able to match price discounts by other long-distance companies and cable providers, which will by law now be able to enter the local markets [11].

Also in April 1996, SBC Communications (the parent company of Southwestern Bell) agreed to purchase Pacific Telesis Group for $16.7 billion. This deal unites the two phone companies serving the nation's two most populous states, California and Texas, and creates a potential customer base estimated at 25 million [12]. This deal created the nation's second largest telecommunications company in terms of market value. The merger's strength seems to reside in international marketing capabilities. More than half of all U.S. phone traffic to Mexico originates in the SBC-PacTel combined territory, mostly due to large populations of Hispanics in both service areas. In addition, SBC owns a stake in Teléfonos de Mexico, the Mexican national telephone company [10].

The logic of these mergers is partly based on simple geography. Bundling, to be effective, requires geographic economies of scale —not only because of market size, but because the more adjacent territory one entity controls, the less cost is involved in providing service in that area. The mergers are also partly based on the need to add value to existing networks. Bell Atlantic, for example, has a huge network covering Washington, D.C. and nearby states, and reaches virtually 100 percent of all homes in its area; these homes make and receive 99 percent of all telephone calls made in the area. A newcomer certainly might be able to sell its telephone service at lower rates than Bell Atlantic, but its customers would be unable to make any telephone calls to Bell Atlantic customers. The customer would want the new firm to be able to connect to households and businesses with Bell Atlantic lines. Odds are the new firm is not going to want to rewire, so Bell Atlantic will have to share its lines. If Bell Atlantic is going to share its lines, it makes business sense to partner with potential competition, and, by doing so, add value to the existing network.

Under the 1996 Act, a local telecommunications provider like Bell Atlantic will be compensated for having to share its lines by being allowed to enter the lucrative long-distance market. But Bell Atlantic, even with its new service partner, is not in the position to rewire the entire nation. The Act, therefore, allows Bell Atlantic to use the existing long-distance lines, and compensates the long-distance providers by allowing them, in turn, to enter the local service markets from which they have been barred for the past ten years [13].

The 1996 Act left responsibility for the regulation of these activities to the FCC. As of April, the FCC had just begun to issue the first of many regulations governing the entry of long-distance carriers and others into the local telecommunications markets. The Bells argued against these uniform federal rules, claiming that the main responsibility to oversee the opening of the local telecommunications markets should be with state regulators and under the purview of state rules, so that states may retain the flexibility to decide what is in their individual best interests and operating environment. Long-distance carriers such as AT&T and MCI, however, favored detailed rules and regulations that leave local operators with less room to negotiate a competitor's entry into the local market [14].

The business impact is unclear, with billions of dollars at stake. As of August 1996, a local telephone company and a prospective competitor have 135 days to negotiate the entry of that competitor into the local market, and these entities may voluntarily agree to specific terms and conditions not contained in the FCC's rules. If no agreement can be reached, the matter goes to arbitration. The nationwide rules would serve as a benchmark for the arbitration process. The FCC believes uniform national rules governing entry of new competition into local markets will make it easier and cheaper for long-distance carriers, cable operators, and even utilities to move into the local markets and attract capital by reducing possible delays in arbitration. The FCC also notes that more than 30 states do not even have rules governing local competition in utilities [14].

It is important to note, however, that there are technically only three ways a competitor can enter the local market — through full facilities-based entry (i.e., creating its own local network), purchasing unbundled network elements from the local carrier, and reselling the incumbent local telco's services. The FCC has indicated certain minimum points of interconnection necessary to permit competing carriers to operate efficiently, and has also set guidelines on a minimum list of unbundled services that incumbent local telcos must make available to new entrants upon request. Included in this list are the "local loops" that extend from Bell switching centers to customers' homes and businesses, as well as the Bells' directory assistance operations, both of which have been jealously guarded since the breakup of AT&T.

Meanwhile, the FCC is also in the process of deciding on other contentious issues, such as the price long-distance operators should pay local telcos for access to and use of certain technologies and services that local telcos provide (interconnections agreements). Under the 1996 Act, local telcos must open their networks to competitors who need to use these networks to complete their services; local telcos are expected to charge competitors for use of certain network services, which can include use of the entire network ("resale"), or elements of the network ("un-bundling"). The FCC finalized its decisions on many of these issues in August, 1996 — and there are already court challenges to these rules by the long-distance operators and the Bells [14].

FCC "Rules of Engagement" for Deregulation of Local Service

The FCC issues regulations in August 1996 to establish minimum benchmarks for how and at what prices competitors may plug into the Bells' local telephone network — an engineering feat that has taken the Bells more than a century and well over $100 billion to construct.

Most of the objections center around the FCC's interconnection pricing guidelines, designed to give competitors access to local networks at discounted prices. The FCC has ordered the Bells to sell their local services at a 17 to 25 percent discount off retail rates; the Bells argued that 5 to 10 percent would be more reasonable since the costs to interconnect are higher than the FCC estimated. The Bells, however, are still hoping that they can persuade state utility regulators to go lower than the recommended 17 to 25 percent discount. States may approve these smaller discounts provided they conduct extensive cost analyses to show that the lower rates are warranted.

One of the Bells, Pacific Telesis, already is facing a problem. California state regulators said that PacTel could resell its residential lines to rivals at a 10 percent discount of its retail rates — an amount much lower than the FCC's recommended minimum 17 percent. Though federal rules typically supersede state directives, PacTel is asking the state's regulators to stand by the 10 percent figure [15].

The Bells are also challenging the FCC's directive to provide network components on an "a la carte" basis — they have historically resisted unbundling these components to make them available to competitors, citing that they were unique assets, and expensive to maintain. In addition, they are challenging the provision requiring them to allow long-distance and cellular competitors to avoid paying access charges to have their calls completed; these charges add up to almost $25 billion a year and, for many states, help to subsidize universal service goals. But the Bells fear that if they do charge these fees, competitors could simply install their own switches and then lease local loops by themselves. MCI, for example, intends to have almost 24 of these new switches in place by year's end [15].

New FCC Regulations and the State of Texas

Despite the more than 700 pages of FCC regulations and instructions on the process of deregulation and interconnection, states have wide latitude in executing these directives. For Texas utility commissioners, there is the added task of balancing the demands of federal regulations that aggressively promote telecommunications competition with the requirements of a state telecommunications deregulation law widely believed to be the most anti-competitive in the United States (California's is seen to be one of the most competition-friendly).

Texas, the second-largest telephone market in the U.S., is considered to be the toughest on potential competitors, and critics insist that the state legislature has tilted the playing field to the advantage of existing local providers such as SBC. Among other things, Texas law requires the "Big Three" long-distance providers to construct their own networks instead of allowing them to resell Bell service, essentially delaying the entry of SBC's strongest potential rivals. It also requires companies that need to use parts of the local network in Texas to pay per minute charges, rather than a flat rate, the most common way to charge customers who want to interconnect. However, some of the Texas utility commissioners have been willing to push the Texas law to its limits (and some would say past them) by taking advantage of a variety of loopholes in the legislation [16].

Communications carriers will now be challenged to find new markets and services that are capable of generating enough revenue to make up for potential losses — at the same time new entrants will be charged with devising and implementing plans to provide high-quality services at competitive prices in order to obtain enough market share to remain in business [8]. Not surprisingly, costs will also become the central focus of firms in the telecommunications field. As telecommunications service providers begin to partner up, regulators and competitors will demand that charges for interconnecting to their networks and lines be fair; in order to assess the fairness of the charges, the relevant costs for services, hardware, and equipment must be defined.

In addition, telephone companies must now be able to define their costs for specific services, both within organizational and administrative units and within geographic areas, to compete effectively for each consumer who now has a choice of provider. Defining these kinds of costs, from either perspective, is complicated and may also prove to be contentious as well. There will, no doubt, be many debates about the accuracy of cost assessments by regulators, customers, would-be competitors, and existing service providers [8].

Paradoxically, this process of deregulation may pave the way for government involvement in the telecommunications industry. When you have mergers of this scale on a national level, and issues over line-sharing and competition on a local level, there needs to be a referee. The federal government may wind up playing that role [6].

Technological Advancement

Another effect of the Act could be a dramatic increase in the use of wireless telephony and related services (cellular, paging, wireless cable), as well as the Internet — which can now be accessed over wireline or wireless systems (using CDPD). Over the past five years the wireless telecommunications industry has seen dramatic changes all over the world; in the United States, cellular subscriber growth rates in some areas have soared to 40 and 50 percent. Also, more businesses are taking advantage of wireless services to provide clients better service at lower cost — by allowing employees to contact them and be contacted by them from anywhere — and by allowing more employees to telecommute. For these reasons, wireless services comprise an increasingly large part of many business engineering solutions [6].

The popularity of wireless telephony for personal and business use, however, has led to a "shortage" of available spectrum, which in turn has led to the creation of a wireless infrastructure that uses new PCS radio frequencies. These new frequencies were auctioned off by the FCC in 1995 for $8 billion, and the availability of new spectrum capacity will further encourage the use of wireless devices. However, smaller companies have been left out of the competitive bidding process, largely because of the vast sums of money involved. The government is attempting to diversify the ownership of this communications infrastructure by auctioning off additional spectrum to smaller companies [6]. The explosive growth of wireless, combined with the big push to install fiber optic cable, has led to the increase in importance of public rights-of-way. This issue will be explored in more detail in Chapter 4.

Also, the ability of telecommunications service and hardware providers to move into markets previously off limits may encourage firms to begin investing in research and development for areas that are new to the firm. Local telcos, for example, can now apply their expertise in this type of service delivery and infrastructure to projects that cover a wider distance. Long-distance firms, now able to move into the local markets, may try to parlay their experience into new ventures that are smaller in scope. What is almost certain is that technology and service delivery will advance as each type of provider attempts to win over customers in new markets.

Consider the choices to be made in the near future over how much of our national telecommunications network will remain wireline, or go wireless. As more homes and businesses desire Internet access, will telecommunications companies want to or be able to convert copper lines to fiber optic to facilitate higher transmission speeds and bandwidth requirements necessary for multimedia applications? How much will a telecommunications service provider be willing to spend to convert copper wires to fiber optics in order to transmit more data at higher speeds? How will universal service goals be met? How much land and infrastructure will the public tolerate being retrofitted for fiber optics in order to manage the bandwidth requirements of the Internet and other advanced technologies?

As telecommunications, computer technology, commerce, and transportation converge, who will be responsible for creating the single architecture which will enable these systems to talk to one another? And, although there are national and international standards organizations attempting to figure out the specifications for a national information infrastructure, is technology, spurred on by competition, outpacing the ability of the standards organizations to guide technological development? The 1996 Act has no immediate answers to these questions. The job has been left to the FCC; ultimately, then, whether this legislation will be successful or not in large part depends on the ability of the FCC to successfully implement the various rules set out in the 1996 Act within the designated time frame and with the support of both the public sector and the private sector.

CHAPTER 4: IMPACTS OF THE 1996 ACT ON ITS

INTRODUCTION

A fundamental and potentially costly component of the ITS architecture is telecommunications technology. The 1996 Act, by changing the competitive and regulatory atmosphere in which telecommunications technologies and systems exist, will not only affect the development of standards for equipment and service provision, but also influence the choice of technology and service provider. These choices, combined with the effect of "bundling" and partnering, will mean that the costs of this critical component of ITS will vary more than in the past, and become a more complex facet of transportation systems planning and traffic management. Informed decision-making is imperative.

The proliferation of telecommunications and computer technologies, combined with increasing user acceptance and larger geographic coverage areas has created a situation in which system development standards need to be set. These standards, which form the basic requirements for interaction between components of the ITS architecture, can encourage wider and more efficient use of ITS. The choices that individual users and public sector agencies make when deciding which technologies to use and how to make them fit together are significant. Choices made with a short-term rather than long-term outlook, can be politically and financially detrimental.

There are many ways telecommunications technologies in support of ITS can be grouped and used together. Some telecommunications technologies are more appropriate for use in specific ITS situations than others, depending on the nature and purpose of the interaction between the driver, the vehicle and the infrastructure. ITS National Architecture documentation, developed by the U.S. DOT's Joint Program Office (JPO) has developed several guidelines for state and local agencies venturing into ITS research and deployment.

The National Architecture (NA) program has put forth a number of recommendations on how a Department of Transportation would tie together users and services by employing a single advanced telecommunications network. Although the NA does not recommend specific technologies for a particular ITS activity or component, it does recommend appropriate interfaces between the various elements of ITS and outlines the options available for the three basic ITS communications media: wireline, wireless, and vehicle-to-roadside. The NA guidelines also provide a list of standards, some for telecommunications applications, that are considered vital to ITS deployment [17]. This chapter will briefly describe the various ways in which telecommunications technologies fit into the ITS architecture, and will then describe some of the situations in which the 1996 Act may affect ITS system deployment and the development of the NA.

TELECOMMUNICATIONS TECHNOLOGIES IN SUPPORT OF ITS

The telecommunications technologies that support ITS generally function as transmitters of the data that make intelligent transportation systems "intelligent." This data can be in the form of an electronic transmission, can be sound or video, can be in analog or digital form, and can be transmitted using wireline or wireless communications devices and receivers. However, it is clear that telecommunications devices are necessary for the efficient transmission of information between fixed elements of ITS, between fixed and mobile elements of ITS, and/or between mobile elements of ITS. Conceptually speaking, telecommunications systems can provide for ease of data transfer in the following ITS situations:

Centralized processing systems, in which users can receive and sometimes ask for general transportation-related information (advisory information, directions, congestion levels, etc.,) from one single, centralized source;

Distributed processing systems, in which users receive this information from way-side systems, such as roadside travelers' information kiosks.

Autonomous processing, in which users receive data on a personal unit, such as an in-cab hand-held computer unit.

OR
A combination of these alternatives.

Any telecommunications technologies employed in ITS, used singly or in an integrated system, are usually designed to provide economical and high-integrity service as the system expands. In addition, they should be able to operate in a manner that provides for low interference from other users [18]. These requirements form the basis for the development of a system architecture in which various technologies are designed specifically to work with each other and thereby facilitate the creation of systems. Creating an "architecture" is no simple matter. It often involves, at its most basic, the development of a system of definition and classification of technologies and equipment. The basic classification for communications infrastructure to support ITS, as proposed by the Organization for Economic Cooperation and Development (OECD), includes four classes of infrastructure, separated according to whether the in-vehicle unit is reached via a "localcast" or "broadcast," and whether the link is one-way (outbound only) or two-way.

A "localcast" indicates a situation where a vehicle would interact with the communications device only when passing it, as in the case of a transmitter or beacon. A "broadcast," or "areacast," indicates a situation where there can be continuous or on-demand interaction between the vehicle and the device. An example of this would be conventional mobile radio where a net of vehicles communicates to a base station, as with cellular telephony. In general, broadcasts result in the least costly infrastructure, but are relatively limited in overall capacity due to the limited amount of spectrum available. Communications networks and ITS systems built on localcasts have a more costly fixed-point infrastructure but have more potential capacity since transmitters can re-use frequencies due to limited geographical coverage of the beacon or transmitter. In a separate class are communications devices that connect vehicles to other vehicles, such as those that transmit a signal from a crashed vehicle warning approaching drivers [19].

Communications techniques that employ any of the four classes described above usually occur in one of two categories: techniques in which the ITS technologies, systems and related infrastructure would share communications infrastructure with other non-ITS applications (as with cellular telephony), such that a public or private agency would presumably pay a fee to a communications provider for the use of shared facilities; and technologies, systems, and infrastructure dedicated exclusively to ITS, presumably under the ownership and control of either a public governmental body such as a department of transportation, or a private agency [19].

Typically, retrofitting or adding on to already existing infrastructure is the easiest and most cost effective in the short run. New construction (owned by the state, municipality, or locality) can usually be justified when long-range costs and/or operational responsibilities for providing ITS and tailoring these systems to the needs of the locality warrant its choice over the lease/use of investor-owned facilities. Along with the economic choices influencing the development of communications architectures for ITS, there are also two "paradigms" for development direction. One is a market- or consumer-driven paradigm, where the decisions regarding whether, when, and how to develop certain ITS systems are made by market forces. This paradigm usually exists where the private benefits of the technology or system outweigh the public benefits, as with driver navigation technologies. The other paradigm is one in which government decisions govern how and in what direction the ITS system develops. Usually this paradigm takes the form of a mandate, and exists where societal benefits outweigh individual benefits, as with safety systems and many kinds of transportation management technologies.

It is also important to note that certain telecommunications technologies are more appropriate for use in specific kinds of ITS situations. For example, with interconnected, short-range ITS systems, wireline, fiber optic, or microwave technologies perform best. For extended-range systems, in addition to the above technologies (depending on the range), FM broadcast, digital cellular, and similar technologies are also appropriate.

However, spectrum in these frequencies is becoming scarce, and expensive, limiting, in many cases, the cost-effectiveness of these technologies. For wide-area systems, the most effective telecommunications technology is via satellite [18].

The situation, however, is considerably more complicated for systems that cover a variety of ranges, or have varying requirements for data transmittal. For example, low data-transmittal rates, although usually not capable of supporting many ITS applications, can be useful for the broadcast of general traveler advisory information. Medium data-transmittal rates are better suited to ITS applications, especially over extended area systems, but these rates may prove inadequate if there are a large number of users within the coverage area. High and very high transmittal rates have the capacity to support most advanced ITS applications, but are costly and technologically more complex [18].

Certain telecommunications technologies are, then, more (or less) appropriate to different ITS systems depending on the nature or purpose of the ITS system and the geographical area it covers. When speaking of system development, the purchase of technology, and the creation of partnerships for research, development and deployment of ITS systems, a Department of Transportation must be able to make these choices and decisions. Current fiscal difficulties in many localities indicate that, wherever possible, market-driven paths should be pursued to make investments worthwhile and purposeful. At other times, economies of scale and issues of equity or ethics dictate that an ITS system be developed and financed using a government-driven path [19].

The final ITS product or system will often be a combination of the two approaches; market pull and near-term economic implications will necessitate the creation of systems with consumer demand and future growth capability. Consumer demand is important because consumers will be paying for ITS user services—whether they purchase a technology or system for private use or they pay for a system through their taxes. Also, near-term implementation is desired in most cases to maintain public enthusiasm and support. The key is to create a flexible architecture and offer a variety of private end-user products, from low end to high end systems, along with public-oriented systems that complement each other and provide for future growth. Public-private partnerships in communications can help to create this "evolutionary" architecture [20]. As the competitive and regulatory atmosphere of the telecommunications industry changes, however, these kinds of partnerships and the ITS products or systems they produce will become more complex.

THE TELECOMMUNICATIONS ACT OF 1996 AND ITS IN THE STATE OF TEXAS

The divestiture of AT&T in the mid-1980's opened new options for states in their regulation of telecommunications. Among other things, the divestiture encouraged states to examine their telecommunications networks and related services, as well as to reconsider (or consider for the first time) how telecommunications would impact economic development within the state. In the midst of the activity caused by these new competitive pressures that were left to the states to sort out, states were forced to think more closely about the nature of their telecommunications use, the costs associated with use (local and long-distance rates, for example), and the costs/benefits of modernization. States also began to understand how telecommunications could be an investment that would promote economic development. What was once a relatively unnoticed utility began to get additional state-level attention.

In the early 1990s, states concentrated on creating incentives for local telecommunications service providers to invest in telecommunications infrastructure in return for a more flexible profit structure. Many of the phone companies seeking increased deregulation supported it based on economic development terms rather than on regulatory ("freedom to compete") terms. Although the battle was waged on a state-by-state basis, each state in turn began to see the potential for economic development latent in a deregulated in-state telecommunications sector [21].

Once states could choose between telecommunications providers, they also needed to make important decisions about current and anticipated telecommunications needs and facilities, as well as the role envisioned for telecommunications within the state. The growing importance of telecommunications in government, defense, and most importantly, the global marketplace, has made states key players in national commerce.

States vary widely, however, in their approach to telecommunications regulation, with some being quite flexible and others having highly complex regulatory frameworks. Regardless of the level of regulatory flexibility, states, in partnership with their public utility commissions, must plan their telecommunications infrastructure and service requirements and ensure that these requirements actively support short- and long-term economic goals. It is important for states to understand the implications of new telecommunications legislation and attempt to analyze how it will affect them and their economic future.

The decisions made by the state of Texas in the next few years regarding its telecommunications infrastructure are extremely important. Increased trade with Mexico, combined with an ever-increasing population places Texas squarely in the center of a variety of telecommunications and transportation issues. Because TxDOT controls much of the available right-of-way in the state, and also owns/operates its own telecommunications network, it must make telecommunications choices wisely.

Texas cities with Transportation Management Centers (TMCs), such as Houston and San Antonio, have a big stake in the outcome of the decisions TxDOT makes with regard to telecommunications standards and equipment, provision of right-of-way, choice of provider (for shared resource projects or interconnections), and levels of technological advancement (which come at a cost). Laredo, Brownsville, and El Paso, are prime targets for the deployment of a variety of ITS technologies that support international trade and facilitate/manage national commercial traffic such as the North American Trade Automation Prototype (or NATAP), as well as those that are state- and city-oriented. The state of Texas must be ready to meet these telecommunications challenges, and do so in a way that encourages economic development in the state and facilitates cooperation with other states whose traffic moves through Texas.

For example, the state of Texas must make decisions on many of these questions:

- Which telecommunications equipment and standards will the state choose for its network?

- What will be TxDOT's policy on leasing or selling rights-of-way for cellular transmitter towers, or fiber optic cable?

- Will TxDOT continue to operate its own network, or will it decide to partner with a telecommunications service provider in the future?

- How will wireless technologies impact the achievement of universal service goals within the state? (Will individuals in rural communities be able to obtain cellular phone service, 500 channels of cable programming, and Internet access through a satellite dish they purchased from a national cable operator, but not be able to make a telephone call to their neighbor because they don't have a wireline telephone and their neighbor is too poor to obtain wireless services?)

The decisions that Texas makes with respect to telecommunications will impact it well into the next century, and the role of TxDOT in these decisions will increase dramatically as it will be forced to make important choices regarding its network and the use/valuation of state right-of way. In addition, the commitment of the state of Texas to ITS technologies and their deployment indicates that TxDOT will most certainly be playing a greater role in telecommunications decisions in the coming years.

Partnering and Competition

TxDOT operates its own telecommunications network to support its activities, particularly ITS activities. Like many departments of transportation across the U.S., TxDOT has built, operated and maintained its own statewide network along state right-of-way. Texas cities, however, are free to make their own arrangements for certain types of telecommunications infrastructure and services related to city operations (such as the telecommunications infrastructure related to traffic signal timing or the tracking and routing of city buses).

As telecommunications technologies and services become more expensive and complex, TxDOT may be reaching a point where the ITS network is becoming prohibitively expensive to construct and maintain without a private sector partner. In addition, the network could become so complex that TxDOT would need to avoid becoming a "utility provider" under law.

Virtually all wireline and wireless services related to the transmissions to or from the TMC's are performed by TxDOT via TxDOT-owned equipment on state right-of-way. This arrangement may change in the future as the telecommunications software and hardware needs for TMC's become more complex and additional telecommunications capacity (such as bandwidth between cities) is required [22]. Should TxDOT seek private-sector telecommunications service providers as partners to boost state network capacity? Will different communications routes be served by different service providers and, if so, what are the implications for this kind of arrangement politically and financially? Will TxDOT impose some regulations on rates, fees, and cost for service on all operators wishing to do business with the state, or choose providers on the basis of competitive bidding (assuming all providers have access to all local wireline infrastructure, which may or may not be the case)? These and other questions indicate a difficult road ahead for TxDOT in defining the role it may be required to play in the future development of the telecommunications infrastructure in the state of Texas.

For many states, these difficulties are compounded by the apparent disinterest (or at least lack of cooperation) on the part of many private telecommunications service providers in assisting with the development, deployment, and operation of various ITS activities. The ITS National Architecture was developed almost exclusively by a combination of transportation and defense industry expertise. With ITS activity so dependent on telecommunications, the lack of involvement by telecommunications firms is troublesome.

In an interview with William S. Jones, the Technical Director at the U.S. DOT's ITS Joint Program Office, in the August/September issues of *COMtrans* magazine, Jones explained that the U.S. DOT was disappointed in the general level of participation in ITS development by the telecommunications industry, and getting these firms to participate has been a "hard sell" in many cases. "'When you talk to the 'old hands' in the traffic engineering business there is no love lost between them and the telephone companies. The traffic community [has been] captive to them, in a monopoly situation...One of my major objectives is to try to convince the traffic community that times have changed. [Because of the 1996 Telecommunications Act] there is now a lot of competition in the telecommunications industry...all the providers...have adopted a new attitude towards customers and service'." [17].

In a meeting between the JPO and representatives of each of the seven regional Bells early in 1996, Jones indicated that the Bells had split into two categories regarding their role in ITS and their anticipated relationship with transportation officials. "'There are a couple [of telephone companies] who see [ITS] as a major new business opportunity and are pursuing it aggressively, for example Southwestern Bell and Bell Atlantic. They are meeting with transportation officials and trying to keep up with what's going on...Southwestern Bell [out West] has gone so far as to conduct one-to-one telecommunications classes for transportation officials. They realize that their customers are not experts in this field and it's very difficult to sell to an uninformed customer especially one that may be biased against you because of past history...Interest falls off dramatically after those two [companies]. Reactions range from 'Let's wait and see if there's really a market here' to 'There is no market'"." But Jones believes that this apparent disinterest on the part of telecommunications providers has much to do with the fact that they are simply not accustomed to dealing with the transportation industry in general [17].

Texas has the presence of a proactive and aggressive telecommunications firm, such as Southwestern Bell, operating in the state. The interest, cooperation and support of this provider may make the state's decisionmaking process easier, with respect to partnering for advanced telecommunications.

THE 1996 ACT AND RIGHT-OF-WAY ISSUES

There are two broad categories under which states can employ ITS technologies. First, ITS technologies can used to support information transfer between DOT offices and mobile crews/equipment, such as salt spreaders, or repair crews. Second, ITS technologies can collect, share, and disseminate transportation information gathered by DOT monitors with the public and with other state agencies, such as the police, fire, and emergency medical services, and public transportation services.

Clearly, total control over a communications network would allow a state to operate ITS technologies free from outside interference (i.e., dependence on a commercial provider and its network). If a state department of transportation built its own telecommunications network (wireline and/or wireless), emphasizing major thoroughfares and designed specifically to meet the needs of the agency and its personnel, it could retain control over its own technology and depreciate costs over the life of a system. In addition, the DOT already owns the right-of-way, thereby eliminating a significant expense incurred by private providers who need to pay for the use of it. A private network could then also be opened up to other agencies if the situation warrants, spreading out costs. Despite the advantages of a state-run network, however, there are some disadvantages, and in light of the coming changes caused by the 1996 Act, some these disadvantages are significant [3].

A state-run wireline (or wireless) network could, for example, run into political difficulties. With voters complaining about high taxes, low levels of service, and bureaucratic inefficiency, it may be increasingly difficult to justify the expense of maintaining a highly complex state-owned network [3]. Many states have found it feasible to take on private sector partners to assist in the development and continued maintenance of the state's telecommunications network. At the same time, telecommunications companies are trying to find more space to install additional fiber optic and cellular service capacity. Highway right-of-way, considered a public resource, has been targeted by both groups for development.

It is reasonable to ask why these state-run telecommunications networks have become unwieldy and costly. The answer lays, for the most part, in the addition of ITS to the telecommunications equation. "'In the past, when you ran a cable to control traffic lights, nobody really worried', said Jones, '[b]ut when you're talking about the kind of networks that we're discussing for ITS — sophisticated, high-bandwidth networks — it becomes a whole different ballgame and the telecommunications industry is worried about that. They're concerned that they have not seen adequate analyses by state and local DOT's to look at their options and say 'should I lease this capacity or should I build it?'." [17].

What makes the networks that support ITS so complex and costly is, first, the video component, second, the extent of data linking and distribution requirements, and third, the reliability requirements stipulated by the DOT for the network. The fourth factor is upgrading. With technology turnover occurring so frequently, a state DOT would have the added responsibility and expense of overhauling the entire network, or significant portions thereof, on a fairly frequent basis. "'It is one thing,'" Jones added, "' to go out and build a network, it's quite another to have the technical expertise to operate and maintain it.'" [17].

The use of highway right-of-way for telecommunications and other public utilities is common. Most (if not all) states have traditional utility corridors in place along state highways. These corridors, in some cases, are not legislatively mandated, but have been given to utility providers by the state for their use. Any utility can install equipment in this utility corridor — which means that this part of the right-of-way is dug up and redug constantly, is crowded, and presents utilities with the constant risk of cable damage. The state gets very little compensation for the use of this resource by the private sector. Many states have started partnering with private firms for exclusive use of certain areas of the right-of-way. This "exclusive use" is a valuable commodity because states usually do not allow firms to have exclusivity in the traditional utility corridor [22].

Sharing the public resource of right-of-way with private telecommunications providers in exchange for telecommunications hardware, expertise and related services is a big issue for many states. These "shared resource" projects, which can be considered a special form of public-private partnering, can further the interests of both the state and the private sector firm because each shares in the resource of right-of-way and the resource of telecommunications capacity. These projects are usually characterized by:

- granting private access to public roadway right-of-way (or public sector conduits in the right-of-way);

- installation of telecommunications hardware along these conduits (including fiber optics and cellular equipment); and
- compensation to the right-of-way owner, usually over and above administration costs. [23]

The BART/Caltrans Project

This shared resource project used a hybrid approach in a recent transaction with a private sector firm for the installation of 71 miles (to be extended to 100 miles) of fiber optic lines along BART right-of-way. These will be 48 strands installed for public-sector use — 44 of these are dedicated to BART and 4 are dedicated to Caltrans, which granted air-lease rights to BART. The $3 million fiber optic conduit (installed by the private sector firm at its own cost) will contain four empty "innerducts" for additional fiber optic cable bundles that will be marketed to the private sector by the private sector firm. To recoup BART's investment in the project, BART and the private sector firm share revenues from the private fiber optic cables for 15 years [23].

Shared resource projects involving right-of-way and telecommunications are especially relevant to the development, deployment and operation of ITS products and services that use both resources. Despite different system architectures in many ITS projects, almost all anticipate or require the use of infrastructure in or on longitudinal right-of-way to link system components.

Although ITS systems can be installed, owned, and operated exclusively by the public sector, shared resource projects offer cash-strapped public sector agencies a way to achieve implementation of ITS with a lower financial burden, and also allow the public sector agencies in charge of ITS implementation to obtain state-of-the-art equipment and technologies [23]. Because the 1996 Act changes the nature of competition in the telecommunications industry, states must be aware of how these "partnerships" with telecommunications providers, existing and anticipated, will be affected. In the state of Texas, these partnering issues , along with other issues relating to telecommunications and right-of-way, are currently being explored.

There are, generally, only a few ways for a DOT to share the resource of right-of-way with the private sector and still obtain compensation. They are:

- The public agency installs its own telecommunications facilities and infrastructure and provides capacity on this infrastructure to private sector firms for a fee or through a leasing arrangement. (This would be a shared resource project only if partnering is involved; for example, if the private sector firm provides some necessary infrastructure components in exchange for preferential lease rates.)
- Private sector firms install telecommunications infrastructure and receive access to right-of-way or already existing telecommunications infrastructure along the right-of-

way in return for providing the public agency with telecommunications service and additional telecommunications infrastructure/capacity.

- Private sector firms receive access to right-of-way and rights to install telecommunications infrastructure in return for monetary compensation to the public agency [23].

There are a variety of nontechnical issues regarding private sector access to right-of-way in partnership with the public sector. These issues can be legal/political, financial, and structural/contractual. Only some of these issues will be explored here, but it is important to note that the changes to the telecommunications industry caused by the 1996 Act must be considered by public sector agencies that wish to use their right-of-way for ITS.

Political Issues

There are significant political issues that could hamper opportunities to develop shared resource projects for right-of-way. One of these issues is the "bypass network" that can be installed by a single public entity to avoid telephone companies' circuit costs and long-distance costs, and/or to ensure the security of data and communications. These "bypass networks" have minimal impact on telephone company revenue in cases where the network is installed by a single organization. However, if many organizations use bypass networks, telephone company revenues could be affected significantly and this network could be perceived as threatening by the telecommunications providers in the state.

Yet, as a consequence of the 1996 Act, the extent to which a telecommunications provider could claim to be threatened, or the extent to which a state may even be able to create a bypass network, is questionable. On the one hand, the recent telecommunications mergers have created an opportunity for telecommunications providers to offer many services in addition to pure telecommunications services. This may make it difficult to prove that any single public sector group could create a bypass network big enough to be a true competitive threat. Yet, by consolidating the number of providers, it may be more difficult for a public sector agency to operate a network on its own without some kind of resource sharing [23].

There is a broader political concern regarding the appropriateness of these public-private sector ventures for shared resources. It is common for a public agency to decide to install a telecommunications system in public right-of-way to create capacity for ITS. This allows the public agency to ensure that data, video, and other transmissions of information relevant to the operations of the agency travel along lines or over cellular networks owned by the agency. The agency is not dependent on the private sector and its economic ups and downs to get its work done; it also manages to keep data of all kinds confidential and within the agency. Yet in a situation where there are opportunities to help finance the ITS network by selling excess network capacity, or by granting the private sector exclusive access to parts of the right-of-way in return for the use of one or more of the cables, the government may be stepping further away from the traditional provision of public services toward actual competition with the private sector [23].

It may be tempting for states to want to join in the flurry of activity concerning line leasing. Long distance companies want to get into the local market, and local providers into the long-distance market. Either they will have to lease each other's lines, or construct new networks, but what is commonly understood by all is that they need to have their networks extend over large, contiguous geographic areas. To make a shared resource project attractive to the telecommunications provider, the public agency may need to ensure extensive right-of-way access. Conversely, cities within a large urban area may only be able to provide a small part of the right-of-way, and will be unable to present a private sector partner with an attractive package; cities like this may then be unable to finance their own ITS projects if they were depending on funds from the private sector [23]. Regional ITS projects also can run into difficulties with multiple states having to agree on the use and sale/lease of right-of-way on stretches of road that abut state lines. With telecommunications companies getting larger and larger, these issues will become more important.

Financial Issues

Financial issues regarding shared resource projects include resource valuation, form of compensation, tax-related issues, and management costs. Our discussion in this section will be limited to resource valuation and compensation issues.

Valuation of Resources

Before a public agency begins a shared resource project, or even begins negotiations on such a project, the agency must determine what it considers to be a fair trade for the resources it brings to the table — the right-of-way. To do this, the agency must know the value of the public right-of-way. The value of right-of-way is not simply a function of land values. It is a function of, among other things, market demand for right-of-way in general, which itself is based on the demand, both anticipated and actual, for telecommunications capacity. It also is a function of right-of-way length being accessed (savings can be achieved through dealing with one right-of-way owner rather than many, but a small piece of Right-of-way may not be all that valuable) and connectivity (the proximity to the Right-of-way and to other connections/other customers). Right-of-way value also varies by region, since market demand for telecommunications and land values also vary regionally, and over time [23].

In the absence of an organized, market-based and relatively independent body to quantify the value of right-of-way, the systematic and objective valuation of right-of-way (and other public resources) is likely to become an area of contention. Such valuation is a significant part of how (or even whether) a shared resource project is structured and which private sector partner is chosen. If the right-of-way is auctioned noncompetitively (i.e., without a minimum opening bid), the ideal situation is one where competition among bidders elicits offers approaching "fair market value" [23]. But in a situation such as that which is now occurring with the 1996 Act, private companies influence this process. Perhaps there is only one winner selected because, after a regional local-long distance merger, there is truly only one company that exists in the area that is large enough. Even if there are new providers as a consequence of increased competition, how will they out-bid the giant? Conversely, if the now-huge company knows there is no (or very little) competition, could the company then submit an unchallenged but too-low bid? In addition, if the value of Right-of-way is partly a function of the demand for telecommunications in an area, how will the recent spate of mergers affect this demand, on a local, state-by-state, interstate, and regional basis?

The flip side of the valuation issue is the valuation of the resources provided by the private sector partner as part of the bargain in the agreement. If there is no barter involved, as in a situation of a direct sale or lease, then the issue is moot. But many shared resource projects involve some process of "barter" where the private sector firm installs some amount of capacity beyond its own needs and dedicates this surplus to the public sector. What is this surplus worth? There are four typical methods to make this kind of valuation:

- The installation of equivalent capacity infrastructure by the public sector;
- The cost to the private sector firm of installing the extra capacity;
- The market value of the excess infrastructure/capacity if leased or sold to another private sector firm; and
- The opportunity cost to the public sector of not having this telecommunications capacity [23].

This last point is interesting in the context of the changing telecommunications industry, and related to the question asked in the above paragraph — in such a rapidly changing telecommunications market, how would one estimate the opportunity cost of lost capacity, particularly when one considers ITS in the equation? With the telecommunications industry growing by leaps and bounds, along with the often proprietary nature of telecommunications technologies and the increasingly important role telecommunications plays in economic development, does it make sense for a state, locality, or region NOT to install excess capacity, and not partner up with a telecommunications company (or two)? And how would a state or region anticipate what the potential economic loss for not doing so may be?

And a last series of questions: what are the implications for the future of ITS in Texas, for example, if swaths of right-of-way are operated in conjunction with a single private sector telecommunications provider? Will TxDOT be required to purchase equipment for its ITS systems from that provider? If not, will a competitor's systems work? What if several larger service providers (SBC, GTE, and AT&T, for example) all provided services for different stretches of right-of-way, all had different agreements for the use of that right-of-way, and, in addition, all were partnered with different Texas cities (the municipalities in Texas are allowed to contract separately with telecommunications service providers for services that are city-related). Would they be able to operate with one another, or would the arrangements become incredibly complicated and expensive?

By granting exclusive rights, the public agency limits the number of third parties with physical access to the right-of-way, reducing possible hazards and equipment failure, and also boosting the value of the partnership for the private sector partner. However, non-exclusivity fosters competition, resulting in cost savings on the part of the public agency or greater public revenues in total from a variety of partners. It also creates confusion, and systemic segmentation (a system with no backbone) [23].

TxDOT is currently in the process of answering questions similar to the ones raised above, and is waiting for the Attorney General's office to issue its opinions. At the time of this writing, the Attorney General's Office has not yet formally responded to TxDOT's inquiries regarding legality of offering exclusive rights to the private sector right-of-way right-of-way. There is a limited window of opportunity for such arrangements, and TxDOT may not be able to take advantage of these partnering opportunities in the near future if these fundamental questions of legal and statutory authority remain unanswered. This may, in the long run, hamper TxDOT's ability to fund and deploy ITS applications in the state.

Other issues concerning right-of-way present themselves when discussing the role of telecommunications at the Texas-Mexico border. These will be discussed in Chapter 6.

CHAPTER 5: MEXICO'S TELECOMMUNICATIONS MARKET

MEXICO'S TELECOMMUNICATIONS INDUSTRY - OVERVIEW

Building a more modern infrastructure capable of moving goods and individuals rapidly and efficiently is a goal of every nation; this infrastructure includes both transportation and communications systems. Infrastructure development projects are expensive, however, and many governments, particularly those in developing nations, find it difficult to finance these major projects solely through tax revenues or other kinds of internal resources. Because of the central importance of infrastructure to a nation's economy, and also because of the size, scope, and cost of most infrastructure projects, the development and financing of these projects have typically been the province of the government rather than private industry, although this is beginning to change.

In many cases, governments have decided to privatize, or sell a percentage of shares in, what had previously been completely government-owned and operated enterprises. Efforts at privatization can infuse state-owned industries with new capital and better access to resources. Yet, privatization also presents the problem of a government losing control of significant and strategic parts of the national economy. For this reason, many privatizations are conducted as partial offerings over a period of time with restrictions on the participation of non-nationals (these restrictions also may be lifted over time).

The world's most dramatic privatizations in the past decades have generally taken place in a limited number of industrial sectors, such as petroleum, transportation, and telecommunications. Telecommunications industries tend to be privatized because governments have realized the strategic importance of a modern telecommunications infrastructure and because the telecommunications industry is generally profitable and secure. Many countries have also found that successful privatization of the telecommunications industry attracts foreign investment capital to the subsequent privatization of utilities, banks, railroads, and other government assets, and attracts commercial activity [24]. This certainly has been the case in Latin America, where a half dozen telecommunications companies privatized from 1989 to 1994. The largest, and arguably most successful of these privatization efforts was the 1990 sale by the Mexican government of 51 percent of Teléfonos de México ("Telmex").

When Telmex was privatized in December 1990, Mexico had an estimated 5.3 million phone lines, or 6.6 lines per 100 inhabitants. By 1994, there were more than 8 million lines, or about 8.8 lines per hundred people. However, the number of phone lines per hundred individuals (or the "penetration rate" of telephone service) is still relatively low in Mexico when compared to other countries; the average telephone penetration rate in developing nations hovers around 20 lines per hundred people, which is seen to be the acceptable average telephone penetration rate for a country to be globally competitive [25]. In addition, telephone penetration rates are still uneven throughout Mexico because telecommunications infrastructure is concentrated in urban areas and, outside of these centers, remains underdeveloped. However, the waiting list for a telephone — 1.5 million names long at the end of 1988 — had been reduced 40 percent by 1994, and most of the names remaining on the list have been on the list for less than one year [24]. Room for growth in this industry remains vast and continues to offer opportunities for investment.

COMPETITION IN MEXICO'S TELECOMMUNICATIONS INDUSTRY

Little more than a decade ago, it was widely believed that telecommunications was a natural monopoly — that the only way to provide universal telephone service at affordable prices was to do so with a single service provider. While most of the industrialized nations have fairly competitive telecommunications markets, the monopoly model has remained the status quo for many developing nations. However, an increasing number of these nations are beginning to realize the benefits of telecommunications competition as a tool for economic development and progress. In view of the increasing importance of information transfer to economic and social development, many of the Latin American nations have moved rapidly to build up their national telecommunications networks. But for Mexico, the pressure to do so was even greater because it shares a contiguous land border with one of the most advanced telecommunications providers in the world [26].

In the 1980's, Mexico faced a serious economic crisis, reeling from the combined effects of a huge national debt, a fall in oil prices, trade deficits, a devaluation of the peso, high inflation, and low investment. The government's priority in this period was to reduce public expenditures, a strategy that greatly affected the operating budget of Telmex. Strapped for resources, the Mexican government increased taxes on telecommunications services while simultaneously reducing its investment in telecommunications infrastructure. This stretched to the limit Telmex's capacity to fund expansion and modernization of its network. A low point occurred when, in 1985, an earthquake in Mexico City virtually destroyed the central hub of the long-distance network and left the country's capitol without telecommunications services with the outside world for two weeks [26].

By the late 1980's, as part of a general program of economic reform, Mexico took the first steps toward restructuring its telecommunications market. In 1989, the government announced its intention to privatize Telmex, and in 1990 Telmex was purchased with a winning bid for $1.758 billion by a consortium comprised of SBC (Southwestern Bell's parent corporation), France Telecom, and Grupo Carso, a Mexican conglomerate. The consortium's bid beat a counteroffer by GTE and Telefónica de España [25].

In connection with the plan for privatization, the Mexican government also permitted competition in local telecommunications services and mobile communications. At the time, the Mexican government decided that the long-distance sector, one of the most profitable segments of the telecom market, would be reserved for Telmex until 1997 to allow the company an opportunity to align its prices with service costs [26]. Apparently, Telmex had long believed that the rates for long-distance services were too high and the rates for local service (local calls and line rentals) too low. In response to Telmex's objections, efforts at tariff rebalancing by the government began in 1987. Since that time, the revenue composition of Telmex has been steadily changing in preparation for competition in the long-distance market. The continuation of Telmex's long-distance monopoly involved a tradeoff, however. The government required Telmex to expand its number of subscribers by at least 12 percent per year (which it has achieved), and to provide telephone service to all towns of more than 500 inhabitants by 1994, a task that is almost complete.

Meanwhile, in December 1990, SBC made its first capital investment in Telmex — US$486 million for a 5 percent equity stake. Analysts were skeptical whether SBC would see a return. Then, in September, 1991, SBC made another equity purchase of US$467 million to achieve a 10 percent equity stake. SBC's investment proved to be profitable and timely; Telmex's earnings increased 44 percent within the first nine months of 1991, and its stock price rose almost 60 percent in the nine months after it was introduced onto the New York Stock Exchange [25].

As mentioned previously, Telmex was required to take certain actions under the privatization agreement, which included providing universal service to a nation populated by over 92 million people and spread over 761,600 square miles through 14 states with extreme variations in standard of living and geography. To accomplish the goal of universal service, Telmex and its partners are using a variety of telecommunications technologies, including standard copper wires, fiber optic lines, and cellular, satellite, and microwave technologies.

Telmex is also in the process of replacing almost 47,000 antiquated switching exchanges with digital switching equipment. These upgrades are occurring rather slowly, although Telmex's program is still considered to be one of the most aggressive in the world. By 1994, the network was 70 percent digital, up from 29 percent in 1990. Another principal feature of Mexico's steadily improving telecommunications system is its long-distance infrastructure, which is comprised of a microwave network and a fiber optic network. The fiber optic cable "backbone," 60 percent of which was constructed by AT&T in partnership with Telmex, links 54 major cities throughout Mexico [25].

In 1991, AT&T began the construction of five cross-border fiber optic cables. These cables operate between Calexico (California) and Mexicali (Baja California Norte), Nogales (Arizona) and Nogales (Sonora), El Paso (Texas) and Cuidad Juárez (Chihuahua), Hidalgo (Texas) and Reynosa (Tamaulipas), and San Diego (California) and Tijuana (Baja California Norte), and are designed to not only handle the international residential calls between the U.S. and Mexico but also to provide business services such as data transmission and facsimile services (Sprint also operates several cross-border fiber optic cables). AT&T also supplies digital switching equipment to Telmex, and owns a majority interest in Grupo ITSA (Grupo Informática y Telecomunicaciones S.A.), a supplier of integrated voice, data, and video communications systems in Mexico; AT&T ITSA is the distributor in Mexico for AT&T Paradyne modems, multiplexers, and channel extension equipment.

To meet and exceed mandated requirements, Telmex has invested an estimated $2 billion per year, with more than 30 percent of its new subscribers added in the last few years. Domestic long-distance calls increased over 10 percent in 1992. International long-distance increased 11 percent between 1992 and 1993. Of international long-distance calls, almost 90 percent of the connections are to the United States and Canada [25]. The 1994 devaluation of the peso, however, reduced the level of capital investment in the telecommunications sector. The privatization of Telmex and the opening of the long-distance market to competition has done much to reverse this trend.

Unlike the long-distance and mobile telecommunications sectors, the local telephone service sector, even though it was technically opened up for competition at the same time, has not been as competitive. Although Telmex was obliged to offer interconnection with operators offering local services, potential rivals have been deterred from the local market by their inability to sell long-distance services. The continuing Telmex monopoly over long-distance services precluded many of the benefits that would have accrued from competition in the local service sector. This will soon change, however, as Mexico continues to reform its telecommunications industry. It has made efforts to separate telecommunications operations from regulation by privatizing the service provider (Telmex), reorganizing the regulatory body that oversees the telecommunications industry (the Ministry of Communications and Transport, or SCT), and by opening up long-distance services to competition. These reforms are currently underway.

MEXICO'S 1995 TELECOMMUNICATIONS LAW

Mexico's telecommunications industry continues to undergo significant legal and regulatory changes. In the wake of the peso devaluation in December 1994, the Zedillo administration announced plans to submit a new draft law to the Mexican Congress designed to promote new private sector competition with Telmex. In mid-January 1995, the Mexican Congress agreed to proposals submitted by President Zedillo to amend the Mexican Constitution to remove satellite communications from the list of strategic areas in which the Mexican government is legally required to hold a monopoly, and to further privatize Telmex, which is also the national satellite carrier.

Following extensive modification, Mexico's Senate passed the legislation in April 1995, with the Chamber of Deputies passing it without modification in May 1995. The new law reflects extensive consultations between the SCT and various potential service providers, and also reflects extensive political compromise. The legislation introduces a wide range of opportunities for competition and new entry (both domestic and foreign) into Mexico's telecommunications market. To further cement the changes, in June 1995 a full reorganization of the SCT was also approved [27,28]. Some of the most important features of Mexico's 1995 Act include:

- amendment of Article 28 of the Mexican Constitution to permit privatization of, and encourage competition in, the Mexican satellite industry;
- increase in foreign ownership limits to 49 percent for most telecommunications services;
- establishment of new spectrum use categories and specification of corresponding spectrum authorization requirements (e.g., the "concessions" required for public telecommunications networks and spectrum use, the "permits" required for resale services and transmitting earth stations, and the "registration" required for provision of value-added services);
- elimination of restrictions on services provided by competitive public telecommunications networks, including long-distance services, after August 10, 1996;
- authority for use of auctions to grant concessions for non-governmental frequency use;
- deregulation of receive-only earth stations;
- adoption of open architecture principles for network interconnection;
- establishment of non-discriminatory tariffing principles; and
- the creation of a new regulatory authority, independent of the SCT, by August 10, 1996 [28].

Satellite De-Monopolization

In 1983, regulations concerning satellite communications (both space and ground segments) were incorporated into the Mexican Constitution as a "strategic area" that would be developed and controlled exclusively by the government. By 1989, this broad control was redefined to encompass only the installation, operation, control, and exploitation of the space segment, while private investors were permitted to establish and operate related ground-based infrastructure (with the exception of international links). By late 1994, the growth in demand for satellite services and capacity, the launch of the Morelos satellites, and the increased pressure on the Mexican government, encouraged the government to open investment and operations opportunities in Mexican space segment facilities to private investors. The 1995 Amendment (passed in March 1995) converts satellite communications from a "strategic" activity, reserved exclusively for the state, to a "priority" activity where private investors may participate and compete [28].

Telecommunications Legislation

Mexico's Telecommunications Act was passed in May 1995 (after the first Satellite De-monopolization regulations in March), and entered into force in June 1995. The SCT was expected to follow up with a full set of rules, regulations, and procedures for implementation and enforcement of this legislation. Some of these rules include:

- ***Foreign Ownership***: The new law permits up to 49 percent foreign investment (i.e., ownership of capital stock) for all services except cellular services, which can exceed 49 percent (with an unspecified upward limit) but subject to specific permission by the National Commission on Foreign Investment.

- ***Regulatory Transparency***: The new law introduced greater transparency in Mexico's developing telecommunications regulatory process, and imposes response times for the government to process service and other applications. In addition, information about all holders of concessions and permits will be available to the public.

- ***Flexible Service Provision Rules***: Public Telecommunications Networks (PTNs) will be able to offer all types of services over their networks on an unrestricted basis. Private networks will not generally need authorization to operate, but will require a concession if they use radio spectrum or are used to provide commercial services. New PTN concessions may not begin sale of basic long-distance services until after August 10, 1996.

- ***Interconnection***: PTN's are required to adopt designs of open-network architecture. Interconnection must: be offered through unbundled and non-discriminatory tariffs; be available to all members of the public; be available at every switching point or other points where technically feasible; permit resale; provide all necessary billing information to users and resellers; enable telephone number portability; and permit the connection of terminal equipment, inside wiring, and private user networks. Interconnection networks must maintain separate accounting for services with unbundled tariffs beginning January 1996.

- ***Tariffing***: Proposed tariffs, including those for interconnection, must be registered with the SCT for public review. No discriminatory practices in tariffing will be accepted.

- ***Auctions Feasible***: The SCT will have the authority to publicly bid all concessions, which may be granted for any non-governmental use of the frequency spectrum (including for satellite orbital positions and orbits, but excluding traditional radio and television).

- ***New Independent Regulatory Organization***: No later than August 1995, the government must create an independent regulatory organization with autonomous procedures and operations, separate from the SCT. This entity will be given the organization and facilities necessary to regulate and promote the efficient development of telecommunications in Mexico [28].

Reorganization of the SCT and SCDT

The SCT encompasses telecommunications, highways, railways, aviation, ports, and the merchant marine. Within the SCT is the Subsecretaría de Comunicaciones y Desarollo Tecnológico (SCDT), responsible for telecommunications regulation and control. The reorganization of the SCT, not surprisingly, continues to be a complex affair. Some of the most important organizational changes will be described here.

Carlos Casasus was appointed to the post of Undersecretary of the SCDT starting in late 1994; during the first half of 1995 he appointed four Director Generals in anticipation of the creation, under the new law, of four General Directorates: Networks and Radiocommunications, Broadcasting Systems, Telecommunications Policy and International Negotiations, and Spectrum Administration.

In July 1996, the Mexican government established the independent entity specified in the Telecommunications Act, the autonomous Federal Telecommunications Commission, with the expectation that the independent nature of this body would free the industry from much of the political pressures it faced while it was handled by the SCT. The new agency will not only regulate long-distance service in Mexico, but also be responsible for overseeing most telecommunications issues.

IMPLICATIONS OF MEXICO'S TELECOMMUNICATIONS LEGISLATION

One of the most interesting aspects of Mexico's telecommunications legislation is that it did not include provisions for direct licensing fees for new long-distance operators. During the last quarter of 1994 and the first quarter of 1995, while the provisions of the Act were being debated in Mexico's Congress, fierce debate raged over the issue of concession fees.

The Finance Ministry, focused on maximizing financial returns to the government, supported large up-front concession fees in the range of $200-$300 million. The SCT, expressing support for expanding access to competitive services, argued that the large up-front concession fees would reduce the number of market entrants, increase service costs, and restrict competition. The Congress approved a plan that does not include license fees for new wireline operators, but requires new wireless operators to purchase spectrum through a process of public auctions. Some public interest groups have questioned this compromise, noting that wealthy foreign companies will receive completely free market access at a time of extreme hardship for Mexican companies and consumers. Still, the Mexican government has attempted to focus on the long-term benefits of competition rather than solely on the shorter-term benefits of revenues from fees [27].

Another issue for new long-distance competitors concerns interconnection with the Telmex network. In early 1994, Telmex proposed interconnection points at ten major cities. Instead, in July 1994, the SCT called for Telmex to provide access to its switches in 60 major cities by 1997, 40 more in 1998, 50 more in 1999 and 50 more in 2000. The SCT also encouraged Telmex to separate its local and long-distance operations to restrict cross-subsidization and make it easier to determine the baseline for cost-based fees.

In July 1994, the SCT required Telmex to charge cost-based fees, provide non-discriminatory access to its network, and negotiate access and interconnection fee agreements with each of its competitors on an individual basis. By September 1995, Telmex began charging internal connection fees to its affiliates. SCT would take on the role of arbitrator if Telmex and its negotiating partner could not agree on a fee. Given the highly contentious nature of interconnection fees and their impact on Telmex revenues, it is likely that many of these cases stand the chance of going before the SCT. Indications are that the SCT might establish a universal interconnection fee for all competitors, possibly on a nationwide basis [27].

A third key issue remaining unaddressed is rights-of-way to build long-distance networks. The law states that rights-of-way that are available to one provider must be made available in equal form to other providers on a non-discriminatory basis. Mexican law, however, also provides the government with broad discretion over the utilization of public properties, and key rights-of-way are held by state companies and agencies, such as Ferrocarriles Nacionales de Mexico (FNM), Petroleos Nacionales de Mexico (Pemex), and the state highway system. Most of Mexico's national telecommunications trunk network is deployed along the highway system, which is where most of the potential long-distance competitors are looking to place their own cables and equipment. Some industry sources suggest the SCT rule-making process will address this issue and that it will not be a competitive obstacle. Potential competitors worry about how much they will have to pay for these rights-of-way [27].

Another issue remaining unaddressed in the new law is how Mexico will achieve its goal of universal service, as the new regulations do not require carriers to provide universal service, allowing them to target particular customers and market segments. Telmex, however, must attempt to provide universal service and has, therefore, expressed concern that while new operators will be able to pick out profitable market segments, it will be left with the burden of serving less profitable markets. It seems that the Mexican government is looking to solve this issue by creating a "telecom fund," similar to Chile's, to help fund telecommunications services in under-developed and under-served markets. All new operators would be required to direct a certain percentage of their revenues into this fund, which would subsidize private sector telecommunications projects in these markets.

Mexico's new telecommunications legislation is a major step forward, but challenges do exist. In particular, many investors point to the recent Telmex purchase of a 49 percent stake in Grupo Televisa's cable television subsidiary, Cablevisión. Many industry players opposed the transaction, arguing that the deal was monopolistic and anti-competitive, amounting to cross-subsidization. The SCT rejected these arguments by explaining that the decision to allow the purchase was certainly partially motivated by a desire to allow Telmex to strengthen its competitive position, but that Telmex's ability to use the Cablevisión infrastructure was limited [27].

Lastly, an understanding of the changes in the Mexican telecommunications industry is necessary and critical for the FCC in its negotiation of border frequency sharing arrangements, as well as in the development of bi-national communications policies which will benefit both nations.

MEXICO'S LONG-DISTANCE SECTOR

Now that Mexico's long-distance sector is privatizing, many of the world's largest telecommunications service providers have formed alliances with Mexican firms. AT&T formed a consortium, "Alestra," with the Mexican industrial conglomerate Grupo Alfa and another conglomerate, "Unicom," comprised of partners GTE, Bancomer, Grupo Visa, and Telefónica de España. Alestra's services will be marketed under the AT&T brand name, with the intent of drawing on brand recognition. MCI partnered with Grupo Financiero Banamex and Accival, S.A. (or Banacci, Mexico's largest financial institution and holder of Mexico;'s largest private network) to create "Avantel," while Telmex announced its partnership with Sprint and SBC. Iusacell (a wireless provider) joined up with Bell Atlantic, its partial owner, to provide roaming service in the U.S. and Canada. Other alliances are also operating.

TELMEX	ALESTRA	AVANTEL	IUSATEL
Telmex SBC Sprint	Grupo Alfa AT&T (20%) Grupo Alfa (25%) Unicom GTE (14.5%) Bancomer & Grupo Visa (25.4%)	MCI Banacci (Banamex & Accival)	Iusacell Bell Atlantic

Telmex has been trying to strengthen itself against competition from the eight different companies which have been offered concessions to enter the market and compete against it (Avantel S.A., Alestra, Iusatel S.A., Marcatel S.A., Investcom S.A., Miditel S.A., Cableados y Sistemas S.A., and Telnor S.A.) . Telmex's strategy is to take advantage of its position as the "owner" of the majority of telephone lines in Mexico; regardless of the choice of long-distance provider, odds are that the call would have to be routed over

Telmex lines — and that means revenue. Telmex will be forced to reduce its infrastructure "rental" fee to prevent competitors from building parallel networks, but anticipates reaping vast revenues from the traffic of calls and other transmissions by other companies over its lines.

In June 1996, the SCT released the rules regulating how customers will be allowed to choose their long-distance provider. Under the plan, which also sets a timetable for opening the market and a new numbering system for area codes, a phone user will be allowed to choose a carrier in one of three ways: in advance; through a subscription; or on a per-call basis by dialing a three digit number. The subscription could be made either in writing or by phone, and an individual would be able to change carriers as many times as desired provided they wait one month before changing the initial selection. Local carriers would be required to provide new customers with a randomly organized list of potential long-distance carriers to choose from at the time they begin service.

The schedule for competition indicated that on January 1, 1997, Telmex would open its long-distance market in Querétaro only. By January 10, Monterrey was to be added. On March 19, other cities will be added, including Guadalajara, Aguascalientes, Mexicali, Tijuana, Puebla, Cuidad Juárez and Veracruz. By May 1, there will be 44 cities opened to competition, which will increase to 60 after 30 days. In 1998, an additional 40 cities will be added, 50 in 1999, and 50 more by 2000. If a user does not choose a long-distance carrier by the time the city opens up to competition, the default carrier will be the company that had previously offered long-distance services. In most cases, this will be Telmex [29].

It is not surprising that the four major long-distance ventures (the Telmex partnership, comprised of Sprint, SBC, and Telmex, Alestra, Iusatel, and Avantel) each have an American partner — these alliances are natural and expected, particularly when the markets are geographically linked with one another. In addition, these partnerships also take advantage of already existing market shares of each partner. For example, in the venture between Iusacell and Bell Atlantic ("Iusatel"), Iusacell is partially owned by Bell Atlantic. Bell Atlantic also recently merged with NYNEX, making it one of the largest telecommunications providers in the United States. The SBC-Pacific Telesys merger made SBC the second-largest telecommunications provider in the U.S. and gives it a huge swath of border territory for service. SBC also has a 10 percent ownership in Telmex, and is partnered with Telmex and Sprint to offer long-distance services. In addition, the Union Pacific Railroad (UP) brought SBC on board in 1996 as a major investor in its failed bid for the concession to FNM's "premier" Northeast rail line.

It also remains unclear what impact the Alestra merger will have on previous infrastructure and network investment plans. Alestra executives indicated that the company will maintain its plan to invest $1 billion over the next five years, but there have been rumors that Alestra is planning to increase its expected investment to $3 billion. It also continues to be unclear what each partner's contribution will be. Prior to the merger, Unicom had planned to invest $900 million on its own to expand its own long-distance network, and it is not known how or whether these plans will be modified [30].

The merger of two formidable U.S. competitors (AT&T and GTE) changes the landscape of Mexico's long-distance market. AT&T's strength is long-distance, whereas GTE's strength is local service. As partners for long-distance, they may springboard into other services such as local service and data transmission.

Sprint, in partnership with Telmex and SBC to offer long-distance services, is partially owned by France Telecom and allied to the Canadian long-distance carrier CallNet. France Telecom has a 5 percent stake in Telmex as a consequence of the 51 percent ownership of Telmex by the consortium consisting of itself, SBC, and Grupo Carso. Telmex, Sprint, and SBC have formed an alliance that now includes all three signatories to the NAFTA trade agreement. The alliance sets up a framework to provide cross-border services for the corporate and consumer markets, including voice, data, and video services. Telmex and Sprint have formed a series of teams to focus on cross-border marketing and trademark licensing. In fact, Sprint's calling card services have already begun to be marketed to Telmex and Telcel customers. Some analysts argue that AT&T would have been a more natural choice for Telmex. Still, Sprint already operates four cross-border fiber optic cables that connect to the Telmex network, and they jointly provide videoconferencing and international data services.

Most analysts agree, however, that, much as with the current spate of mergers in the U.S., the consolidation of the long-distance market in Mexico will likely increase the cost of doing business for all long-distance providers as marketing and advertising costs per customer are expected to continue to rise [31]. Yet, it is also expected to dramatically reduce the cost of telecommunications services for those making the highest volume of calls — businesses that spend thousands of dollars per month on long-distance calling services between the U.S. and Mexico.

MEXICO'S CELLULAR INDUSTRY

Perhaps the most dramatic development in Mexico's telecommunications industry is the rapid growth of cellular telephony. Cellular services are growing at unprecedented rates throughout the world; however, they are growing even more rapidly in Latin America because of a variety of pre-existing functional limitations on wire transmission infrastructure and antiquated billing systems. These problems are being remedied, but in the meantime it can still take over a year to get a telephone installed in many Latin American countries.

By contrast, at least in Mexico, it is possible to purchase a cellular telephone and get service the same day. Mexico opened the mobile communications services market in 1989-90 as part of Telmex's privatization. This opening proved successful virtually from the first day

— by the end of 1994 there were more than 560,000 subscribers; by 1991, Mexico had captured an estimated 70 percent of all the cellular customers in Latin America. The penetration rate for mobile communications services in Mexico after five years was ahead of ten other countries, including Belgium, the Netherlands, Spain, and Turkey over a similar period of development (five years after the launch of mobile telecommunications service capabilities). The major difference between Mexico and these other nations was that the other nations all had monopolies five years after the launch of these services — new entrants into the competitive Mexican market brought advanced expertise, technology and vast amounts of capital [26]. Mexico is now the largest cellular market in Latin America.

The SCT divided Mexico into nine cellular regions, with two authorized licenses for each region. "A-band" licenses were assigned to nine different companies that have, over the last few years, consolidated into three organizations. "B-band" licenses were assigned to Telcel (Telmex competes in the mobile communications market under the name "Telcel"). The May 1996 penetration level of cellular service was 0.9 percent of the total population, which amounts to approximately 725,000 subscribers nationwide — Telcel alone had a total of 435,000 subscribers by March 1995. The largest regional competitor to Telcel is Iusacell, which also operates in the Mexico City region and has about 86,000 customers [26]. On October 11, 1993, Bell Atlantic announced it would invest over $1 billion in Iusacell, which purchases a 23 percent share and options to purchase stock up to 46 percent [24]. Both Telcel and Iusacell pay the same interconnect fee to Telmex.

To an extent, growth in the mobile communications industry in Mexico may reflect significant unmet demand on Telmex's fixed wireline network, but the higher prices for mobile services make it a relatively expensive substitute. Telcel, however, is aggressive in its distribution and marketing strategies, targeting the business user and reinforcing the concept of a cellular telephone as a necessity for both the business and non-business uses, rather than a luxury item. Telcel also makes it easier for the non-business user to pay for calls by using a debit card that can be purchased from any Telcel agent or at distribution outlets. Telcel customers also have "roaming" capability in all major U.S. and Canadian cities, and, through and agreement with SBC, Telcel can offer customers automatic call delivery in areas served by SBC [31].

COMPUTER TECHNOLOGIES AND THE DEVELOPMENT OF THE INTERNET IN MEXICO

In the U.S., as a consequence of advanced technology, market competition, and the absence of tight regulation, access to and development of the Internet, as well as its use as a business tool, is inexpensive and widespread. Beyond the initial cost of a computer and a modem, the individual user in the U.S. needs only a telephone line and access to an on-line service. For those unable to afford their own computer, public schools, libraries, and even cafes provide easy access to the Internet. In the U.S., telephone lines are ubiquitous and relatively easy to get installed. The relative cost of on-line services is quite low: around $20/month for a basic hookup and unlimited access, or $2.95 an hour for access to a premium virtual community. In Mexico, things are much different, although the recent privatization and involvement of U.S. telecom companies in the Mexico's long-distance service market is expected to decrease the level of difficulty in obtaining Internet service and connections there.

The market for on-line services in Mexico (and in Latin America) is enormous. The number of users connected to the Internet in Mexico is estimated to be growing by 20 to 30 percent every month, with the number of individuals connected to the Internet by the year 2000 expected to be over 750,000. The number of commercial Internet providers in Mexico is also growing fast in response to the opening of the long-distance market [32].

This may have interesting implications for the development and use of ITS systems and technologies (in-vehicle and outside of the vehicle) that employ on-line services, and their more widespread acceptance and use in Mexico and at the Texas-Mexico border.

CONCLUSIONS AND UPDATE

Many businesspeople in Mexico welcomed the changes in Mexico's telecommunications market that began on January 1, 1997. These high-volume corporate callers, often spending between $600 and $10,000 per month on long-distance cross-border communication, expect to receive huge savings, pointing to the reductions that will occur on what is now a per-minute charge of $1.60 to call the U.S. and Canada. Although many of these firms have not yet decided on a provider, the competition between long-distance providers for these high end users has resulted in extreme reductions in per-minute costs.

Winning over high-volume customers is a lucrative market — two-way calling volume between Mexico and the U.S. is the second-highest in the world after U.S.-Canada traffic. Mexico's estimated $4 billion annual long-distance market is also expected to double over the next five years in response to competition. And newcomers have been quick to move in to the market. Collectively, they plan on investing an estimated $5.8 billion to build 31,620 miles of long-distance infrastructure and advertise their competitive rates and advanced services.

Alestra, for example, is spending an estimated $1 billion through the year 2000 to build its own 5,332-mile national fiber optic network. Like its competitors, Alestra has targeted the "golden Triangle" of Mexico City, Guadalajara, and Monterrey, which accounts for more than two-thirds of all long-distance calls in Mexico. Avantel has invested $600 million into what is expected to become a $1.8 billion, 11,160-mile fiber optic network that is expected to cover more than 80 percent of Mexico's national and long-distance markets. Iusatel's strategy is to bypass Telmex's lines completely with a hybrid system of wireless and wireline technologies that would make rewiring one's home or business unnecessary.

Rather, calls from a phone unit would be transmitted by radio to a central transmitting station where the calls would then connect to a land-line system, allowing the user to access outside telephones, pagers and faxes. This system's advantage is that it can bring service to areas of Mexico where there is no landline service, or where the cost of laying down cables would be prohibitive. There is some question whether the Mexican government will allow this service to operate [33].

Meanwhile, Telmex is also using aggressive tactics to retain customers. It is offering, among other things, deep discounts (as much as 38 percent off standard rates) for callers who sign three-year contracts with the carrier. Although customers do not have to sign these contracts, they will still have to deal with Telmex because Telmex continues to retain its monopoly over costly "basic service" (since it owns the lines into each and every phone). Business lines can still cost up to $500 to install, with basic service fees continuing to rise past $13 per month. Yet, Telmex also wants to turn its own long-distance network, with the help of its own long-distance partners, into an information superhighway, offering both homes and businesses an array of bundled services via both telephone lines and the coaxial cable television lines of its soon-to-be-acquired cable television company, Cablevisión.

And if none of this proves to be as successful as anticipated, Telmex also plans to offer long-distance service in the U.S. in 1997. As a consequence of NAFTA reciprocality provisions, Telmex is currently in negotiations with the FCC over what type of access it will be allowed in the U.S. market. Telmex plans to submit a formal petition in early 1997. Apparently, it plans to operate through one of its partners, Sprint, which is the third-largest long-distance carrier in the U.S., and offer a wide range of services that would include selling U.S. service in Mexico in Spanish at cheaper rates than other U.S. long-distance competitors [34].

Yet, as of January 1997, despite all efforts, the Telmex alliance , as well as the Avantel group, are trailing in market share in both Querétaro and Monterrey (the first two cities opened to competition) behind Alestra, the AT&T alliance.

In conclusion, the privatization of Mexico's long-distance network has meant welcome relief, especially for businesspeople, from an inefficient and expensive monopoly operating with antiquated equipment. Although there has been confusion over the balloting process, and the rates for interconnection, the privatization seems to be moving along quickly, with each competitor eager to snag a significant market share of what will become an extremely lucrative market — not only because of the volume of calls made but because, for both MCI and AT&T, Mexico represents the link needed to complete their proprietary networks in the U.S. and Canada. With operations in Mexico, both companies will now be able to develop uniform telecommunications networks that span all of North America, the world's most lucrative call corridor. The marketing advantage of a transcontinental network is extremely significant.

Lastly, Mexico will benefit greatly as its telecommunications infrastructure and systems move into more complex national and international linkages. New voice and data "superhighways" will deepen Mexico's economic links with the U.S. and Canada by providing the infrastructure to retain and attract new investment and commerce. Advanced telecommunications will also help pave the way for the deployment of ITS at the border and in the interior of Mexico to better manage and accommodate this increased commercial activity [35].

CHAPTER 6: THE EFFECTS OF CHANGES IN THE TELECOMMUNICATIONS INDUSTRY ON ITS IN THE TEXAS-MEXICO BORDER AREA

TELECOMMUNICATIONS AND ECONOMIC DEVELOPMENT

Telecommunications and transportation infrastructure and services are critical for economic development and growth — not only in a nation generally, but in its separate regions and cities as well. The U.S.-Mexico border region is a special illustration of this point. The region is unique in many respects, but one that stands out is that it straddles an international border between two nations with different levels of economic development. Individual cities along this border are, almost paradoxically, highly interdependent, as if there were no border. Yet these cities struggle with economies that are often crippled by the economic and social difficulties the border presents.

Imagine, for example, how difficult it is for the average American city to finance, build, and maintain its infrastructure. Imagine, then, how difficult it must be for similar projects that must span an international border. The fact that the U.S. and Mexico have different languages, currencies, and levels of economic development, not to mention styles of government, further hampers the situation. Telecommunications infrastructure is important to the development of the border, and has, as many infrastructure projects have, fallen victim to these same difficulties — but the situation is changing. It is important, however, to understand how telecommunications affects economic development in general before one can understand why it is so important to the communities at the U.S.-Mexico border.

Telecommunications as a Factor of Production and Part of the Value-Added Chain

Telecommunications infrastructure and service can be considered a "factor of production," similar to transportation and other kinds of activities involved in the creation of a good. If an item, such as raw materials or a truck, or a service, such as telecommunications or electricity, plays a necessary role in the production process, the costs and benefits associated with it must be assessed and figured into the firm's production plans and budget. Often, a firm will make a location decision based on the relative availability and costs of each factor of production at that location. In this sense, the existence or nonexistence of a variety of factors of production (or services that facilitate them) plays an important role in the attractiveness of a location to a business.

As an economy grows, markets increase in size. As markets expand, not only do they cover more area geographically, but they also include more customers. As a firm's production increases to serve this increasing demand, mass production techniques are employed to take advantage of economies of scale. As more product goes out into an expanding geographical area, transportation costs to the firm rise dramatically. They may rise even further if the firm's source of raw materials is not located near the site of production — raw materials will have to be shipped to the factory. Transportation, then, becomes an increasingly important factor of production.

Railroads, highways, and airplanes allow the firm to obtain its raw materials as well as distribute the final product. Transportation infrastructure did not create this demand but does enable a variety of innovative production, manufacturing and distribution, techniques to become economically viable by linking markets and permitting firms to realize economies of scale. Telecommunications infrastructure serves a similar function as a factor of production, but supports it differently. Since the advent of mechanized, mass-production techniques, telecommunications services and technologies have become an integral part of production and are extremely important in today's high-tech manufacturing and distribution strategies.

As industrial technology has developed, production processes have become more complex, and the organizational and informational tasks of production have grown to be much more important. By 1980, for example, it was estimated that 50 percent of all economic activity in the U.S. was accounted for by information creation and processing. Information creation, transmittal, manipulation, and storage has become an industry of its own. Advanced telecommunications infrastructure is a necessary component of the flexible production processes and logistics management techniques so important to commerce — which means that transportation, telecommunications, and economic development are quite closely linked. In today's global economy, nations, regions, and cities looking to retain and attract business must, therefore, have an efficient telecommunications and transportation infrastructure [21].

From a microeconomic standpoint, telecommunications infrastructure and equipment also "adds value" to certain manufacturing and production processes. The concept of a "value-added chain" is a way of indicating the interlinked steps in a business that contribute to increased productivity and create "value". Specific telecommunications technologies and systems facilitate or benefit certain particular points or processes in production. Some parts of a business, however, are more open to telecommunications-based productivity enhancements than others. Some have a greater dependence on telecommunications than others. Within the firm, telecommunications enhances the performance of workers, the production line and overall operations, transportation and shipment tracking, customer service, inventory management, billing, and, in most cases, also costs less than the failure to obtain (or use) such services or equipment. In fact, the cost of telecommunications services and equipment in the long run typically hovers at 1 percent of overhead when compared to wages, machinery, or raw materials [21].

As indicated in the first chapter, the basic function of telecommunications is to overcome distance and save time. Depending upon the level of technology used, telecommunications can greatly extend the capacity for communicating information within units of time, as in the comparison between a telephone call and a burst of data through a modem. Telecommunications also supports coordination of many people and activities, often in real time (such as live video feeds or the telephone), or in delayed store-and-forward fashion, as with electronic mail and EDI. Appendix C summarizes many of the benefits of telecommunications in the value-added chain.

As indicated previously, some businesses are more prone to enhancement via telecommunications than others. One such situation is where there is a need to coordinate between decentralized business units, such as with the *maquiladora* plant. Another such situation is a business that operates under "just-in-time" manufacturing strategies[1] — again similar to the *maquiladoras* and other large manufacturing facilities at the border. In addition, operations supporting inspections for the Customs Service and Immigration and Naturalization Service (INS), are telecommunications-intensive due to information requirements.

MAQUILADORAS, TELECOMMUNICATIONS AND ITS

Many large U.S. firms do business in Mexico by conducting a part of their manufacturing with *maquiladoras*, firms in Mexico that assemble or finish goods, which have been shipped in pieces or parts from the U.S., and then send these goods back to the U.S. for sale and distribution. The advantage of *maquiladoras* is said to be in the relatively low cost of Mexican labor and in the reduced duty charges for the finished goods upon reentry into U.S., which are based only on value added during the production process. Many *maquiladoras* are jointly owned by Mexican and U.S. partners, although the percentage of ownership tends to vary and the parent company is typically from the U.S.. Most *maquiladora* plants are located only a short distance from the border with the U.S. to save transportation costs. The *maquiladoras* represent a significant source of revenue and employment for Mexico.

Currently, *maquiladoras* exist in a variety of production sectors, including textiles and electronics. Many *maquiladora* activities, particularly the assembly of electronics, or the manufacturing of textiles and apparel, are automated. In addition, many of the parent companies are often large U.S. companies or multinationals; both types of firms,

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[1] "Just-in-time" manufacturing is characterized by two fundamental ideas: 1) that inventory exists only to cover gaps in production, and reducing inventory will redirect management's attention to production inefficiencies; and 2) that inventory represents tied-up capital and the longer a good is sitting in a warehouse as inventory, the odds increase that it will be damaged, stolen or rendered obsolete. The goal of JIT is therefore to eliminate as much as possible both raw material, work-in-process, and finished goods inventories. A JIT program focuses on reducing the inventory carrying costs and production disruption costs. Just enough material is ordered for a specific production run, reducing storage and inventory costs at various phases of production and distribution, as well as the costs of obsolescence. Production disruption costs are mitigated through an ongoing process of equipment maintenance and automation.

however, are decentralized over great distances. Lastly, most *maquiladora* operations employ just-in-time manufacturing techniques, which are telecommunications-intensive. These combined factors require the *maquiladora* plant to have an advanced and highly efficient telecommunications system within the plant and with its parent. The trans-border nature of this communication has been a significant issue for *maquiladora* operators, not only because of outdated trans-border regulatory agreements, but also because securing quick and reliable hookups and service from Telmex has, until recently, been a problem [21].

Telecommunications and ITS in the El Paso-Ciudad Juárez Area

States and cities function as hubs of telecommunications concentration. It is especially important for cities to understand how telecommunications infrastructure and regulation can influence their economic development. Telecommunications infrastructure issues are significant for the city of El Paso, for example, because of the *maquiladora* plants across the border and the data transmission requirements of the border port-of-entry inspections points. In addition, the economic development of El Paso is highly tied to Cuidad Juárez. Modern telecommunications links are important not only for the continued day-to-day activities between the two cities, but particularly for the continued operation of *maquiladora* plants and maintenance of their production schedules.

The relatively low level of sophistication of trans-border communications has consistently raised questions on both sides of the border on how to best develop telecommunications networks in support of the *maquiladoras* and border-related commerce generally, and how to have efficient communication between the *maquiladora*, the parent company, and the transportation providers moving materials back and forth. Examples of how some *maquiladoras* have operated their own telecommunications networks in an effort to bypass the Mexican system can be found in Appendix D.

For the communities of El Paso and Cuidad Juárez, efforts at using telecommunications technology to facilitate and attract economic development have been hampered because of the border and by the significant differences between the telecommunications systems on both sides of that border. Historically, there has been relatively little initiative on the part of the City of El Paso to encourage the growth and development of the special advanced telecommunications infrastructure and services which would become necessary to promote the *maquiladora* industry. Part of the reason has been that, until recently, Southwestern Bell (the local exchange carrier for the area) was prohibited from the transborder telecommunications business.

Also, until recently, under a longtime agreement between AT&T and Telmex (described in the previous chapter) that included a partnership for the installation of cross-border fiber optic cables, working with AT&T/Telmex was the only way to get adequate cross-border telecommunications services [21]. But since the privatization of Telmex in 1989, and the relaxing of regulations in a variety of areas since then, there are now many different options for cross-border telecommunications links. These include other fiber optic networks and connections, a variety of cellular and satellite options, and the effect of competition in Mexico's long-distance sector by consortia whose members include the U.S.'s largest telecommunications technology and service providers.

Maquiladoras must be able to respond quickly to changing market conditions and be able to communicate quickly and effectively with their parent companies, plants, and suppliers on both sides of the border and around the world. *Maquiladoras* also range in size from small companies using basic voice communications to large companies employing sophisticated networks. Many of these plants have, in the past, made efforts at creating their own microwave networks to facilitate communication. Years ago, when *maquiladoras* were first starting to sprout up along the U.S.-Mexico border, most located themselves outside the industrial complexes which already had telecommunications infrastructure and connections in place. Needing telecommunications services, many chose to use microwave technologies due to their low cost (compared to wireline installation) and the speed with which a company could install the necessary equipment.

As seen in Appendix D, large telecommunications users have often bypassed the public telecommunications network (Telmex) by installing their own microwave/cellular links, using satellite technology, or leasing lines from private providers in order to have continued and guaranteed flexibility and lower cost. This has created another set of problems, in which large corporations, having avoided the public network, cause the revenues that would have contributed to the development of a more advanced public network to disappear, along with the pressure for service upgrades. This, then, leaves smaller operations which cannot afford to bypass the network with little or no opportunity to upgrade their telecommunications networks. Over time, many firms also discovered that microwave-based systems were difficult to maintain, could be unreliable, and had limited capacity for expansion.

Many local microwave carriers could not achieve the fast, high-bandwidth, complex communications connections the *maquiladoras* needed (especially with the advent of computer-aided manufacturing technologies) to stay competitive over the long term. Just-in-time production strategies and inventory applications, along with the necessity of making large amounts of production, accounting, and sales information accessible to personnel in diverse geographical areas, often makes microwave an inefficient technology — one cannot ordinarily use microwave telecommunications to centralize information and data in the same way as one can with fiber optic technology. Microwave systems also cannot generally support multimedia applications and services [36]. Many of the *maquiladoras* switched to wireline communications after several telecommunications firms installed crossborder fiber optic lines to serve the *maquiladoras* and burgeoning NAFTA-related non-*maquiladora* trade. As trade increased, telecommunications solutions at the border, and particularly for the *maquiladoras*, have changed dramatically, and will change even more with the deregulation of the telecommunications markets in the U.S. and in Mexico [21].

As Telmex undergoes privatization and modernization, and partners up with U.S. and other foreign firms to provide advanced telecommunications services, the pressure for large companies to bypass the network will decrease. This will hopefully lead, over time, to the more aggressive use of information and telecommunications technologies by firms doing business in Mexico. It will also be a key factor in Mexico's growing international competitiveness. In addition, it may mean that Mexican firms, city governments and city planners will be more likely to invest in and encourage the use of ITS once these kinds of technologies become more feasible and less expensive to operate in the interior of Mexico. U.S. firms and research institutions can play a big part in making this happen.

Lastly, the use of information technologies and ITS products will become more important in the interior of Mexico as trade-oriented traffic moves further away from the immediate commercial zones of the border region. Even now, *maquiladora* plants have begun to move away from the commercial zones and into the interior.

CROSS-BORDER COMMERCIAL ACTIVITY AND ITS

Although one aspect of U.S.-Mexico trade revolves around the operation of the *maquiladoras*, which are usually close to the border, much trade activity involves the transport of goods from a point in the interior of one country to a point in the interior of the other. This means that telecommunications technologies and ITS systems used in connection with U.S.-Mexico trade must be able to function beyond the immediate border area, and this poses a challenge — particularly for U.S. firms trying to transport and track shipments into or from the Mexican interior.

Both *maquiladora* and non-*maquiladora* operations use a variety of technologies to facilitate the production, distribution, storage, and transport of goods across the border and often far from the border. To accomplish the coordination of these activities (which usually fall under the category of "logistics management"), firms employ a wide variety of advanced technologies, and network them within the firm and with other networks outside the firm. These networked commercial technologies complement ITS and in so doing can help to decrease (or manage) congestion arising from commercial traffic. For example, many of the commercial vehicles carrying cargo bound for the border, a *maquiladora* in Mexico, or a destination in the interior of Mexico, are now equipped with a variety of in-vehicle technologies designed to facilitate the transport, tracking, and/or intermodal transfer of the shipment.

Many of these systems take advantage of Internet technologies, are EDI capable, and involve transponders, radiotransmitters, on-board computers, and other devices. These systems work in tandem with other ITS initiatives such as Custom's AES which uses electronic data transfer, or weigh-in-motion (WIM) sites that facilitate weight inspections as a vehicle approaches the border. In addition, new Customs initiatives, such as the North American Trade Automation Prototype (NATAP), are based on EDI and Internet technologies that originate with firms far from the border.

Still other ITS systems at the border that facilitate commercial transportation management operate independently of (or sometimes in concert with) in-vehicle ITS. These would include variable message signs, signal timing, the operation and coordination of transportation management centers, and various systems that facilitate safety, weight and customs and regulatory enforcement measures, provide rapid emergency response (particularly important for hazmat incidents and hazmat transport), and remote monitoring of sections of the roadway traversed most frequently by vehicles involved in U.S.-Mexico trade.

What is important to note is that these kinds of systems are virtually nonexistent at the present time in the interior of Mexico, making northbound trade movements from the interior difficult for firms to track, and making southbound trade movements into the interior of Mexico also difficult to track, either from outside or inside the vehicle. Some larger American trucking firms have entered into strategic alliances with Mexican firms, and/or opened up offices in Mexico, to, among other things, facilitate shipment tracking and delivery. Often, these kinds of alliances involve technology transfer between the American firm and the Mexican trucking firm with which it contracts. The American firm can then install its own in-vehicle equipment in the cab of the truck operating in Mexico, and use satellite technologies to track the shipment and communicate with the driver. Most Mexican trucking firms do not consistently employ such technologies.

Such technology transfers and partnerships are important in the age of just-in-time manufacturing, where a delay of days, even hours, can confuse an entire production schedule. They are also extremely important for trucking firms that move less-than-truckload (LTL) cross-border shipments, or are involved with cross-border intermodal shipments. The ability to track a shipment, or adjust/customize routing, is of paramount importance to these firms. ITS technologies allow these movements to occur smoothly. Yet, in the Mexican interior, these systems and technologies are only beginning to be used by transportation providers. Hopefully, with the privatization of Telmex, the de-monopolization of Mexico's satellite program, and the opening of the long-distance sector to competition, there will be a surge in the willingness and ability of Mexican transportation providers to integrate in-vehicle and in-road ITS devices into their operations.

Commercial Vehicles and ITS

Transportation is the major link between a firm's plants, warehouses, markets, distributors, and raw materials sources. Transportation creates time and place utility in goods; it enables a firm to move goods physically to a desired location at a desired time. For many firms, transportation costs represents the largest percentage of a firm's distribution costs, with inventory and warehousing costs also amounting to a sizeable percentage of the costs of distribution. A firm's choice of transportation mode greatly influences many of the firm's costs as well as the nature of its production. For example, rail and water are not usually as fast as truck or plane, which means the firm must adjust its production schedule and inventory levels if it chooses a slower (or faster) mode of transport.

Each mode of transport also limits a firm in different ways with respect to the location of pickup and drop-off points for a shipment, and may requiring the firm to ship intermodally. Either way, the firm must be able to time its production with the requirements and limitations of the mode of transportation it uses, and devise a way to track its shipments and comply with the regulations governing shipments using that mode. For those firms whose shipments must cross the U.S.-Mexico border, ITS devices and technologies, both in-road and in-vehicle, can therefore be an important part of the bottom line.

Many firms, and *maquiladoras* in particular, employ "just-in-time" manufacturing strategies that allow them to fine tune their production cycles and inventory levels to get more products made in less time, and have only a small amount of capital tied up in inventory. In fact, over the past decade, most U.S. manufacturers have adopted some kind of flexible production schedule. One of the most crucial components of a "just-in-time," or flexible production strategy, is the computerization and automation of as many aspects of production and distribution as possible. The bottom line is, however, that in adopting these techniques and technologies, a firm reduces its order cycle time and inventory levels to such an extent that transportation becomes one of the focal points, along with the technologies that facilitate it. Routing technologies, weigh-in-motion, two-way satellite communications networks, advanced vehicle and shipment tracking techniques, electronic toll and fee collection, transponder applications, and electronic document filing and information exchange are all aspects of ITS that can dramatically affect production and, therefore, the cost of the good. .

At the border, these technologies have become a necessity because of the requirements of customs and immigration inspection. The ITS technologies in use at the border are telecommunications intensive, and therefore experience a specific set of problems in a region where the technologies that prove so useful on one side of the border may be nowhere near as useful on the other side. This is not only a problem with a difference in technological development that, in any case, is fading away, but more a problem of lack of widespread use. Most Mexican highways are not equipped with the advanced ITS technologies that many U.S. roads provide to complement in-vehicle ITS and assist the driver. Therefore, most in-road ITS systems exist on the U.S. side of the border. This may be changing dramatically in the next few years, though, as a consequence of the increasing involvement of U.S. telecom giants in partnership with Mexican firms to provide telecommunications services.

North American Trade Automation Prototype (NATAP)

One of the main goals of NAFTA is to facilitate trade. In order for this to occur, it is necessary to harmonize documentation, standardize data elements required for documentation, and work toward the development of an international "syntax" for information exchange. NATAP was developed to allow experimentation and evaluation of an electronic system that would achieve those three requirements. The prototype's design is based on common commercial data elements presented in a standard syntax (UN/EDIFACT) that is acceptable to all three NAFTA governments for the export, in-transit, and import of goods. NATAP attempts to integrate the information and regulatory needs of both Customs and the INS with various other statistics through the use of advanced information and transportation technologies (ITS) [37].

NATAP is a process that employs the principles of electronic commerce and is based on the sharing of commercial information on a shipment among trading partners and the submission of this information to Customs for analysis prior to the arrival of the shipment at the inspection point. It is based on the premise that there exists for every transaction, whether domestic or international, a common set of information routinely used and exchanged between trading partners. Therefore, it attempts to minimize the amount of data that must be transmitted, attempts to reduce duplicated data, and attempts to allow the system itself to generate other kinds of data, such as duty rates, or the identification of ports-of-entry (the radio frequency device near the border can detect this data and add it to the file). Another goal of NATAP is to create a non-stop conveyance of goods across an international border using ITS technologies.

The NATAP system is based on the use of a "value-added" network, or VAN. Essentially, a VAN is an electronic post office specifically designed for the acceptance, transmission, and possible generation of data. A VAN is not data storage network, and the VAN is not designed to become a central database for commercial transactions. In the prototype, the seller initiates the transaction through the VAN by constructing a data record of the invoice details for the goods; this data file is identified by a transaction number assigned by the seller. The shipper constructs a data record with the information required for a typical bill of lading; this data file is also assigned an identifying "trip/load" number, with this number (and only the number, not the data) coded onto a radio frequency device, transponder or "smart card," located on the truck or rail locomotive. These two numbers and their associated commercial information form the common data record for the shipment. This record can be exchanged and shared electronically among the various trade-related businesses that are involved with moving the shipment to its destination, and will also form the basic record used by the government for Customs and Immigration purposes. Any additional information related to the shipment can be added, modified, or generated when necessary [37].

As the conveyance approaches the border of the exporting country, a roadside antenna will pick up the trip/load number from the transponder on the vehicle, and Customs will be queried. If all the shipment data is present in the system and correct, the conveyance will get a "green light" to proceed across the border. A similar antenna will exist at the entry to the importing country, and the same process will be repeated. With respect to immigration regulations, the prototype assumes that each driver (or, in the case of rail, crew member) is pre-approved and has been assigned a registration number as part of the transportation data. Each individual will also be in possession of a "registration" card at all times, which INS is considering for electronic processing purposes [37].

Many state/provincial transportation departments and agencies are involved in the development of this prototype. Transportation agencies and law enforcement officials have stated that there is a need for capturing electronic data to ensure that drivers' licensing, insurance, and vehicle safety requirements are being met; they would like to see this as part of the NATAP system so they would no longer have to stop commercial vehicles to obtain this information. Also involved are the various agencies that administer corridor-wide ITS programs for commercial vehicles, such as the I-75 and HELP programs. These agencies need to coordinate their own system architecture requirements with the NATAP system (and vice versa) so these systems complement, rather than interfere, with one another [37].

Obviously, communications hardware, software, and services are an integral part of the NATAP system. Telecommunications hardware and service links will be required between all the participants in the process: the seller, the shipper, the broker, Customs officials, INS, and also between Customs field locations and Customs processing sites. Computers, modems, monitors, printers, and radio frequency device monitors will also be required. Other factors that need to be included are electrical and telecommunications services that form the basis of this system. It was not indicated in the NATAP materials which firm or agency would provide the telecommunications services for this prototype.

From a hypothetical standpoint, however, one could envision a linking of the NATAP system sites with the TMCs that serve the roadways leading up to the border. Ideally, the TMCs could provide information on roadway congestion or routing if necessary, as well as sites which would facilitate remote enforcement of WIM sites. This information could be provided to the truck driver via his or her in-vehicle computer terminal, or by radio broadcasts on a dedicated channel.

SUMMARY

As of August 11, 1996, the Telmex monopoly over the domestic and long-distance telephone market in Mexico expired, opening up Mexico's telecommunications industry to competition and starting it on the road towards integration with global networks. Increased competition by consortia that include the U.S.'s largest telecommunications providers will greatly effect the provision of telecommunications hardware and service in Mexico. The immediate beneficiaries of the privatization may not necessarily be the local residential user but rather the larger corporate and government clients that operate across states and internationally, make a huge volume of calls, and require more advanced telecommunications and computer networking services.

Cities along both sides of the border must begin thinking about how these dramatic changes in the nature of telecommunications will begin to affect them. How will increased competition in the U.S. and Mexico affect initiatives such as NATAP, or the operation of the TMCs? How will TxDOT manage issues of right-of-way, particularly those stretches of right-of-way that abut border infrastructure? There are not yet answers to these questions, but it pays to examine some of the alternatives in order to formulate the appropriate solutions at an appropriate time.

It seems likely that the market for ITS research and deployment at the U.S.-Mexico border will soon be increasing dramatically. As Mexico's border cities and interior cities begin to feel the effects of competition, they will also have access to more advanced technology at (hopefully) less expensive rates. These cities will have easier access to better hardware and software, and the benefit of timing, in the sense that each of the consortia for long distance is scrambling for market share (on both sides of the border). Many of the U.S. firms that are part of these consortia are actively trying to position themselves to be the firm chosen to provide certain services. These firms are eager to break into new markets and be the first to establish a presence. With respect to ITS, the market is still wide open.

CHAPTER 7: MAJOR FINDINGS AND RECOMMENDATIONS

GENERAL RECOMMENDATIONS

It is clear that both the public sector and the private sector will be affected by the new telecommunications legislation passed in the U.S. and in Mexico. It is also clear that many of these effects are not yet known, and may not be felt in the immediate future. This does not mean, however, that telecommunications policy issues should be ignored. This study has shown that certain issues will be important for federal, state and local governments, as well as the private sector, to continue to track in the coming year. These issues include:

- The extent to which public-private partnerships have formed or not formed for the purpose of research and/or deployment of telecommunications based systems, such as ITS.

- The position and attitude each state takes with respect to telecommunications deregulation — which states are taking a pro-competition stance, which ones are not, and how each state is managing its responsibility to set the ground rules and interconnection fees for competition in the local market.

- The manner in which states are or are not attempting to pursue "shared resource" projects for right-of-way and for ITS with private telecommunications providers and whether or not each state's strategy (partnering or not partnering, and, if partnering, the structure of the partnership) has been successful. A related issue to watch is whether or not the window of opportunity for these projects is closing.

- The extent to which U.S. telecommunications providers' involvement in the Mexican long-distance market will or will not affect the deployment of ITS systems at the border and in the interior of Mexico.

RECOMMENDATIONS AND RESPONSIBILITIES — THE PUBLIC SECTOR

Wireline and wireless telecommunications systems are the keys to building a national ITS infrastructure. Although the 1996 Act opened the telecommunications industry to competition nationwide, many of the benefits of this competitive market structure will not be felt immediately. The FCC has issued benchmarks, guidelines, and rules for regulatory change, but each state is also free to issue its own rules and guidelines for interconnection arrangements (i.e., the price that long-distance competitors will have to pay to plug into local telephone networks and the procedures for such activity).

Although states have been given much leeway by the federal government with respect to opening of the local telecommunications markets, this comes with a great responsibility. States must ensure that the decisions they make not only benefit the state's own economy and citizenry in the long and the short term, but also do not hinder commerce and economic development in surrounding states, regions, or the nation.

The Federal Government

The federal government can set the tone for the direction of events as they unfold in each state. By setting the proper tone at the federal level, states may more likely be encouraged to follow suit.

Recommendation 1: **Ensure that states set interconnection rates fairly.**

Recommendation 2: **Ensure that states do not hinder competition and, in so doing, adversely affect other states.**

It is important to note that the implementation of the local competition provisions of the 1996 Act has been extremely difficult and controversial. The FCC, in late 1996, took action to remove many of the statutory, regulatory, and operational barriers to local telephone service competition. The FCC indicated the three "paths of entry" for competitors, prescribed minimum points of interconnection that the local incumbent operator must provide to the competition, and set forth a methodology for states to use in establishing interconnection rates and the rates for the purchase of unbundled elements. Yet each and every state is free to ignore the FCC methodology.

Each state's public utility commission (PUC) will be able to determine for itself (within certain limits) the cost for newcomers to connect to, or lease parts of, existing phone networks within the state. PUCs will also have to decide how customers who switch service can keep their existing telephone numbers (number portability), and at what level to set the fees telcos will have to pay to subsidize service to low-income customers (universal service). The answers to these questions will be different in each state, and will determine the competitive picture in each state [16]. Some states will be more aggressive than others in setting the interconnection rates and rules. In many cases, a state's position on local competition and interconnection depends on the relative position and strength of the local carrier and the extent of its influence within the state. In many states, the local Bell operating company can exert significant political influence.

In fact, the FCC interconnection order was challenged by several state regulators, regional Bell operating companies, and other carriers. They argued that the FCC overstepped its bounds with the order. Resolution of these conflicts will take place this year, with the FCC trying to defend its competition rules before the federal appeals court and Congress. In the meantime, the Eighth U.S. Circuit Court of Appeals in St.

Louis agreed in October 1996 to suspend key portions of the rules and is scheduled to begin hearing oral arguments in January 1997. Despite the court's stay of the rules, local carriers and their "rivals" have already signed interconnection agreements across the country without the "benefit" of FCC guidelines.

Faced with the prospect of each state having its own separate and different regulations for entry into the local telephone service market, intra-state and intra-regional commerce could certainly become a headache, if not an administrative nightmare, especially for the private sector. And those firms and states that pushed through interconnection agreements before the final agreement on what the regulations will be — will this have been a positive or negative move for them?

Recommendation 3: **Support the creation of public-private partnerships in telecommunications at the state-level.**

Recommendation 4: **Support partnerships designed to facilitate the research and deployment of ITS.**

The federal government should encourage (with legislative and regulatory support) private sector participation in the creation of the national intelligent transportation infrastructure and architecture. Such participation reduces research costs, not only on the federal level, but on the state level as well. The kind of participation also works to ensure that both the public and private sectors each have a stake in creating a technologically advanced, yet commercially viable ITS infrastructure. With explicit federal support of partnering initiatives on the state level, states will be encouraged to use this option.

The States

Planning for telecommunications and transportation infrastructure, and then creating that capacity, is a strategic investment for the nation as well as each of its states. The public sector must acknowledge that the changing competitive atmosphere in the telecommunications industry calls for proactive and innovative responses and strategies not only by the federal government but by the states as well.

In creating these strategies and policies for telecommunications, state agencies should seek the counsel, advice, and involvement of major private sector service and technology providers and university research organizations. By doing so, state agencies will find it easier to make necessary changes in policy. State officials must recognize that their way of understanding the role of, and their interaction with, telecommunications providers and related network services is currently undergoing a "paradigm shift." This will encourage to move toward the creation of a more comprehensive and integrated telecommunications infrastructure conducive to meeting state requirements for economic development.

Recommendation 1: Creation of State "Master Plans" for Telecommunications Services at the Legislative and Agency Levels

State officials should consider it their responsibility to ensure that their states are equipped to respond to the changes the new telecommunications legislation will bring. These officials should develop strategies to enable their states to take advantage of the new opportunities telecommunications competition will present and ensure that the state is not adversely affected by the mergers, alliances, and struggles over interconnection that are the apparent by-product of the legislation. State officials should also attempt to ensure that the telecommunications sector in the state is developed in support of the state's long-term economic plan. This would entail that the state and each of its agencies develop a strategy for and policy on the use and development of telecommunications networks, services, and related infrastructure. These strategies and policies should be carefully integrated with existing and future statewide initiatives.

To avoid a narrow view of the possibilities and potential difficulties that will present themselves, the creation of a "master plan" for telecommunications should be a product of consensus-building committees that include private sector firms and individuals in advisory capacities. At the highest levels of state government, policy goals for economic development should directly and specifically address the role of telecommunications technologies and services in the state, provide a "vision" for how these goals may be achieved in the short- and long-term, and describe the role that each government agency will play in the achievement of these goals. It will be important that this vision also include a methodology and strategy for the creation of organizations and processes to continually improve, monitor, and evaluate the state's progress [21].

Each state agency should also prepare a "master plan" that addresses its own current and anticipated needs for telecommunications and related services, and the role it expects its network to play in the larger state plan for economic development. At the agency level, it will be important to seek the input of users, service and equipment providers, engineers, and policy professionals, and make them part of this process team. Such a "master plan" is especially important for state departments of transportation because of the important role that transportation-related telecommunications systems (such as ITS and transportation management centers) play in the future economic development of most states. Individual cities may also want to produce a similar "master plan."

As a related issue, cities and states should consider integrating telecommunications planning into their governing structure. For example, individual cities or state agencies (such as DOTs) may want to consider creating a "Telecommunications Office" to facilitate cross-sectoral cooperation, research, and planning on various telecommunications applications and technologies, such as the development and deployment of ITS, the integration of the TMCs into the state's long-term telecommunications and transportation plans, the examination of issues of right-of-way for telecommunications, and other issues. By doing so, states, state agencies, and individual cities can help to reinforce the role of telecommunications policy in an otherwise engineering-oriented sector, and bring the two together in such a way that both aspects can operate in parallel and in support of one another.

Recommendation 2: Encourage Strategic Investment and Planning for ITS

States should consider making strategic investments in telecommunications and ITS, especially through partnering, to benefit special industries or regions. Strategic investments of this nature will position states so they may take advantage of long-term socio-economic trends. These "strategic investments" in telecommunications technologies, systems, and infrastructure should target cities with unique needs that would benefit from better telecommunications infrastructure and the use of ITS technologies, such as border communities. The city is an important level of analysis because cities are "nodes" for telecommunications and transportation activities and infrastructure—yet cities ultimately have little power in making many decisions in these areas [21].

Another important level for strategic investment is the transportation "corridor." These corridors, based on the highway infrastructure, are valuable for telecommunications providers because these are the rights-of-way they seek and these are the roads in which most ITS systems are located. These corridors also connect the TMCs to one another, and in many cases form the conduit for a great deal of economic activity. In assessing where to deploy advanced technologies and how to make them most beneficial to the state, states should look first to their transportation corridors.

FCC rules leave state utility regulators wide latitude in executing deregulation. This has many implications for ITS. First, if states are considering shared resource projects with private sector telecommunications providers and are also free to set interconnection rates, what impact will this have on the cost and operation of state telecommunications networks, particularly those operated by state departments of transportation? How will these arrangements affect corridor-wide ITS projects that cut across several states or even international boundaries? If states no longer share a common rate structure or attitude about local competition, what will the future for intra-state ITS systems be? By making a commitment to the partnerships and policies that influence the outcome of these issues (and others), states may begin to answer these important questions.

Recommendation 3: Encourage Research into Telecommunications and ITS

States should encourage research into the effects and consequences of increased local telecommunications competition, service bundling, and merger activities with respect to the state's economic structure, transportation industry, and urban plan. This research can form the basis for an intelligently articulated "master plan."

Policy and financial analysis should be undertaken to determine what the best direction should be for public-private partnerships in telecommunications, the use of right-of-way, and the long-term policies of DOTs with respect to maintaining telecommunications infrastructure and adding new capacity. This should be an important research area because telecommunications service pricing will affect the valuation of resource sharing partnerships and other activities related to the use of right-of-way.

Recommendation 4: Educate Individuals and Groups About the Relationship Between Technology, Transportation, and Economic Development

Many citizens are unaware of the role that telecommunications and intelligent networks play in the economic development of their state, their city, and the region of which they are a part. State government should promote "stakeholder forums" [21] to help individuals of all types and positions gain a better knowledge of the applications of telecommunications to their own economic livelihood and the economic well-being of the cities in which they live and work.

This "education" could be jointly undertaken by state representatives, representatives of the private sector, and representatives of organizations within the state that conduct research related to the application of telecommunications and intelligent networks. They should begin with the education of their peers; stakeholder groups should be organized and given "seminars" on the state of the industry, state of legislation and regulation, and on the potential of intelligent networks of all kinds in the future. These seminars, of particular importance for planning telecommunications networks and infrastructure at the border, can eventually become cooperative planning sessions.

The State of Texas and the Texas Department of Transportation

Planning for telecommunications and transportation infrastructure, and then creating capacity, is a strategic investment for the state of Texas. Texas must place itself in a position where it can take advantage of the window of opportunity presented by new telecommunications legislation in both the U.S. and Mexico. The Texas ITS infrastructure is part of a larger national (and international) intelligent network, and

TxDOT must acknowledge that the changing competitive atmosphere in the telecommunications industry calls for proactive and innovative responses and strategies.

The assumptions and premises of state telecommunications regulation and development should be reviewed and evaluated in light of how well they buttress the long-range economic plans of the state. This is an absolute necessity if Texas plans to take full advantage of the opportunities presented by the new legislation, as well as the opportunities presented by Texas' increasing role in international trade.

The state of Texas faces many unique issues, many of which arise from the fact that Texas is a major crossing point for international commerce with Mexico and that Texas' border covers a large percentage of the entire U.S.-Mexico border. This means that many of the communication and transportation needs of the state, particularly as they relate to economic development, are unique to the state and will be heavily influenced by the effects of telecommunications deregulation in both countries.

Recommendation 1: Creation of "Master Plans" for Telecommunications Services and Partnering in the State of Texas, On the Legislative and Agency Levels

The state of Texas must better understand the long-term effects of its decisions with respect to local telephone competition. How forcefully will Texas be willing to defend regulations that many believe to be anticompetitive? Will Texas be served in the long run by limiting (or at least delaying) competition in the telecommunications sector, possibly losing business to other states which have taken a more pro-competitive stance? How will these legislative and political decisions affect the development and deployment of technologies that help to manage transportation within the state? These are important questions that the development of a state telecommunications master plan may help to answer.

A "Master Plan for Telecommunications" developed by at the agency level by TxDOT, for example, should highlight the interrelationship between telecommunications, transportation and economic development. It should address several major areas, including:

- right-of-way issues as they relate to telecommunications and partnering with the private sector;
- the creation of an integrated transportation/telecommunications plan for the Texas-Mexico border; and
- the present and future role of ITS throughout the state.

Most important in the short term is the need for TxDOT and the state Attorney General's Office to work out a policy on use of right-of-way for telecommunications and the rules for creating partnerships with telecommunications providers.

Recommendation 2: Develop Strategies and Policies for the Use and Valuation of Right-of-Way

The TxDOT "Telecommunications Right-of-Way Task Force" was created in early 1996 to guide TxDOT regarding its policy on the use of right-of-way for telecommunications in an attempt to begin to set some standards and rules under which TxDOT could partner with private telecommunications providers for services. The Task Force realized that, although there were few states in the nation with definitive answers to these issues, they had a responsibility to attempt to move forward in the state of Texas. Some basic issues the Task Force set out to explore were:

- lease versus ownership of telecommunications facilities;
- resource sharing (what it means and what are the objectives);
- use of the TxDOT telecommunications network by other agencies; and
- Possible conflicts involving public sector ownership of or sublease of excess capacity [38].

The Task Force then sought the opinion of the Texas State Attorney General's Office on legal issues pertaining to these matters, including, among other issues, whether TxDOT could allow a private use of state-owned property, either by allowing a private telecommunications provider to use existing excess TxDOT network capacity or by allowing this private company access to an area of the right-of-way outside of the "traditional utility corridor" for the firm's private use (and whether the firm must be charged for this use) [39].

The Task Force sent correspondence on this matter to the Attorney General's Office as far back as January 1996 asking for an opinion on TxDOT's legal questions regarding use of right of way. The Task Force has not, as of the writing of this report, received a response from the Attorney General's office on these matters. TxDOT is still unclear on what its policies should be for the use of right-of-way for telecommunications. Activities of the Task Force are on hiatus until the questions of statutory authority are addressed by the Attorney General's Office. Unfortunately, without legal guidance, TxDOT is unable to act on these issues, and the window of opportunity for these kinds of projects in the state of Texas is shrinking.

As telecommunications firms are each jockeying for market share, they are aggressively seeking new partners and niches. The largest telecommunications providers in the U.S. are each also involved and competing against each other for market share in the Mexican long-distance market. Without a policy on right-of-way for telecommunications and a policy on partnering with telecommunications providers (particularly with respect to international telecommunications infrastructure and services), TxDOT may be unable to take advantage of otherwise positive and beneficial partnerships which will help to support extensive ITS efforts throughout the state.

Recommendation 3: Develop a Plan for Effective and Efficient Deployment of and Investment in Telecommunications-Based Technologies at the U.S.-Mexico Border

The increasingly interdependent relationship between telecommunications and transportation combined with the changing competitive atmosphere of the telecommunications industries in both the U.S. and Mexico will have a marked effect on the development, deployment and use of ITS in Texas and at the Texas-Mexico border. For certain agencies, such as TxDOT, these strategies and policies should also take into account the state's function as a major crossing point for U.S.-Mexico trade and the fact that this trade is a major contributor to the economic health and growth of the state.

Expediting and managing this trade and its related transportation movements is a technology-intensive task heavily dependent on telecommunications. It is imperative that agencies such as TxDOT develop a plan for deploying telecommunications-related systems (i.e., ITS) at border crossings that takes into account the changing telecommunications landscape in the state of Texas and in Mexico. A commitment to long-range telecommunications planning in concert with Mexico is particularly important in discussions of planning for transportation-related infrastructure.

Given resource limitations, it is important to strategically explore new telecommunications technologies, applications, and systems for the border. Border states and cities should be moving from a comprehensive plan for managing commercial traffic and other economic activity at the border to a more strategic, targeted set of priorities for the use of existing technology, and a targeted set of specific research goals for the application of new technologies. Lastly, border states and cities should make an effort to assess how partnering can be used to leverage limited financial resources, as in shared resource projects. Metropolitan Planning Organizations (MPOs) can be instrumental in these activities.

Perhaps now that the competitive landscape for telecommunications services is changing in both the U.S. and Mexico, it will become easier, simpler and more profitable to develop and deploy innovative and advanced technologies and services in the border areas, and by doing so also encourage continued research into new opportunities for ITS in the area. An important part of this is to make an effort to create harmonized standards for advanced telecommunications-based systems at the border. If a standard can be agreed upon between the U.S. and Mexico for crossborder systems, and a minimum set of technologies and system needs developed, then the business of modifying systems for border crossings can begin. NATAP has already begun this process.

Recommendation 4: Develop Strategies and Guidelines for Partnership Development for Cross-Border Transportation, Technology Exchange, and Research

Consider a future situation in which Mexican trucks will be operating legally within the state of Texas. How will ITS technologies designed to support U.S. standards and equipment benefit the Mexican drivers who may not be equipped to take advantage of many basic in-vehicle technologies? When U.S. trucks and drivers begin to travel in Mexico, a nation that does not yet have ITS extensively installed in its cities or on its roads, will the in-vehicle ITS systems the U.S. drivers and their firms rely on be of practical use?

Consider the present situation in which the U.S. government is investing in new electronic Customs and Immigration inspection programs such as NATAP. Consider that the wide variety of specialized ITS systems for the border are just an extension of ITS in the rest of the U.S. border states. In order to create a situation in which "seamless" transportation can become a reality, cross-border partnerships must be created and nurtured to facilitate education, economic cooperation, and technology transfer between communities on both sides of the border.

Unfortunately, Mexico does not have legislation similar to ISTEA in place, and there is little coordination at the local level for advanced transportation systems planning and research. In this sense, it is difficult for an MPO on the U.S. side of the border to find an administrative body with similar responsibilities on the Mexican side of the border, making coordination and cooperation difficult. This is beginning to change, but slowly. It is important for U.S. transportation research institutes and MPOs to develop plans for joint educational/training programs, technology transfer, and collaborative research with Mexican counterparts, either at the university or government level, and with private industry.

Recommendation 5: Develop a Prototype for Public-Private Partnerships for Telecommunications Services in Texas

There are efforts underway throughout various state agencies to assess the benefits of partnering, and describe ways to make it effective on an agency-by-agency basis. However, partnering opportunities for telecommunications services are time-limited, in the sense that the window for these opportunities is will be closing as private telecommunications providers find alternatives to public-private partnerships in the absence of strong direction and support from the public sector. Though there are many examples of successful public-private partnerships in transportation technology and management, these partnerships are not easy to create and sustain, and they are also not without risk.

Private sector investment in public sector ITS systems has been difficult in many cases because there is a lack of a stable institutional, legal, statutory, and regulatory framework for this kind of cooperation, inadequate data (particularly on ITS benefits), and a variety of financial and business risks. It is not surprising that these kinds of partnerships are even more difficult when dealing with transportation systems (and related technologies) that cross international borders.

Recommendation 6: Encourage Research and Education

These two recommendations are closely related. Without research into the qualitative and quantitative benefits of ITS programs throughout the state (and in the nation as well), and without educating individuals and groups in both the public and private sector about ITS, it will be difficult to develop support for deployment of these projects in the future. Once benefits are quantified, the populace is educated, and legislative support obtained, investments in these technologies and systems can be made strategically, and effectively to benefit the state in both the short- and long-term.

RECOMMENDATIONS AND RESPONSIBILITIES - THE PRIVATE SECTOR

Telecommunications Providers, Transportation Firms, Shippers and Others

The private sector can play a major role in the outcome of telecommunications deregulation and the development/deployment of ITS by encouraging the development of innovative financing and partnership arrangements with the public sector and assuming more risk (for a bigger payoff). Transportation firms and shippers can assist research organizations and departments of transportation in their efforts to create system architectures for ITS that serve the needs of the vehicles that will use them. Private sector stakeholder groups can offer "seminars" to public sector personnel on their technology, research and legislative needs. Groups comprised of both public and private sector personnel can give similar educational "seminars" to the general public to increase the knowledge and use of ITS technologies and increase user acceptance.

CLOSING COMMENTS

Almost 10 million people live in the U.S.-Mexico border region; productive and vibrant relationships exist between the individuals, communities, and businesses on both sides of the border. Extensive social, economic, and cultural exchange form the foundation of the border region's commercial and industrial life. The extent of these crossborder activities has grown immensely since the passage of NAFTA, requiring border states and municipalities, both cooperatively and individually, to reassess and strategically plan for their infrastructure needs. The U.S. Department of Commerce estimates that approximately $16 billion will be required to meet border transportation, environmental. and energy infrastructure needs over the next decade (there is no reliable estimate of housing infrastructure costs). It is estimated that approximately two thirds of these needs will occur on the Mexican side of the border.

Important issues must be faced in the coming years if both the public and private sectors are to respond adequately to border infrastructure needs. Population and economic growth at the border and in the states along the border will require both the public and private sectors to develop innovative methods of constructing and maintaining the region's roads, bridges, seaports, airports, housing stock, water and sewer facilities, and energy facilities [40].

Economic difficulties experienced by both the U.S. and Mexico in the 1990's, however, have made it more difficult for state and local agencies at the border to respond to the infrastructural needs of the region. The recession in the U.S. during the early 1990's compounded by Mexico's peso devaluation in late 1994, severely restricted the amount of capital available for large-scale infrastructure projects at the border, and dramatically increased the risk involved in financing these projects. Unemployment and other changes in the job markets in both countries dramatically affected the tax base of many border cities, and left many with little or no financial capability to develop new infrastructure or expand capacity on existing projects. However, given recent economic improvements in both countries, the public and private sectors should have more opportunity to create infrastructure partnership opportunities and explore innovative financing techniques.

Telecommunications is a fundamental part of economic development in the border region. Telecommunications infrastructure, capacity, and service play a fundamental role not only in cross-border commercial activities and transportation, but in any project that requires communication, exchange or generation of data, use of computers or fax machines, or the automation of production and monitoring of operations. The telecommunications sector in both the U.S. and Mexico is changing dramatically, presenting both the public and private sectors with vast new opportunities for research, investment, partnering and financing.

The first step in the creation of cooperative relationships in support of commercial activities at the border is to focus on creating institutional capacities and relationships. The fact that federal, state, and local governments in the U.S. and Mexico are decentralizing makes the creation of these institutional capacities and relationships both easier and more difficult to achieve. Particularly in Mexico, increased independence of government at all levels may encourage innovation and allow room for the creation of new partnerships and alliances. On the other hand, decentralization may also place more responsibility on the shoulders of state and local governments. These local governmental bodies may not be adequately prepared, financially or administratively, for these new responsibilities.

This is a problem for border communities, where the colonias have virtually no government, and cities such as El Paso, Brownsville, and Laredo have project needs that far exceed their funding ability. MPOs have taken some of the pressure off local government with respect to planning, but cannot solve the fundamental problems of project funding and interagency cooperation. They also cannot draft the federal legislation which would help support their efforts.

Like many cross-border infrastructure development projects, the creation of telecommunications capacity is expensive. Yet, unlike many infrastructure projects such as roads, bridges, and water treatment plants, telecommunications infrastructure plays a supporting role in cross-border activities. This creates a situation in which telecommunications infrastructure and services are often placed behind other needs. Inattention to this area, though, did not dramatically impact economic development — until recently, the choices regarding telecommunications service and equipment providers were relatively uncomplicated. There were long distance providers and local providers, there was Telmex, and that was all there was. A city or state generally knew the market, and knew the players in it.

This is no longer the case. Government agencies are no longer dealing with a known market with known service providers, standard services, technologies and prices. The public sector, faced with the prohibitively high cost and increasing complexity of telecommunications services and equipment, is actively seeking private sector partners to help it maintain and operate its own telecommunications networks. New policies and precedents must be set in response to new telecommunications regulations, and the only way for this to occur in support of long term goals is to address partnering for telecommunications. Because telecommunications is such an integral part of the border economy, this focus is crucial for border states and cities.

There is a close relationship between what constitutes effective governance and how well the local government finds private sector partners. This relationship is based in the notion that, at a time when most cities' financial resources are limited, the effective and innovative use of limited resources is a hallmark of effective government. A government's ability to develop private sector partnerships is based in collaborative planning, education and training, as well as the existence of organizations that encourage such cooperation. This idea is certainly not a new one. But at a time when so many things are changing — such as the telecommunications markets in the U.S. and Mexico — this kind of cooperation takes on much added importance.

APPENDIX A: ITS-SPECIFIC WIRELESS COMMUNICATIONS APPLICATIONS**

ANALOG CELLULAR TELEPHONY AND RADIOPAGING

Analog cellular technologies provide good quality voice service and acceptable data transfer capabilities. Many transportation firms (such as UPS) rely on analog cellular networks nationwide for package tracking and delivery confirmation functions. Analog cellular equipment costs have rapidly decreased since the technology was introduced, but air time costs are still high. Analog cellular networks and technologies were also not designed with data transfer in mind, and therefore perform poorly in comparison to digital packet data systems. In addition, their coverage areas are primarily urban, which limits their usefulness in remote areas. This is not usually a problem for firms which are located or do most of their business in or around urban areas, but it can become a hindrance to individuals who travel over wide or remote areas or for systems which must serve large or remote areas. This is a problem for ITS systems (in-vehicle and in-road) that must cover large regions. Lastly, analog cellular transmissions can be overheard by anyone with a modified scanner, which makes them ill-suited for communication or data which must remain secure.

Radiopaging is also an attractive and useful technology, with robust channels and signals that can reach deep inside buildings. The technology is simple, integrating various digital signaling techniques. Some pagers are simple tone-only models, and others employ technologies that enable the display of alphanumeric messages. Some pagers can even support tone-and-voice messaging. Like most cellular services, paging is primarily an urban service, and is also a one-way service; a message recipient must be near some kind of telephone (wireline or wireless) to respond to a page. Yet, it is a simple and affordable technology [3].

DIGITAL CELLULAR TELEPHONY

Digital standards for cellular transmission have greatly improved the reliability of cellular service and made networks more hospitable to data transmission. Packet data technologies vastly improve the flow of data from mobile units, avoiding the midstream breaks in a data file that occur frequently with analog systems. Although digital equipment is more expensive than analog, digital airtime rates are advertised as less expensive than analog by up to 40 percent.

An up-and-coming problem with digital cellular technology is that different commercial

** Unless otherwise indicated, information in this Appendix is adapted from Elliot and Dailey, Wireless Communications for Intelligent Transportation Systems [3].

providers have adopted different digital standards. This not only makes it difficult for consumers to understand their options, but hinders the use of the technology over widespread geographical areas. This will become a problem if states chose digital cellular applications as part of an ITS system that covers many cities, or crosses state/regional lines.

CELLULAR DIGITAL PACKET DATA (CDPD)

A great deal has been written about the promise of this technology to finally bring low-cost and reliable data transmission to cellular services. CDPD uses the short breaks between cellular calls on a network to transmit bursts of data along radio channels that would otherwise be idle. Some claim that CDPD technologies can support data transfer rates up to 19.2 Kbps, a good speed for wireless. Like digital cellular, CDPD offers reliable service by its use of packet data transmission techniques and error checking algorithms; but because CDPD uses vacant space on already existing cellular channels, it can only travel as far as its cellular network will allow. Cellular operators hesitate to extend their networks far beyond cities because the high cost of the cellular infrastructure requires a large customer base — unlikely to be found in rural areas.

PERSONAL COMMUNICATIONS SERVICES (PCS)

PCS is a cellular system that uses equipment that can operate on greatly reduced transmitter power. Instead of relying on larger transmitter towers, it can employ transmitter/receivers small enough to be mounted on the sides of buildings. Because of the reduced power usage, PCS equipment can be smaller, lighter, and be able to run longer per charge. It is also believed that these systems will be able to accommodate more callers than standard cellular networks and offer lower airtime rates. Auctions for the first PCS licenses began in August, 1994, and construction of these networks is underway. ITS engineers are keeping watch on developments with this technology because it could become a much less expensive resource for mobile voice and data communications.

CONVENTIONAL PRIVATE LAND MOBILE RADIO AND ENHANCED SPECIALIZED MOBILE RADIO (ESMR)

Having been around for some 40 years, one of the oldest mobile communications technologies is private land mobile radio. The FCC has set aside frequencies to help private industry and public safety groups to improve productivity and safeguard the public safety and welfare. These public service radio allocations include the frequencies established by the FCC for highway maintenance. All state DOT's (and emergency services personnel) use these channels for voice communications with workers within range of their towers. Private land mobile radio is decidedly not high tech, but it is simple and very reliable, and the equipment used to receive these communications is also rugged and dependable. The spectrum it uses is freely available, which offers DOT's huge cost savings. There are, however, only a limited number of channels available, and the conversations on the network are not private. Only by switching to a digital system could a DOT prevent others with scanners from listening in.

ESMR technology is private land mobile radio gone digital. Rather than using widely spaced radio transmitter towers, ESMR providers employ smaller cells so they can reuse frequencies. ESMR handsets can support voice, data messaging, and paging. And although ESMR air time is less expensive than cellular, the handsets are more expensive.

ARDIS AND RAM

As wireless communications matures as a technology, the market is becoming more specialized as providers begin to target particular mobile communications needs. One example is a radio data network (RDN) that occupies a niche serving firms or individuals which need mobile data communication almost exclusively, such as long-haul truckers, field service workers, workers desiring constant access to E-mail accounts, etc. The two major players in this area of communications are the Advanced Radio Data Information Service (ARDIS) and RAM Mobile Data. Both these services have been operating since the early 1990s and use their nationwide radio licenses to provide data networking to a wide variety of firms across the U.S., such as a major sporting goods manufacturer that uses ARDIS to enable its salespeople check warehouse inventories, and a major rail line that uses RAM to track the location of train shipments and continuously update work orders completed by the engineers.

Both systems have fairly low transmission rates, but the radio channels are quite robust, so they offer reliable messaging especially in urban areas that are usually harder to reach. However, both systems have limited reach in rural areas, the modems are very expensive, and the pricing schedules for air time are extremely elaborate.

RICOCHET MICRO CELLULAR DATA NETWORK

The Ricochet Micro Cellular Data Network is another example of an RDN that provides low-cost, high-speed data communications for operations like public utilities. Unlike ARDIS and RAM, Ricochet uses a frequency-hopping spread-spectrum transmission standard that allows efficient use of radio spectrum and security against message interception. Calls from various customers share the same broad range of frequencies, but individual calls are moved along with their radio carriers, whose frequencies are also continuously varied. This approach has been used for years by the military because of the difficulty in message interception. Ricochet does not support voice transmission.

The Ricochet system also employs a "mesh network" in which system intelligence is spread throughout the system rather than concentrated in a few hubs. This allows data connection to occur faster without crowding channels to and from the message center. Unlike ARDIS and RAM, Ricochet also takes advantage of unlicensed frequencies, so it does not have to gain FCC approval to build its network in any city. But since it will have to share the unlicensed frequencies with other industrial, scientific, and medical users, interference may be a problem as use gets heavier. Ricochet uses small transmitters the size of cereal boxes, easily attached to light and telephone poles; it can also be installed and put into service easily and at relatively low cost.

RADIO FREQUENCY WLANS (WIRELESS LOCAL AREA NETWORKS)

Local Area Networks (LANs) interconnect the personal computers, making it easier for individuals in the same office to share applications and transfer data files. In some cases, the fact that these networks are fixed (non-mobile) is inconvenient — for example, a doctor or nurse who wants continuous access to patient data as they are making rounds throughout the hospital. WLANS provide this mobility by replacing the traditional interconnecting cables with wireless radio connections. This technology was designed primarily for indoor office applications, so WLANs have a limited range and their adapters are unsuited to weather extremes. WLAN use is also complicated because different providers have different and proprietary system/transmission standards.

However, WLANs operate in unlicensed bands so they do not require FCC licensing, and no air time charges are accrued because they are operated in-house. Equipment is relatively inexpensive, but transmission speed is slow (although improving). And although many ITS applications are unsuited to this kind of technology, one could envision its use in certain situations where wireless LANS would be useful to a DOT — for employees who work at weigh stations, motor pools, airports, ferry docks, toll collection booths and border crossings. In an innovative application of interest to ITS engineers, one WLAN system allows scientists on a passing boat to gather computer data from research sensors on ocean buoys.

Infrared WLANs operate the same way as radio frequency WLANs, but use infrared wavelengths (that border on the visible light spectrum) to carry data transmissions. The FCC does not regulate these frequencies, and they are immune from the radio interference that complicates other kinds of radio transmissions. They have fast transmission speeds, and, because the signals cannot pass through walls, offer some degree of protection from eavesdropping. They are, however, made exclusively for indoor use and are, therefore, unsuited to most ITS applications.

ANALOG MICROWAVE RELAY

Microwave technologies have several characteristics that make them especially well-suited for the wireless delivery of large quantities of voice, data, and video information.

Above 1 GHz, where most of the microwave spectrum exists, radio signals begin transmitting in straight-line paths. This gives operators the ability to establish discrete radio connections between points and avoid broadcasting the signal over a wide coverage area — as long as there are no obstructions in the way of the microwave beam. Microwave relay towers can therefore be strung together over long distances to link two remote locations as well as the in-between station where the towers are placed. Microwave signals are also fairly secure. Another attractive feature is their greater transmission capacity.

Police and ambulance services often make use of terrestrial microwave systems, which is useful if other public communications lines are disabled by a disaster. TV stations use microwave-equipped vans to deliver stories from remote locations back to the studio. The relay towers, however, are permanent in nature, and extremely conspicuous because of their height. The FCC also licenses special microwave bands for use by government agencies and some private industry, and frequently offers licenses for rural communications purposes.

Not surprisingly, there are digital microwave relays as well. Digital microwave technology evolved in parallel with the national ISDN (integrated services digital network) infrastructure that was designed to transport packetized, multimedia signals. Digital microwave signals provide "cleaner" end signals than analog because the binary transmissions are regenerated at each relay station — there is hardly any degradation. Yet, compared to analog signals that are boosted (amplified) at each repeater site (adding noise to the original transmission that microwaves do not have), digital microwaves are not as powerful. In addition, their digital nature makes these transmissions even harder to intercept and reassemble. Again, like their analog counterparts, these transmissions cannot reach beyond the horizon (because they travel in straight lines) and require uninterrupted lines of sight.

Specialized kinds of microwave relays (short-haul and "tropospheric scatter") have different degrees of applicability to ITS. Short -haul systems are designed for short range communications. However, at the specific range (18-23 GHz) in which these systems operate, signal attenuation and scatter from rainfall is a major problem because the raindrops interfere with the short wavelength signal. To compensate, relay towers are placed closer together and are backed up with radios. Despite these shortcomings, the cost and general reliability of these transmissions are more than adequate for most ITS applications.

Tropospheric scatter microwave relays are the opposite of the short-haul systems. They are able to transmit over the horizon at distances of over 200 miles. In this technology, high-powered microwave signals are aimed into the troposphere and a small fraction of the signal is reflected back to earth and can be received by highly sensitive equipment. These systems are favored by oil companies desiring to maintain operations control communications with unmanned offshore rigs. The FCC, with very few exception, does not generally grant permits for these systems, and they therefore cannot be considered useful for ITS.

GEOSTATIONARY AND LOW-EARTH-ORBIT SATELLITES

Satellites placed in orbit at a certain height and speed appear to be holding still above a fixed point on the earth. Geostationary satellite technology enables the construction of satellite dishes anywhere on the ground that remain fixed on one spot in the sky. These satellites are the only technology currently widely available to provide high quality voice communications and data transmissions anywhere in any state (or on the globe), regardless of the size of the state or the rural location of the dish. The costs associated with satellite transmission, however, often limits its use. Phone calls using satellites can cost $10-$15 per minute. Also, the orbital plane above the equator can only hold 180 satellites, which must serve all the countries of the world. Although costly, service is extremely reliable.

Low-earth-orbit (LEO) satellites orbit much closer to the surface of the earth than geostationary satellites (only 500 miles above the surface, compared to 22,300 miles above the equator), and therefore experience less interference and distortion (like the signal delays that make some long-distance calls so awkward). LEOs do not hold a fixed position in the sky, so if operators want to provide customers with continuous coverage, they must deploy 20 or more so their orbits "blanket" the earth. "Big" LEO's operate at above 1 GHz and can support both voice and data. "Little" LEOs use the frequencies most common for VHF transmissions and only carry data. The "big" LEOs offer a more cost-effective alternative to the geostationary satellites — but no LEOs, "big" or "little," have yet to be launched.

The "little" LEOs will eventually permit data transmissions throughout the U.S. at reasonable rates with relatively inexpensive personal handsets; the transmissions will be secure and two-way communications may be possible. DOTs with rural areas might find this technology attractive. The "big" LEO efforts have gotten the most publicity, however. The Iridium project, spearheaded by Motorola, was first, followed by Teledesic, financially supported by Craig McCaw (of McCaw Cellular) and Bill Gates. Teledesic projects an operational network size and complexity unmatched by competitors — it is expected to involve the launch of *840 refrigerator-sized satellites* into circular orbits. This technology will not be cheaper than land-based communications, but is expected to be much less expensive than geostationary satellite transmissions.

APPENDIX B: FREQUENCY ALLOCATION TABLE

U.S. Frequency Allocations			10 KHz	Very Low Frequency	**Radio Frequency Bands**
	AM Radio	1 MHz	30 KHz	Low Frequency	
		3 MHZ			
	Amateur		100 KHz		
	Police Teletype				
		10 MHZ	300 KHz	Medium Frequency	
	Aeronautical				
	Marine		1 MHz		
	Amateur and CB	30 MHz			
	Paging		3 MHz	High Frequency	
	Private Land Mobile			(shortwave)	
	Meteor Burst		10 MHz		
	Cordless Phones				
	TV Chs. 2-6		30 MHz	Very High Frequency	
	FM Radio	100 MHz			
	Little LEOs		100 MHz		
	TV Chs. 7-13	300 MHz			
	Paging		300 MHZ	Ultra-high Frequency	
	Priv. Land Mobile				
	TV Chs. 14-69		1 GHz		
	Cellular phones				
	Narrowband PCS		3 GHz	Super-high Frequency	Microwaves
	Big LEOs	1 GHz			
	Common Carrier Microwave		10 GHz		
	Unlicensed Spread Spectrum	3 GHz		30 - 300 GHz	Extremely High Frequency

Adapted from: *Wireless Communications* (Elliot and Dailey, 1995), p. 31.

APPENDIX C: BENEFITS OF TELECOMMUNICATIONS IN THE VALUE-ADDED CHAIN

Business Decentralization: Telecommunications networks enable the components of a firm to coordinate with each other, as well as coordinate with suppliers and distant markets. Because various business activities can be conducted efficiently over great distances, a firm can decentralize to take advantage of favorable locations. This has occurred, for example, in the case of maquiladora plants, in which firms have relocated their production facilities to take advantage of favorable tariff rates.

Market Expansion: Telecommunications networks can increase market size, share, and sales by enhancing customer service (i.e., the use of "800-" numbers or computer assisted ordering and distribution) and widening the distribution area. This is especially useful for firms located in rural areas, and for smaller firms.

Improved Decisionmaking: Telecommunications networks allow larger amounts of information to be acquired, stored, and used in effective and innovative ways, improving the speed and quality of decisionmaking. This becomes particularly important for operations employing just-in-time manufacturing techniques.

Reduced Distribution Costs: Computer-based logistics management techniques facilitate coordination, tracking, and scheduling of transportation services via mobile radio or cellular units. Units can be rerouted to avoid deadheading, making distribution of a firm's product more efficient.

Cutting Inventory Costs: Using computer and telecommunications systems to track inventory and move it efficiently is an important part of manufacturing practice; inventory and warehousing costs take up a large percentage of a firm's costs. Cost savings in this area can be achieved by both large and small firms, and are significant for those firms employing just-in-time production techniques, such as *maquiladoras.*

More Efficient Use of Labor: Telecommunications and computer applications can substitute for labor or make existing labor more efficient.

Increase Scope of Management: Information technologies allow the management of more operations and/or more people.

Competitive Pricing: Information networks facilitate the calculation of business costs and provide a more accurate basis for pricing and competing in the market.

Improved Training Opportunities: Costs involved in training personnel can be decreased by using telecommunications technologies to bring training opportunities to the firm through such means as videoconferencing, computer-assisted instruction and the like.

APPENDIX D: EXAMPLES OF TELECOMMUNICATIONS TECHNOLOGIES IN MAQUILADORAS

COMPANY "A": USING THE PUBLIC TELECOMMUNICATIONS NETWORK

Company "A" is one of the world's largest toy manufacturers and is a subsidiary of a large American-owned multinational corporation. Its assembly plant is in Matamoros (located in the Mexican state of Tamaulipas and almost directly across the border from Brownsville, TX, where its main offices are located). Company A's Matamoros plant has been doing real-time computing with Company A's mainframe located in Buffalo, New York and is connected to it via two data lines (one is a backup) that go first through the office in Brownsville. The office in Buffalo, NY has the responsibility for the purchase of production supplies and receives the data necessary to make those orders over the lines set up by Telmex. Should Telmex be unable to supply Company A with advanced telecommunications capability, the maquiladora operation would no longer make any sense at all to continue; should Telmex be unable to repair or service these lines, or upgrade them, or make connections to its trading partners, the maquiladora venture would rapidly become unprofitable and probably close.

COMPANY "B": USING MICROWAVE/CELLULAR TECHNOLOGY

Company B is one of the largest electronics firms in the U.S.. It has principal research facilities in San Diego, California, five manufacturing plants in the Los Angeles area, and an assembly plant in Arizona. It also has subsidiaries all over the U.S., manufacturing a variety of related goods, including six locations in Texas that serve as warehouses for materials moving to Mexico. Company B also owns plants in Taiwan and several in Mexico. Its Mexican operations are located in Matamoros, Reynosa (the sister city to McAllen and also in Tamaulipas) and Cuidad Juarez (sister city to El Paso and located in Chihuahua). Company B uses several microwave systems for its transborder communications, and its network configuration permits the exchange of necessary data (inventory, payroll and production schedules of various plants) between any U.S. and/or Mexico office although the transmissions must be rerouted through the main office.

COMPANY "C": USING SATELLITES

Company C is the Mexican operation of a large multinational corporation, but is not the typical maquiladora operation: first, it is a software producer and, second, it is located far from the border in the city of Monterrey (popular cities away from the border also include Chihuahua and Guadalajara). However, distance from the border created problems because the firm can no longer use microwave/cellular systems with nodes at the border, and communication via telephone to the U.S. was prohibitively expensive. Company C decided to solve its problem by using satellite communications services from INTELSAT which provide it with a Monterrey-Baltimore link. The satellite link is part of Company C's private communications network and is used primarily to send software requirements and system architecture specifications between Monterrey and Baltimore. It is also used for internal voice communications, fax service and audio/video transmission.

(Adapted from: Williams, *The New Telecommunications* , pp. 27-28)

Appendix E: How Does Telecommunications Work?

The information below was culled from three sources: Britannica OnLine's section on "Telecommunications Systems", 1995; Marvin Smith's "Radio, TV & Cable: A Telecommunications Approach" (Holt, Rhinehart & Winston: NY, 1985, pp. 67-81), and a presentation by Dr. Costas N. Georgihiades, Electrical Engineering Dept., Texas A&M University, January, 1996, entitled, "Digital Communications With Applications to ITS,"

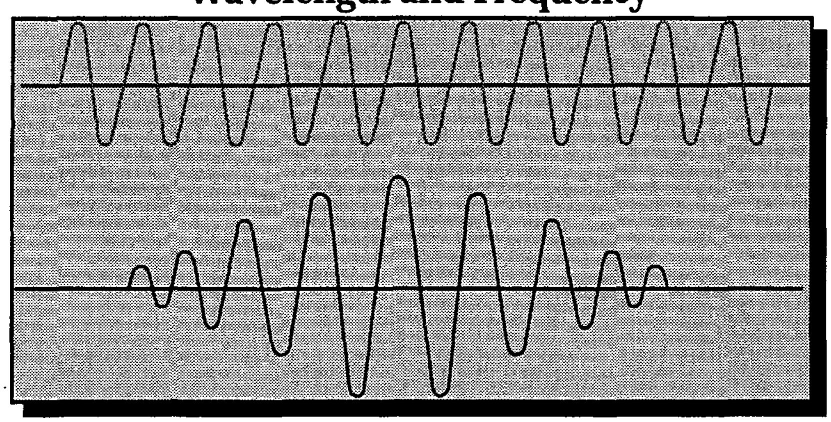
There are many ways to communicate information over distances. One can make gestures and communicate information visually. One can write a letter and communicate information physically. Or, one can make a telephone call, and communicate information by using invisible electromagnetic waves.

In a "wave," information and energy move from one place to another but no material object actually makes that journey. When an individual makes a telephone call, a sound wave carries their voice into the telephone. This sound wave is converted into an electromagnetic wave in the telephone, and this wave passes along a telephone wire (which can be copper, or an optical fiber) to your partner on the other end, or through space (as in the case of a cellular phone).

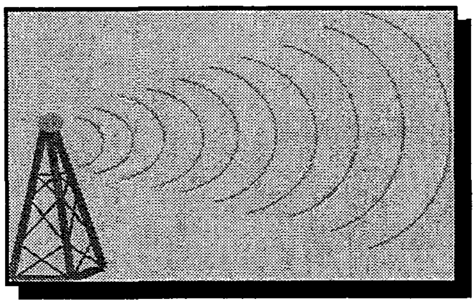
The Electromagnetic Spectrum

Electromagnetic waves come in many forms, and their different forms fill up the electromagnetic "spectrum". The most familiar electromagnetic wave is visible light. Also belonging to the electromagnetic spectrum are x-rays and Gamma rays, ultraviolet (UV) rays, infrared rays, microwaves, radio waves, and sonar. These rays each behave differently, and these differences are traceable to differences in wavelength and/or frequency; each wave type occupies a different area of the electromagnetic spectrum, from very short to very long. Waves also can be described by their "frequency". Wavelength describes the length of the repeating wave shape, and the wave's frequency describes the frequency of its repetition over a unit of time.

Wavelength and Frequency



X-rays are very short waves with very high frequencies; sonar employs very low frequencies and extremely long wavelengths. Other forms of electromagnetic waves fall between these extremes. Each kind of electromagnetic energy also exists within a certain part of the spectrum; radio waves, for example, do not exist in the same area as microwaves or the infrared transmissions that come out of your television remote control. In addition, virtually all electromagnetic energy can bear information in some form.



Radio waves

Frequency is a description of the number of complete waves that pass by in one second; it is expressed in hertz (Hz). If 10 complete waves pass by in one second, the frequency of that wave is 10 Hz. Because the portion of the spectrum we use for tele- and radio-communication consists of energy with frequencies of thousands, millions and billions of hertz, the prefixes kilo-, mega-, and giga- are typically used. In addition, the higher the frequency, the shorter the wavelength. X-rays, for example, have very high frequencies and short wavelengths. Radio waves have much lower frequencies and longer wavelengths.

Waves can also be described by their amplitude. Amplitude indicates the "power,"or energy, of an electromagnetic wave, which is expressed in watts. "Attenuation" occurs when a wave loses amplitude, or energy. A sound, for example, can lose energy when it is absorbed by something, such as an acoustic tile. Attenuation also occurs as a sound moves across space -- you can't hear people far away. Frequency and wavelength can exist independent of wattage. When a radio station transmits its signal (a radio wave), it emits this signal at a certain frequency (in FM, or Frequency Modulation) and power (wattage). The higher the power, the longer the distance you may travel away from the central transmitting station and still hear your favorite tune.

Actual transmission of many radio waves, however, involves not a single-frequency wave but rather a frequency band whose width is proportional to the information density of the transmission. This "bandwidth" increases with the amount of information carried by a signal. Bandwidth will be discussed in more detail below.

Radio waves travel in straight lines -- the curvature of the earth limits, then, how long an ordinary radio wave may travel. A 330-foot radio tower can transmit its signal only about 19 miles, but if that wave is bounced around in the ionosphere or through the Earth's surface, radio transmission over very long distances can occur.

Radio waves also can be interrupted or disturbed as they travel from the transmitter to a receiver. Most individuals have experienced losing a radio signal when driving behind a mountain or near tall buildings. Although radio waves can penetrate non-conductive materials, such as wood, bricks, and concrete fairly well, they cannot pass through electrical conductors such as water or metal. An individual can usually listen to the radio in a building made of wood and brick, but others, who may live in or be surrounded by structures made of a high percentage of metal such as in larger cities), can have poorer reception. The inability of radio waves to pass through conductive materials is the same principle that allows telephone conversations.

Whenever transmission of electromagnetic energy between locations with minimal energy loss, disturbance or distortion is required, the waves are guided by wires and cables, such copper wires and fiber optic cables. Wireless transmission is preferred when the locations of receivers are unspecified or moving, as in cellular communications, or do not need to be specific, as in the case of radio and television broadcasts. Cable television is an interesting case, because it is wired to a specific location, for which you pay a service fee. This allows you to obtain pay-per-view services, for example, and allows you to obtain high-quality reception.

Wireless and Broadcast Networks

Telecommunications comprises technologies that range from point-to-point, like the telephone, fax, or E-mail, to broadcast networks, such as television and radio. The early history of communications shows that it occurred mostly on a point-to-point basis. Broadcast technology was not invented until the 1860's, with attempts to create a wireless telegraph; in 1895, Marconi was the first to demonstrate the wireless telegraph by sending long-wave radio signals over a distance of one mile. By 1901, these signals could be sent transatlantically, but it was not until after 1910 that the idea of broadcasting (sending one message to any group of receivers) became a reality. In 1927, a new service, designed to broadcast sound and images, was termed "television". Its first public demonstration was staged by the American Telephone and Telegraph Company (AT&T), which also indicated its doubt that the new technology would ever be used for commercial purposes.

Switching

We typically view telephones and similar technologies as point-to-point, from one user directly to the ear of another. But as additional users are added to simple point-to-point systems, the need for connections grows exponentially until one reaches the practical limit of the number of linkages which can be made in this manner. The problem is solved by connecting users to a central office, called a "switch". The earliest switching systems were "switchboards", where an operator physically plugged different lines into one another at the request of the caller. The operator's function was eventually taken over by electronic devices, and today the switch is a powerful computer that not only makes connections, but routes calls over the most efficient circuits, records billing information, and helps to troubleshoot on the network if there are problems.

Prior to 1984, when AT&T was split up, our telephone network was a single hierarchy of switches owned by one company, AT&T. Every telephone was connected to a local switch, called the "local exchange", which were themselves interconnected by "interexchange" networks, including access to national and long-distance networks. Many office buildings had their own internal network, called a "private branch exchange", or PBX. Today, because of the advent of computer technology, these networks are increasingly "intelligent", allowing for the "seamless" transmission of information along a wide variety of transmitters, the coordination of a wide variety of telecommunications services into networks, and "multiplexing", the simultaneous transmission of multiple messages on a single communications network.

Bandwidth

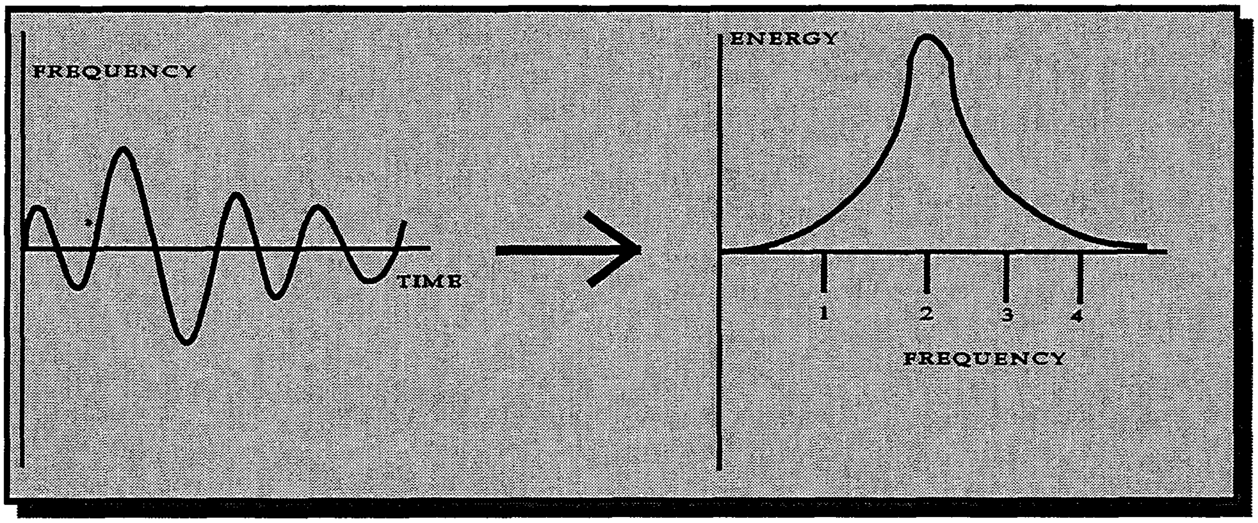
Spectrum is divided into bands, with each band covering the transmission of a type of electromagnetic wave. These bands are further divided into smaller bands. The radio frequency band, for example, is divided into smaller bands from very low to super high frequencies, and within these bands operate various kinds of users, such as telephones, radio broadcasts, and television. Usually, the amount of bandwidth required for a transmission reflects how much information needs to be transmitted. AM transmissions require a small bandwidth, about 5Hz, but the quality of the transmission is poor. A fairly large bandwidth is required for television, because light and picture detail must be transmitted. In general, the higher the bandwidth, the less the distortion.

Over the years, communication engineers have developed the powerful radio frequencies and wavelengths at the bottom end of the radio spectrum, which comprise less than 1 percent of the total (the "long and strong" approach to transmission). This approach assumes that the portion of spectrum you have to work within for your particular transmission (or "bandwidth") is scarce and expensive, as well as crowded. Just as you can get your message heard in a crowded room by talking louder, you can overcome a crowded and noisy channel with more powerful signals. However, the policy of economizing on a narrow band of spectrum by using this approach led to using it all up. Everyone was talking louder, and no one was able to hear anyone. Today, the favored regions at the bottom of the spectrum are so full of radios, pagers, phones, television, long-distance telephony, aerospace transmissions, and other uses that this portion of the spectrum is indeed getting scarce.

With a digital system, you can operate on higher wavelengths and frequencies, but in the conversion of the radio (analog) signals to digital, you can lose fidelity and increase complexity.

How Does Digital Technology Work?

Digital sound is achieved by a process in which analog signals (waves) are transformed into a series of binary digits. This process involves "sampling" and "quantization." In sampling, an analog signal is "sampled" over discreet units of time; one analog signal four



seconds long can be sampled a certain number of times every second. Mathematical equations and theorems govern how frequently a signal should be sampled, however, it is enough to say here that this process revolves around bandwidth. Signals of some length, say four seconds long, can contain within them a range of frequencies. Think of a four second out take of a favorite song. Or four seconds of a movie, or four seconds of a telephone conversation.

In the above figures, the signal on the left has a range of frequencies and amplitudes, which the graph to the right describes in a bell-curve distribution. You may note that most of this signal covers frequencies from 1 to 3, with very little activity at the extremes. That means, for sampling purposes, that most of this signal covers 3Hz -- it has a bandwidth of 3Hz. A signal should be sampled at least twice its bandwidth per second to be reconstructed with any degree of accuracy. A CD player averages 44.1 thousand samples per second. Each sample, through a process of quantization, is assigned a numerical value in the form of a binary digit (bit) which corresponds to the amplitude of the signal at that moment.

However, there are an infinite number of amplitude possibilities for each sample. We limit these possibilities artificially by allowing each sample a discrete range of possible amplitudes. This is known as "quantization." Each amplitude possibility is assigned a binary digit, or bit. It is this bit, and strings of them together, that make digital sound. For example, in an 8-bit quantization, each sample can be represented by 8 possible different bits that indicate amplitude. Telephone speech, for example, has a sampling rate of 8,000/sec, with each sample having the ability to be digitally represented by 8 possible amplitudes -- each of these eight amplitudes had its own binary number. This results in a stream of bits -- in the case of the digital representation of speech, that is a flow of approximately 64,000 bits per second. In CD's the sampling rate is 44,000 samples/sec. With 16-bit quantization, the bit rate goes up to 705,600 bits per second.

With an initial digital code for the sample (produced by the analog-to-digital converter), the digital information takes up a great deal of space and transmission time. The process of compression is used to represent the source signal most efficiently using the smallest number of bits -- this is what compressed video does, and you can get compressed video of various resolutions as well, depending on the purposes for which you need it. The digital-to-analog converter reads the encoded information and changes it back to audio signals via an amplifier device.

Wireless Systems

There are several distinguishing characteristics of wireless systems, both analog and digital. In evaluating whether a certain type of wireless service is appropriate for your own needs or the needs of your business, or to the needs of a particular situation (such as in the creation of an ITS system), it is helpful to consider the following:

- ***Reliability*:** Wireless systems, analog and digital, are severely handicapped if customers cannot have their messages reliably conveyed. The broadcast environment presents challenges to wireless systems. These challenges include interference from natural and man-made sources, signal fading and multipath occurrences, shadowing from tall buildings, and blockages from terrain such as hills or deep valleys.

- ***Coverage:*** Most mobile wireless technologies concentrate in cities and their suburbs, with rural wireless communications often viewed by the service provider as prohibitively expensive — often, the expense of constructing the wireless infrastructure to serve a rural area is seen as non-recoupable because there are fewer individuals using the system. This is often complicated in the case of ITS applications along highways which run through rural areas and have no wireless link to the traffic management headquarters in the urban center.

- ***Transmission Speeds:*** Transmission speed and throughput (the amount of message-specific data that can reach a recipient in a certain time period) are both important to the efficiency of wireless technologies. However, transmission speed figures provided by operators can often be misleading. Because all wireless systems must incorporate some method of error correction (limiting the full data capacity available on radio channels), the transmission speed is often less important that the throughput figures. Most wireless providers charge by the number of minutes spent on each call, so high transmission speeds and throughput are important. Other providers, using packet data technology, generally charge according to the amount of data sent in each transmission. Other systems employ store-and-forward network designs, which allow messages to be placed in queue until their turn arrives for transmission; these kinds of services can delay transmissions from seconds to minutes or even hours, so as a tradeoff these kinds of networks usually offer lower subscriber fees and air time costs.

Some systems do better with voice and others with data, so it is important that transmission speed not be the only criterion for choosing a type of wireless service. Cellular telephony typically does not support data transmission. Other mobile systems such as radio data networks and meteor burst technology ignore voice altogether.

- ***Equipment and Air time Costs:*** There are very few situations in which wireless technologies are cheaper to purchase and use than wireline systems — wireless will usually exist at a premium. Yet, increasing competition in the wireless marketplace gives customers increased service options and in some cases reduced costs for transmitters, receivers and air time.

- ***Security:*** Analog transmissions have been relatively easy to intercept. For years, radio buffs have been able to purchase scanners to intercept cellular transmissions. The transition to digital wireless makes it more difficult to listen in, and easier for manufacturers to design equipment that can encrypt signals and keep them secure. In the case of ITS, there are situations in which the public would best be served by being able to intercept broadcasts (such as traveler's warning transmissions) — encryption is undesirable in this situation. On the other hand, during severe emergency situations, or if private citizens are using in-vehicles technologies such as transponders, ITS managers may want to use encrypted signals.

- ***Simplex versus duplex:*** Simplex services only support one way communications — paging is a good example, as is remote sensing, or one way radio transmissions. Duplex services, such as cellular phones, can carry full two-way conversations. Not all mobile phone systems are duplex, however, because full duplexing demands greater bandwidth and is, not surprisingly, more expensive and complex to provide.

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