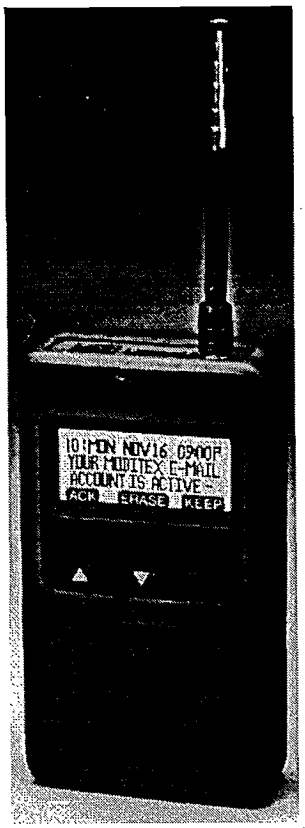
WIRELESS PERSONAL COMMUNICATIONS



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Information Technology Industry Branch
Computers and Telecom Products

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FORWARD

This document published in October, 1994 presents a profile of wireless personal communications activities and organizations involved with this technology sector in Canada. It is intended to provide an overview of several key parameters effecting this sectoral area and some of the Canadian capabilities related to wireless personal communications at the time of publication.

Recipients are welcome to provide us with any comments or information that are of interest to this sector. For more information, please contact:

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I. Overview

The world is undergoing a transformation to a next generation of communications systems. Wireless technology is playing a key role in the evolution of these systems. The role of cellular communications and portable computers have enabled individuals to become more mobile and this trend is on the increase.

Wireless technologies are key enablers of much of the convergence activity in the communications world. The utility of mobile communications from a subscriber's perspective is proven. Mobility sells as manifested in the substantial compound annual growth rates for cordless and cellular phone sales.

The shift to wireless is as dramatic in the 90's business as the evolution from the mainstream to PC was to yesterday's workplace, industry experts say (ComNet 94). The power of hand-held devices is altering the workplace and, for a growing number of users, the way they operate. In turn, productivity and that all-important customer satisfaction are improved and enhanced. The technology allows users to conduct business in remote locations away from the office, such as inputting data directly from the field and instantly accessing inventory records and customer files.

This analysis will focus on wireless personal communications in its broad sense. Technologies and services include the following: cellular (voice and data), PCS, mobile data, paging, wireless LAN, wireless PBX, SMR, cordless phones and accessories.

II. Major Wireless Personal Communications Sub-sectors

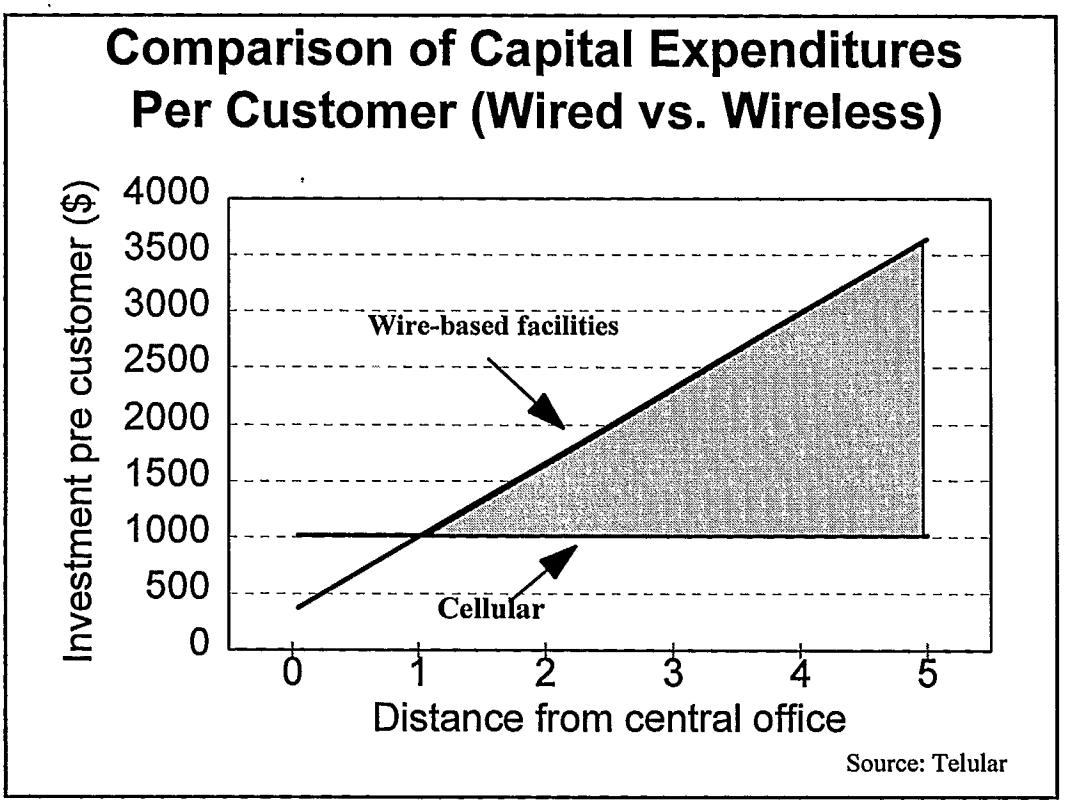
Cellular

Digital cellular systems are currently being deployed globally, and many new consumer electronics products are targeted to the marketplace. PDAs, personal communications, pen-based computers, will revolutionize the way in which people communicate. Cellular communications and portable computers have enabled the workforce to become more and more mobile and the trend to mobility is increasing. These factors are giving rise to the birth of a new industry - mobile data. With the advent of these products, non-voice applications are expected to grow faster than voice during the next decade.

The cellular marketplace is undergoing dynamic changes and will continue to do so throughout the transition to full digital functionality. The advantages include: Improved system capacity, coverage and channel access enabled by increases in spectral efficiency up to six times over current systems, improved clarity and call quality, lower incremental costs per subscriber and enhanced services providing such unique capabilities as privacy and high-speed data access and retrieval. With the arrival of digital RF capability, service providers will have increased voice and data capacity available to them. Faster and more efficient data transmission will be possible from mobile subscriber units. A host of enhanced features linked to SS7 networking and ISDN are expected. Digital cellular will open the world of the future for mobile and personal communications.

Cellular costs are driven by volume and new technology. The cost of an average cellular telephone has fallen from over $2000 in 1986 to a little over $100 today. Due to microprocessors and ASICs which are doubling in power and halving in price every tow years the cost of cellular phones is tumbling. Wireline costs are driven by real estate, right-of-way, labour intensive installation and long planning horizons. Therefore, the cost trend in the 1990 has been a linear decrease in cost per subscriber for cellular and an increase in cost per subscriber for wireline users. (figure 1) The end result is that close to 50% of all telephone lines will be wireless by the year 2000.

Figure 1



PCS (Personal Communications Services)

There are many different interpretations and uses of personal communications concepts, terminologies and systems in existence today. The broader meaning of personal communications is the concept of small pocket-sized telephones that can be used every where at low cost. As new frequency bands are allocated and more operators are licensed, there will be an increasing number of systems, concepts and technologies under the umbrella of personal communications. Twenty (20) to thirty (30) percent of the population in the developed parts of the world are expected to have "personal communications" by the end of this decade. As the world becomes more reliant on mobile personal communications, users need to have the assurance that communications will be available, no matter where the caller roams. The implementation of new wireless access technologies is shaping the evolution of the cellular industry from its analog past to its digital future. As cellular markets mature, as new services are introduced, and as wireless data offerings and PCS services are defined, every aspect of the industry will be influenced.

PCS (Personal Communications Services) will evolve as a person-to-person model rather than station-to-station. PCN (Personal communications Networks) will incorporate advanced network services. The result will be a single, unified, next generation wireless voice/data

architecture incorporating: voice, paging, data massaging, FAX and position tracking.
The biggest issues of all particularly in the US are:
Lack of spectrum
Politics - regulatory and legal
Infrastructure - signal availability, signal quality, performance
Interoperability - and internet working; transparency; value-added features, hand off between services
Capacity - bandwidth, compression, spectrum re-use
Cost of products and services.

Some analysts predict a worldwide micro cellular system with adaptive bandwidth management is the answer outdoors, and mixed-media wireless for indoors, with automatic bridging between the two. Wireless will not replace wire - expect more co-operation and less competition. The next generation of cellular communications will be based on smaller pocket-sized handsets, individual phone numbers, and advanced network services. By the year 2000 advances in wireless communications technology should enable cellular service providers to compete with the local wireline network.

PCN systems will consist of a large number of low-power microcell transmitters that increase system capacity by allowing greater frequency re-use. Because of lower power requirements the handsets will be able to used smaller battery cells. Lower voltage circuitry will allow the optimal use of new batteries such as lithium cells which have good power density. These factors will reduce the weight, and size of handsets. Industry analysts forecast that the worldwide market for personal communications will account for annual revenues of $50 billion by the year 2000, and the number of subscribers could reach 150 million. The U.S. is expected to account for most of the world market and should generate revenues of $20 billion to $25 billion.

Mobile Data Communications:

Mobile data has become one of the most active and intriguing wireless communications markets in North America in the last year. Mobile data is perceived by may to represent one of the best market opportunities for equipment and service providers in this sector in the coming decade. Wireless data communications is emerging as one of the most important strategic technologies of the 1990s. Virtually every major computer manufacturer is exploring ways to apply the capabilities and promise of this technology to their product lines in the hope of seizing a potentially substantial user base.

Presently, mobile data service have not evolved into a mainstream market but remain a niche market segment characterized by two main components. One segment of the market is served by dedicated data network operators such as RAM and ARDIS who satisfy customer requirements in largely field service type applications. The second segment of the market is represented by data over cellular networks who have adopted data interfaces to meet

messaging needs. One of the more exciting developments in this area is packet switched data over cellular (CDPD). In summary, the range of CDPD planned service and equipment is broader and more comprehensive than any alternative thus far, embracing as it does both packet and circuit-switched data. Circuit and packet-switched cellular data services will compete not only against each other but also against the other packet radio networks such as ARDIS and RAM Mobitex.

The mobile data market is a dynamic and innovative environment where leading-edge developments can easily change the demand for transmitting wireless data. Wireless data communications is emerging as one of the most important strategic technologies of the 1990s. Virtually every major computer manufacturer is exploring ways to apply the capabilities and promise of this technology to their product lines in the hope of seizing a potentially substantial user base.

Paging

Basic radio paging can be accomplished with a numeric pager, which is the most common type of pager used today. Wireless paging systems are capable of offering several options including tone, digital, alphanumeric, and computer interface. Digital type pager are most common today, because of their enhanced capability of being able to receive a message. Paging services are of importance to a workforce on the move, and in order to compete against cellular, paging service companies are introducing new technologies and service offerings. In spite of the popularity of cellular telephones the paging industry is surging along the growth curve and its popularity is on the increase. However, the growth of mobile data will have an impact on the paging industry and personal communication service providers will definitely impact the future growth of paging.

At the present time, the cost advantages and simplicity of usage meets the financial criteria of many individuals and with the advent of two way paging, paging devices could be part of the wireless landscape for some time to come.

Specialized Mobile Radio (SMR)

Specialized mobile radio comprises two-way radio products used throughout North America by police forces, government agencies, utility companies and other businesses requiring fleet dispatch communications. A system typically includes one or more base control stations networked with each other and with vehicle-mounted or hand-held portable radios. It may also include the capability for both voice and data transmission, interconnection with telephone networks and on-line computer access. The second business segment for SMR is the market for amateur, marine and citizens band radios.

SMR is an option to cellular users since it has dedicated spectrum allocated to its transmission and this has resulted in SMR operators employing digital technology to create a wide digital

mobile systems. SMR adds diversity to the wireless world and the spectrum is not as crowded as is cellular and they do not require standards bodies to approve their networks.

Wireless LAN

Wireless LAN products are enjoying increased popularity because of their advantages over wired LAN products. Today, the local area networking market is experiencing a rapid shift from coax-cabled networks to more intelligent structured wired networks based on star topologies. Wireless LAN products are available in many LAN and transmission configurations and speeds using radio frequency and infrared technologies.

The rapid growth of portable PC and laptops will generate new demand for simple, mobile connectivity to networks. Wireless LANs provide an attractive solution for organizations that continually changing their floor plans and PC work groups. Wireless LANs will primarily be sold as a complementary solution to wire-based network communications with organizations wanting the flexibility to integrate wireless systems with their existing wireline networks.

Wireless PBX

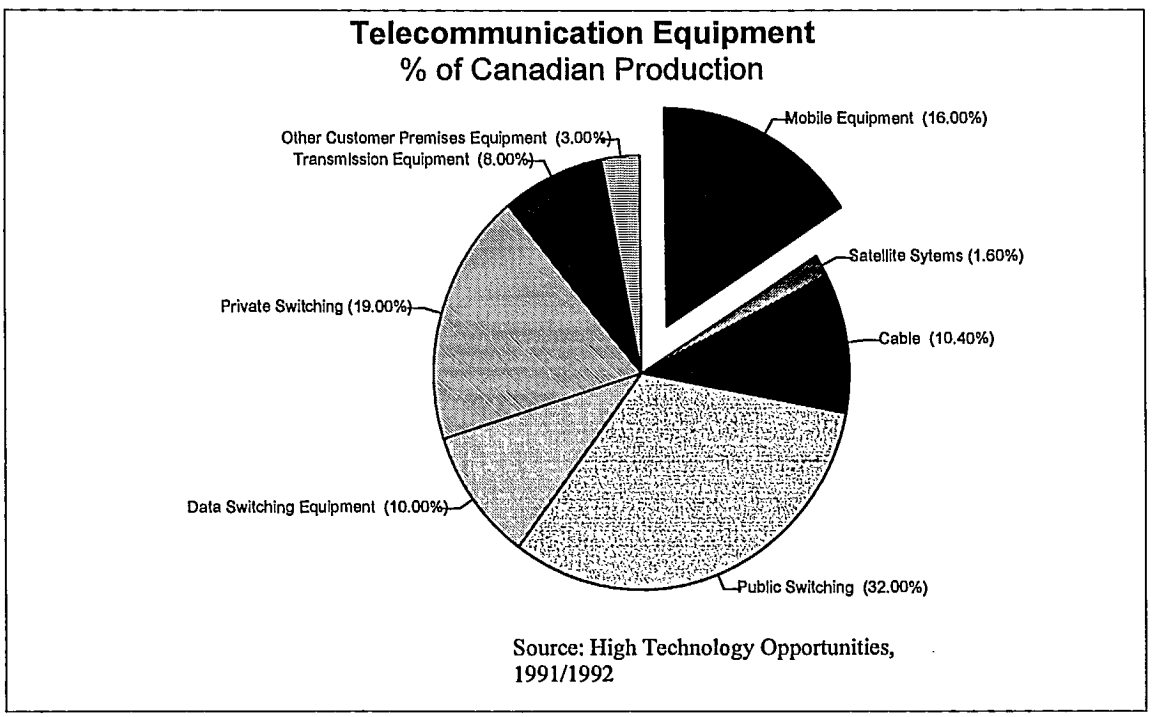
A wireless telephone system is of great value to office personnel who are away from their offices a great deal of the time and to those who have need of being immediately accessed. The ability to shift personnel without incurring expensive wireline costs is another consideration in implementing a wireless PBX system. Mitel announced in March 1994 that it will offer wireless adjunct systems to its PBX customers. The Spectralink PCS 2000 and PCS 2000 systems will allow PBX users to use cordless phones within their buildings (4/94).

III. Structure and Performance:

Output and Performance

The wireless personal communications sector is situated primarily in B.C., Alberta, Ontario and Quebec. The sector employs over 7500 in equipment manufacturing. The firms are mostly Canadian-owned, the largest and most important being Northern Telecom whose wireless operations are primarily located in Calgary. Approximately 50 additional small to medium sized firms (Appendix A) make up the rest of the sector and they account for approximately 15% of the Canadian production of telecommunications equipment (Figure 2). With total shipments of $6.74 billion in 1992, the wireless percentage of the market would be about $1 billion.

Figure 2



Source: High Technology Opportunities, 1991/1992

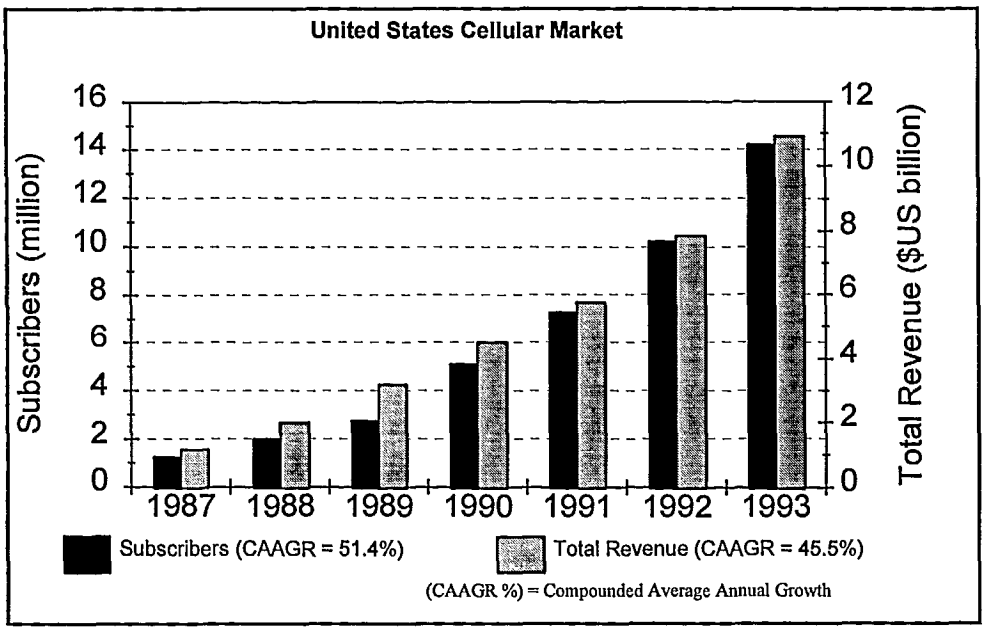
The NGL study of 1990 for CTAC showed that the growth rate for the wireless/mobile sector was 36.6% which more than doubled the growth rate of the next fastest growing equipment category data communications (Figure 3).

Figure 3

Canadian Production by Equipment Category			
Equipment	**Canadian Production ($ Million)**	**% of Total Sector Production**	**Growth Rate**
Public Switching	1, 897	25.7%	9.0%
Transmission	430	5.8%	1.0%
Cable	641	8.7%	13.3%
Satellite Systems	81	1.1%	-9.3%
Data Communications	626	8.5%	15.5%
Private Switching	1,032	14.0%	1.2%
CPE	172	2.3%	6.7%
Wireless/Mobile	1,214	16.5%	36.6%
Related Microelectronics	1,285	17.4%	N/A
TOTAL	7,378	100%	9.6%
Source: NGL Consulting, 1990 a strategic Plan for the Canadian Telecommunications Equipment Industry			

The key market for Canadian wireless companies is the United States (Figure 4) with most companies exporting over 90% of their production. In some areas, Canadian business lags behind its counterparts when it comes to embracing wireless technology. For example, there are only 2,000 users of the ARDIS (Advanced Radio Data Information Service) network in Canada.

Figure 4



The domestic market has a regulated framework that sometimes works to the disadvantage of Canadian manufacturers, such as in the case of packet data radio networks, where the Mobitex network is designed to support voice and data services, Canadian network are restricted to providing data communications. Similarly, 80% Canadian ownership is required for paging network service providers but broadcasters are allowed to use sub-carriers to provide similar services without meeting Canadian ownership requirements. In the latter case, the domestic market base requirements can be reduced for equipment producers.

The Canadian industry is increasingly seeing the value of forming joint ventures and alliances in the sector and these realities are quickly becoming a part of the wireless manufacturing landscape. Companies such as Simmonds Communications has just completed a joint venture with Roamer One of the U.S. to develop and manage a Specialized Mobile Radio (SMR) network in the United States for voice and data communications, using narrowband technology in the recently licensed 220 megahertz radio spectrum. Due to channel congestion on current frequencies, this market has been identified as a major new growth opportunity for the land mobile radio market and a Canadian company has leadership in this field.

The wireless industry has strengths in the following areas: mobile data communications products, paging networks, cellular phones, industrial radio controls, two-way radio products, CDPD modems, wireless LANS, cellular network equipment and PCS systems.

R&D Performance

The industry is highly global in its outlook and basically they rely on world markets for their sales. Because the wireless personal communications industry is at the leading-edge of technology, most manufacturers do R&D and manufacture in Canada. R&D for the sector is around 15% of revenue, and this high level of R&D is required to support the development of leading-edge products.

Canadian technology in this sector is regarded as some of the best in the world and international wireless manufacturers such as Ericsson, JRC and Motorola have established significant operations in Canada to exploit the talent that exists in the country. 450 of the 530 people who work for Ericsson in Montreal are involved with R&D for their cellular system CMS 88. The number of employees in this facility is expected to grow to 600 by the end of the year. Wireless communications firms in Canada are among the top R&D spenders as shown by the following table.

Key Communications Firms Among Top-100 R&D Spenders (1993)
(Source Research Money)

1992 Rank	Company	R&D Expenditure	R&D/Sales Ratio
1	Northern Telecom	1,190.5	11.3
13	Ericsson Communications	62.3	36.14
46	Motorola Canada	20.8	3.43
60	Rogers Cantel	16.5	2.73
100	BCE Mobile Communications	7.1	0.36

The wireless industry subsector has several important manufacturers who are subsidiaries of multinational companies including Motorola, Ericsson, JRC, Canadian Marconi, Sierra Wireless, and Telular. In contrast to other IT sectors, these Canadian subsidiaries spends the same percentage of revenues on R&D, as their parent firms. Motorola is one of the world's leading providers of wireless communications with over 1600 employees in its Canadian operations. Motorola has established the Advanced Data Radio Laboratory in B.C. this initiative will sponsor unique data radio communications research to proliferate wireless data communications technology in Canada and to expand the participation of Canadian technology companies in this global market such as Digital Dispatch Systems of B.C. who has currently sold mobile data dispatch systems to the Dayton Yellow Cab Company in the U.S.

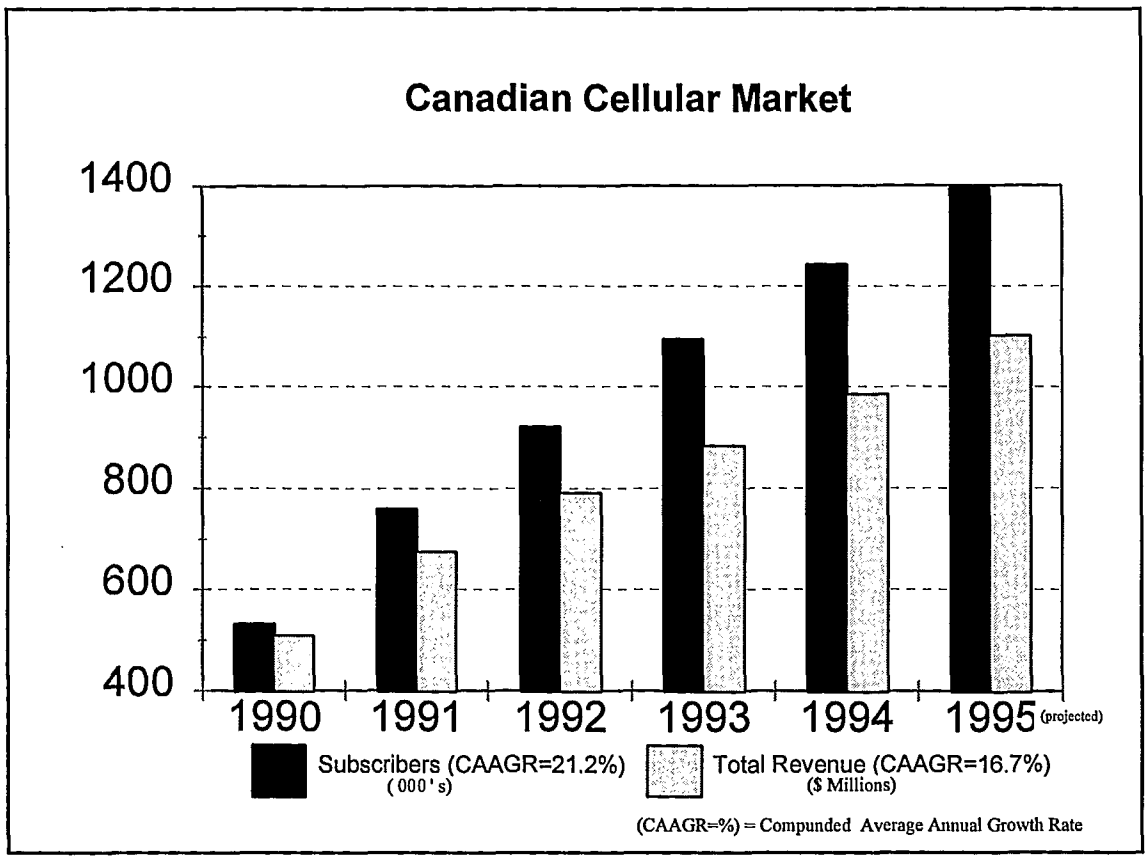
Growth and profitability depend primarily on which technologies are targeted for R&D investment and companies such as Northern Telecom who target broad areas are finding this strategy less feasible today. This scenario opens up opportunities for smaller niche players that can select a single field in which to compete in the open systems market.
Success in the wireless sector means companies such as Northern Telecom, Ericsson and Motorola are spending up to 10-14% of their revenues on R&D. Currently, wireless R&D is focusing on the capacity limitations of analog cellular mobile radio and developments are aimed at the migration to digital technologies using TDMA and CDMA techniques. Digital signal processing techniques are permitting a greater number of derived channels within a given bandwidth and of subscribers within a given area. Companies such as Spectrum Signal Processing and MPR Teltech could be well positioned to find opportunities in this area.

Industry Linkages in Canada

The high growth in the wireless communications industry reflects the increase in cellular and wireless subscribers e.g. paging. Wireless equipment purchases by governments, businesses and residential users are also increasing. Rogers Cantel and Bell Mobility are the two most important mobile communications providers in Canada and there infrastructure is of strategic importance to Canadian wireless equipment manufacturers in many of the leading-edge technology areas. Companies like PCS Wireless have been involved in field trials with Rogers as well as with Northern Telecom.

Bell Mobility's cellular operation reported a subscriber increase of 28% from 1992 to 1993. Cellular service and the sale of cellular equipment represents over 86% of the revenues of BCE Mobile (1993). The key customers for wireless equipment in Canada are the service companies such as Bell Mobility and Roger's Cantel who account for over 90% of the mobile communications service market with revenues totalling over $900 million in 1993 (Figure 5). BCE Mobile had capital expenditures of 162.8 million in 1993.

Figure 5



Rogers Communications Inc. owns 80% of Rogers Cantel Mobile Communications Inc. which is Canada's largest cellular service provider serving over 480,000 cellular subscribers and with a national paging service with nearly 100,000 subscribers. The Cantel network forms the longest cellular communications corridor in the world stretching 5,600 kms. With the implementation of the digital network, Cantel anticipates to have 1.3 million subscribers on line by 1999. Cantel buys its digital network equipment from Ericsson.

Because of the high start-up costs, neither of the two cellular companies Cantel and Bell Mobility are profitable and neither are making the returns observers foresaw from this business.

Several important teaming agreements have been reached between Canadian niche wireless players such as Ericsson Communications Canada and PCS Wireless Inc. of B.C. The underlying value in this alliance is that Ericsson has access to the Canadian firm's antenna array which will significantly lower the cost/user of Ericsson's system configurations.

There are five Canadian companies who are the members of the Paging Services Council of

Canada: Maclean Hunter Communications, Cantel Paging, Bell Mobility Paging, Ultrapage and the Beeper People.

Canada's four licensed digital public cordless telephone companies who will introduce their services in 1994-95 are: Canada Popfone, Mobility Personacom, Telezone and Rogers Cantel Mobile.

ARDIS and MOBITEX

There are two main mobile packet-switched data network services in Canada: Bell Mobility ARDIS and Rogers Cantel Mobitex. Canadian business lags behind its us counterpart when it comes to embracing wireless data technology. For example there are only 2,000 users of the ARDIS (Advanced Radio Data Information Service) network in Canada. ARDIS Users pay only for the data "packets" they send and receive.

There are an estimated 200,000 wireless data communications users worldwide, yet the market is forecast to grow to an astonishing 26 million users by the year 2000. Fuelling that growth is the accelerating trend towards mobile communications and the growth of faster microprocessors and technologies like the Newton that allow completely portable personal communications.

ARDIS is also targeting the 650,000 pager customers in Canada by offering two-way paging service based on Motorola's two-way pager. It presents a tremendous marketing opportunity for service based organizations. They can show their customers how they can deliver their service, where their staff is and where their parcel is and so on. RAM Mobile Data initiated service in 1991, focusing on the same vertical markets applications addressed by the established ARDIS system. The major application is providing mobile access to central data bases for sales and field services personnel.

In 1993, Motorola's Mobile Data Division in B.C. was scheduled to introduce an InfoTAC modem/massaging device modified to work on the Mobitex network and Gandalf Mobile systems of Nepean, Ontario was to introduce its family of Mobitex radio modems.

Motorola Mobile Data Division sold its Utility Service Management systems Software to Mobile Data Solutions Inc. (MDSI) of Vancouver. MDSI, a software company specializing in computer-aided dispatch and communicating software for utilities, is now responsible for ongoing development and enhancement of the Utility Field Service Management System, servicing current customers and marketing the system worldwide.

Northern Telecom

Northern Telecom is the most dominant company in wireless communications in Canada. There are seven major cellular network manufacturers in the world: Ericsson, Motorola,

AT&T, Northern Telecom, Nippon, Siemens and Nokia. Northern Telecom has approximately 8% (1994) of the global market share based on the number of cellular network subscribers.

Northern Telecom is Canada's largest wireless equipment manufacturer with wireless headquarters in Calgary. Northern's global centre for manufacturing cellular products is in Calgary which manufactures cellsites for transmission of cellular phone calls and base stations for the company's low power, wireless personal communications services. Northern's total operations in Calgary now employ 2,200 people and increase of 700 from fall 1993. Jean Monty, the president said he expects Northern's wireless business to do $1 billion in sales in 1995. These driving factor fuelling new growth is the success of the PCS product line with the greatest demand occurring outside of Canada and the U.S. where the growth potential is higher because of limited penetration. The acquisition of a portion of NovAtel in 1992 enabled Northern to acquire and installed base of equipment in the Americas.

Northern Telecom is establishing a new category of business in the wireless sector, Ericsson and AT&T both have considerable market share in terms of cellular network equipment and NT hopes to change its relative position as cellular network operators make the transition from analog to digital products and as the mobile services market expands into PCS. Northern Telecom has marketed a wireless PBX in 1992 a product that will allow end users the ability to carry their personal handsets throughout the office.

Northern Telecom has a strategic alliance with Motorola which will sell and service cellular networks throughout North America and Latin America. This venture will sell and support Northern's high-capacity cellular switching system the DMS-MTX, and Motorola's EMX product line. This joint venture has supplied equipment to BCE Mobility. Cellular service providers' preferences has motivated firms such as Motorola and Northern Telecom, to form partnerships encompassing both research and marketing. This joint venture is focused solely on North America, Latin America and the Caribbean. Motorola-Nortel enhances the competitive position of both Motorola and Northern Telecom by combining Motorola's expertise in radio base station equipment with Northern Telecom by combining Northern Telecom's expertise in switching technology. This alliance has enabled the two firms to offer complete cellular networks comparable to those offered by firms such as Ericsson.

In May 1992, NT acquired a significant portion of Novatel a former Canadian company which manufactured radio transmitters and receivers used in cellular network base stations. As a result of this acquisition Northern obtained an installed base of equipment in North America, South America and the Caribbean. The company has merged NovAtel's R&D personnel and equipment into the NT Wireless Systems Centre in Calgary to create products for personnel communications services. In July 1992, NT announced a major investment and strategic alliance with Matra Communications of France. This venture will combine NT's switching expertise with Matra's strengths in radio communications. The Matra alliance appears to be an undertaking by NT to be a presence in the European radio market. The objective is to

undertake product development activities. The Northern Telecom and Matra joint venture gives both firms the ability to sell a complete networks in the European GSM market.

IV. Competitive Performance of the Industry

The competitive overview will include an analysis of the competitive environment within the market: The number and size of companies and research organizations in the canadian environment and the factors which affect all players within the market. There are also highlights of selected vendors including specific equipment vendors in the market along with their product offerings in the particular area. Within the telecommunications area and in particular the wireless subsector, the competitive performance of the industry is being affected by several factors.

Competitive Advantages

One of the outstanding competitive advantages that Canadian companies have is access to a highly skilled personnel. Ericsson has chosen Quebec as its centre of software research because of the availability of skills in the information technology field. Another advantage is the motivation of the workforce where employees tend to remain with companies for a long time as is the situation with Ericsson in Montreal compared to the Dallas operation which sees rapid turnover in employees.

The various governments in Canada have recognized the importance of the telecommunications sector in Canada, and significant initiatives and investments have been made by governments to promote this sector. The CRC is a leading-edge research centre for mobile communications and generic research and development of radio communications technologies is a key element of their research program. They also administer the IRAP program to support research in this sector, and many wireless firms have benefitted as a result of the R&D programs put in place by various governments. Centres of Excellence such as TRIO, TR Labs, CITR, CCMC etc. (Appendix B) all have extensive wireless research program which are funded in large part by various levels of government. Over 21 universities and colleges perform advanced research in wireless and mobile technologies.

The Canadian trade commissioners and EDC, CCC have all played a significant role in promoting the export of Canadian wireless products which is of great assistance to an industry which is highly export-oriented and where the majority of firms export over 90% of their production.

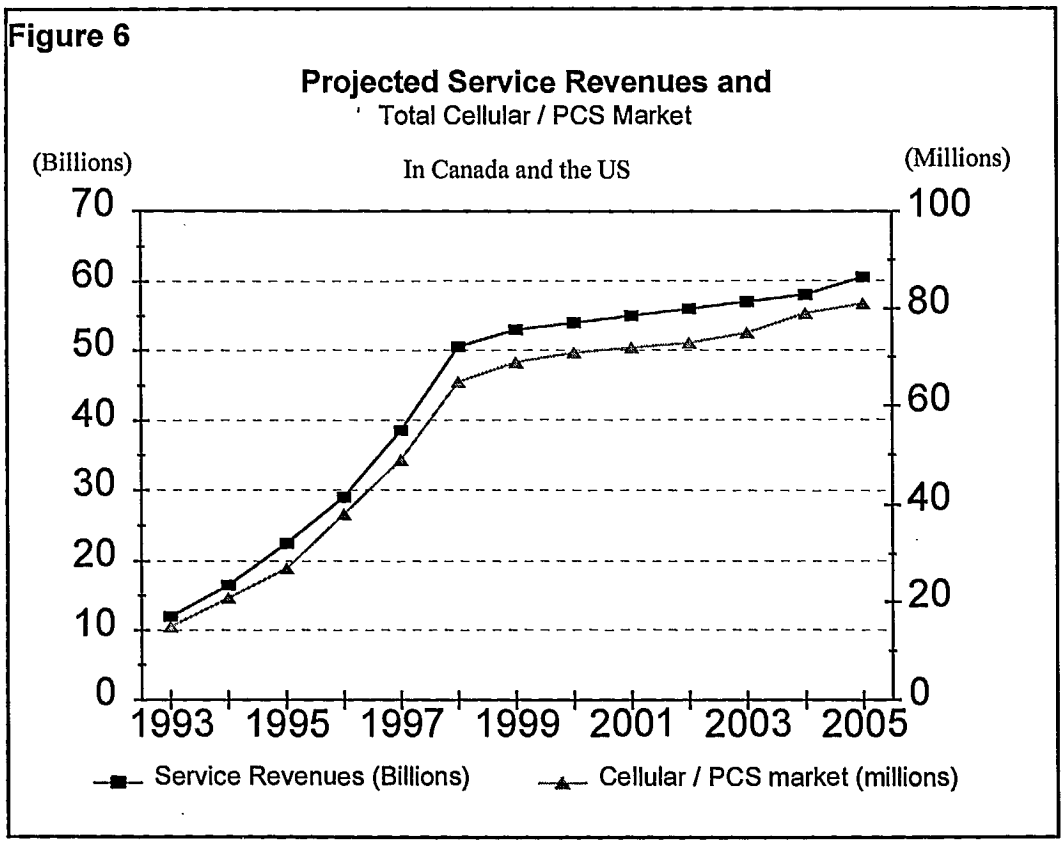
Canada's $6 billion software industry is of significant competitive advantage to wireless equipment manufacturers. Canadian companies develop software for a switching systems used in paging and mobile communications networks. Software is becoming an integral part of wireless systems and Canada has been capable of providing a good supply of highly trained people in this sector.

The vertical integration of Bell and Northern Telecom has fostered the development of one large MNE that can compete on a truly national scale. Northern Telecom is ranked as fourth

in the global cellular market. In July 1992, NT announced a major investment and strategic alliance with Matra Communications of France. This venture will combine NT's switching expertise with Matra's strengths in radio communications. The Matra alliance appears to be an undertaking by NT to be a presence in the European radio market. The objective is to undertake product development activities. The Northern Telecom and Matra joint venture gives both firms the ability to complete networks in the European GSM market. Northern Telecom's reputation in the wireless sector is a significant factor in promoting Canada's leadership role in wireless telecommunications technologies and services.

As a result of the FTA, Canadian firms have ready access to the U.S. market. The U.S. market is among the first to demand and adopt emerging technologies, new techniques, and enhanced services. Proximity to this dynamic market offers Canadian firms a marketing advantage and opportunity for further rounds of product development and the ability to identify new market opportunities quickly. (Figure 6)

Figure 6



Another competitive advantage has been the industry-university collaboration in the sector. Non-profit organizations such as TR Labs, CITR and TRIO have established university/industry partnerships by sharing research led by some of Canada's best researchers in wireless personal communications. These labs contribute trained people, produce innovative technology and achieve business growth for their industry sponsors. Wi-LAN and TR Labs

have developed a 150 Mb/s wireless LAN which is a major achievement in the wireless LAN field.

Competitive Disadvantages

In spite of the fact, that we have the longest cellular network in the world and large cellular usage rates, the growth potential of the cellular market in Canada is limited. Because of the relatively small size of the Canadian domestic market, the wireless equipment industry must be focused on the export market. Northern Telecom is the dominant force in the wireless sector but there are other significant players such as Glenayre and Dataradio who are at the cutting edge in wireless market niches such as paging systems and mobile data communications. These companies have achieved success by capturing an important share of the U.S. market in their respective areas.

While many of Canada's competitors demand high levels of local content and manufacturing and/or R&D from foreign-based MNE's, Canada grants large concessions to manufacturers of telecommunications products for nominal commitments.

Exports and Imports

Investment Canada reports that mobile and wireless equipment represent about 17% of Canada's total production and Canadian production in this category has grown by over 30% annually since the 1980s. An estimated 65% of Canadian production is exported. It is also estimated that over 70% of Canadian exports are to the U.S. (source Investment Canada)

Imports of wireless personal communications products are also significant. In 1992 , imports were valued at $371 million with the United States representing over 70% of the total. Imports from the United States and EC have been growing but decreasing from the Pacific Rim. (source: Statistics Canada, 1992).

An analysis of Canadian export performance in foreign markets for telecommunications equipment during the period from 1988 to 1992 (from Data Resources Inc.), the Canadian growth rate (10%) is slightly above the total market growth rate (8.9%). As a result, Canada's overall ranking is second to Japan. This assessment ranks countries who produce leading-edge wireless products and services such as Sweden (ranked 9th), France (ranked11th), United Kingdom (ranked 15th), Germany (ranked 16th) and Finland (ranked 18th) whereas the Philippines is ranked fourth with a growth rate of 20%.

One possible conclusion to derive from the above rankings is that the wireless equipment category (based on present classification system which is undergoing revision) as defined by Statistics Canada(8525) and the U.S. Dept. of Commerce includes a considerable amount of consumer electronics equipment in the wireless category in order to show that Korea,

Philippines, Malaysia , China and Hong Kong sell more wireless equipment that does Sweden's Ericsson which exports 11% of its $7 billion in net sales to the U.S. and 2% to Canada.

Technological Benchmarking

According to a technological benchmarking study on the Canadian telecommunications industry done for Industry Canada (1994), in the case of wireless technology, R&D spending appears to be less important but there is a significant difference in numbers of patents associated with smaller companies then those above the median sales of the industry. The wireless systems equipment sector comprises 20% of telecommunications patents and records the largest increase in annual patents from 1986-1993. Canada shows an increased emphasis in patenting in the wireless systems sub-area. BCE (northern Telecom) files the most patents in this area, but its output has been relatively flat compared to growing Canadian patent output indicating either smaller firms are involved in wireless or the technology is being developed for foreign companies. When measured against countries other than the U.S. and Japan, the chief competition is between Canada, Germany, Sweden, Finland and Korea. According to a Conference Board of Canada Report (1990), the Canadian corporate tax system provides greater overall incentive for companies to engage in R&D than do the tax systems of the competitors mentioned above. Based on the fact that development of a technology base correlates with the development of products, we can expect these companies to be chief competitors for Canada in the future. However, citation of Canadian patents is almost as frequent as that of U.S. and Japanese patents which would indicate the Canadian technology base in the wireless sector is competitive and leading edge.

V. Standard and Regulatory Issues

Standards related issues are critical to wireless, since without them wireless cannot move forward. Standards are not a pretty process - but for wireless they are essential. A single wireless standard is highly unlikely, since different media have different characteristics and the two broad approaches (stationary and portable) have different requirements.

The CRTC with regard to regulation is of the opinion that the market for cellular phones and other wireless telecommunications services is competitive enough that full regulation is not necessary to safeguard the public interest. This is consistent with the overall policy objectives, including fostering increased reliance on market forces for the provision of telecommunications services and ensuring that regulation where required, is efficient and effective. In August 1994, the CRTC decided to cease from regulating rates in cellular and Public Cordless Telephone Service (PCTS). This ruling exempts wireless service providers of non-telco carriers from the obligation to file tariffs. To get a radio paging license in Canada, you have to meet certain Canadian ownership requirements and prove that the service is worthwhile.

Wireless carriers want regulations that apply to their industry extended to radio and television stations that use their broadcasting spectrum to compete in the delivery of telecommunications services. As it currently stands, broadcaster licensees can lease frequencies to provide wireless services such as paging without proving they meet the same ownership requirements required by other wireless carriers. This policy issue will become more visible once broadcasters convert to digital transmission and provide other new services.

CT2 Plus provides unique opportunity for Canada to add value to the wireless technology momentum established in Europe and the U.S. Enhancements proposed in this standard are recognized worldwide, and timely exploitation could provide the basis for product innovation in Canada.

The compatibility feature of CT2 Plus will ensure that the Canadian public will find within the personal communications services, a wide range of products and services offered by a number of service providers. Canadian manufacturers and service providers will learn first hand how to serve the personal communications needs of Canadian consumers. Another public policy issue that will affect the introduction of PCS services is the ability to interconnect to the so-called "intelligent network", and interesting questions arises as what percentage will be paid for by radio-based subscribers. Other public policy area that will have to be addressed is local service competition between wireline service and PCS. The movement from a "duopoly" in cellular services to "oligopoly", where there will be a greater but still limited number of players.

Standardization issues that must be resolved include: structure architecture, competing standards, global and WARC recommended standards, mobility, capacity, system

management, capacity and network integration. Another issue that has yet to be finalized is tougher restrictions on scanners that can breach security of communications over cellular phones, pagers and radios.

VI. Market and Technology Trends

This area will provide a discussion of the factors affecting the development of the mobile communications market in Canada.

Evolution of Cellular into PCS

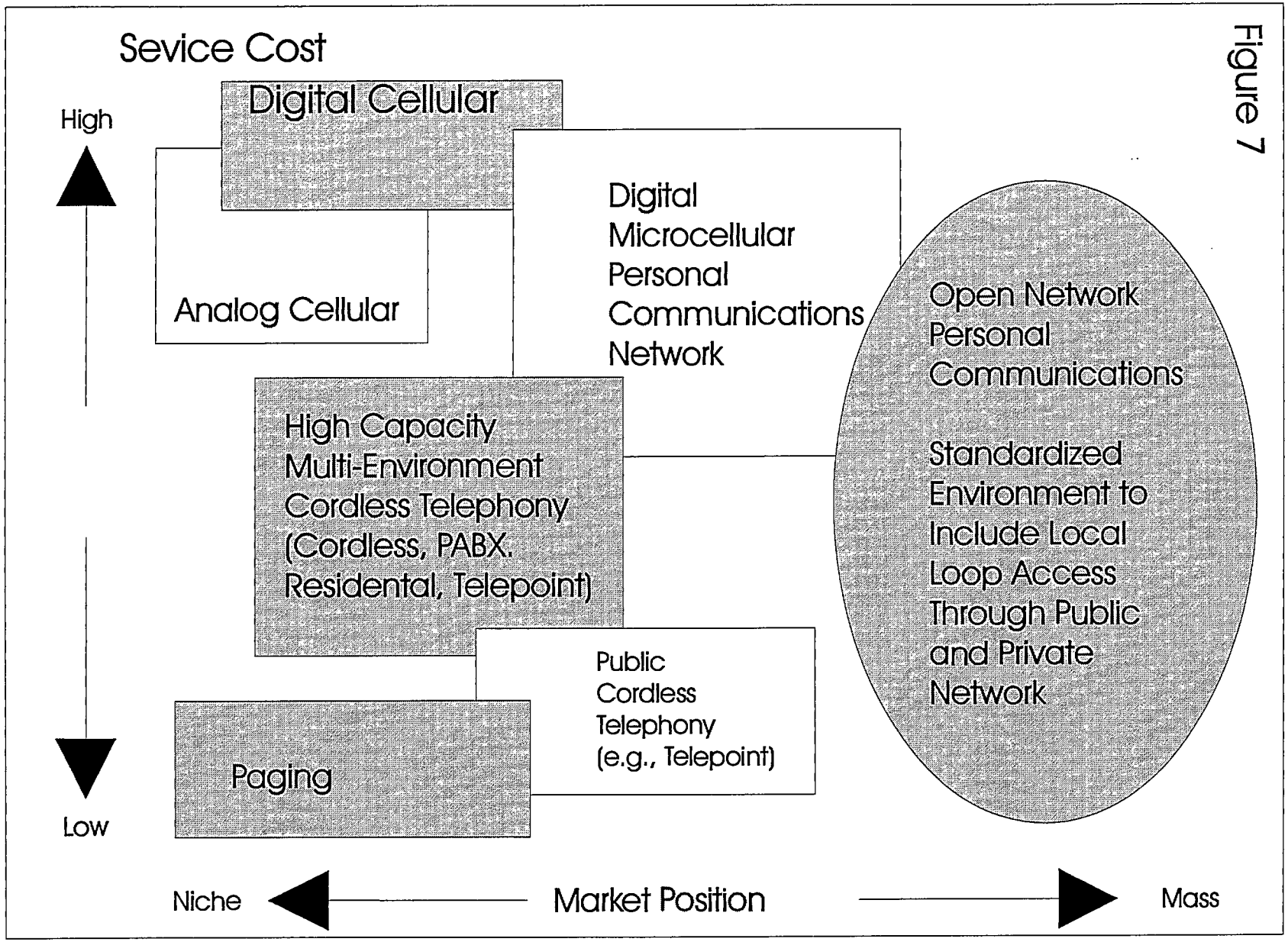
Mobile data networks currently exist that provide access to host computers, e-mail retrieval, remote monitoring, electronic transactions, dispatch, automated field services and other applications. These are cost effective applications for business. These applications are making wireless networking one of the most promising technologies to emerge in the 1990s. Previously, there was both a lack of user awareness and of viable applications which hindered demand and slowed the technological implementation process. Service and equipment costs were high and often unreliable. With many of the inherent problems resolved the future for vendors is much clearer. The market is now established, with users in a variety of application markets currently involved in a variety of technology segments e.g. cellular (Figure 7).

The industry is seeing a growing number of affiliations and joint ventures and alliances. These affiliations are enabling more efficient research and development to occur in both technology and applications. The advancement of standards coupled with increasing visibility of mobile data are also driving the move to merger activity.

In Canada we see these affiliations being implemented by some of the major cellular players. Bell Mobility Cellular has formed an alliance with Delrina Corp, Lotus Development Corp and Intel to work on ways to more effectively send wireless E-mail or FAX. Cantel Data has partnered with GDT Softworks of Vancouver to offer wireless E-mail via its Cantel Mobitex network. Using software designed by GDT Softworks, messages may be received using laptops, personal digital assistants, FAX machines or pagers. Inmedia Informatic of Montreal has reached an agreement with three firms to launch a wireless electronic mail service in Canada. Inmedia, Ericsson RIM and Cantel have developed a system that sends documents through a wireless modem over Cantel's radio frequency network. The information is then picked up by Indedia's e-mail service which directs the mail to any user of public mail systems. and anyone with a fax machine.

Public Digital Cordless Services

The broader meaning of personal communications is the concept of small pocket-sized telephones that can be used every where at low cost. As new frequency bands are allocated and more operators are licensed, there will be an increasing number of systems, concepts and technologies under the umbrella of personal communications. Twenty (20) to thirty (30) percent of the population in the developed parts of the world are expected to have "personal communications" by the end of this decade. A large growth is foreseen for various forms of text, data and electronic mail which will gradually increase the need for higher data rates in


Sevice Cost
High
Low
Digital Cellular
Analog Cellular
Digital
Microcellular
Personal
Communications
Network
High Capacity
Multi-Environment
Cordless Telephony
(Cordless, PABX,
Residental, Telepoint)
Public
Cordless
Telephony
(e.g., Telepoint)
Paging
Open Network
Personal
Communications
Standardized
Environment to
Include Local
Loop Access
Through Public
and Private
Network
Niche
Market Position
Mass
Figure 7

the systems.

The movement is from demand limited analog based systems, into higher capacity digital systems, where in the medium to long term unit costs of this service are set to fall. PCN service providers and manufacturers can stimulate the market and gain a share of this business segment by being competitive and making long term commitments, since the PCS market is predicted upon low price and ubiquitous availability.

PCS will have to fit into a wireless environment where mobile services, such as cellular and paging have already staked out a substantial territory. Companies like Telezone have recently expanded its PCS network to include downtown locations in Toronto such as the Eaton Centre. Installing these service base stations allows landlords to enhance the telecommunications infrastructure of their properties and give added value to tenants. Telezone is the first Canadian company to announce the deployment of a national PCS network and growing coverage is a positive step to advancing a comprehensive PCS infrastructure in Canada. Industry analysts forecast that the worldwide market for personal communications will account for annual revenues of $50 billion by the year 2000, and the number of subscribers could reach 150 million. The U.S. is expected to account for most of the world market and should generate revenues of $20 billion to $25 billion.

Cellular service providers in the industrialized countries are moving towards upgrading their analog wireless operations to digital technology to increase the variety of services provided and to enhance existing levels of capacity and technological efficiency.

Public 2-way digital cordless telephone service is being introduced into the Canadian marketplace. Subscribers to this service will be able to use cordless phones to communicate with telepoint base stations which will be located in urban high traffic areas. The standard being adopted for the common air interface is CT2 Plus which has been allocated the 944-948 Mhz radio spectrum by the former Department of Communications. This service will be offered by four licensed Canadian companies who must maintain a minimum of 80% Canadian ownership. The suppliers of this service are: Canada Popfone, Mobility Personacom, Telezone and Rogers Cantel Mobile. Initial success PCS stories are firms like Telezone which signed an agreement to provide cordless PCS services to Marathon Realty in Montreal, Toronto and Vancouver.

Because this is a unique technology based on the fact that PCS services will be offered in the 2 Ghz band in the United States, it is expected that the majority of equipment supplied to meet the CT2 Plus market will be manufactured in Canada by major manufacturers such as Northern Telecom. The digital cordless market is expected to be approximately $140 million in 1997. To be successful in this marketplace, equipment suppliers must offer enhanced communications services and products in order to differentiate themselves from the cellular and mobile communications market providers.

Cellular

Industry representatives speculate that the adoption of open systems architecture will motivate further specialization among network equipment manufacturers . In an open systems environment, it will become much more difficult for horizontally integrated manufacturers such as Ericsson and NEC to remain internationally competitive suppliers of both cellular switches and cell site equipment. The ability of each manufacturer to fund both radio and switching research and development will likely decrease, motivating them to focus resources on areas where they are most competitive.

Significant improvements in the next generation of network equipment because of new technologies such as DSPs will enable manufacturers in the short term to sell their systems for a premium since they will enable cellular service providers to offer better services and reduce overall operating costs. The overall consensus is that although other competitors are preparing to enter the cellular network manufacturing industry as the digital cellular networks are deployed, the six predominant manufacturers will continue to maintain industry leadership till the year 2000. Similarly, the five main companies involved in cellular phone manufacturing e.g., Motorola, Nokia, Matsushita, Mitsubishi and NEC which presently account for 65% of total cellular phone sales are again expected to dominate in this market because of their core competencies and expertise in the areas of ASIC design, antenna and radio, and ergonomic design capabilities and advanced manufacturing techniques. Manufacturers with previous experience in radio manufacturing report they are better able to anticipate consumer demands for new features and to bring these units to market ahead of their competitors.

The cellular industry has come to a cross-road. While cellular technology is still in a high-growth mode, users around the world are beginning to think of broader PCS communications. Ironically, this is happening at a time when cellular itself is undergoing a transformation from analog to digital technology. Cellular equipment providers must face tough investment and technology decisions. Circuit and packet-switched cellular data services will compete not only against each other but also against other packet radio networks such as ARDIS and RAM Mobitex

Another emerging trend is the focus on the mobile office. The idea of cellular as-in-the car units is disappearing. The cellular industry has been enormously creative in expanding the capacity of analog systems. New switching technology which differentiates between voice, facsimile and data transmission allows cellular subscribers to transmit faxes and data from their cellular phones at special rates. Subscribers today want phones they can take with them no matter where they go, and as a result, this segment of the market is growing faster than car phones. Continued growth in cellular users will be important if cellular is to be a mass-marketed vehicle, and cellular service providers will have to find a way to win over a larger portion of Canadians who are not subscribers. Making cellular more attractive to more people

will be key to the technology's long-term success. Cantel has introduced the Amiga system and Bell Cellular has introduced the Excel package designed to give occasional users a price break.

Wireless Data

The sustained growth rate of cellular telephony to over 1M subscribers in 1993 has been nominally affected by data; very few subscribers presently transmit data over cellular circuits. During the remainder of the decade, data usage growth will greatly exceed the growth rate of pure voice service and the percentage of cellular subscribers transmitting data is forecast to rise to nearly 25% by 1997. A considerable portion of the projected data growth is slated to be carried by the emerging cellular packet data services, well-suited to applications relying on efficient, low-cost short message transmissions. Within the data-over-cellular market as a whole, the most popular applications reported by carriers are portable FAX, remote monitoring, and wireless electronic mail. The initial primary users of data-over-cellular services are large corporate and governmental organizations. But the growth of database access services and the introduction of public cellular massaging services are together likely to add a balance of small business, professional and personal use subscribers to the data-over-cellular market after 1995.

Packet switching permits greater spectrum efficiency than is possible with circuit-switched transmissions by allowing a communications channel to be used by many users, each using the channel only for the time required to transmit a packet or sort of packets. Cellular Digital Packet Data (CDPD) is a data-over-cellular protocol. This protocol will ensure that there is no loss of investment in existing cellular equipment. Field measurements indicate that cellular voice channels are idle about 40% of the time overage. Packet-switched cellular data systems are targeted at four broad categories of applications. These are transaction applications, interactive applications, broadcast applications and multicast applications.
Some examples are credit card verification, taxi dispatch, fleet management, point-of-sale, inventory control, emergency service. Interactive applications involve accessing to host or data services. Broadcast applications involve messages that are of interest to a wide audience, e.g., traffic advisory. Multicast applications involve messages that are of interest to a pre-specified group and are not acknowledged. Private bulletin boards are a common example.

Data PCS Opportunities

Personal computer manufacturers plan to weigh in - by 1995/1996 they expect to sell 20 million personal computers that can communicate with other local users without using wire. The following have been identified as opportunity areas in the wireless data sector:

CDMA
Systems integrators
The Information Highway
Commercial data products
Nationwide paging

PCMCIA cards	CDPD
PDAs	Wireless health care uses
Digital messaging	Handwriting recognition
Internal cellular modems	Hand-held data terminals

Paging

There are over 650,000 paging devices being used in Canada today with Motorola, NEC and Panasonic supplying the majority of the market. On the service provision side, Cantel Paging, Bell Mobility and BCTel Paging will dominate the market as a result of being part of larger organizations that can offer integrated service packages for mobile users particularly in mobile data communications.

Telepoint

Telepoint operators will be attacking the market from the other end. They will have the advantage of an acceptable entry price but will be constrained in the degree of mobility that they can offer. Given the failure of public telepoint services in the UK it is understandable that many countries are being cautious over the introduction of commercial telepoint services. It is highly probable that future telepoint type services would be of interest to telecom providers who already have a national infrastructure in place.

GLOSSARY OF ACRONYMS

AMPS -	Advanced Mobile Phone System
ARDIS -	Advanced Radio Data Information Service
ASIC -	Applied Specific Integrated Circuit
CCC -	Canadian Commercial Corporation
CDMA -	Code Division Multiple Access
CDPD -	Packet switched data over cellular
CRC -	Communications Research Centre
CRTC -	The Canadian Radio-Television and Telecommunications Commission
CT2 -	Second generation cordless telephone
CT-2Plus -	Enhanced versions of CT-2 cordless public phone technology
DSP -	Digital Signal Processing
EDC -	Export Development Corporation
GHz -	Gigahertz
GSM -	Global System for mobile Communications
IT -	Information Technology
LAN -	Local Area Network
M -	Mega
MBPS -	MegaBits Per Second
MHz -	MegaHertz
MNE -	Multinational Enterprise
PBX -	Private Branch Exchange
PC -	Personal Computer
PCMCIA -	Personal Computer Memory Card International Association
PCS -	Personal Communications Service
PCN -	Personal Communications Network
PCTS -	Public Cordless Telephone Service
PDA -	Personal Digital Assistant
R&D -	Research and Development
RF -	Radio Frequency
SMR -	Specialized Mobile Radio
SS7 -	Signalling System 7
TDMA -	Time division multiple Access
TQM -	Total Quality Management
WARC -	World Administrative Radio Conference

APPENDIX A

Canadian Manufacturers of Mobile and Wireless Personal Communications Equipment

Company	Address	Telephone	Nature of Business	Corporate Data
ATS	101 - 21 Antares Drive Ottawa, Ontario K2E 7T8	613 - 723 - 1103	Wireless LANS	ATS is a privately held Canadian company
Bestar Radio	9914 Cote de Liesse Lachine, Quebec H8T 1A1	514 - 695 - 1344	Bestar manufactures VHP/UHF radios. The company also offers customized product design services.	The firm started operations in 1993 and is privately held by the management of the company
Cantel	Toronto-Dominion Centre	416 - 229 - 1400	Cantel is the largest cellular telephone company in Canada and currently serves over 480,000 cellular and 100,000 paging subscribers	Rogers Cantel Mobile Communications Inc. is 80% owned by Rogers Communications.
Telular Canada Inc	1165 Franklin Blvd. Cambridge, Ont. N1R 8E1	519 - 740 - 2686	Telular Canada is an industry leader in developing wireless communications technologies and systems	Telular Canada Inc. is a public Canadian firm founded in 1987. Part of its holding are held by Motorola Inc.
Comprod Communications	138 de la Barre Bouchard, PQ J4B 2X7	514 - 641 - 1454	Comprod manufacturers antennas and 2-way radio communications products	Privately owned firm established in 1975.
Northern Telecom Wireless Systems	5550 Skyline Way N.E. Calgary, Alberta T2E 7L7	403 - 232 - 4200	The company's facility in Calgary is a centre for wireless technology development and a production centre for wireless access controllers.	Northern Telecom Wireless Systems is NT's newest manufacturing group and is responsible for the manufacture of cellular radio components and PCS systems
NovAtel	6732 - 8th St. N.E. Calgary, Alberta T2E 8M4	403 - 295 - 4500	The Personal Communications Products division is supporting the company's existing and future endeavours in wireless and personal communications	JRC has purchased NovAtels American cellular telephone division. JRC has taken over the Lethbridge plant. Telexel Holding a private Alberta firms owns the company.

RIM	180 Columbia St. W. Waterloo, Ontario N2L 3L3	519 - 888 - 7465	Research in Motion is a world leader in the engineering wireless computing industry and is known for its Mobitex technology	RIM is a privately held Canadian Company
IRIS Systems Inc.	123 Bannatyne Ave. Winnipeg, Manitoba R3B 0R3		IRIS is a full service vendor of an integrated communications network for electric, gas and utilities. Manufacturing is subcontracted.	IRIS is a Canadian company with 40 staff on board with emphasis on engineering.
TEKLOGIC	1331 Crestlawn Drive Mississauga, Ontario L4W 2P9	416 - 625 - 5673	Teklogic is a world leader in radio frequency data communication for warehousing and distribution systems.	The firm is headquartered in Mississauga with a U.S. facility in Kentucky.
Canadian Marconi	600 Dr. Frederik Philips St-Laurentm, Quebec H4M 2S9	514 - 748 - 3157	CMC's Communication Systems Division builds one of the best line-of-sight tactical radios in the world and sells primarily to the United States Army.	Canadian Marconi is a subsidiary of GEC in the United Kingdom with Canadian and US shareholders owning 48% of CMC. The firm has over 2300 employees.
Motorola Canada Ltd.	4000 Victoria Park Ave. North York, Ontario M2H 3P4	416 - 499 9148	Motorola in Canada consists of 7 major business entities including the paging and wireless data group.	The company is a wholly owned subsidiary of Motorola, Inc. on of the world's leading wireless equipment manufacturers.
Ericsson	8400 Decarie Blvd. Ville Mont-Royal, P.Q. H4P 2N2	514 - 738 - 8300	Ericsson Research in Montreal is the R&D centre for L.M. Ericsson's software products which account for approximately $200 million in revenues for the Canadian subsidiary.	Ericsson Canada is a fully owned subsidiary of LM Ericsson which operates over 100 countries. L.M. Ericsson is the world's largest cellular equipment manufacturer.
PCS Wireless	7000 Lougheed Hwy. Burnaby, B.C. V5A 4K4	604 - 689 - 7722	PCS Wireless is the only distributed antenna array equipment supplier in the world. The firm sells its DAA products as an OEM option to PCS equipment vendors such as Ericsson.	PCS Wireless is a Canadian firm maintaining a low volume manufacturing and general operations staff of 25 to perform board and unit level assembly and configuration.
MDSI	6742 Baker Rd. Delta, B.C. V4E 2V2		MDSI provides mobile data products targeted at utilities and dispatch oriented organizations such as taxi companies.	MDSI was incorporated in 1992. The company was formed as a result of a purchase of the Utility Application Software Division from Motorola by former employees.
Bell Mobile Communications	6505 Trans Canada Suite 200 Saint Laurent, P.Q. H4T 1S3	514 - 748 - 3200	BCE Mobile is a wireless carrier and mobile communications holding company which provides services through various businesses such as Bell Mobility and Skytel.	BCE Mobile is 70% owned by BCE Inc. BCE is Canada's largest telephone company.

Simmonds Communications	5255 Younge St. Willowdale, Ontario M2N 6P5	416 - 221 - 1900	Simmonds offers wireless communications equipment and is a systems integrator with an open approach for wide area networks.	SCL is a Canadian company with headquarters in Toronto and is an ISO 9002 certified facility.
JRC Canada Inc.	450-31 St. North Lethbridge, Alberta T1H 3Z3	403 - 329 - 7600	JRC Canada is developing and manufacturing cellular and wireless communications products for North America. It manufactures cellular phones as well as accessories.	JRC Can. is a newly established subsidiary of Japan Radio Co. Ltd., a leading global manufacturer of telecommunications equipment. Manufacturing is in Lethbridge.
Mobiltex Data Ltd.	3460 - 26 St. N.E. Calgary, Alberta T1Y 4T7	403 - 291 - 2770	Mobiltex Data provides OEM design, manufacturing and consulting for industrial mobile data systems and signalling products.	Mobiltex Data is a private Alberta company founded in 1985 with specialization in providing mobile data systems to the gas and oil sector.
WI-LAN	308, 809 Manning Rd. Calgary, Alberta T1Y 4T7	403 - 273 - 9133	WI-LAN commercializes a family of high speed wireless LAN products for the global market with speed up to 100Mbps.	WI-LAN was founded in 1992 and it has an office in California.
Glenayre	1570 Kootenay St. Vancouver, B.C. V5K 5B8	604 - 293 - 1611	Glenayre is a worldwide provider of wireless personal communications including radio paging, voice Messaging, alphanumeric Messaging and mobile data systems.	The firm was purchased by the N-W Group Inc. of New York with headquarters established in Charlotte, N.C.
MPR Teltech Ltd.	8999 Nelson Way Burnaby, B.C. V5A 4B5	604 - 294 - 1471	MPR has the largest R&D capability in Western Canada. MPR has world class expertise in the wireless sector in RF product design, mobile data protocols, CDPD and RF propagation and system analysis.	MPR Teltech is a subsidiary of BC TEL Canada's second largest telephone company. Besides its international portfolio, MPR provides support to the BC Tel group of companies.
Omnex Engineering	1100 Lansdowne St. Coqutialam, BC V3B 5E2	604 - 944 - 9247	Omnex designs and manufactures industrial radio remote controls using advanced CDMA technology and fibre optics interfaces.	Omnex is a privately held company which employs approximately 15 people. They have established themselves as a supplier to several large European machinery firms.
Spilsbury	1495 Franklin St. Vancouver, B.C. V5L 5B6	604 - 254 - 6411	Spilsbury specializes in the design and manufacture of commercial HF, VHF, and UHF radio products for voice and data.	Spilsbury is a privately held firm operating primarily in B.C.

Dataradio	5500 Royalmount Town of Mount Royal H4P 1H7	514 - 737 - 0020	Dataradio manufactures fixed and mobile radio data communications products. The mobile data system is popular among utility and public safety organizations	Dataradio is a privately owned firm with majority ownership held by 2 principals who form the management team of the company.
RF TEL	164 Aime Vincent Vaudreuil, P.Q. J7V 5V5	514 - 424 - 8150	Manufacturer of VHF and UHF rural radio telephone systems, designed to operate where wireline systems are not economical	RF-TEL is a privately held company owned and operated by the firms management.
Gandalf Mobile	2 Gurdwara Road Nepean, Ontario K2E 1A2	613 - 723 - 6500	GMSI develops and markets mobile data communications systems for the transportation market. It is a leading supplier of traffic dispatch systems and offers Mobitex modems.	In 1990, the Computer Dispatch Systems Div. of Gandalf Technologies became a separate firm known as Gandalf Mobile Systems Inc. Geotek Industries of the U.S. became a major partner in 1993.
Daniels Electronics	43 Erie St. Victoria, B.C. V8V 1P8	604 - 382 - 8268	Daniels is a manufacturer of radio communications equipment with specialization in mountain top repeater systems, generally used for remote area services.	The firm is privately owned with a client base located primarily in Western Canada
Ultimateast	60 Water St. St. John, Nfld A1C 5X4	709 - 576 - 4747	Ultimateast is a R&D company established in Eastern Canada with development capability in marine communications	Ultimateast is a privately held Canadian firm.
RMS	1590 Kootenay Vancouver, B.C. V5K 5B8	604 - 293 - 4343	Products include high throughput mobile voice data and computer aided systems for rapid transit and bus systems.	In 1990, Glenayre acquired majority interests in RMS with the strategy of combining the manufacturing operations of RMS with the traditional mobile communications business.
Silcom Research Ltd.	308 Katimavik Road Kanata, Ontario K2V 1A1	613 - 591 - 1342	Silcom designs radio paging receivers for digital alphanumeric services. They develop low power radios using the most advanced ASIC circuits in their wireless products. The company is a developer and supplier of mobile data hardware and software products.	Silcom Research was founded in 1989 and is a privately held Canadian company.
CML Technologies Inc	75 Boul. de la Technologie Hull, Quebec J8Z 3G4	819 - 778 - 2053	The company designs and manufactures control consoles for Ericsson GE for their mobile radio communications systems.	CML is privately held with part ownership by two of Canada's largest institutional investors. CML is known for its innovative technologies and does its own manufacturing in Hull.

Cycomm International	815 Hornby St. Vancouver, B.C. V6Z 2E6	604 - 684 - 7200	Cycomm develops voice and data privacy security products for cellular, radio and landline communications	Cycomm is a public company and Bell Cellular is a major distributor of its cellular products in Canada.
Sierra Wireless Inc	Burnaby, B.C.		Sierra Wireless is working on CDPD technology that will enable transmission of data over cellular voice channels	Sierra Wireless is backed by U.S. based Sierra Semiconductor and MPR Teltech, companies which are working on CDPD development.
Davicom Technologies	2765 de l'industrie Trois-Rivieres, P.Q. G8Z 3X9	819 - 370 - 4343	Davicom designs and manufactures RF products such as antennas, filters, duplexers and combiners ranging to 960 MHz.	Davicom founded in 1990 is a privately hed company owned and operated by the firms owners.
Szeto Technologies	5895 Bessette St. St-Laurent, P.Q. H4S 1P1	514 - 331 - 9152	The company is a specialized manufacturer of telecom equipment including radio paging and CT-2 Plus cordless digital products.	The firm was founded by Mr. Szeto in 1986 and is privately owned.
R.A.C.E. Technologies	1495 Franklin St. Vancouver B.C. V5L 5B6	604 - 254 - 6411	The Vancouver based company designs and manufactures RF data modems for use with portable computers and adapters to select the best HF channel.	Privately held, this B.C. company was founded in 1990.

APPENDIX B

CANADIAN ORGANIZATIONS IN THE PERSONAL COMMUNICATIONS (PCS) SECTOR				
Company	**Address**	**Phone**	**Corporate Profile:**	**Scope and Focus**
TRIO	340 March Road Kanata, Ontario K2K 2E4	613-592-9211	TRIO's mission is to enhance the Canadian competitiveness of Canadian telecommunications companies through university /industry partnerships by sharing research led by Ontario based researchers. Expenditures in these areas are approximately $1 million with 25 university professors and 45 graduate students being involved. Collaboration exists with 9 Canadian corporations.	In the area of low power radio, The thrust is the development of a lower power, universal digital radio system. Central projects supporting this effort are: development of low-power handheld receivers portable radio networks with TDMA access modem technology wireless link security.
TR Labs	3553-31 St.NW Calgary, Alberta T2L 2K7	403-282-5870	TR Labs currently ranks in the top 20 communications research organizations in Canada as measured by R&D expenditure. in the non-profit category it is second only to CRC. TR Labs organizes the Wireless Conference in Calgary held on an annual basis. A world first has been achieved by demonstration of a 150 Mb/s wireless LAN which is capable of interfacing into fibre optic systems requiring high bit rates and very low bit error rates. Through joint industry and university collaboration in applied telecommunications research TR Labs will contribute trained people and innovative technology to achieve business growth for their industry sponsors.	One of TR Labs major research categories includes wireless communications in such projects as : network planning to enhance cellular system base station coverage, frequency reuse and capacity. In the PCS area, work is proceeding on concepts which reduce power requirement s for mobile units. Low-power circuitry research is continuing, antenna improvements and high frequency work is also being done. TR Labs collaborates strongly with the University of Alberta, University of Calgary and Saskatchewan. They have over 35 public and private sponsors including some of Canada's most prominent wireless companies.

Communications Research Centre	3701 Carling Ave. Ottawa, Ontario K2H 8S2	613-998-2261	The Communications Research Centre (CRC) has a staff of over 200 engineers and scientists supported by over 50 technologists, CRC has collaborative R&D arrangements with over tow dozen research organizations. Its major clients include federal government departments, universities and private industry.	CRC conducts leading-edge research in key area such as: mobile communications, radio propagation and prediction and personal communications. The Communications Technologies Research Branch performs generic research and development in radio and satellite communications systems. Research activities are organized around emerging terrestrial radio communications technologies and systems. Work is taking place on mobile terminals small enough for personal portability. Most of the basic research into radio-wave propagation conducted in Canada is carried out at CRC. Technology and knowledge transfer is taking place to industry in various ways in order to take laboratory innovations and develop them into new products sometimes in exchange for royalties on the sales of the applications.
Canadian Institute for Telecommunications Research (CITR)	McGill University 3480 University Montreal, Quebec H3A 2A7	514-398-8104	CITR is a non-profit organization that carries out market-oriented, precompetitive research at 17 Canadian universities and research centres. The company's six main areas of research involve over 28 projects and some 300 professionals. Industrial collaboration is an important part of CITR's strategic direction and over 10 major Canadian telecommunications manufacturers play a leading role in establishing the direction and content of the research program. CITR is one of 15 networks funded by the government of Canada which receives revenues in the order of $4 million from the government to undertake its research activities.	Research is focused on key enabling technologies such as mobile communications where major work emphasizes spectrum utilization and transmission techniques that can increase the capacity of digital cellular. Other efforts are directed at increasing the reliability and throughput of wireless channels that will be required for wireless local access services of the future. Wireless indoor digital communications research is directed providing broad wireless transmission channels using millimetre wave frequencies. The budget for both of these projects is in excess of $1 million (1992).

Canadian Centre for Marine Communications (CCMC)	St. Johns, Newfoundland A1B 3N9	709-579-4872	The CCMC supports and assists the development of Canada's marine communication industry. established in 1989 as a non-profit corporation, CCMC is strategically positioned between research institutions and private industry. The Centre assists its industrial partners in the development of new products and services for national and international markets. CCMC is owned by its approximately 100 members who pay membership fees of $55.00 The remainder of the revenues $1.5 million (1993) come from government sources such as ACOA who is a major contributor. Eight percent of CCMC's resources are devoted to its laboratory facilities and its technical personnel. Members can access the facilities, equipment and expertise of the Centre to support the development of marine communications products and services.	Three principal programs are being pursued: radio and satellite, "Smartship" and EMI/EMC. in antennas and radio communications. The main elements of CCMC's program focus on new applications and technologies for marine mobile systems and the extension of HF and VHF marine communications technologies. One active area in radio communications for CCMC has been in the development and refinement of radio antenna systems.
Advanced Radiodata Research Centre (ARRC)	11411 Number Five Road Richmond, B.C. V7A 4Z3	604-277-1511	Motorola opened a new research centre and laboratory in Richmond, B.C. in 1993, Motorola will invest $4M in the laboratory for a three year term. Grants, financial assistance for academic research, funding for software developments programs and dedicated capital equipment, and other operating costs will be funded under this investment. The advisory board consists of nine members - five from Motorola, two from Industry Canada, one Canadian software company and one representative from a canadian university.	Two primary ARRC programs will be available: financial grants and assistance to university science and engineering facilities for applied research ind data radio communications, and practical assistance to Canadian software companies to enable the development and subsequent marketing of applications and connectivity programs for wireless data communications. One key area of research is the development of data radio throughput enhancement software which maximizes the available communications bandwidth for wireless data communications.

National Wireless	1122 Mainland St. Vancouver, B.C. V6B 5L1	604-687-7644	National Wireless was incorporated in 1989 with the purpose of conducting research in wireless communications in Canada. It is being funded by Industry Canada and its 38 members and over 200 clients most of whom are from Western Canada. This organization is actively moving to deliver services nationally through alliances with organizations such as TR Labs, TRIO, CITR and CCMC.	Services are being offered in four area: people development, product development and funding and consortia development. National Wireless delivers services for other communications technologies but the wireless technology is still a major activity in the association since many of its members have a strong wireless focus. National Wireless is sponsoring conferences and will be hosting a Wireless Data conference in 1995. It is a co-sponsor of the annual "Wireless Conference" held in Calgary for the last 6 years.