Ministry of State

Science and Technology
Canada

Ministère d'État

Sciences et Technologie
Canada

security classification

cote de sécurité

CASE HISTORIES OF EIGHT DOC INNOVATIONS

(Vol. II)

working paper

document de travail

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EIGHT DOC INNOVATIONS

(Vol. II)

MOSST-DOC STUDY

Ministry of State for Science
and Technology (MOSST)

Department of Communications
(DOC)

MARCH, 1980

TABLE OF CONTENTS

INTRODUCTION AND ACKNOWLEDGEMENTS

The eight innovations from the Space and the Research sectors of the Department of Communications (DOC) were chosen for detailed examination as the case histories of DOC's experience in technology transfer. The studies in this volume trace the history of the development of these innovations and the mechanisms used for their transfer to industry. A detailed discussion of the factors common to all eight case histories has been carried out in the MOSST report entitled, "Technology Transfer by DOC Laboratories: A Case Study of Eight Innovations", adjunct to this volume.

The case histories in this volume were prepared by a joint DOC-MOSST study team, in close consultation with the members of DOC's Communications Research Centre (CRC) scientists and the research managers who worked on the development of the eight innovations. The study team comprised Mr. J. Lyrette and Mr. T.W. Davies from the Department of Communications and Dr. B. Bhaneja from the Ministry of State for Science and Technology. Mr. Roy M. Dohoo acted as a consultant on the case histories from the Space sector. The study team would like to acknowledge its thanks to the scientists and managers within and outside DOC who kindly made their time and experience available in the preparation of these case histories.

SPACE SECTOR

CASE HISTORIES

Scanning Electron Microscope

Introduction

Electron microscopes, which typically have magnifications of the order of 100,000, can be of the tranmission or reflection type. If of the transmission type, the target specimen has to be very thin - of the order of 100A^{o}. Electron microscopes, of the reflection type, are more common and are easier to use. In the middle 1960's the development of the scanning electron microscope began and promised an ability to examine a larger area specimen and its changes on a real-time basis, much along the lines of a TV picture.

Not only is a scanning electron microscope a complex equipment but, at the time the technology transfer was undertaken, there existed no Canadian company to which the technology could be transferred. Therefore, this case history involves the transfer of technology and the establishment of a new company - SEMCO Instrument Company Limited. It is not intended to dwell on the problems encountered in the early years of SEMCO (although a study of the resolution of them might provide a valuable insight to the difficulties of establishing a new high technology company) and they are mentioned only to explain the major role played by the National Research Council (NRC) in sustaining the company after the initial transfer of technology from the Communications Research Centre (CRC). Not only is this case history unusual in the involvement of four government departments and agencies (CRC, NRC, Canadian Patents and Development Ltd (CPDL) and the Department of Industry, Trade and Commerce (DITC)) but it involved also the movement of staff from CRC to industry.

History

In 1967 it became clear to those managing the space program at the Communications Research Centre (CRC) of the Department of Communications (DOC) that increased emphasis should be placed on reliability analysis. One of the most promising tools in the pursuit of reliability was the Scanning Electron Microscope (SEM) and CRC had no experience in SEM technology. Consequently Dr. P. Thornton, who was a SEM expert at the University of Wales, and two of his students joined the staff of the Defence Research Telecommunications Establishment (later CRC) and set up an analysis facility using the SEM bought from the University of Wales. In accordance with the original plan the work changed gradually from an analysis of failed devices to an analysis of the failure modes of devices and the manufacturing techniques which led to these failure modes.

In parallel with this reliability analysis work, Dr. Thornton and his team, now augmented by physicists and engineers on staff at CRC, continued the development of SEMs. After about a year, Dr. Thornton left CRC and the group was directed by Dr. C.D. Cox. One of the successes was the mini-SEM and the group tried, unsuccessfully, to interest manufacturers in Canada. About this time the group was visited by individuals from U.S. companies, which later introduced to the market SEM's incorporating CRC ideas, before the SEMCO product was available. This premature disclosure was undoubtedly undesirable but its deleterious effects were compounded by subsequent delays in Canadian production. After the unsuccessful search in Canada CPDL was asked to handle the mini-SEM, and a licence was sought by a U.S. company - Ultrascan - which was run by Dr. R.F. Webb, who had learned indirectly of the mini-SEM design. CPDL agreed to license Ultrascan provided that the mechanical components were manufactured in Canada. Before the agreement was signed Dr. Webb left Ultrascan due to illness and, after a period of indecision, Ultrascan declined the licence. Some months later Dr. Webb, who had considerable enterpreneurial experience in the USA, and CPDL agreed that a licence would be granted to a new company to be formed by Dr. Webb in Canada. In the fall of 1971, Dr. Webb, with the encouragement of DOC and DITC, which made PAIT funds available, established the SEMCO Instrument Company Limited but was unable to find sufficient capital, under acceptable terms, in Canada. Almost accidentally, Carl Zeiss Limited learned of the mini-SEM design. Zeiss, which manufactured transmission electron microscopes but did not market a SEM, assessed the CRC concepts, offered to buy 49% of the SEMCO stock, and agreed to provide world-wide marketing. SEMCO was committed to deliver an instrument, meeting agreed specifications, to Zeiss after eighteen months. The company was originally established in the premises of Computing Devices of Canada but moved within a few months to its own premises in Ottawa.

It was recognized that, in order to transfer the technology effectively to SEMCO, some CRC staff members should be made available to the company. As it was difficult to place government employees in industry, there being no Interchange Canada program at that time, it was agreed, at the suggestion of CPDL, that Dr. D. Shaw and another CRC staff member would be seconded to CPDL and that, as part of the arrangement under which SEMCO obtained the mini-SEM licence, these two CRC staff members would go, under contract, to SEMCO. SEMCO paid their salaries, but it was agreed that they could return to CRC after the technology transfer had taken place.

After about a year it was determined that the design of the electronics of the mini-SEM NOVASCAN 30, although containing novel features, was not suitable for production. Additional capital was required and, as only part of this was made available by Zeiss, Dr. Webb had to find the additional funding. Nevertheless SEMCO continued development and delivered, two years after its start, its first instrument to Zeiss. But because of the improved performance of instruments manufactured by at least one of the companies which had examined earlier the CRC mini-SEM development work, Zeiss declared that the SEMCO instrument was not marketable and SEMCO was forced to upgrade the instrument and to commence the design of a range of "accessories" to make the instrument more marketable. At this time (1973) it was decided to increase the R&D effort at SEMCO and it was arranged that, under the IRAP program, the National Research Council (NRC) would pay the salaries of eight engineers and scientists and that NRC would retain the rights to inventions, with SEMCO having the first rights to exploit them. This enabled SEMCO to recruit Dr. Shaw, Dr. Cox and other members of his group who were involved in the design of the mini-SEM. (The addition of SEMCO to the list of companies who had agreements with the government concerning the transfer of superannuation rights made it easier for these public service employees to join a private company.) Because SEMCO did not have adequate facilities, NRC provided essential laboratory space, support facilities and consultants, in a program which was, in effect, a precursor of the Incubator program. In addition, to the provision by CRC of capital equipment for use by the group at NRC, SEMCO received contracts for the completion of the development of the mini-SEM borrowed from CRC and a wide-angle display for use by CRC in its reliability analysis work.

Unfortunately, great efforts to improve the production quality were not completely successful (manual adjustments to instruments after final assembly continuing to be required) even though the Industrial Engineering group of NRC's Technical Information Service, which had helped to establish it, regarded the production line organization as sound. It is likely that any company, and especially a new one, placing on the market the first models of a new development, in an area of such high technology, will require its best technical expertise "standing by" to deal with the almost inevitable inperfections. In 1976 SEMCO had the necessary expertise in the group at NRC but it had been set up under the Industrial Research Assistance Program to meet the longer term research requirements of future generations of SEM's and not to deal with problems arising from imperfections in production models.

In March, 1976, a serious illness forced Dr. Webb to sell his interest in the company to Zeiss. However, in 1977, Zeiss decided, for a variety of reasons, to sell its interest in the company to Mr. Brian Evans, although agreeing to continue to provide SEMCO's sales organization on a world-wide basis.

SEMCO had encountered serious financial and organizational problems and its growth was not as rapid as might have been anticipated in such a high technology company. This lack of rapid growth was probably due to an under-estimation, by all concerned, of the difficulties of developing a commercial product, with the consequent delay leading to a loss of some of the early markets. Nevertheless SEMCO gradually overcame the problems of the NOVASCAN 30 and developed, at NRC, the prototype of the second-generation instrument - the NANOLAB 7 - which was displayed in Los Angeles in April 1978. It was at this time that the first five-year SEMCO-NRC Incubator period ended and the time when SEMCO took over its own marketing in North America. The second Incubator period was shorter and with fewer SEMCO staff at NRC. The main subject of development was the high brightness electron source, now used in SEMCO production. The development of the third generation of SEM (NANOLAB 9) was transferred to the company's premises under a PILP contract signed in 1978 and is now nearly complete. SEMCO now builds a SEM of high quality and a line of attachments which have earned a reputation throughout the world for quality and technical support.

Conclusions

In examining this case history several events and attitudes which facilitated or hindered this successful transfer of technology can be identified:

(a) the concept provided by Dr. Thornton
(b) the premature disclosure of the techniques
(c) the encouragement of CRC management

(d) the entrepreneurial activity of Dr. Webb in the establishment of a new company

(e) the initiatives and support provided by CPDL

(f) the support provided by DITC

(g) the willingness of CRC staff to take positions in industry and the agreement on the transferability of superannuation rights

(h) the underestimation, by all concerned, of the difficulty of converting the laboratory technology to industrial production, especially when the recipient company was being formed at the same time

(i) the continuous support of NRC through the Incubator and PILP programs.

LOW COST EARTH TERMINALS

Introduction

A space communication system includes not only the satellite in space but the transmitting and receiving earth terminals. A standard earth terminal in the INTELSAT system for international communications includes an antenna with a diameter of 30 m. The high cost of such a terminal is acceptable because of the limited number required and the high level of traffic handled by each. However, domestic systems including a large number of earth terminals, each with little traffic, require low cost earth terminals to minimize the overall system cost. The same considerations are even more important in satellite broadcasting systems where the number of earth terminals may be several hundred thousand, if not millions.

History

Very early in the 1970's agreement was reached between the Department of Communications and the National Aeronautics and Space Administration to develop and launch the Communications Technology Satellite (later known as HERMES). Central to this proposal was the development of a 200 watt transponder whose output was to be radiated by high gain, narrow beamwidth (2.5^{0}) antennas to provide experimental broadcast services. Clearly if such a service was to become operational, the size and price of earth terminals should be reduced as far as possible. The earth stations procured to permit the carrying out of communications experiments using HERMES were too large and too expensive for large scale acceptance by the general public for use as broadcast receivers and it is interesting to note that none of the proposals originally made for the use of HERMES was for broadcasting alone. What was required was a truly low cost earth terminal (LCET).

In the early 1970's Logan and Associates of Montreal carried out a study for CRC and concluded that the promised reduction in prices of SHF components was not justified and that component prices would not fall sufficiently to allow the development of a LCET in the $500 to $1000 price range. By the middle of the 1970's, field effect transistor amplifiers and low cost low conversion loss mixers became available. Because it was realized that problems of multipath transmission were less serious than had been considered in the past, it was believed at the Communications Research Centre, and indeed around the world, that earth terminals of sufficiently low cost could be produced.

Although it had been planned to begin work on the LCET in 1974, the start was delayed by the requirements of the HERMES FET amplifier development. The early work was done in-house, with a team of eight or nine at its peak, to obtain a full understanding of the problems involved, and at the University of Manitoba where work was carried out, under an eight thousand dollar contract, on the design of a 90^{0} prime focus scalar feed. Because of this parallel work at U. of Manitoba it was decided to build a Cassegrain antenna (4 ft. dia.) at CRC. This design employed double-conversion and a tuneable high IF - a new concept for LCET's, later adopted by SED Systems Ltd. (SED) and many other designers. The design of the indoor unit (IDU) used conventional communications circuit technology. A $4000 contract was awarded to Electrohome Ltd. for a paper study of the design of an LCET IDU using Electrohome's production technology. To this task Electrohome brought a knowledge of the large scale production of consumer electronics, but CRC had to provide all the technical knowledge required for the design of the IDU. A year later a $10,000 contract was let to Electrohome for the fabrication of two tunable IDU's. Both contracts were funded from CRC's base funds. It would have been preferable to let a larger contract at the time of the paper study but funding was not available.

In the meantime a second demonstration unit was bult at CRC. Abandoning the Cassegrain antenna design, this unit used 4 ft. and 2 ft. antennas with a prime focus 90^{0} high efficiency scalar feed, designed in cooperation with U. of Manitoba, which is mass-producible in plastic.

This unit included an all-alumina MIC in the prime focus-mounted receiver and a surface acoustic wave (SAW) filter in the IDU. A third demonstration unit used an all-duroid MIC (as it is appreciably cheaper than the all-alumina version) and a novel low cost temperature compensated oscillator, which is now the subject of a patent application.

Up to 1978 consideration had been concentrated almost entirely on the problems of broadcast quality reception. In that year it was realized that for direct-to-home broadcast reception a much lower quality signal was quite acceptable. As a result a request for proposals for the low cost outdoor units was issued by CRC and following an evaluation of the proposals received a $122,000 contract was let to SED for the development of two "developmental models" outdoor units and a preliminary investigation of volume production techniques. It may be noted that, to a large extent, SED was able to bid successfully on this contract as the result of a contract awarded to SED three years earlier to establish itself as a supplier of microwave components for earth stations to be used in satellite communication systems. A second contract to SED in 1979 ($375,000) called for system performance studies, the planning of the pilot production of 100 LCET's and the fabrication and delivery of 100 LCET's using 1.2 m. and 1.8 m. antennas and Electrohome IDU's. (As a result of this contract, SED offered later in 1979 to supply LCET's, in quantities of 100, at a cost of $2500. each.) Electrohome was to manufacture 25 units to their original design and 75 units having improved design and performance. An additional smaller contract ($66,000) has been placed with Electrohome to examine further improvements and to perform a market study to determine the feasibility of Electrohome entering the very large LCET market that is forseen.

The technical difficulties which have been experienced by Electrohome were generally anticipated and the company has required considerable assistance from CRC as, indeed, has SED. In spite of the difficulties, an enormous amount of technology has been transferred to SED and to Electrohome but more is likely to be required before either company can expect to capture an appreciable part of the consumer market that is likely to develop. Nevertheless, the technology transfer which has already taken place has enabled SED to bid successfully on contracts to supply about a hundred higher quality earth terminals.

It should be noted that while the CRC-generated information has been made available to SED, as the result of winning a contract in a competitive situation, and to Electrohome as the result of directed contracts, the technology generated at CRC has frequently been drawn upon by manufacturers not only of LCET's but of larger TV-receive earth terminals.

Conclusions

From a study of this case history a number of considerations affecting the transfer of technology can be identified:

(a) the existence of a company which had been funded earlier to establish itself as a supplier of microwave components for satellite communication system earth terminals;
(b) the cooperation with a university researcher;
(c) the importance of government purchases to consolidate the technology transfer;
(d) the availability, later in the program, of funds intended to facilitate the early development in industry of sub-systems;
(e) the problem of finding companies, where large scale manufacture is foreseen, with both a manufacturing and technical capability.
(f) the necessity, in situations such as (e), of extensive direct interaction between the company and CRC.

FIELD EFFECT TRANSISTOR AMPLIFIER

Introduction

A field effect transistor (FET) is a solid state device used to obtain amplification at microwave frequencies. It became available in the early 1970's. This case history refers to the first use made of a FET amplifier in a spacecraft. FET devices are now used widely, not only in spacecraft, but in the ground stations of space systems.

History

About the middle of 1973, Watkins Johnson, a U.S. company, ran into stability problems with the 12 GHz Transferred Electron Amplifier, which the company was building for inclusion in the payload of Communications Technology Satellite (later HERMES). CRC microwave specialists were asked to look at the problem and agreed with the manufacturer that it was unlikely that the difficulties could be overcome quickly. It was decided, therefore, to use a Field Effect Transistor (FET) Amplifier instead. None of the U.S. companies active in the field, was prepared to guarantee performance and schedule and to accept a fixed price contract. Since CRC had a better microstrip technology base and a greater MIC capability than existed elsewhere in Canada it was agreed between RCA and CRC in October 1973 that the amplifier be built by CRC, with a May 1975 completion date. An attempt was made to integrate in the development work engineers from RCA Limited (now Spar Aerospace Limited) which was building the spacecraft transponder. This had limited success only because of the preference of the company for transferred electron amplifiers and difficulties in personal relations between CRC staff and RCA staff sent to participate in the FET amplifier development.

Fairchild was the only supplier of completely packaged devices (the FMT 940) but when a number were bought and tested it became clear that, at that time, the company could not measure the performance adequately. Meanwhile it was found that Plessey in the U.K. was willing to supply devices in chip form. Samples, produced on a laboratory, rather than a production line, basis, were made available by Plessey and CRC designed and had fabricated the chip package. (It was ironic that, at that time, the only technology transfer was to Plessey in the U.K.)

Work at CRC on the Fairchild device and Plessey device amplifiers continued in parallel. As Fairchild supplied a packaged device, progress with this was quicker and the first operational amplifier was available in April 1974. However the narrower gate structure used by Plessey provided a better device and, although the device was not packaged, the amplifier design proceeded quickly. By the fall of 1974 the first engineering model using a Plessey device was followed by a qualification model using a Fairchild device. Eventually CRC produced engineering, qualification and protoflight amplifiers using Plessey devices and the same amplifiers with Fairchild devices. All this was done in eighteen months by a design team which totalled nineteen at its peak, including two RF design engineers and three technicians, with good support in packaging and power supply design and in reliability analysis. This technical team could not have achieved such remarkable results without full administrative support and the help of the Department of Supply and Services in expediting requisitions.

Redundant FET amplifiers, each using either the Plessey or the Fairchild device, were flown on Hermes. In its life in space of nearly four years, the Hermes satellite used only the FET amplifier with the Plessey device and no abnormalities in performance were reported.

No licensable or patentable technology was developed at CRC in the course of this development work - circuit techniques generally are not patentable - although a good deal of technological innovation was involved, as, for example, in the use of kovar to design packaging capable of meeting the temperature specifications. Much was learned on RF design (including the design of butterfly bias networks and filtercons - bias-feed through networks with RF shunting) and the failure mechanisms which can lead to degraded reliability. After the CTS deputy project leader, an RCA employee who had been seconded to CRC and who was convinced of the value of FET amplifiers in space applications, returned to RCA the climate for technology transfer was greatly improved. All the knowledge which had been acquired at CRC was made available to RCA and undoubtedly contributed to the success the company had in designing FET amplifiers for use in the RCA Satcom (6/4 GHz), the Anik B spacecraft (6/4 GHz and 14/12 GHz) and the TDRSS.

Another spin-off occurred when, in 1975, a contract was awarded to SED Systems Ltd. (SED) to establish itself as a supplier of microwave components for earth stations to be used in satellite communication systems. As a result SED have built 4 and 12 GHz low noise amplifiers using FET's. In the course of this development CRC personnel spent weeks at SED and SED engineers and technologists visited CRC to make use of the knowledge acquired in the design of the FET amplifiers for Hermes.

It is apparent that the technology transfer which occurred during and after the development of the FET amplifier was not achieved by transfer of information by licence but rather in repeated interchange of information between engineers over a long period.

Conclusion

In examining this case history several events and attitudes which facilitated or hindered the successful transfer of technology can be identified:

(a) the existence of a small strong team with excellent R&D facilities at CRC;

(b) the speedy development of the technology, with full management support, to meet strict time constraints;

(c) the existence of a chosen instrument after the CTS (Hermes) contracts were let;

(d) the reluctance of the chosen instrument to accept initially the value of the technology;

(e) the receptiveness of the chosen instrument after the return of senior staff seconded to CRC for the duration of the Hermes program.

DELTA CODEC

A Delta Codec is the hardware implementation of a system for the digital coding and decoding of an analogue signal, commonly a voice signal. The technology considered here is concerned with an adaptive form of the system whereby the input analogue signal is sampled periodically and a binary bit generated. The logic level of the bit is dependent on whether the sampled signal is greater or smaller than the signal of the previous sample. Decoding to recover the analogue signal is achieved by periodically charging and discharging a capacitor integrator by predetermined variable steps.

This development work began in 1969 when the Communications Research Centre (CRC), then the Defence Research Telecommunications Establishment, needed a codec to demonstrate the properties of digital voice transmission. With about 1/2 Person Year of work spread over two years, the High Information Delta Modulator (HIDM) was built. In 1970 consideration was given to the choice of coding techniques for UHF satellite communications. The HIDM was not suitable for high quality voice transmission and during the summer of 1970 a digitally companded modulator was developed. In 1972, as a result of its requirements for a thin route system in the North, Telesat discussed with CRC the possibilities of using a digital voice system and specifications were generated. There existed no capability in Canadian industry and U.S. industry could not meet the specifications. As a result of the Telesat interest, Canadian Patents and Development Ltd. (CPDL), to whom the CRC suggestion had been disclosed, considered patent action but declined to act because it could see little hope of financial return. The matter was not pressed by CRC engineers because they thought improved systems were in the offing. However, in January 1973, CRC published a Technical Note describing performance tests on the delta codec and about that time requested competitive bids for the conversion of the experimental circuit into a production-oriented unit and the building of two codec units. The successful bidder, SED Systems Ltd. (SED), redesigned the analogue circuits while retaining the CRC digital circuits and produced two units (MODEL 6090 CODEC) by mid-summer. Although nearly 50 units were sold to various government departments, the unit was not suitable for large scale manufacturing.

In these early models the feed-back loop in the coder, which provided the signal to be compared with the incoming signal, was implemented in analogue form. In 1974 it was decided to consider a fully digital implementation and a $30,000 contract was awarded to SED for a study of digital coding techniques. During the course of this contract, it became apparent that a University of Saskatchewan professor, Prof. D.E. Dodds was carrying out work, under an NRC operating grant, which bore on the digital codec, and he was awarded a small CRC contract to consider the application of some of his ideas. From interaction between Prof. Dodds, Mr. A.M. Sendyk of SED and Mr. D.B. Wohlberg, the CRC Project Engineer, evolved the idea of an Exponentially Variable Slope Delta (EVSD) Codec. With the digital implementation of the Delta Codec a more stable performance, with lower manufacturing costs, can be achieved so that the EVSD Codec gives a better performance than the more conventional Continuously Variable Slope Delta Codec and at equal or lower cost. The EVSD Codec has now been patented in the U.S.A. and will be patented in Canada.

Following the study contract at SED, the RCMP, who had a requirement for a low-cost low-power digital codec for voice transmission systems, gave SED a contract for less than $20,000, for the design implementation using Large Scale Integration (LSI). Technical support was provided by CRC. One of the few Canadian companies capable of fabricating the required integrated circuits, Bell Northern Research, was awarded an RCMP contract (about $80,000) in 1977, to develop the necessary IC's based on the SED design. With the success of this development, the RCMP is now about to let a $60,000 contract to Northern Telecom for the iteration of the design and the production of about 3000 codec units, for use in RCMP communications equipments. SED retains the rights to exploit the codec in markets outside the Government.

The biggest application of the EVSD codec is likely to occur in digital mobile communications for users such as the police and the military and in satellite communications, especially in the upgrading of Telesat thin route services. To meet the satellite communication requirements, CRC investigated the implementation of a full duplex system and in 1979 let a directed contract ($30,000) to SED for the design of a toll quality full duplex LSI version. CRC is now (December 1979) awaiting responses to requests for bids for the IC's based on the SED design. SED is to be the sole source contractor to generate the specifications for the IC's, to manage the contract and to evaluate the devices. Providing the development of the IC's proceeds satisfactorily, the manufacturer will be required to sell the LSI codecs to SED, which sees a large requirement for several years for incorporation in SED manufactured communication equipment. SED will pay royalties to the CPDL.

The transfer to industry of codec technology has been under way since 1973. Under present plans, CRC hopes to complete, by 1981, the transfer of its technology in this area.

Conclusion

The following elements which facilitated this successful transfer of technology can be identified:

(a) the continuing codec design work undertaken at CRC in support of a satellite communications R&D program;
(b) the parallel work at the University of Saskatchewan under an NRC operating grant;
(c) the ability to transfer laboratory hardware;
(d) the operational requirement of, and the development funding by, the RCMP.

RESEARCH SECTOR

CASE HISTORIES

TELIDON

Introduction

Telidon technology allows users to retrieve information from any number of data banks plugged into the system or eventually to have direct terminal-to-terminal contact with another user. The main components in Telidon are slightly modified television set or display monitor, the phone and/or cable, and a computer. The federal communications department announced in August, 1978, the development of a key component in the system -- an interactive device between the communications system and the television set -- and was able to give laboratory demonstrations of the system. Telidon makes it possible for a user to employ his full home TV set to access information on anything from antique cars to zoology. A user can, for example, phone a data bank and by punching a few buttons on a key pad retrieve pages of information for display on his modified TV set. The information can be in textual and/or graphical form and can be transmitted to the user via the telephone line, coaxial cable, optical fibre or off-air broadcast for instant display.

Attached to the TV set is a special interface device which receives instructions from a computer and converts these signals into texts and images to appear on the screen. For home use, a key pad, or for business use, a key board (like a typewriter) can be wired to the device or operated by remote control.

History

Work in this area started around 1969 with computer-aided design for the CRC Space Program. After the transfer of the laboratory from DND (DRTE) to DOC, emphasis shifted to interactive graphics for communications purposes. From 1969-1973 considerable effort went into building special hardware and in producing the necessary software to establish a capability in interactive graphics. This led to the development of an interactive graphics programming language and later to the picture description instructions. The latter represents an efficient protocol to interact graphics from one computer terminal to another over narrow band systems.

In September 1975, CRC became aware of NORPAK Ltd. through work they had performed for DREO. CRC initiated a contract with NORPAK for $15K for the development of hardware and software components for future interactive colour display systems based on the CRC developed technology. In November of the same year, a contract with NORPAK was initiated to further develop, in close collaboration with CRC, a prototype colour display system for a total of $19K.

From 1974 to 1976 a close working relationship developed between DREO's electronic warfare section, NORPAK Ltd., and the CRC image communications section. At that time, CRC provided assistance and consultation to the former under the Military Communications Research Program. The military requirements for advanced display helped to focus some of the research at CRC. War gaming at the Royal Military College (RMC) provided the first application of the concept of the common visual space. A small system was set up to test some of the ideas of graphic communications using CRC, DREO, RMC and the University of Manitoba as the nodes.

At the same time, the Image Communications Program was given approval to replace its existing computer (PDP-9) and display system (home-made) with a new system. CRC was so impressed with the ability and progress made by NORPAK on the development system that DOC decided to order the total computer display system from NORPAK at a total cost of $57K of which only $19K represented the display component. The other $38K covered the purchase of the PDP-11/40 computer system.

The total funding provided to NORPAK in 1975 by CRC was $91K, of which only $72K represented development funding.

By 1976/77, the work at CRC was sufficiently advanced to produce three patent applications:

(i) An Interactive Visual Communications System - February, 1976;
(ii) A Touch Sensitive Input Device for Computer Graphics Displays - January, 1977 (DND sponsored work);
(iii) An Interactive Graphics Programming Language - March, 1979.

In 1976, NORPAK Ltd. applied and obtained a license on (i) and in June, 1976, NORPAK Ltd. submitted an unsolicited proposal to DSS for the development of an Incremental Graphics Processor. The proposal was accepted and CRC, with assistance from NRC, acted as scientific authority. The contract was valued at $124K including $10K from CRC during FY 1976-77 and $5K in FY 1977-78, the remaining being DSS bridging funds. This proposal was accepted by the DSS review committee because it was very strong technically (all digital, micro-computer driven) and represented a new approach to traditional black and white display system design. NORPAK's strong technical ability was again demonstrated by completing this 12 month developmental program approximately three months early.

NORPAK applied for and was awarded the Department of Industry, Trade and Commerce's PAIT grant in July of 1976 for $360K, with $180K being supplied by the company. This funding was to be used to bring the products developed, in conjunction with CRC and DSS, to a production stage. This project was sufficiently productive and IT&C extended the project under the new EDP program for another six months. Then in August, 1978, DOC announced its version of the Canadian Videotex System called TELIDON and launched a $97M four year program. The corner stone of the program was the equipment developed and built by NORPAK Ltd. based on CRC technology.

It is clear that the technology transfer which occurred during and after the development of TELIDON was not achieved only by the transfer of information by license, but rather in repeated and continuing interchange of information between DOC and NORPAK engineers over a long period of time.

Conclusion

In examining this case history, several events and attitudes which facilitated or hindered the successful transfer of technology can be identified:

(a) the existence of a small strong team with excellent R&D facilities at CRC;
(b) the existence of a company which had been funded earlier to establish itself and which was able to further develop the technology;
(c) the importance of government purchases to consolidate the technology transfer;
(d) the continuing design work undertaken at CRC in support of the R&D program;
(e) the availability, later in the transfer process, of funds intended to further develop the TELIDON system;
(f) the availability of government program to assist high technology companies in further developing the technology;
(g) the necessity of extensive direct interaction between the company and CRC; and
(h) the speedy development of the technology, with full management support.

FIBRE OPTICS COUPLER

Introduction

Interest in fibre optics at CRC dates from about 1970, when the optical group became aware that glass fibres with sufficient purity capable of carrying light with losses of less than 20 db/km were being produced. This was considered to be the threshold for practical use of fibre optics for communications systems. The optics group began to look at fibre optics by concentrating on the propagation characteristics of fibres and also considering questions on how to launch and receive the light beam and techniques of coupling it from one fibre to another.

History

A coupler consisting of twin biconical tapers held together with epoxy was developed at CRC in 1976. The performance of the coupler was not considered good enough for practical use, and, although it was reported in the literature, the work was left dormant for a time. A later review of the literature indicated a second type of coupler, produced by two scientists in the U.S., in which two fibres laid side by side were fused to produce a coupler junction. The performance of this coupler was also poor. Scientists at CRC led by Dr. B.S. Kawasaki found, however, that by using a combination of these and other techniques a coupler having unsurpassed performance could be fabricated. This work on the Fused Bi-conical Taper Coupler was reported in March, 1977. Since then, several other novel devices based on CRC coupler technology have been reported that considerably enhance its range of utility.

Under the military communications research program carried out at CRC for DND, some work had already been done to show the application of fibre optics on board ships. DND was interested in fibre optics as an alternative to conventional cabling on board the Canadian patrol frigate and other future ships. Efficient and cheap coupler devices would be required to make an effective data bus. It was decided that DND would fund a contract with industry under the military communications program at CRC to develop commercial versions of several devices based on the bi-conical taper coupler technique.

Representatives from Bell Northern Research (BNR) and Canada Wire and Cable (CWC) were invited to CRC to see the coupler and witness demonstrations of the technique.

CWC won the bid for a $157K contract in 1977. (BNR did not bid but is fabricating couplers using CRC technology.) For the duration of this contract which was successfully completed in 1979, frequent advice and assistance was given by CRC scientists to CWC personnel both at CRC and the CWC plant. Canstar, a subsidiary of CWC, is now selling a family of devices based on the coupler in Canada and the U.S. These devices should make possible the implementation of versatile local area networks using optical fibre in industrial control applications, for data networks and to meet other peripheral terminal interconnect requirements.

Conclusion

The following elements which facilitated or hindered the successful transfer of technology can be identified:

(a) the continuity of personnel was considered important from the invention through to the transfer;

(b) the frequent contact between government and industrial scientists was considered essential; and

(c) the operational requirements of and development funding by DND was very valuable.

MOBILE RADIO DATA SYSTEM

Introduction

The Mobile Radio Data System (MRDS) is a computer based, data communication system for mobile units using radio links. The user (one of a fleet of mobile units) can report his position and status to and/or request information from a central control facility by using a specially designed computer terminal located in the mobile unit.

History

Late in 1972, Mr. W.L. Hatton, Director of Communications System R&D recommended that CRC undertake a project based on the recommendations of the Computer/Communications Task Force. These recommendations included the concept of government laboratories fostering selected areas of computer/communications technology and applying these to Canadian needs via industry.

Combining these task force recommendations with the "make or buy" policy and the expertise of the government scientists, the project was begun by making several studies to determine the capabilities of the Canadian electronics industry, the user needs and market situation, standards, and the extent and sophistication of technology in use.

A market study conducted under contract by Woods, Gordon & Co. identified mobile radio data terminals as one of the best areas to address. This choice was doubly appropriate because the department's mandate to manage the use of the spectrum requires an intimate knowledge of developing communications technologies and because CRC had existing expertise in radio communications.

The major objectives of the resulting Mobile Radio Data System project were:

- To foster the development and use of advanced communications systems of value to Canadian users, specifically, the use of mobile radio links for data transmission.

- To provide information of use in the management of radio spectrum and in development of standards.

- To support the development of the Canadian communications industry.

The leaders in the application of this new technology and its most sophisticated users were identified as the police forces. The major users, however, were likely to be in the transportation sector of the economy -- bus, railways, taxis, etc. Other identified users were utility companies, ambulances and fire brigades, delivery companies, etc.

In October, 1974, DOC approached the RCMP who agreed with a proposal to cooperate in a joint project to specify, design and develop a modular radio communications system which would satisfy the major requirements of the Canadian Police Forces. The expertise which was to be established through the development of this police communication system would then provide the base for the development in industry of mobile data communications systems for police and non-police users.

The design and development work for a demonstration system was to be done by Canadian industry. Early in 1975, industry was briefed on the program which included a requirement that the selected contractor commit himself to enter the Mobile Radio Data Systems (MRDS) business. MacDonald, Dettwiler and Associates (MDA) won the Phase I contract to develop detailed systems specifications and trial plans. This contract showed that an MRDS supported by all the latest computer aids was beyond both the means and the requirements of most police forces, and consequently a smaller system was selected for implementation and installation as a test case. The Vancouver Police Force was interested. An agreement was reached between DOC, RCMP, and the City of Vancouver, wherein the city agreed to pay for all hardware components of an operational system with the federal agencies paying for the development work.

The Phase II work was divided into two contracts. Phase IIA ($0.6M) was intended to produce an operational system for the Vancouver Police Force. This system when completed and tested would be available for immediate use. Phase IIB ($0.6M) was intended to produce a completely Canadian built terminal and system, designed to meet police needs and those of the transportation sector. In the case of the police, this included the capability of accessing the RCMP data base from their vehicles and the capability for headquarters messages to the field force.

In 1978, MDA in consultation with Ventures West Ltd. (partially owned by the Canadian Development Corporation) and others, were instrumental in creating International Mobile Data Incorporated (IMDI). MDA transferred the necessary technology and personnel to IMDI to produce and market the system. The new system includes a microprocessor-based controller, the mobile terminals, and the base station controller. IMDI is now in the process of marketing systems. Based on the success of the trial system, the Vancouver Police Force is buying a complete set of the new Canadian-manufactured terminals for their fleet. Other potential markets include various German and American police forces and some non-police applications as well.

With the successful completion of Phase IIB (the development of the advanced equipment and software) and the setting up of a Canadian company dedicated to the exploitation of this technology, a major objective of this project is considered to have been achieved.

Conclusion

The following elements which facilitated or hindered the successful transfer of technology can be identified:

(a) the existence of a small active company looking for a new marketable product line;

(b) the presence of a strong manager who guided the project initially and sold the idea of government-industrial cooperation on the joint venture to higher management; and

(c) the operational requirements of police forces and active assistance of the RCMP.

SYNCOMPEX

(Synchronized Compressor and Expander Voice Processing System for Radio Telephone)

Introduction

Fading on HF communications circuit has always been one of the major disadvantages of HF radio communications networks. The British LINCOMPEX (Link Compressor and Expander) system has been developed to help overcome this fading by transmitting a compressed voice signal in which the voice amplitude information was carried as an FM signal in a frequency-adjacent, control channel and used to reconstruct the signal at the receiving end. The system worked well but because of its analogue design and its requirement for highly stable frequency devices it was large and expensive. Although recommended by CCIR, it has found use only on major international radio telephone circuits. The problems of fading remain for the average HF users, some of whom, like those in Northern Canada, depend heavily on HF communications as their only link to outside areas.

History

In 1975, the Director of the Communications Systems Directorate, Mr. L. Hatton, assigned S.M. Chow the task of designing a small and inexpensive equivalent to LINCOMPEX using digital techniques. The result was the SYNCOMPEX design which among other things digitized the information carried on the control channel and did not require highly stable frequency sources. It could be added on to existing radio sets. Potential sales for such a device could be large including Third World countries, in addition to the Canadian users in Northern and isolated areas.

Since no technical assistance was available within the directorate to build and test the design, discussions were held with industry leading to an unsolicited proposal by the Canadian General Electric Co. (CGE) in August, 1975, to produce three breadboard models. A $79K contract was awarded in January, 1976, and completed by December. CGE, having no marketing mechanism for the devices, decided not to proceed beyond the R&D stage.

A request for proposals resulted in Canadian Marconi receiving a six month $49K contract to test and evaluate the device over a radio network. This contract was completed in August, 1977. The tests indicated that further design work on the control channel would be required to make it more robust when selective fading is encountered.

A new $91K contract was let with Marconi to redesign the channel to overcome the observed deficiency. This included computer simulation of the coding schemes and some on-the-air tests of the digital portions. This contract ran from January, 1978, to September, 1979. It was intended to have Marconi continue with follow-on directed contracts to build and test models based on the new design leading to a pre-production prototype.

Unfortunately, although the design and tests were successful, and the company was willing to continue (expecting to have a marketable product), delays in contract negotiation resulted in Marconi's subsequent withdrawal from the negotiations and dispersal of their design team in January, 1978.

Further in-house work was carried out in the fall of 1978, by the engineer in charge with the assistance of a technician. The resulting design model was then transferred to Miller Communications Ltd., under a contract to produce test models of the syncompex design. These models will be fully tested over actual HF links. DND contributed funds for this last contract and will participate in the tests with the intention of possibly using these devices in the Canadian Forces.

Conclusion

The following elements which facilitated or hindered the successful transfer of technology can be identified:

(a) the lack of in-house technical assistance and equipment forced an earlier than optimum approach to industry;

(b) the speed of the contracting process was sometimes too slow for industry, resulting in a lack of continuity of industrial personnel in the transfer process and eventual withdrawal by the company concerned; and

(c) visits by the CRC engineer were considered essential for the limited success of the first two industrial contracts and is proving to be very important with the current firm.