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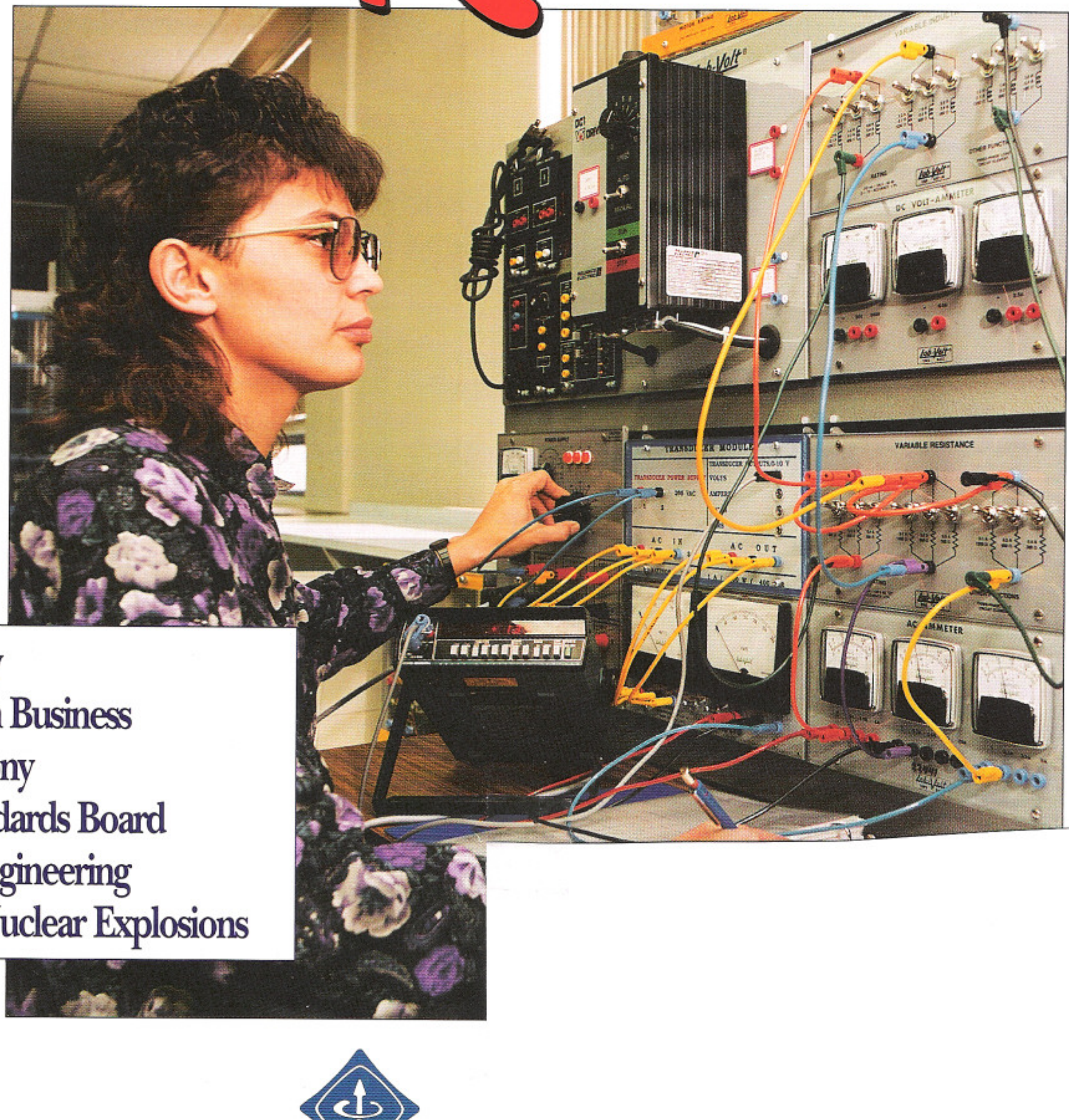

Women in Technology
Gandalf and its Modem Business
Digital Cellular Telephony
Canadian General Standards Board
Testing and Integrity Engineering
Seismic Recording of Nuclear Explosions

IEEE

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IEEE Canada

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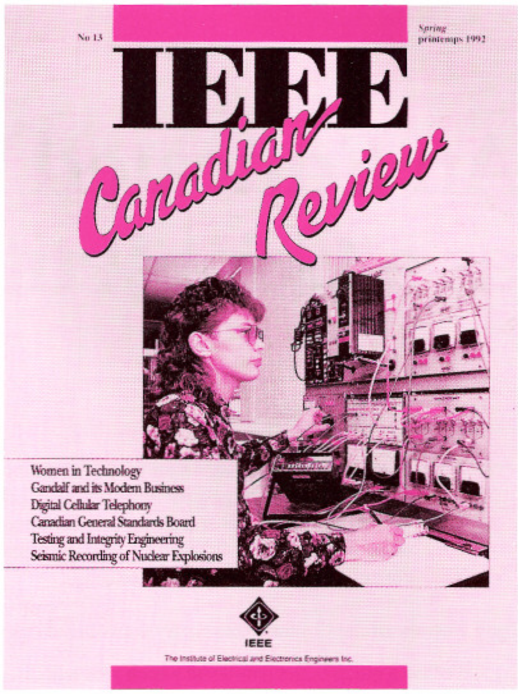
Cover picture

Our cover picture shows **Geraldine Bouvier**, an Electrical Engineering Technology student at Red River Community College, Winnipeg, performing an experiment on a three-phase power circuit. It typifies the growing impact of education on the place of women in technology.

Photo couverture

La photo en page couverture montre Geraldine Bouvier, étudiante en technologie du génie électrique au Red River Community College, Winnipeg, en train d'effectuer une expérience sur un circuit triphasé. Cela représente l'impact grandissant des programmes d'enseignement sur l'insertion des femmes dans les domaines technologiques.



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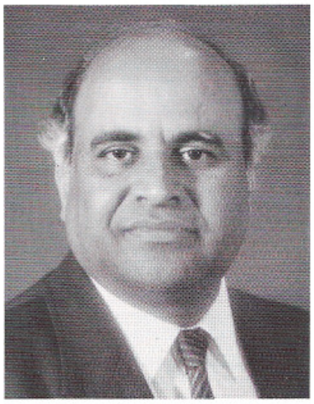
An Educated Workforce as a Competitive Edge

by Dr. Vijay K. Bhargava
Director, IEEE Canada



Of the several inputs received from our members concerning the question "What programs, services, and infrastructure will be needed for Electrical and Computer Engineers and their profession, in Canada in 2001", I found two responses to be very constructive and thought provoking.

Tony Bonney of the Canada Remote Systems in Toronto suggests that:

(a) We "get a much better handle on which jobs will disappear in the next ten years, which will be around for the next twenty five years, and which will likely come into being in the next ten years."

(b) "Get engineers with appropriate knowledge to provide volunteer services in the school and community colleges to train people for the new jobs, passing on their practical knowledge".

Our immediate response to Tony, with respect to the second question, was to bemoan the lack of volunteers. But somehow we have to try and tackle these problems. We propose to have a full discussion on these topics at the three council meetings this spring and report to you in the very near future.

Alain Beaulieu of National Defence has given considerable thoughts to these and related problems. He suggests that an educated workforce with a penchant for continual training is what will provide the Nation with a competitive edge. Being in the business of education and continuing education, I fully agree! But first we have to, as Tom Peters suggests in "Thriving on Chaos", undergo a cultural adjustment: education and training must become a corporate and national obsession. IEEE Canada through its Educational Activities Committee (Chaired by Dr. George Lampropoulos), and through its Public Awareness Committee (Chaired by Mr. Michael Giroux) have a role to play here. They will need our help and I invite you to get in touch with them through our regional office.

In order to increase the benefit of education, precompetitive information has to flow freely inside and outside of the corporations. For example, IBM imputes the success of its research laboratory in Zurich, Switzerland, to the ethnic diversity and the multitude of disciplines available at this location. The researcher pool is in a constant state of flux with visiting scientists and summer students. (It may interest you to know that the current IEEE Secretary, Mr. Karsten E. Drangeid, a Norwegian by birth and married to a Swiss from the French canton, is the immediate Past Director of this prestigious laboratory.) While this may work for a big international corporation, smaller companies can derive somewhat similar benefit by attending conferences organized by various IEEE entities. IEEE Canada has been active on this front through our Conference Advisory Committee (Chaired by Mr. John Grylls). We actively promote cooperation with conferences organized by non-IEEE entities as well. We suggest that you get in touch with John should any opportunity present itself.

IEEE Canada has a role to play in sustaining an educated workforce through Education, Public Awareness and Conferences. Not surprisingly, our Membership Development Committee Chair, Dave Kemp reports that the membership in IEEE Canada is increasing. This is at variance with Regions 1 to 6.

Moving away from the main theme of this article, I would like to provide you with a brief report on my activities. During January 12-14, I attended the new director's orientation in New York and New Jersey. I intend to share the excitement and usefulness of this exercise with many of you when I visit your section. During January 17-19, I attended a RAB/TAB Director's retreat in Austin, Texas. The retreat allowed us to fine-tune the 1992 goals of the Regional Activities Board and to better understand the Technical Activities Board. On February 10, we had the pleasure to host our President, Merrill Buckley, Jr., at the University of Victoria. A sell-out crowd of 65 attended his luncheon talk entitled "Practical Aspects of Career Development". During February 11-16, I attended my first Board meeting which was held in Vancouver. One of the highlights was an Industry Relation Luncheon hosted by IEEE for B.C. Electrical and Computer Engineering leaders from industry, government and the academia. An important decision of the Board was to open an IEEE office in Singapore. This will certainly strengthen the transnational character of our society. On February 19, I attended a meeting of the Board of IEEC Inc. An important item on the agenda was the establishment of the "IEEE Canadian Foundation". On February 20, I presented a talk on Global Wireless Communications to the IEEE Canadian Atlantic Section in Halifax.

I am sorry to end this Perspective on a sad note. Mrs. Leslie McNaughton Sykes died on March 1, 1992. The Region has lost a dear friend. Her presence will be missed at future presentations of the McNaughton Medal.

In memoriam

Mrs Leslie McNaughton Sykes died on March 1 1992, in her home in New Jersey, following a courageous battle with cancer.

The younger daughter of General A.G.L. McNaughton, she and other members of the family were very active and always interested in IEEE CANADA activities. Mrs Sykes and her husband Calvin have attended many McNaughton Medal presentations, and future award ceremonies will miss her ready wit and humor.

We salute the memory of Mrs. Sykes and extend our profound sympathy to Calvin and the other members of her family.

Gandalf Technologies and Its Surprising Modem Business

Integrator of Canadian Standards Activities

by Stephen Bernard
Engineering Manager
Gandalf Data Ltd.
Nepean, Ontario.

The term modem - almost unknown 20 years ago - is now a familiar word for most PC users and business professionals. Modems play an important role in everyday life, from automated banking machines and fax machines to satellite communications. From their modest beginnings modems have evolved greatly, using advances in microprocessor technology and software to overcome communications barriers once thought insurmountable. As we move into the 21st century, modems continue to move more data over grater distances than ever before.

Le terme 'modem", presqu'inconnu il y a vingt ans, est maintenant un mot familier à la plupart des usagers des ordinateurs personnels et des professionnels d'affaires. Les modems jouent un rôle important dans la vie de tous les jours, depuis les guichets bancaires automatiques et les télécopieurs jusqu'aux communications par satellites. Depuis leurs modestes débuts, les modems ont grandement évolué, utilisant les progrès dans la technologie des microprocesseurs et des logiciels pour franchir des barrières de communications qu'on avait déjà cru insurmontables. En cette aube du 21 ième siècle, les modems continueront à transmettre plus d'informations sur de plus grandes distances que jamais auparavant.

In 1970, two entrepreneurs working out of 400 square feet of space in Ottawa and with a capital outlay of $500, unveiled an asynchronous modem that had an effective range of 13 miles and could be purchased at a price equivalent to a four-month lease of slower conventional telephone company units. The modem's low price and impressive technical capabilities took the communications industry by surprise. **Des Cunningham** and **Colin Patterson**, Gandalf's founders, had changed the communications industry through engineering insight and business intuition.

Today, Gandalf Technologies Inc. is a leading international designer, manufacturer and supplier of a broad range of information networking products, systems and services and one of Canada's foremost high technology companies. Still driven by engineering insight and business acumen, Gandalf is preparing for the conversion of the public telephone network to the Integrated Services Digital Network (ISDN) by developing terminal adapters (modems) that operate at 192 kbit/s. Surprisingly, these data sets use an evolved version of the baseband modulation featured by the company's very first modem.

What is a modem?

The term "modem" is a contraction of "modulator/demodulator." A modem (or *data set*) is a device that receives digital data and converts it to analog, typically by modulating a tone (called a carrier frequency), or extracts data from a modulated carrier and converts it back to a digital format.

Cunningham and Patterson's original LDS 100 modems created a new communications industry by directly transforming the data through a process known as baseband encoding. These early modems were hardware-based (i.e. no microprocessors) and converted the user's data to different pulses and other shapes on the line. There is no real carrier in baseband modulation, but the technique serves to carry data very cost-effectively over short distances. Those early data sets are still widely used.

The significance of the modem is that it is used to communicate data over extended distances, normally through the universally available public switched telephone network. Initially, modems required four wires – one pair to transmit and a second pair to receive. When techniques evolved to reduce this requirement from four wires to two wires, modems could be used conveniently on virtually every subscriber line in the world.

As data communications became an international reality, the global market could not cope with the welter of techniques devised by local telephone companies. Today, the standards for modem communications are established by such bodies as ANSI, IEEE, CCITT* or ISO.

Technical Considerations

A voiceband modem is restricted to a 2.5 kHz frequency band which exists from about 500 Hz up to about 3 kHz. The modem's task is to start at at the midpoint (roughly 1700 Hz), and change that 1700 Hz carrier tone in such a way that it reflects the incoming data.

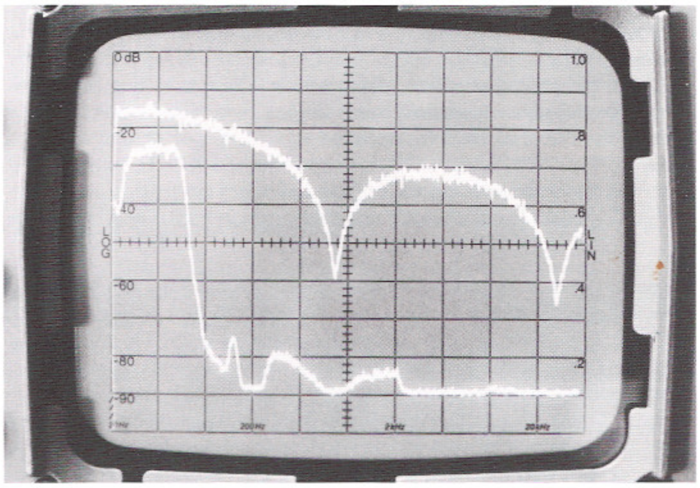


Figure 1. This oscillogram shows a modem compressing data into a small bandwidth. The upper trace demonstrates the frequency spectrum (9600 bps data). The lower curve shows the modem output confined to frequencies of 500 to 3500Hz.

* *International Telegraph and Telephone Consultative Committee, one of many standards organizations. Its standards are recommendations, not legal requirements, for compatibility between equipment and networks.*

The primary technical problem exists in the relationship between bandwidth and noise. There are many forms of noise – white, impulse, phase shift, amplitude shift, crosstalk, quantization, and harmonic distortion. Noise on the telephone transmission lines can cause considerable problems when identifying data at the receiving end. When modulation is not restricted by bandwidth, then distinguishing between noise and data is less difficult. However, as more digital information is placed within the narrow 2.5 kHz voice band, the demodulation procedure must become more precise, and the probability of mistaking noise for data increases.

There are both theoretical and practical limitations to the amount of data that can be transmitted in relation to bandwidth. Nyquist's Theorem generally states that one must sample an analog signal at twice its frequency in order to achieve faithful digital encoding. The converse of this theorem indicates that there are limits to how much digital information can be crammed into 2.5 kHz for a given noise level. Generally, the telephone network guarantees a signal to noise level of 24 dB, and a bandwidth of 3 kHz. Under these circumstances, the Shannon Theorem predicts a limit of 23 kbit/s on normal telephone networks because the time needed to distinguish the data from the noise becomes impractical beyond that rate.

Technology and performance

Only 2.5 kHz of bandwidth is available on long-distance telephone circuits, where signals are amplified and filtered. Higher bandwidths are available on simple wire circuits running between two points. Early modems were designed for this type of circuit only and could not be used over the dial-up network. These bare-wire circuits are usually confined to a building or a campus, and span distances of the order of 10 km, in contrast to dial-up circuits which span distances of hundreds of miles. Consequently, early data sets operated well over pairs of wires where there was relatively little noise and the available bandwidth was limited solely by the characteristics of the wires, not by amplifiers or other circuitry in the voice network. The simple baseband encoding techniques were implemented solely in hardware and were very cost-effective. However, in order to transmit typically 9600 bit/s, this technique required nearly 10 kHz of bandwidth for an efficiency of basically one bit per Hz of available bandwidth.


A modem undergoes quality testing in Gandalf's manufacturing plant in Nepean, Ontario.

The solution to sending data via the telephone was a technique called Frequency Shift Keying (FSK). Frequency shift keying, which is easy to do in hardware, involves changing the carrier between two frequencies to represent the incoming binary data. Thus, FSK uses a tone of one frequency to represent a binary "0" and a tone of another frequency to represent a binary "1". With the proper selection of frequencies, this technique allows bi-directional data to be transmitted over a single pair of wires. A popular early modem, the Bell 103 modem, operated at 300 bits per second and used frequencies of 1070 Hz and 1270 Hz to transmit, and 2025 Hz and 2225 Hz to receive. Since the transmit and receive frequency ranges do not overlap, the "103" modem could transmit simultaneously in both directions. However, this technique still achieved only one bit per Hz efficiency.

The next stage was to group data into "bauds". A baud is a modem's way of packetizing the data it receives from the terminal. For example, if each group contains four bits, 16 different combinations of 1's and 0's are possible. The modem maps each baud onto the carrier in a combination of 16 amplitudes and phases at any given point in time. This process describes a generic QAM (Quadrature Amplitude Modulation) modem that is used today in a range of applications from dial-up to satellite communications. A 16-level QAM device handles 9600 bit/s in 2400 Hz, for an efficiency of four bits per hertz (see Figure 1). The principles of QAM were known when Gandalf's founders made their first baseband data set, but QAM did not become technically cost-effective until 10 years later.

As microprocessors were introduced during the 1970's, digital signal processing (DSP) rapidly became the dominant way of implementing the modem. DSP uses digital numbers to produce analog tones, to change those tones, and also to demodulate and filter the carrier. Single chip DSPs were introduced early in the 1980's and they now form the heart of any competitive modem. DSPs implement algorithms to detect and compensate for channel impairments or changes over time. Increased processing power led to unlimited distance or "metropolitan distance" modems which communicate at distances of 200 miles and beyond, while still operating within the 2.5 kHz bandwidth. Today's modems possess more computing power than a typical desktop PC, albeit in a very specialized task.

The combination of increased computing power and sophisticated algorithms led to the echo cancellation technique. Echo cancellation permits modems to receive and transmit using the same frequencies on the same pair of wires. Even though the transmit signal is much higher in power than the receive signal and swamps the receive signal, the modem, because it knows what it sent, is able to subtract the transmit signal and determine the receive data. For example, the simple Bell 103 modem referred to earlier operates at only 300 bits per second in the 2.5 kHz bandwidth. By comparison, a V.32 modem using echo cancellation can operate at 9600 bits per second in the same 2.5 kHz. Today, this technique allows bi-directional, or full duplex, transmission over telephone lines at 14.4 kbit/s and soon 19.2 kbit/s.

In ISDN, dedicated silicon implementation of this echo cancellation technique allows operation at up to 192 kbit/s over distances of three miles (from the user to the nearest telephone switch). Such high data rates can be sustained over pairs of wires which run from the telephone company office to individual users, since these pairs are un-amplified and unfiltered. Once inside the telephone company premises, special types of amplifiers and circuits must be used to pass this 192 kbit/s data over long distances. The telephone company charges a fee for these special circuits, but the fees are coming down fast.

About 1985, Gandalf introduced a "data over voice" modem which used the time compression modulation (TCM or "ping pong") technique to send bursts of data between modems very quickly. The transmitting modem stores data from the user and outputs it in short, high-frequency, bursts. At the remote receiver, these short bursts are stored and then expanded into a continuous stream of lower-speed data that the terminal can accept. Both sender and receiver have the illusion of continuous data flow (full duplex transmission) when, in fact, it consists of a series of short bursts. The same technique is still used today in some data services offered by the telephone companies.

TCM has a cost advantage, but is limited in range and is quickly giving way to echo cancellation. Echo cancellation has the advantage of much longer range and greater noise immunity, albeit at much higher complexity.

Problem solving through software

The industry turned to simple coding early (e.g. grouping data into bauds) as a means of increasing data flows. Since the introduction of microprocessors and DSPs, *software* now determines how a modem operates.

Digital signal processors and other silicon innovations have profoundly impacted a modem's ability to compensate for line impairments, but frequently protocols must finish the job. Such protocols combine line processing with data manipulation to obtain capabilities like error correction and trellis encoding. These are data techniques that either correct errors or manage to reduce or eliminate errors.

Trellis encoding is a type of forward error correction that adds data to the transmit signal. Instead of correcting errors by retransmission of data, this approach builds a specific kind of pattern into the data through the encoding technique. The receiver continuously compares the received signal with the previously received signals stored in its memory. Normally, a signal is smooth as it goes through its transmission, but noise causes a break in the pattern. The receiver notes where noise has violated the induced pattern and predicts, based on the pattern, what the data should have looked like in the absence of noise and corrects it. Today, virtually all high speed modems, such as V.32 dial-up modems or V.33 leased line modems, use trellis encoding to minimize errors introduced by the channel.

High-speed modems are synchronous because the receiver needs to sample the line at the correct instant to be able to process the data it receives. Synchronization often involves a setup sequence or a handshake sequence, for although the receiver doesn't know what the data is, it has to know roughly where to look to inspect and validate it. Asynchronous data is converted to synchronous data by techniques such as MNP (see below) or CCITT V.42. These protocols encapsulate the information in packets which can be transmitted synchronously; they also allow errors to be detected and the packets to be retransmitted.

MNP (Microcom Networking Protocol) is a de facto standard that was developed by Microcom Corporation in the United States. Unlike trellis encoding, MNP packetizes the data with a cyclical redundancy check (CRC) that can detect the presence of an error and then request the transmitter to resend the data. MNP does not need to correct the data, it just knows there is an error somewhere and takes action. The equivalent international standard is CCITT V.42, which includes MNP as one of its operating options.

The net effect of these techniques is that the user sees only error-free transmission although something less than that may be flowing between the modems.

Data compression techniques, such as V.42 bis, allow still greater effective throughput by removing redundancies from user data. In the case of written text, typical gains of up to 4:1 are achieved. As a result, a V.32 dial-up modem operating at a line rate of 9600 bit/s can support user data rates of up to 38.4 kbit/s.

In effect, text is very redundant. For example, if you see the letter Q you know it's usually followed by a U; if you see "char" the odds are good that the word is "character". Furthermore, the letter E occurs more often than the letter Z. Probably the most frequent character is a simple space. However, computers are very arbitrary about it and assign a fixed 8-bit code to each and every character. Data compression uses the rules of character strings and statistics to assign short bit sequences to commonly-occurring characters or words, and long bit sequences to infrequent characters or strings. The average data transmitted is therefore reduced from 8 bits per character down to, say, two bits per character. For instance, a data compression algorithm would have picked up the number of times the word "character" was used in this paragraph, and could have compressed this whole word (9 characters or 72 bits) into as little as 12 bits.

Back to baseband modulation

Optical fibre-based digital networks have transcended the 2.5 kHz bandwidth limitation, allowing inexpensive baseband techniques to be used at high data rates. Telephone companies now commonly offer digital services from 64 kbit/s to 1.5 Mbit/s and are testing services which will extend this to 40 Mbit/s and beyond. All use baseband encoding.

The impending shift by the public switched telephone network to ISDN envisages putting 144 kbit/s on every desktop or in every home serviced by a single pair of wires. The ISDN Basic Rate Interface will consist of two 64 kbit/s full-duplex channels plus a 16 kbit/s control channel, and it will employ this same silicon-based, high-speed baseband modulation in the form of echo cancellation (previously described).

Local area networking (LAN) has also embraced baseband techniques which are virtually unchanged from those used 20 years ago, but which are now able to operate at orders of magnitude faster because of advances in silicon fabrication. This combination of silicon chip technology and baseband encoding has enabled Ethernet in the past three years to surge to speeds of 10 Mbit/s over limited range using widely available telephone wiring, with speeds up to 100 Mbit/s not far behind.

Glossary

Asynchronous data sets are modems designed to accept asynchronous data from a terminal or computer and to send this data over ordinary un-amplified wires.

Asynchronous data is data which occurs at random time intervals, such as characters typed at a keyboard. **Synchronous data**, on the other hand, uses clocks and other timing signals to align data into fixed time intervals.

Baseband refers to signals which occupy a frequency range from DC (0 Hz) up to some maximum frequency which depends upon the transmission rate of the data .

Baseband modulation is a way of mapping, or encoding, binary data in baseband signals. A simple example is to map a data "1" into a positive pulse and a data "0" into a negative pulse. This is simple, but has the disadvantage that it is polarity sensitive and if a pair of wires is reversed, all the data will be inverted. Another example is to vary the width of the pulses, i.e. a data "1" could be a pulse of 50 microseconds duration and a data "0" could be a 100 microsecond pulse. This type of mapping is independent of whether the pulse is positive or negative and therefore is not affected by a reversal of the wires.

"Data over voice" originated by considering the frequency range of the signals involved. Voice occupies the lowest frequencies (from 500 Hz to 3 kHz). Data can be superimposed on the same wires at higher frequencies (from 20 kHz to 300 kHz or even higher). Thus, considering the frequencies involved, the data is "over" the voice. Because frequencies of up to 300 kHz are involved, this technique is only useable on un-amplified wire circuits over limited distances.

LAN (local area network) consists typically of up to several hundred interconnected users covering a physical range that may extend to thousands of metres.

Protocol is a set of rules used to determine how two entities communicate. It can be as basic as what language is to be used - English, Spanish or French. In modem terminology, a protocol can also mean a method of manipulating the data. For example, an error-correcting protocol will define how an error is detected and corrected. The key is that both parties must adhere to the same protocol for it to work.

Silicon refers to chips - microprocessors - that are fabricated in silicon.

Surface-mount refers to the method in which components are incorporated onto a circuit board. In the past, components have had wires which go through holes in the board and are soldered to copper pads surrounding the holes. The holes take up space, and components cannot be mounted opposite each other on the board. Surface-mount components simply contact pads on one side of the board (i.e. they mount on the surface). Aside from being smaller and easier to handle, it allows greater component density since both sides of the board can now be used.

Synchronous modems transmit signals which vary at precise intervals and the receiving modem uses its local crystal clock to sample that signal at the same interval. In practice, there are small but significant deviations (± 0.01%) in crystal frequencies between the modems, and various techniques are employed to make minor variations in the receiver's crystal clock to exactly match the transmitter's clock.

WAN (wide area network) encompasses widely-dispersed LAN's and can be measured in thousands of users over thousands of kilometres.

No lack of insight or intuition

The information handling market is evolving and expanding rapidly. Over the past 20 years Gandalf has diversified its product and service offerings into multiplexers, data switches, network processors, local area network products and mobile communications, in addition to modems. The company typically spends 11 to 12 percent of its revenue on R&D and in fiscal year 1991 this amounted to $17.9 million. The further implementation of surface mount technology in product fabrication should reduce the size and cost of products. Gandalf estimated the value of its target market to be $3 billion and believes it will rise to $16 billion by 1995.

Gandalf has conducted international operations since 1975 and has a presence in 85 countries. Its products are designed to OSI (Open Systems Interconnection) standards and such things as power supplies are compatible with the varying national offerings around the world. The company customarily earns 30 percent of its revenue from each of Canada and the United States, and the remaining 40 percent from the rest of the world. The Free Trade Agreement is expected to have a negligible effect on the company because the pre-FTA tariff only amounted to 3.9 percent. Also, there are few U.S. modem manufacturers.

Changes in the global market are shutting down established niches, but these changes also are opening opportunities to enter alliances that tap new niches. The merger between Gandalf Technologies Inc. and Infotron Systems Corporation of Cherry Hill, N.J. on August 2, 1991 exemplifies this strategy.

Various modems that have been developed over the past 20 years.

Both Infotron and Gandalf had been in business for 20 years; Gandalf in the the LAN niche and Infotron in the wide area network (WAN) niche. Both companies possessed a loyal customer base and they focused their development programs on continuing to serve their existing customers. Both companies successfully adapted as technology evolved from the hardware development of the 1970's into the software-dominated development of the 1980s. However, the changing telecommunications environment now demands that each company develop innovative products in both LAN and WAN technologies just to retain existing customers.

Gandalf and Infotron combined can compete in the rapidly evolving global market. Their pooled technologies provide the ability to turn a number of separate networks into a single seamless combination of wide area and local area networking. Seamless means that a user on the network sits down at a personal computer and has the ability to connect to any database accessible by the network in such a way that there are no problems with passing though boundaries that exist between one LAN and another, or between the LAN and WAN. Both companies' commitment to R&D have produced advanced products which will keep the new company competitive through the 1990's.

Gandalf Technologies Inc. was founded on engineering insight combined with an intuition as to where the telecommunications industry was heading. Those essential elements still drive the company today. ■

About the author

Stephen Bernard, B.Sc. (Physics), Bishop's University (1974), Lennoxville; M.Sc. (Electrical Engineering), Queen's University, Kingston (1979). Mr. Bernard joined Gandalf in 1979 as a DSP software designer and worked on Gandalf's first digital modem. His expertise in modem technology spans short-range modems to dial-up products. He now is an engineering manager in the Network Components Group which develops desktop products for the LAN and ISDN markets.

Commentary / Commentaires

The IEEE Canadian Review

Nurturing a new venture

by Robert T.H. (Bob) Alden, Ph. D., P. Eng.
Chairman of the Advisory Board, IEEE Canadian Review

As I look back to 1987, when we discussed the concept of a unique Canadian IEEE magazine with Section representatives across our country, I remember many of the suggestions - high quality, breadth of interest, complementary to SPECTRUM, value to all members- involvement from coast to coast - and a range from technical specialist to generalist.

Once the concept was accepted, the most significant challenge was to find the first editor. I knew **Richard Marceau** from his many IEEE activities in the Montreal area. In particular, he had produced a number of high quality conference publications. We talked and communicated - late into the night - usually after other IEEE events. We shared a vision. He expanded the vision and added the structure. He knew how to do it. And his employer, Hydro-Québec, was very supportive of IEEE. Thank you, Richard, for your unique contribution; and "bonne chance" in your doctoral studies that caused you to leave the editor's post.

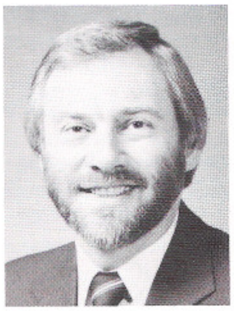
There is one more specific credit that must be noted. My good friend, **Wally Read** and his Montreal based association CEA, have provided untold personal and corporate support since the inception of the "Review". Without this kind of strategic support, our magazine could not have come into being.

The previous issue was the first for Ted Wildi as Managing Editor. For much of the past year, while **Tony** and **Gerry Eastham** were our "interim editors", Ted was working behind the scenes to set the stage for a successful 1992 and beyond. Welcome Ted.

My thanks to all these dedicated volunteers and the teams of Associate Editors, those involved in production, and the authors. I believe the IEEE Canadian Review has met the high goals that our Sections and Region set at the outset. To maintain this fine tradition, we need the continued support of volunteers and corporations. Please send your ideas directly to any of us listed on page 3, or via the IEEE Canada Office. ■

About the author

Bob Alden is Professor of Electrical and Computer Engineering at McMaster University in Hamilton, where he founded the Power Research Laboratory. His primary technical interest is the improvement of power system performance. His IEEE activities span the range of local section, chapter and student branch operations, to management of regions and technical societies. He has also been involved in conferences, magazines, and standards as well as authoring and reviewing transactions level papers. Dr. Alden has just completed four years on the IEEE Board of Directors - two as Region 7 Director and two as Vice President for Regional Activities. He is now conducting his second campaign for the Presidency of IEEE.



Women in Technology– Where are They?

Why do we need women in technology?

The Canadian Engineering Manpower Board predicts that by the year 2000, Canada will have an estimated shortfall of at least 10,000 engineers. Despite this shortfall, enrolment of women in engineering schools remains dismally low with a national average of 14% in 1988-89. Less than 5% of all students enrolled nationally in technology programs are women.

The urgency to diversify women's participation in the labour force grows out of the rapid pace at which changes are taking place in the technological realm. These employment projections indicate a rising need for technically competent workers at every level. Unless we reverse the current trend, there will not be enough engineers to meet the challenges of the future.

Why don't young women consider careers in technology?

Well, for one thing, many young girls drop Math 300 (which includes algebra, trigonometry, differential equations and calculus) before they realize it is required for university and college programs such as computer technology, and electrical, civil and mechanical engineering. They close the door to over 100 occupations by dropping math and science 300 courses, mainly because they lack self confidence in their own abilities to do well in subjects that require mathematical manipulations. They are not encouraged by parents, teachers and guidance counsellors to stick with these courses.

A study by Labour Canada shows that the most significant shift in girls' openness to scientific/engineering occupations occurs at age eleven or twelve. So by grade six, boys and girls are making career "guesses" based on what they have learned is appropriate for them. They don't necessarily select a specific occupation at this age, but rather they eliminate some options. This happens because they have internalized the cultural/social expectations for their gender.

Cheryl Van Nest (foreground) and **Angela Rinella,** both students in the Pre-Technology for Women class, learn the engineering applications of computers. *(photo by Jim Woroniuk, RRCC)*

by Win M. Torchia
Department Head, Women's Programs
Red River Community College

A look at why young women are not entering technology, and some suggested initiatives to overcome this trend.

Une constatation: les jeunes femmes n'embrassent toujours pas les carrières technologiques; on propose quelques remèdes pour contrer cette tendance.

Occupational sex stereotyping is still prevalent among Canadian children and adolescents, because children learn at a very young age that the world is polarized to male and female. In society's eyes, young boys are expected to be active, dominant and rational which translates into being oriented towards scientific, technical and management areas and are rewarded for these characteristics. Girls, on the other hand, are typified as passive, submissive, and emotional, which translates into an orientation to naturalistic and social areas, and are also rewarded for having these characteristics.

This polarization applies to all areas of society, not just to divisions in the labour force. Young people receive the message loud and clear that if you don't fall on the correct side of the line for your gender, your sexuality and identity are in question. It's no accident, then, that the workforce is similarly polarized into "male" and "female" jobs.

Donna Stewart, M.A., reported in The Manitoba Teachers' Society Equality News (Sept. 1991), that many adolescent girls still believe in the "Cinderella Syndrome" ("happily-ever-after" theory). The facts, however, are that men ("modern princes") have a tendency to:

- die young (1 in 10 before the age of 50),
- get sick or suffer an injury on the job,
- be laid off,
- earn too little to support the family,
- often leave the family.

"Modern Cinderellas" need to understand the realities of the modern workplace:

- They will need at least two years of post-secondary education to access stable, well-paying jobs - with a future.
- Most of them will be back in the paid workforce before their children are three years of age and they will remain in the workforce 28 to 48 years.
- In "good" jobs, those with responsibility and a living wage, they will be adding to their skills and knowledge on a regular basis, so the better their

basic level of education, the more employable they will be.

- They will earn two-thirds of what men earn unless they get outside the twenty "pink collar ghetto" occupations in clerical, sales and service sectors (i.e. secretaries, sales clerks).
- Lastly, all jobs are becoming more technical. Women shut themselves out of many occupations when they drop maths and science.

We now recognize that encouraging young female students into technologies must be addressed at least by the junior high level, if not before.

How Can We Encourage Young Girls to Consider Technological Careers?

First, if you are a parent, you can do many things. Be aware of the likelihood and nature of the future labour force and help them select courses accordingly. Parents impact greatly upon the career choices and future economic welfare of their sons and, in particular, their daughters. It's all too rare that parents speculate about careers with their daughters as often as they do with their sons.

Girls should have a wide experience - building with Lego as a child, working and playing with computers, experimenting with chemistry or science kits and participating in science fairs. All of these experiences can change a young girl's attitude towards technology - it can be fun! For the past twenty years, the majority of participants *and winners* at the Manitoba Schools' Science Symposium have been girls, but has the influence of home and society in general, with the male-dominated science teaching profession, dissuaded girls from seeking a post-secondary science- related education?

There are other areas that impact on career choices.

School visits from young professional women employed in engineering and science still have the greatest impact on student recruitment. A speaker can answer specific questions, respond to the tone of a particular group, and emphasize specific points. Visits personalize these professions. Nothing is more vibrant or motivating than informed speakers who are interested and enthusiastic about their chosen careers. Also, nothing emphasizes that engineering is a viable career option for women more effectively than having a first exposure to the profession from a woman.

Peer groups are a major socializing influence particularly in the adolescent years. Because male attitudes strongly affect female decisions, boys as well as girls must understand the importance of eliminating sex barriers to free the choice of education and employment.

Since 1981, there have been four international conferences on Girls in Science and Technology. As early as 1973, a workshop on Women in Technology and Science was held at the Massachusetts Institute of Technology, to develop strategies for encouraging more young girls to enter the technology areas. Teachers all over the world are examining the ways science is taught in schools to explain the missing female in the world's technological areas. However, many teachers still believe that girls are not naturally talented at science — this becomes a self-fulfilling prophecy.

Teachers' expectations are not the only hurdles the potential female scientist/technologist must face. In practical work with equipment, girls tend to be timid. Boys have often had plenty of experience with plugs, circuits and mechanisms of all sorts before coming to school. Most girls are not encouraged to experiment with such things or given the kinds of toys which develop these skills.

Counsellors nowadays are so over-burdened with crisis situations that they fail to provide the early counsel and support for girls who might be candidates for technological careers. They often fail to realize that in the future girls might be technologists, engineers or scientists.

Image plays a big role. In many foreign countries, the idea of women in engineering and other technological fields does not seem to be unusual.

In the spring of 1990, the University of Manitoba developed an initiative to inform grades 5-12 female students about careers in science and engineering. The students' image of an engineer or scientist was reported as follows by the two female undergraduate engineering students doing the study:

"If students of this age have heard of engineering, they have the impression that it is a manual "blue collar" occupation involving either construction work or fixing engines. Engineers were perceived as wearing hard hats, taking readings on a clip board, in a room full of steam valves and rusty pipes. Only a few students, with relatives who are engineers, understand that engineers are involved in design. Most students' ideas of scientists come from comic books or movies where they are portrayed as "mad", with weird hair, a white coat and glasses, or as evil geniuses. A few students knew that scientists were professional people who did research."

If students have the above image of male engineers and scientists, imagine how weird they would perceive a female engineer and scientist.

What Can You Do As An Employer?

Employers might consider recruitment of women from a variety of sources.

For women without training beyond secondary school level — train them in your in-house technical areas.

Women with college/university training could have knowledge that would be transferable to technical and scientific occupations. For example, there is a surplus of teachers, and those with training in math or technical subjects might readily transfer to high tech areas.

Women with previous extensive scientific training might wish to re- enter the workforce. An absence from the workforce is too readily assumed to have rendered a woman's skills obsolete. More experimentation with job placements and more encouragement to participate in training programs could be given to women.

Part-time and summer employment in scientific and technological fields would provide young girls with excellent opportunities and motivation. This work experience would not only provide the employed students with examples of the practical applications of their scientific and technical knowledge, but would also communicate to other students the acceptance of girls and women in these occupations.

How Can We Encourage Women of All Ages to Look at Technology?

As Department Head of the Women's Programs Department at Red River Community College, I became aware in the late '80's that the demographics indicated imminent skills shortages in technology. The work force was aging and baby boomers had not gone into these fields in large numbers. Also, technological change was reducing the number of traditional jobs for women. The majority of new entrants to the labour force by the year 2,000 will be women.

These factors led us to develop the Pre-Technology for Women program in 1987 as a means to encourage re-entry women to look at technology as viable career. The course was designed to be an exploratory program and was used as a bridge either to specialized training in a two year engineering technology program at the College, or to immediate employment in a technology area where the student utilizes in-house training.

Who Are the Women Entering the Pre-Technology Program?

Their ages vary and their backgrounds differ, but essentially they are all after the same thing - taking control of their lives. They are making changes that would not have been possible ten years ago. They all have a common need — they want a career that will make them financially independent.

Carol was a 25-year-old salesperson who saw no possibility of advancement and was desperately seeking something else. Carol became acquainted with the Pre-Technology program through her Canada Employment Counsellor. She was interested in becoming a sound engineer so she thought she would explore electronic technology through this program.

Pat was a divorced woman in her 40's with a Chemical Engineering Technologist's credentials but was unable to find a job. As she says, "I thought I would end up as a bag lady — money was running out, and I considered moving into my car! I had reached the end of the line as to where to apply for jobs. Although I still had confidence in my abilities as a technologist, I found employers didn't." She decided to give the Pre-Technology program a try, if only to add structure to her life and to get some new ideas in job search techniques.

Lisje arrived in Canada in 1980 from Jakarta, Indonesia. She had received training in Pre-Med but dropped out and had been at home raising a family for the past nine years. According to Lisje, "I wanted to get into the work force. My children did not need my full-time care anymore. My husband heard about the Pre-Technology program and encouraged me to take it because my basic interest was technology." The 16 week program introduces women to some new skills in the areas of drafting, computers, electronics, math, and physics. Reading and study skills, as well as technical report writing, are also offered. An important segment of the program is the personal growth component where the emphasis is on self-awareness, confidence and self esteem building and the practice of assertive communication. Students set realistic goals for themselves. Rounding out the program is a three week hands-on work experience in a technological area of the student's choice.

So where are Carol, Pat and Lisje now? Carol discovered she had a natural talent for drafting and swung away from her first plan to become a sound engineer. She entered RRCC's Architectural Drafting program and is now a draftsperson-estimator. Carol says: "I feel I have a *real* job now. My salesperson's job seemed like an extension of my summer job when I was a teenager. I acquired friends from the program, developed confidence in my math ability and, most of all, gained the incentive to take Architectural Drafting."

Pat had an unusual experience which led to employment in her field. The class was on a tour of the St. Boniface Hospital Research Centre, and the tour guide, a research scientist at the Centre, noted Pat's technical questions and enquired about her background. It just happened that they immediately required someone with her background. Pat was interviewed after the tour and hired! Pat says: "I love my work. I'm supervising a junior technician and doing method development in biological fluids in chromatography. I know my skills are valued."

Lisje decided to do her work experience for the University of Manitoba at Health Sciences Centre. Her supervisor was pleasantly surprised with the competence Lisje showed in testing blood from new born babies for Duchenne Muscular Dystrophy. Lisje says, "Now I am just waiting for the University to receive their grant so that I can be hired on a full time basis. Pre-Technology helped build my confidence, improved my English — nobody laughed at me — and I felt welcome in a group of all Canadians!"

Carol, Pat and Lisje are only three of the successful graduates to come out of the Pre-Technology for Women program. This course is an example of how Red River Community College is helping women attain more meaningful careers in technology and greater self- fulfillment.

Red River is certainly not alone in developing programs to encourage women to enter technological fields. Universities and colleges across Canada are also developing bridging and re-entry programs. One example is the University of Manitoba's Access Program for Women in Science and Engineering.

Science Culture Canada contributed $180,000 to eight science camps last summer. Over 4,000 young people attended various science camps at universities, institutes and research centres across Canada. Thousands more participated in workshops and travelling exhibits.

The problem is definitely recognized that we must encourage more youngsters into the science and technology fields to overcome the projected shortfall and it is encouraging to note the initiatives that are already underway.

The responsibility for change must be shared. Change, as we know, is usually a slow process. To effect the changes required, they must be co-ordinated on all levels: educational systems, course offerings, educators, counsellors, employers, organizations, unions, governments and parents and culture.

As **Monique Frize**, P.Eng., holder of the Northern Telecom NSERC Women in Engineering Chair, University of New Brunswick, recently stated: "Women can be excellent engineers, designing the technologies of the future, and making unique contributions to the world of today and tomorrow."

Let's use the other half of our human resources in the future! ■

About the author

Win M. Torchia is a Canadian pioneer in the development of programs enabling women to be employed in alternative occupations, beginning with Northwestern Ontario's first Introduction to Non-Traditional Occupations in 1977, and culminating in the development of Pre-Technology for Women in 1987. Besides being involved in adult education in the College system in Ontario and Manitoba, Ms. Torchia has extensive management experience, varying from positions at CN Rail, Winnipeg, to college administration. She was nominated for Winnipeg's "Woman of Distinction" award in May 1991 and is currently Department Head, Women's Programs at Red River Community College, Winnipeg.

Seismogram Reading upon the Quiet Canadian Bedrock

Sorting out naturally occurring earthquakes from clandestine underground nuclear tests proves to be no easy task

by Professor Kin-Yip Chun
Geophysics Division, Department of Physics
University of Toronto

Seismology provides the primary means of monitoring nuclear tests. Supplemented by surveillance satellites and other National Technical Means, seismic methods are now able to detect and identify low-yield nuclear explosions.

La séismologie permet principalement de surveiller les explosions suite à des essais nucléaires. À l'heure actuelle, les méthodes sismiques peuvent détecter et identifier les explosions nucléaires même de faible intensité, en s'appuyant sur les données fournies par des satellites de surveillance et d'autres moyens nationaux techniques.

Seismic analysis in Canada is finding useful applications in the detection of underground nuclear explosions. Founded in late 1985, the seismic verification research team at the Physics Department, University of Toronto, consists of several seismologists. They work in tandem with the Geological Survey of Canada (GSC) and with the Arms Control and Disarmament Division, External Affairs and International Trade Canada (EAITC). The research objective is to achieve reliable means of monitoring nuclear tests taking place underground - the only testing environment not subject to international ban under the 1963 Limited Test Ban Treaty. A major reason why a ban on underground nuclear testings has not been achieved is the difficulty surrounding effective verification of treaty compliance.

Since its inception, the Toronto team has been receiving research support from EAITC. The work carried out at Toronto covers wide-ranging topics pertaining to earthquake versus explosion source discrimination as well as nuclear explosion yield estimation at regional and teleseismic distances. Regional distances lie within 2500 km of the epicenter, while teleseismic distances are those beyond 2500 km.The travel paths of regionally recorded seismic signals are confined within the outer shell of the Earth, made up of the crust and the uppermost mantle. The regionally recorded signals are typically quite complex in waveform and notably richer in high-frequency energies than their teleseismic counterparts.

The research essentially involves "forensic" interpretation of wiggly lines known as seismograms (ground motion amplitude traced as a function of time) by eagle-eyed scientists well grounded in mathematical physics. In this article, some illustrative aspects of our work will be discussed. Readers interested in a comprehensive overview of the recent Canadian research in nuclear test ban verification – especially on seismic monitoring at regional distances of low-yield nuclear tests – should consult *Arms Control Verification Occasional Papers No. 8*, published in July, 1991 by the Arms Control and Disarmament Division of EAITC.

Dawn of The Nuclear Age

Code-named Trinity, the 19.3-kiloton atomic test on July 16, 1945 in the desert of New Mexico released a flood of light, an intense heat wave, and a thunderous clap accompanied by reverberating shock waves in the brightened valley. The U.S. monopoly of the weapon of mass destruction was short-lived: on August 29, 1949, the Soviet Union made their first successful atomic test in the Ust-urt desert. In the ensuing years, Britain, France, China and India successively joined the nuclear club. A number of other nations are said to be potential candidates for club membership.

Nuclear Test Ban Treaty and Its Verification

A comprehensive test ban treaty (CTBT) would ban all nuclear tests, large and small in all environments; a low-threshold test ban treaty (LTTBT), on the other hand, will ban only nuclear tests with yields above a certain threshold level. What constitutes an appropriate threshold level is a matter of both political and technical judgement. Many verification seismologists consider a threshold level lying somewhere in the 5 to 10 kiloton range to be a realistic starting point, while some deem a lower level (as low as 1 kiloton) to be a more appropriate choice. The pros and cons of having an LTTBT as a stepping stone towards an eventual CTBT are matters beyond the scope of discussion here.

Technology for Arms Control Verification

Over the three days extending from June 21-23, 1991, Ryerson Polytechnical Institute hosted a Workshop and a Conference concerning the role of science and engineering in society.

The one-day Workshop on "Technology for Arms Control Verification in the 1990's" was co-endorsed by IEEE Canada and by Science for Peace. Under the direction of Workshop Convener **Peter Brogden** and Consultant **Walter Dorn**, the workshop, addressed the following topics:

1. Industry and Arms Control
2. Satellite and Airborne Detection and Imaging
3. Undersea Detection
4. Nuclear Non-Proliferation in the Middle East
5. Seismic Verification Methods
6. Detection of Chemical Weapons Materials

The full proceedings of the Workshop will be published in early 1992, and further information about the publication will be available through the IEEE Canada office.

However, some of the authors have agreed to submit articles to the IEEE Canadian Review based on their presentations at the Workshop. This issue includes the first of these articles, by **Professor Kin-Yip Chun**, on some of the signal processing he has developed to separate seismic signals generated by earthquakes, from those generated by underground nuclear test explosions.

The two-day Conference was organized by the Toronto Chapter of the IEEE Society of Social Implications of Technology (SSIT), with the general theme of "Preparing for a Sustainable Society". A selection of the papers was published in the December 1991/January 1992 issue of SSIT's Technology and Society Magazine

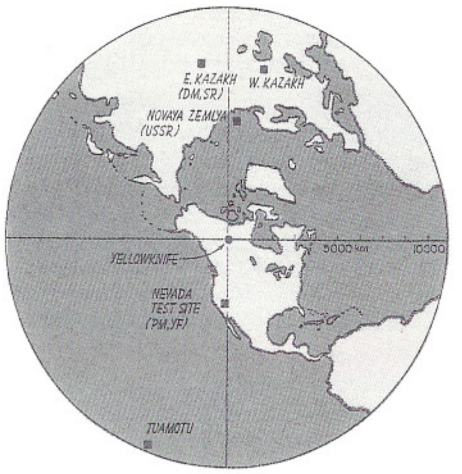


Figure 1a. Canada's listening post at Yellowknife and its geographic location relative to major nuclear test sites.

The underlying rationale for reaching an arms control agreement is simple: by virtue of being similarly restrained in weapons testing or deployment, all assenting states expect to gain national security benefits. The actual realization of the anticipated benefits depends on each signatory being in compliance with the terms of the agreement. Since treaty violations by even one signatory could threaten the national security of others, a demonstrable capability for monitoring treaty compliance becomes vitally important.

The Earth as a Filter

It is conceptually useful to consider the Earth as a linear filter characterized by its time-domain response $G(t)$ to a unit impulse. The output $U(t)$ to any arbitrary input $S(t)$ is then given by

$$U(t) = S(t) * G(t)$$

where * denotes the convolution operator.

The equation takes a form familiar to electrical engineers. In seismology, $U(t)$ is the ground motion, which is measured by a recording instrument of high fidelity. $S(t)$ is the source term, which, in the case of an earthquake, contains both the fault rupture time history and the source radiation pattern, the latter being determined by the fault orientation. $G(t)$ is determined by the properties of the Earth, both elastic and anelastic.

From the above equation, it is clear that the discrimination of the explosion source and the estimation of its yield entails a reliable knowledge of the Earth structure. The correct interpretation of the observed seismic data also demands a knowledge of the physics of wave propagation in complex wave media, and practical methods for accurate quantification of individual path effects.

Canada's Seismic Array

An array of spatially distributed sensors can be used to extract signal characteristics of propagating waves, such as seismic and electromagnetic disturbances. The radar sensors are receiving antenna elements; the passive, listening-only sonar sensors consist of sound pressure-sensing electromechanical transducers (hydrophones) immersed in the underwater medium; the seismic sensors (seismometers), anchored on solid rock, are similar to hydrophones and they are sensitive to minute ground vibrations.

The manner in which an array is illuminated by the incident wavefield can be analysed to yield information, such as the direction and speed of the propagating wave. Featuring a cruciform layout in Canada's quiescent Northwest Territories, near the city of Yellowknife, the Yellowknife Seismic Array (YKA), is one of few such facilities in the world (Figures 1a and 1b). It is operated by GSC, and possesses an enviable recording history spanning nearly three decades. Upgraded two years ago at a cost of $3.5 million, the YKA is now equipped with state-of-the-art recording instruments designed for high fidelity, high recording dynamic range (144 dB) and a total recording frequency band ranging from 2.8 mHz to 40 Hz. The YKA acts like an inverted radar, picking up seismic signals from beneath the Earth's surface instead of from the sky. It is linked by geostationary satellites to the GSC's National Seismology Data Centre in Ottawa, some 3,300 km away. As a result, near real-time analysis of the data is achieved.

Research in Wave Propagation: Theory and Observation

The recent advent of high-performance, inexpensive computers has made possible routine applications of synthetic seismogram analysis methods. A synthetic seismogram is a ground motion record that is calculated using a theoretical seismic source (input) embedded in a model Earth (wave propagation medium). The synthetic seismogram analysis methods involve detailed waveform comparisons between the calculated and the observed ground motion records.

The extent to which information on subtle earthquake versus explosion source details may be retrieved from seismic data depends on the degree of our understanding of the physics of wave propagation in heterogeneous media. Ray methods are used for wavefield computation. The paths of rays cut wavefronts at right angles. The laws of reflection and refraction are analogous to those in geometrical optics. The simplifying assumption is made that all signals propagate along a single wavefront, determined by the eikonal equation. This is a first order partial differential equation named after the Greek word meaning image.

The characteristic waves of the eikonal equation provide a way of constructing the set of wave fronts and orthogonal rays. This approach is tantamount to neglecting the scattering effects due to the inhomogeneity of the medium. Consequently, these ray methods fail to properly handle such basic wave phenomena as scattering-related wave dispersion, partial reflection from a region of rapidly changing seismic velocity, and phase shift near a caustic*. The Toronto team has recently succeeded in developing a new ray-Kirchhoff method which overcomes the above shortcomings, permitting proper application of the synthetic seismogram analysis in realistic Earth models.

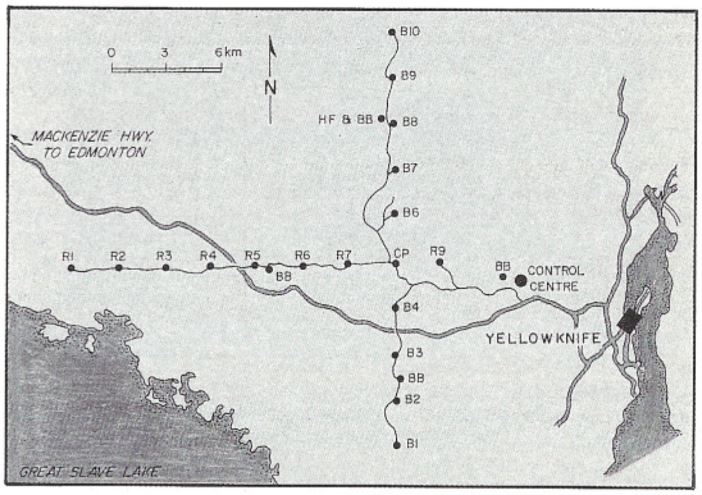


Figure 1b. Layout of the 22 listening stations. This medium-aperture Yellowknife array senses vibrations produced by near and distant seismic events. All are digital stations relaying their data by radio to the Control Centre and on to the Geological Survey of Canada in Ottawa by Anik satellites. *(Adapted from figures supplied by the Geological Survey of Canada).*

The Earth filter $G(t)$ is attenuative in a complex, frequency-dependent manner; consequently, a seismic signal travelling from point A to point B suffers both energy loss and waveform distortion. Because the Earth is laterally (as well as radially) heterogeneous, the wave propagation effects are path-specific. That is, these effects (geometrical spreading, anelastic attenuation, and wave scattering) are generally not the same for two different paths having the same distance from the epicenter. Determination of the observed path-specific attenuation is difficult, owing to the usual presence of contaminating factors which can easily dominate the attenuation effects one wishes to measure. These factors can arise, for example,

* *A caustic is a boundary between a region with an interference wave packed between two trains of waves and a neighboring region with no waves.*

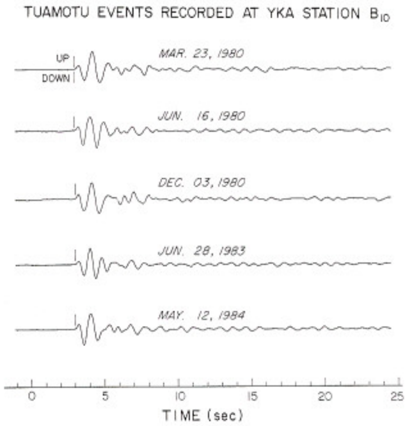


Figure 2. Seismograms of the five nuclear explosions recorded at the YKA vertical-component station B_{10} during the French Tuamotu tests. For each record, the primary *P*-wave onset is characterized by an upward swing, as expected from an explosive source.

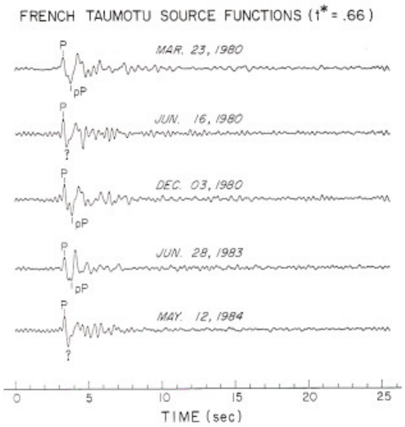


Figure 3. Source functions of the same French Tuamotu explosions as in Figure 2. These source functions, which were derived by using a path attenuation t^* of 0.66 sec, reveal a small, secondary phase pP (see Figure 4) trailing 0.4 sec behind the first *P* onset. The time lag suggests a source depth of a few hundred meters - much shallower than those of most earthquakes.

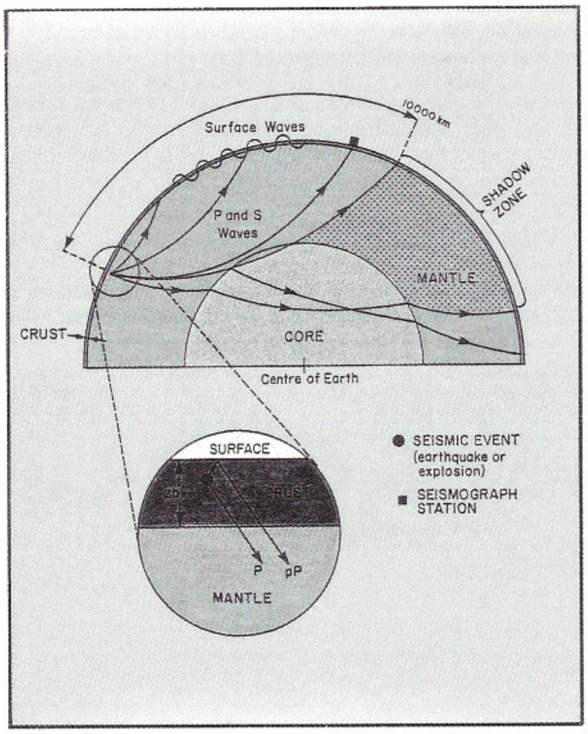


Figure 4. Seismic ray paths. *P* stands for compressional wave whose propagation is associated with changes in density of the material; *S* stands for shear wave whose propagation is associated with a rotation of the material without change in volume. The shadow zone is caused by waves deflected by the Earth's core. Travelling along the surface of the Earth, the surface waves have slower speeds than the bodily *P* and *S* waves and behave like ripples in a pond. The circular inset shows the primary *P* phase and the depth phase pP, an elusive signal much sought after by forensic seismologists. The travel time difference between the two corresponds roughly to the time taken by the pP signal to complete the detour above the source depth. (*Adapted with permission from an original drawing supplied by Geological Survey of Canada*).

from localized seismic wave focusing/defocusing due to the presence of complex, shallow geological structures beneath the recording station, and from seismic source radiation patterns determined by the fault geometry of the earthquake source. For regional wave types P_n and L_g of seismic verification interest, it is now possible to achieve reliable, high-resolution attenuation mapping using two newly developed methods.

In what follows, we show an example of the fruitful seismological application of an advanced signal processing technique which first appeared in a 1982 IEEE proceeding (Vol. 70, 1055-1096) by D. J. Thomson. Known as the multiple-window spectral analysis technique, the method optimizes the trade-off between the variance and the spectral leakage by using multiple orthogonal tapers. This yields well-constrained, smooth spectral estimates in portions of the spectrum which are at or near a plateau, while retaining excellent resistance to spectral leakage in the regions characterized by a steep fall-off. We have shown that this method produces reliable attenuation estimates, known as the t^*.

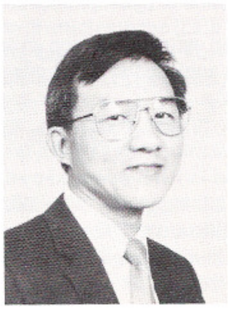
Figure 2 shows the vertical-component ground motion records obtained at YKA array station B_{10} of five underground nuclear explosions. The explosions took place in the French Isles Tuamotu, some 9 500 km away. With their Richter magnitudes ranging from 5.5 to 5.7, the smallest of these explosions had an explosive yield of about 100 kilotons.

The *P* wave onsets all show an upward first motion, consistent with that predicted for underground explosions. Figure 3 shows the nuclear explosion source functions that were extracted from the records displayed in Figure 2. These source functions were obtained using a multi-channel deconvolution technique and a precise t^* value determined by Thomson's signal processing technique. The extracted source functions clearly feature an unmasked secondary pulse trailing some 0.4 seconds behind the primary *P* arrivals. This secondary phase is known as the depth phase pP (Figure 4). The 0.4 second time separation between *P* and pP reveals that the source event is merely a few hundred meters deep, typical of the burial depth for nuclear device detonations having a Richter magnitude of 5.6 to 5.7. This depth is much shallower than the source depths of most natural earthquakes. Note that for naturally occurring earthquakes, the time lag between *P* and pP is typically several seconds. For deep earthquakes, it can be more than two minutes.

Before one can estimate the explosive strength of the source, the t^* measure of seismic attenuation is needed. This enables us to correct for the effects of seismic amplitude loss along the propagation path due to the Earth's anelasticity . We have been able to show that the difference between our

About the author

Kin-Yip Chun is Assistant Professor of Geophysics at the University of Toronto. He received a B.A.Sc. in Engineering Science from the University of Toronto, his M.A. from Columbia University and his Ph.D in solid earth geophysics from the University of California at Berkeley. Dr. Chun has authored and co-authored some two dozen scientific articles and conference proceedings on seismic verification of nuclear test ban treaties. Dr. Chun served as an official member of the Canadian delegation to the 32nd session of the United Nations Conference on Disarmament (July 29 - August 9, 1991), held in Geneva, Switzerland.



new 0.66-second t^* value for the Tuamotu – YKA path and the values found in the literature is large enough to cause a factor of two in the estimated yields of these French nuclear explosions.

Seismology provides the primary means of monitoring nuclear tests. Supplemented by surveillance satellites and other National Technical Means*, seismic methods are now able to detect and identify low-yield nuclear explosions. Such means can even detect explosions where deliberate evasion schemes are used, such as in cavity decoupling, where a cavity is employed to reduce the coupling of the explosive energy to the solid Earth.

Conclusion

Canada continues to play a major role in international negotiations concerning future nuclear test ban treaties. Blessed with a vast natural proving ground of varying geological environments for testing seismic verification techniques and a long tradition in earthquake monitoring research, Canada is in a privileged position, geographically and technologically, to contribute to processes of achieving verifiable nuclear test ban agreements. ■

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* *National Technical Means is any technical means available to a party monitoring from outside the territory of the country being monitored.*

Neighbours

by Dr. Ray Findlay, Chairman, Student Activities Committee (SAC)

My grandfather never founded a financial empire nor made a fortune in business nor did he establish a dynasty. But he did build his own house with the help of his neighbours. On Saturday nights in winter he would sit around the old potbelly stove in the kitchen. He would tell his friends about his last fishing expedition of the summer or try to find out from them why his beans did so poorly that year. He and his neighbours communicated about things that were important to them.

My grandmother was the philosopher in the family. She would sit in her rocking chair and tell me about life. I was only seven at the time so it was pretty much wasted on me. All, that is, except the warm feeling I get whenever I think about her. In our modern society I sometimes think we've lost something that our forbearers thought was valuable - the ability to talk to each other as colleagues, neighbours and friends. In our professional lives it seems to be as much a problem as elsewhere.

Communication, the key to successful engineering, seems to be passing us by in IEEE. I'm not talking about radar or microwaves or antennas, or some other esoteric technical type of communication. I'm talking about *dialogue*. Talking to people; communicating common goals, hopes and aspirations; working with each other, the things which ultimately matter.

Sections have trouble linking up with Student Branches. Consequently, Students don't get to talk to Members. Members don't seem to be able to find the time to talk to other Members. They don't have the time to welcome new members to the profession, to compare notes and give guidance. When was the last time you found time to nominate someone for membership or an award, or to nominate someone to be a Senior Member or a Fellow? When have you found the time to reach out to someone else, some other volunteer who might need a helping hand.

Did you know that Sections, the backbone of IEEE, rarely have enough volunteers around to do the job? And as for that great investment in Canada's future, our Students, how often have they benefitted from your assistance, counsel or friendship? Has someone told you lately that you are doing a great job? It feels good doesn't it? We should be able to do it more often.

Information: too much or not enough?

Who can help us when we need it? Well, there is a plethora of material available, sent from Headquarters, to amuse and confound the interested volunteer. You can find out anything there ever was to know about running a Section or Chapter or Student Branch, in stacks of publications. But who has time to read these voluminous works?

Those of us in the technical areas find it even more difficult to stay abreast. We can hardly keep up with all the technical reading each month, let alone all the other stuff that crosses our desks. But 40% of our membership do not belong to any of the constituent technical societies in IEEE. They try to keep up just with the aid of Spectrum. That's a tough job lately, the magazine is getting thinner, and there seem to be more advertisements than ever. We ought to tell someone about that.

How many of us have tried to get information out of Headquarters? Rarely is that an easy matter. We don't know who to talk to! All too often we get frustrated before we've found the answer: we give up. All of this wonderful technology to help us communicate but we seem to be doing a worse job at it than our grandfathers did.

I have something important to show you.

There was a spring that trickled out of the hillside at the end of our street. It was pure and cold. All the children would gather around that spring on a hot day to quench their thirst. It was better than the soda pop none of us could afford anyway. When a new family moved to the street, my grandfather would meet them. He would put an arm around the young father's shoulders and say, "Come with me, I've got something important to show you." He would take the fellow off to the spring. "You can always get water here," he would say, "even when your well dries up in summer."

I think we need to rejuvenate those old values. When someone new moves into our company we need to put an arm around his shoulder and say, "Come with me, I've got something important to show you." Then take them to an IEEE meeting. Introduce them to your friends and colleagues. Help them feel that they are part of your neighbourhood. And if your new colleague is someone who has just graduated, how much easier you will have made their transition from school to workplace. And how much more enriched both your lives will be.

While you are still feeling good, pen your thoughts on what should be done to improve IEEE. Do you want to start a Mentor Program for your local Student Branch? Do you think IEEE should have a Customer Service Department? Do you have an idea how to improve Spectrum or your Section? Send your ideas to the President or one of the Vice-Presidents, or the Chair of your Sections, or even me. Tell us what needs to be done and how you can help. Our society is run by volunteers like you and me. We have made it the greatest technical society on earth. Let's do our bit to keep it that way. ■

About the author

Ray Findlay, a registered professional engineer in the Province of Ontario, received his BASc (1963), MASc (1965) and PhD (1968) from the University of Toronto in Electrical Enginering. He taught at the University of New Brunswick from 1967 to 1981, when he joined McMaster University as Professor of Electrical and Computer Engineering.

His research interests include fields and losses in electrical power devices in which he has more than 100 technical papers and 2 patents.

In 1989, he was awarded the IEEE Regional Activities Board Award for Innovation.

Testing, a Vital Tool in Product Integrity Engineering

by Robert Koller, P.Eng.
Product Integrity Section Head
Electronics Test Centre

Testing is important because it provides tangible evidence of a product's strengths and weaknesses. There are two basic forms of testing: voluntary and mandatory. Voluntary tests are driven by internal needs, such as product improvement. Mandatory tests are typically those defined as part of government regulations addressing product safety for consumers.

The testing of electronic equipment can be divided into four groups: Performance, Safety, Electromagnetic Interference, and Environmental Stress tests. A recent addition to this list, Energy Efficiency testing, is an outcome of recent energy conservation efforts.

With Quality becoming synonymous for survival, testing is playing an increasingly vital role in the development phase of all products.

Les essais sont importants parce qu'ils font ressortir de façon tangible les points forts et les points faibles d'un produit. Ils peuvent être volontaires ou obligatoires. Les essais volontaires répondent à des impératifs internes, telle l'amélioration du produit. Les essais obligatoires sont ceux qui définissent la réglementation gouvernementale sur la sécurité des produits pour les consommateurs.

Les essais sur de l'équipement électronique touchent quatre paramètres: la performance, la sécurité, l'interférence électromagnétique et le stress sur l'environnement. Dans la foulée des efforts de conservation d'énergie, on a récemment ajouté à cette liste les essais d'efficacité énergétique.

La qualité étant désormais synonyme de survie, les essais jouent un rôle de plus en plus important pendant la phase de développement de tout produit.

Electronic and electrical product manufacturers strive to make their products better. One of the disciplines in engineering that deals with this issue is product integrity engineering. What is product integrity engineering? Product integrity engineering is synonymous with product assurance engineering. Both refer to engineering disciplines where the focus is in assuring that a product will perform favorably during its lifetime. Product integrity and product assurance engineers are responsible for performing a number of different tasks during the life cycle of a product, the life cycle phases being defined as; design, manufacture, test, and use. These tasks continue to become more diverse and more important as manufacturers become more competitive. They include such activities as reliability, maintainability, and safety analysis, quality assurance engineering, human factors engineering, and logistic engineering.

The diversity of these activities is immense, and beyond the scope of this article. The focus of this article is to look at one of the more powerful verification tools that product integrity (product assurance) engineers have at their disposal, that is, the physical test.

Test results provide hard evidence. Tests help prove that a product meets its design specifications and expose both the strengths and weaknesses in a product. Of course, if a test procedure is in error or tests are poorly planned or performed, then the results of such tests are of no value. Product integrity engineers must therefore be familiar with test standards, preferably experienced in actually performing tests themselves or witnessing tests, and knowledgeable of where reputable test labs are located that can perform the various tests effectively and expediently. Test labs exist for just about every type of test requirement one could imagine in the electronics and electrical fields. These range from independent labs specializing in electronic components testing, to the more familiar safety test labs operated by CSA (Canadian Standards Association).

A concept often overlooked by those new to the test game is the concept that failures can be useful. It is through failed tests that we learn the most. Take for example a vibration test that a product manufacturer must perform for a client. Assume the product passes the vibration test and you call it a day. That may be great, but you really haven't learned very much about your product. An alternative would be to continue the vibration test, but at a higher intensity, and wait for something to break. When something does break, the modification required to fix the weakness may not have a significant cost associated with it. The benefit, however, may be very significant, in that your product robustness may increase substantially from that simple fix.

Test Technologist **Morris Scarpino** measures low frequency radiated magnetic fields with the product under test in the RF anechoic chamber. The test is being conducted to MIL-STD-462, RE01.

It is worth defining the two types of test activities implied by the above example, that is, *mandatory* testing, and *voluntary* testing. Mandatory testing involves testing to the specific requirements of a client, or as required by government regulations or industry standards. Mandatory tests must be performed and passed, otherwise the possible consequences could be non-acceptance, liability charges, or fines. Voluntary testing includes all other

Test Technologist **Duane Friesen** exits the walk-in chamber after performing a functional test on a commercial product which is undergoing a – 55°C low temperature test.

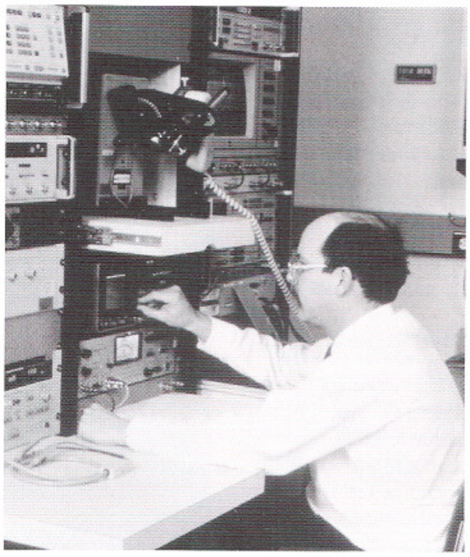
testing. Voluntary tests may be conducted to learn about the limitations of a product or provide insight into how to improve a product.

Some examples of mandatory tests might be submissions to CSA or UL (Underwriters Laboratories) for safety certification. As well, passing a Communications Canada (DOC) electromagnetic emissions test might be required before a product can be sold in Canada. If the equipment connects to a telecom network (such as a telephone or modem) passing a DOC CS03 certification test would be required. Also, if a manufacturer's client contractually requires operation at high and low temperatures, then a test must be performed to cover this requirement.

An example of a voluntary test might include a test performed during the product design stage to check or improve the performance of a product under certain environmental stresses. Other examples include accelerated life tests to determine product reliability, unofficial pretests to assure the passing of an important mandatory test at a future date, or possibly environmental stress screening tests to prevent the shipment of products with latent defects.

In the past, voluntary tests were not considered important. Today, the message of quality improvement can be heard in the boardrooms of almost every company. Directors of manufacturing companies have to think this way nowadays if they want to remain competitive. What this means for the product integrity engineer is more voluntary testing. One of the first steps the product integrity department can take is to develop internal company test standards. Company test standards are usually a mix of custom test procedures and test procedures taken from existing commercial or military test standards. The test procedures could include everything from a transportation vibration simulation test, to a simple coffee spill test. During the initial phases of a project, certain tests and test criteria can be chosen from internal company test standards. These voluntary tests can then be budgeted for and scheduled into a project, just like the mandatory tests. Finally, to improve the success of a project, testing needs to be planned and performed *throughout* the design phase as opposed to the traditional approach of performing tests during the last phases of a project. By then, time and money are scarce and it is too late to redesign a product in order to correct the problems that appeared during the tests.

It is evident that the range of tests being performed on electronic and electrical products throughout the country is broad indeed. We can however classify the tests into four general categories:



Bill Hoffart, Terminal Attachment Section Head, sets up a telephone to undergo DOC CS03 terminal attachment certification tests.

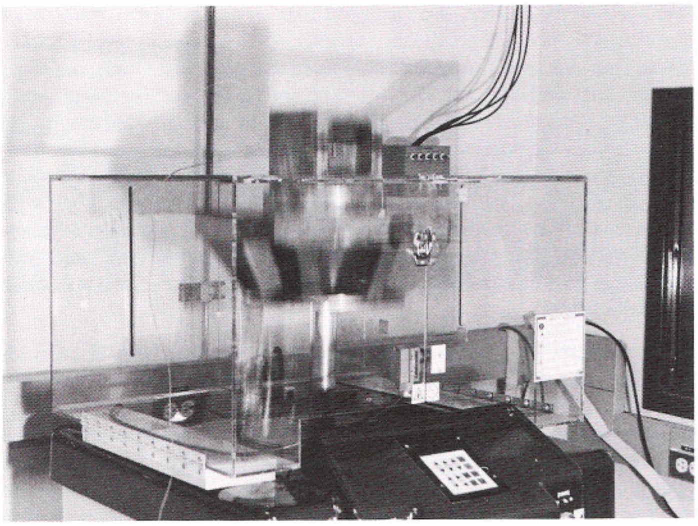
1. Performance Tests - These tests are developed to verify the functional performance of a product. Normally, they are developed by someone who is familiar with the product, such as a design or project engineer. The goal of a performance test is to prove that a product meets it's design specifications. These tests are sometimes described as functional tests. Often, industry-specific test standards exist which must be, (or can be) used for this purpose. Examples of organizations that write and publish standards that emphasize performance requirements are the IEEE (Institute of Electrical and Electronics Engineers) and the EIA (Electronics Industry Association). Performance tests, or condensed versions of them, are normally carried out along with safety, EMI, or environmental tests. For this reason, it is always advantageous to ensure that a concise performance test procedure is available, with well documented setup instructions, in a step by step format, and with clear pass/fail criteria.

2. Safety Tests - For electrical or electronic products to be sold in North America, safety testing usually involves submitting samples of a product for CSA and UL safety testing. These tests can be performed by CSA or UL themselves, by some independent commercial laboratories or, in some cases, by the manufacturer himself at the manufacturer's facility . Each option has advantages and disadvantages, and should be investigated thoroughly by the party wishing to obtain these safety certifications. For UL the term used is a safety *listing* as opposed to CSA's terminology of a safety *certification*. Safety tests are almost always mandatory and come with well-defined requirements.

3. EMI (Electromagnetic Interference) Tests - More and more electronic equipment in use today uses computing and communications components in their designs. As well, circuit board designs are becoming more dense than ever before. These realities have forced electronic equipment manufacturers to pay closer attention to the potential for electromagnetic interference within a product as well as between products. Traditionally, EMI tests have been thought of as another type of environmental test (i.e the radio frequency environment). Today a substantial portion of a product's test budget goes toward EMI testing. Because of this, and because of the specialized nature of EMI testing, it is more appropriate to categorize EMI testing separately. Military and civilian standards exist that define allowable emissions and operating requirements for equipment in the presence of interfering signals. Some standards-writing organizations (SWO's) in this area of testing include the U.S. military, FCC (Federal Communications Commission), Communications Canada, and IEC (International Electrotechnical Commission). As with safety tests, EMI tests are almost always mandatory, with requirements well defined.

4. Environmental Tests - Environmental tests involve subjecting a product to a controlled environmental stress such as high temperature, low temperature, humidity, vibration, shock, altitude, dust, salt fog, rain, wind, or fungus. Environmental stresses are classified as either naturally occurring such as rain, or induced (man-made) such as a coffee spill or transportation vibration. In some cases more than one stress may be applied at the same time. Depending on the test requirements, a performance test may be required while an environmental stress is being applied. In other cases, a performance test may only be required before and after the application of an environmental stress. During its lifetime, a product may be subjected to a wide variety of environmental stresses. Even products designed to be used in a relatively benign environment, such as computer equipment destined for use in a temperature/humidity controlled computer room, could go through harsh transportation environments before arriving at the computer room floor. There are many standards in existence that address the issue of environmental testing. Typical standards used in environmental testing include MIL-STD-810 which is a U.S. military standard and IEC-68-2 (International Electrotechnical Commission). There are a host of environmental test standards written by industry-specific organizations such as NEMA (National Electrical Manufacturers Association) and BELLCORE (Bell Communications Research), just to name a few.

Environmental tests have traditionally been thought of as one-time qualification tests, and are usually performed on only one or a few product samples.



Electronic components are mounted to the cube test fixture on the shock machine. These shock tests are being conducted in conformance to MIL-STD-750, method 2016, at 2000 G.

Although qualification testing is a big part of environmental testing, there are other applications where it is used for a different purpose. Much literature exists today describing the use of ESS (environmental stress screening) as a means to prevent shipping products with latent defects. ESS tests normally use temperature shock (rapid cycling between high and low temperatures) and/or random vibration as the environmental stresses. ESS tests are performed on not just a sample of the manufactured products, but on all the products manufactured. ESS testing is a 100% screening test. The IES (Institute of Environmental Sciences) is a strong proponent of ESS and has extensive literature available on this subject. The address and phone number for the Institute of Environmental Sciences is 940 East Northwest Highway, Mount Prospect, Illinois, 60056, telephone (708) 255-1561.

Environmental testing can also be set up to use accelerated test stresses in which test-to-failure is the objective. From this type of test one can learn where the "weakest link" may be in a product. As mentioned previously, the fix would be considered worthwhile if it improves the robustness of a product. As well, test-to-failure tests can be used to obtain a measure of a product's life. An example of this type of test might involve using high temperature as the stress. Groups of products, say 10 to a group, would be placed in a high temperature chamber, one group at a time. An automatic method of recording the functionality of each product during the test might be used. As the products fail, the time at which failure occurred would be recorded. After all products in the test group fail, the next group could be tested-to-failure at a different high temperature. With this data, and proper attention to life testing rules and mathematical models (there are a variety of do's and don'ts in this field of testing) one can estimate the expected life of a product. The rated life is assigned to a product as a function of its expected life.

Environmental tests should be tailored for each product type. This concept of *tailoring* an environmental test requires the test planner to investigate what stresses the product will actually be exposed to. This requires monitoring a typical installation of a product and recording the day-to-day environmental stresses (such as vibration, temperature, and humidity) that it is subjected to. This information is analyzed and the recorded environmental stresses can then be reproduced in the test laboratory. This approach is quite different from the more straightforward (but possibly not so realistic) approach of using "cookbook" test criteria to define environmental test requirements. In many instances environmental tests are mandatory, and in many instances they are performed on a voluntary basis.

Other test categories exist for electronic and electrical products which don't necessarily fall into the categories listed above, but nevertheless deserve mention. One category is testing to certify for "connection to the public telephone network". These tests cover verification of specific technical requirements laid out by such organizations as Communications Canada, and the FCC. The term often used to describe these tests is "Terminal Attachment Certification Tests". A significant portion of electronic equipment requires such certification, including telephones, fax machines, answering machines, and modems. Typical certification tests include transmitted signal power, terminating longitudinal balance, on-hook terminal impedance, and off-hook terminal impedance.

Another category worth mentioning, in step with today's green movement, is energy efficiency testing. Recently, Jake Epp, federal Minister of Energy, Mines and Resources, announced that energy efficiency regulations will apply to specified electrical products. Efficiency testing will be required, and minimal efficiency criteria will be imposed on such products. The existing Energuide appliance labelling program, which is part of this initiative, is to be expanded upon. Exact details as to the list of electrical products to be included in this program has not been issued, but will probably include all major home appliances.

One other significant category of tests could be defined. So far, all the tests discussed have dealt with a finished product, or a near finished product. What about the components that go into making that product? This area of testing is called *component* testing. As part of the requirements, the tests on components themselves could include performance tests, safety tests, EMI tests, and environmental tests. This type of testing stems from one of the most basic and important concepts in product improvement, that is, a product is only as good as its parts.

Testing has always been and will continue to be a powerful control and verification tool for electrical and electronic products. Product integrity engineers use tests to prove mandatory as well as voluntary requirements. A well-planned product integrity program provides a competitive edge with improved product quality and a faster time to market.

Profile of The Electronics Test Centre

The Electronics Test Centre, located in Edmonton Alberta, provides EMI testing, Terminal Attachment Certification testing, and Environmental testing services to a wide range of standards. A short list of some of the major test facilities includes a large walk-in temperature and humidity chamber (85 cubic metres), three smaller temperature and humidity chambers (1 to 1.5 cubic metres), an altitude chamber (2.5 cubic metres), a salt fog chamber (1 cubic metre), a 44.5 kN (10,000 lb-force) vibration shaker system, an Avco shock machine, an RF anechoic chamber (207 cubic metres), an EMI open field test site, and a modern terminal attachment certification test facility.

Clients of The Electronics Test Centre include commercial product manufacturers, military and aerospace product manufacturers, and importers and exporters of electronic products. As well, users of electronic equipment or components may request special evaluation tests. The staff are highly skilled and pride themselves in being capable to take on the most technically challenging test programs. The Electronics Test Centre is accredited and recognized by the Standards Council of Canada, the Department of National Defence, Communications Canada, and the Federal Communications Commission in the U.S.A. For more information on the Electronics Test Centre, call (403) 450-5370.

About the author

Robert Koller obtained his B. Sc. degree in Electrical Engineering from the University of Alberta. Prior to joining the Electronics Test Centre, he spent a number of years with SED Systems Inc. of Saskatoon, where he was involved with the design, integration and testing of the Suprathermal and Energetic Mass Spectrometer that was built for the National Research Councilof Canada This instrument was placed aboard the Japanese EXOS Spacecraft, launched in 1989. He is currently Section Head of ETC's Product Integrity Lab.

The Canadian General Standards Board

The central standards development and quality management organization for the Government of Canada

The Canadian General Standards Board (CGSB) is in the business of assuring the quality of goods and services in the Canadian and international marketplace. Our work touches almost every area of Canada's economy, including both the private and public sectors. Our services help assure buyers, whether it's the Government of Canada or the average Canadian citizen, that the products and services they want have the quality they need. We do this in a number of ways, from product specifications to inspecting manufacturing facilities to the ISO 9000 series of quality standards.

CGSB, a division of Supply and Services Canada, is located in Hull, Québec, across the river from Ottawa. Our current operating strength consists of 57 employees, with approximately 15 more on contract.

Mandate

Established in 1934 with an initial mandate to bring order and quality to government procurement, CGSB has become the central standards development and quality management organization for the Government of Canada.

Firefighters protective clothing for protection against heat and flame are covered by CAN/CGSB - 155.1 - M88.

by Jeffrey D. Weir
Special Projects Officer
Canadian General Standards Board

The Federal Government's central standards development and quality management organization works to see that organizations, both public and private, have a greater understanding of the many benefits of standardization and how these services can increase quality in the manufacture and delivery of goods and services throughout the Canadian marketplace.

L'organisme central d'élaboration de normes et de gestion de la qualité du gouvernement fédéral s'emploie à veiller à ce que les organismes des secteurs publics et privés soient davantage conscients des avantages de la normalisation et comprennent mieux comment de tels services peuvent améliorer la qualité de fabrication et de livraison des biens et la qualité de prestation des services sur l'ensemble du marché canadien.

In 1973, CGSB was accredited by the Standards Council of Canada (SCC) as a Standards-Writing Organization (SWO). We were accredited in a broad range of subject areas, such as firefighter's protective clothing, where we had developed standards for procurement. This meant CGSB had a mandate to write standards in many subject areas to offer its programs nationally and to the private sector.

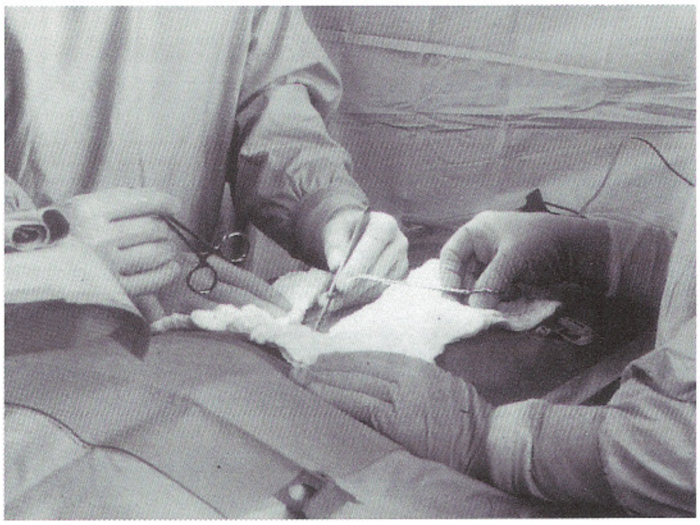
In 1980, CGSB moved to cost recovery for its activities. As a result, Canadian agencies and Supply and Services Canada (SSC) are billed for services rendered. Another significant step was taken in 1989, when CGSB was accredited as a national Certification Organization by the Standards Council of Canada (SCC). As an accredited SWO and Certification Organization, CGSB today is mandated by the Standards Council of Canada to conduct work in specific subject areas, such as surgical rubber gloves and insulation, and we are an integral part of the National Standards System.

Overview of Services

CGSB operates along four primary service lines: standards development, quality management, publications and professional services. Each is identified in the sections which follow:

1).Standards Development Services

Our Standards Branch offers a full range of services for international standards, National Standards of Canada and CGSB standards and specifications. CGSB currently has 1,554 active standards, accounting for 59% of all the standards developed by all five accredited Standards-Writing Organizations in Canada.



Disposable Sterile Surgical Rubber Gloves (20-GP-25M) are among the 1500 standards that are set by the CGSB.

CGSB develops these standards by drawing upon the expertise of over 5,000 volunteers from all sectors. These volunteers donate their time and effort to the consensus standards process, which involves approximately 400 technical committees in over 100 subject areas. The standards development service line has three major clients: Supply and Services Canada (SSC), other public sector organizations, including federal and provincial departments, and the private sector.

2).Quality Management Services

Quality management services include qualification, certification and quality assessment programs and inspection services. Qualification programs have been used by SSC and other public and private sector procurement offices since they were first offered in 1979. The programs enhance procurement by establishing a listing of suppliers who have demonstrated their ability to supply goods and services that meet performance and quality assurance standards. The quality of listed products and services is established and monitored through scheduled testing against the standard and facility audits for quality assurance. CGSB has over 175 qualified program lists, referencing 200 manufacturers supplying 1,200 products in a wide range of subject areas.

Certification programs, while similar to qualification programs, offer a higher level of quality assurance by requiring more frequent plant audits and product evaluations. Once approved, manufacturers are licensed to use CGSB's certification mark on their products and marketing material. Certification programs are most often demanded for the following: health and safety related products, for reference in regulation and for products with high rates of failure. These programs are also used by manufacturers to gain a competitive advantage in their specific marketplace by assuring customers that their products meet a specific registered standard.

The programs ensure goods and services purchased are of the required quality. As a result, the procurement process is simplified and enhanced, eliminating the use of additional SSC resources to perform quality assurance tasks. The lists are provided to over 65 public sector procurement bodies and more than 175 private sector agencies, such as hospitals and universities in Canada and the United States.

The Quality Assessment Program compares vendors' quality assurance plans against the appropriate International Organization for Standardization (ISO) 9000 standard, the leading indicator for quality in industry. This allows manufacturers to demonstrate, through annual evaluations of their quality systems, that they are a source of consistently reliable, quality products. Assessment programs are now being developed in the manufacturing, distribution and services sectors.

Inspection services are a small but active market with other government departments. CGSB currently performs finished product inspections for the Canadian International Development

Agency (CIDA) and Correctional Services Canada (CORCAN). CORCAN is now using CGSB to help them develop and implement a system that will meet the requirements of the ISO 9000 quality standard. CGSB can refer to CSA and international standards when performing finished product inspections.

3) Publication Services

CGSB's publication service consists of the sale and/or distribution of documents produced by our organization. Our publications include the following: over 1,500 bilingual standards; over 175 qualification and certification product listings; an annual Catalogue of Standards, indexing all of CGSB's publications, and the Quarterly Journal, listing work-in-progress and promoting standardization services.

CGSB operates an on-site Sales Unit to take orders by phone, fax electronic communication, letter and over the counter. The Sales Unit also processes orders for promotional videos explaining CGSB's services and the standardization process.

4) Professional Services

CGSB provides various professional services for SSC, including representing the Department on the following: the Product Quality Management (PQM) Committee, whose mandate is to strengthen product quality management within SSC; the Intergovernmental Committee on Procurement Standards (ICOPS), which works to further the economic benefits of standardization by harmonizing federal-provincial procurement standards and associated listing programs, and; the Treasury Board Advisory Committee on Material Specifications (TBACMS) and its four sub-committees (information technology, furniture, environment and quality assurance), which coordinate procurement in the federal government.

Benefits

The Canadian General Standards Board, an integral part of Supply and Services Canada, supports the Department by:

- reducing the cost of developing standards by providing a centralized source of expertise;
- reducing the cost of procurement through a simplified and consistent definition of requirements;
- reducing the risk and the associated cost of acquiring goods of unknown quality.

CGSB services also provide benefits for Canadian business, including the following:

- promotion of Canadian exports
  Our impact on industry is significant. The cost savings in having to qualify in only one jurisdiction for reference both nationally and internationally are substantial. More and more, Canadian industries are recognizing the value of international standards, third-party certification and quality assessment as they strive to become more competitive in the North American Free Trade and European markets.

- promotion of effective and efficient regulation
  Standards and third-party certification is starting to be recognized as an alternative to publicly funded regulatory enforcement. CGSB's standards are currently referenced in a number of regulatory environments such as Health and Welfare Canada, Transport Canada, Agriculture Canada and Consumer and Corporate Affairs Canada.

- promotion of fair and open bidding
  CGSB develops National Standards of Canada through committees that have representatives from all sizes of companies from every region of the country. Any business producing or distributing a product or service that meets the requirements of the appropriate standard can now compete for government contracts on a level playing field, no matter how small they may be.

Example of a CGSB product certification listing mark.

A New Direction

On February 28, 1991, the Honourable Gilles Loiselle, President of the Treasury Board Secretariat, announced the Canadian General Standards Board would become a Special Operating Agency (SOA). An SOA is a new organizational model that will provide a better service to clients at a competitive price. In short, we will become much more like a private company.

The SOA approach will also promote improved efficiency by freeing up resources formerly used for process control; providing staff with greater incentives for finding better, more efficient ways of carrying out work, and by focusing more clearly on reducing operating costs.

The Canadian General Standards Board is scheduled for full implementation of its SOA status by April 1, 1992. Needless to say, we are excited about the prospects this initiative entails. Based on the past experience of other public organizations that have embraced the SOA concept, CGSB expects to improve our services to both the government and to our private sector clients. We will also seek to build more long-term relations with our clients. In the end, we believe our new direction will help us do more with less.

The Agency, as a whole, will work to see that organizations, both public and private, have a greater understanding of the many benefits of standardization and how these services can increase quality in the manufacture and delivery of goods and services throughout the Canadian marketplace. That means more sales for companies, better profits and, in the long run, a stronger more prosperous and more competitive Canadian marketplace.■

For further information on the services provided by CGSB, please contact the following:

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About the author

Jeffrey D. Weir is a Special Projects Officer in the Office of the Secretary, Canadian General Standards Board, in Hull, Québec. Mr. Weir is the author of "Europe 1992 - Standards, A Key to Industrial and Financial Expansion in the Global Technology Era" (1990) and "The Canada-United States Free Trade Agreement: Impact on Technical Standards and Manufacturing Industries" (1991). (Both publications are available from the CGSB Sales Unit).

Letters to the Editeur / Lettres à l'éditeur

Dear sir,

In the Fall issue of the Review, you printed an article by Dr. Taylor on the present state of physics education in Ontario. Included in the article were twelve questions which I tried to answer, using what physics I remember from twenty years ago. I have now gone through the Winter 1992 edition, but the answers to the test were nowhere to be found. Please furnish the answers so I, and others can get some sleep at night. I did find it very interesting.

Michael Reiser, Sudbury, Ontario

Professor Taylor has provided the following answers using "g" = 10 m/s^2: (1) 5cm (2) 1080 m (3) 14 m (4) ball thrown up (or down) (5) 4 m/s (6) 32.8 km/h, N19°E (7a) 100 m (7b) 45 m/s (7c) 9 s (8) 161 m (9a) 877 m (9b) 173 m (10a) 6.1 s (10b) 1644 m (10c) 3170 m from A (10d) 371 m/s (11a) 41.4° (11b) 4.5 min (11c) 495 m from starting point (12) 40 min, 176 km S 17.75° E of base B.

Dear sir,

The article, "Savings and Other Benefits of Energy Efficient Motors" (Winter 1992), provides interesting reading. I am particularly interested in motor rewinding. I worked as a Training Manager in a Lagos-based firm in Africa, whose major business was the rewinding of motors of all dimensions. In terms of the efficiency, life expectancy and the operating temperature of rewound motors, we never had any serious problems. The major problem that we initially experienced was that in times past, many of the rewinders made wrong choice of wire gauges. Since Nigeria could not entirely depend on buying new machines, this method (of correct rewinding) has been very useful to the country's engineering industry for over twenty years.

Enyinda N. Okey, Fredericton, New Brunswick

Letters to the editor

Letters should be addressed to the Managing Editor. They should include the writer's name, address and telephone number and may be edited for purposes of clarity or space.

HAMILTON SECTION NEWS

On January 20 1992, the Hamilton Section sponsored a unique dinner in honour of all Past Chairmen of the Section whose IEEE history started in 1963. The purpose of the meeting was to honour these past members as well as give them the opportunity to reacquaint contacts, highlight accomplishments and gather years of accumulated volunteer experience for future Hamilton activities.

Twenty seven people attended the dinner with **Ken Peacock**, the local Section Historian, acting as Master of Ceremonies. The meeting was dedicated to the late **A. Herb Sievert,** the first Hamilton Section Chairman, who himself was the Section Historian from 1964 - 1991. Each Section Chairman spoke about his term of office and related experiences.

For more detailed information on this meeting please contact IEEE Canada Office.

Cellular Telephony (Part 2)

Digital technology comes to the the rescue

by Tony Hontzeas, P.Eng.
Ericsson Communications Inc.

Today's cellular telephony uses analog voice and control channels. This means that when a particular cell runs out of capacity, the cell must be split by adding extra hardware. This increases the cost of running a cellular network considerably.

Through digital voice and control channels as well as time division multiplexing digital technology allows a capacity increase of as much as a factor of six without requiring the capital outlay or introducing the maintenance costs that analog technology does. Further, since digital technology will be phased in, the cellular network will be able to provide service for both the traditional analog mobile phones and the new digital phones.

La téléphonie cellulaire actuelle utilise des canaux de voix et de contrôle analogues. Ceci implique que lorsqu'une cellule atteint le maximum de sa capacité, de l'équipement additionnel doit être ajouté afin de subdiviser la cellule. Il en résulte des coûts supplémentaires considérables.

Par ailleurs, l'utilisation de canaux digitaux permet d'augmenter jusqu'à six fois la capacité, sans pour autant ajouter les coûts reliés à l'équipement et la maintenance additionnels comme dans le cas de la technologie analogue. De plus, puisque cette technologie digitale sera introduite graduellement, les réseaux de communication cellulaires devront être flexibles et offrir leur service autant aux utilisateurs du traditionnel téléphone cellulaire analogue qu'à ceux du téléphone digital.

Although a more thorough treatment of cellular telephony is given in the September 1990 issue of the IEEE Canadian Review, we will briefly review some fundamental principles.

We recall that a cellular network consists of a given geographical region divided into subregions called *cells* (Figure 1). Each cell consists of a low-power analog transmitter/receiver known as a *base station* (BS) whose main purpose is to establish a communication link with any mobile telephone (or car phone) that is within the base station's vicinity and thus give the mobile phone access to the cellular network. The BS uses a *control channel* to send non-speech control information to the mobile phone. For instance, the information could instruct which *voice channel* (VC) to use. On the other hand, the VC's are used by the car phone and the base station to transmit/receive speech over the airwaves. The BS also contains signal strength receivers that allow it to measure the VC signal strength.

Now all BS's in a certain region are connected to a central computer over signalling links, and it is this computer that handles telephony traffic and instructs the BS's on how to handle each mobile phone. This central computer is called a *Mobile Telephone Switching Office* (MTSO) and is nothing more than a regular telephone switch with extra hardware for cellular control.

When a driver is talking through his or her car phone, the mobile phone hardware modulates the speech signal into a frequency within the 800-900 MHz FM band and uses one of a cell's available voice channels to transmit the signal to the base station which, in turn, sends the voice information to the MTSO. The BS then receives speech information from the MTSO, transmits it via a voice channel to the mobile phone and the mobile phone in turn demodulates the signal and presents it as audible information to the driver.

If the car is driving out of a certain cell's range, special signal-strength measuring hardware in the cell's BS will sense the mobile phone's deteriorating signal and alert the MTSO. The MTSO will then order the BS's in the surrounding cells to tune to the VC used by the mobile phone, and provide the MTSO with signal strength measurements. The MTSO will then choose the BS that provides the strongest measurements and order the mobile to tune to a free VC in the cell controlled by this BS. The process of choosing a new cell for the mobile phone is called *Locating* and the process of the mobile phone relinquishing one VC and re-tuning to another while at the same time maintaining speech is called *Handoff*.

Frequency re-use and cell splitting

Low power BS's allow cellular technology to make excellent use of the limited frequency spectrum allocated by the FCC. Each cell can participate in *frequency re-use* (FR) by employing the same set of frequencies another cell uses, on the assumption that the cells are far enough apart so that channels within the two cells do not interfere with each other. Ideally, each adjacent cell should be able to use the exact same frequencies that its immediate neighbour uses, but FM makes this impossible. If the number of available VC's is not sufficient to provide the existing subscriber base with acceptable service, then *cell splitting* is performed. This involves lowering the BS's transmission power and adding an additional BS. Thus, as the number of cells is increased by repeated splitting, frequency re-use may be used more frequently, thus increasing the number of available channels and improving the system's ability to handle more telephone traffic within the 800 MHz spectrum band.

The capacity problem

Ideally, cell splitting and frequency re-use should allow a company providing cellular telephone service (the cellular operator) to adapt to increasing customer demand. However cell splitting requires the operator to purchase new BS's and to install signalling links between the new BS's and the MTSO. If the number of cell sites to be split is large, then this will require a large capital investment and will also increase the cost of running and maintaining the network. In order to make ends meet, many operators have to pass on this cost increase to their customers in the form of higher subscription and call charging rates.

A solution was needed that would allow a capacity increase while at the same time keeping the operation and maintenance costs stable. This solution is provided by digital technology.

Digital voice channels

Today, when a subscriber talks over a mobile phone, the phone will convert the speech to analog pulses, frequency-modulate those pulses and transmit the modulated wave to the BS. Similarly, the BS will use analog FM to send speech information over a particular voice channel or signalling information over a control channel.

Each available voice channel in a cell can only be used by one mobile phone at a time. If by accident, say, two or more mobile phones attempt to use the same voice channel to transmit/receive speech to or from a BS, then crosstalk will occur. This unwanted effect is also called a party line and is very common in landline networks with badly insulated telephone wires.

With digital techniques, it is possible for many mobiles to use the same voice channel at the same time with no interference at all. This is done through a process know as *Time Division Multiplex Access* (TDMA) (see Figure 2). A mobile phone will now take the speech information received from its handset microphone and encode it into a series of bits. This series will then be transmitted over the airwaves to the BS, but the transmission will only be allowed at certain time intervals called *Time Slots* (TS). Similarly, a mobile phone will only be permitted to tune into certain time slots. The digital information the mobile phone reads from these TS's will be decoded into analog pulses, sent to the mobile phone's earphone and converted into intelligible speech.

Each base station will be able receive/transmit a frame of six TS's at a time which implies that each BS will be able to communicate simultaneously with six mobile phones.

The time slot that a mobile phone is allowed to use is chosen by the MTSO and is communicated to the phone via the BS's control channel at call setup.

Each TS will be modulated by using a form of $\pi/4$ Quadrature Phase Shift Keying ($\pi/4$QPSK) which involves applying a symmetrical baseband signal x(t) to a carrier $\cos(2\pi f+m(t))$, where $|x(t)|=1,3$ and $m(t)=x(t)*\pi/4$. In practice, the cosine carrier is generated by a linear combination of the orthogonal basis vectors $\sin(2\pi f)$ and $\cos(2\pi f)$ and allows improved error performance because of the large distance between complementary signal space points.

Thus the operator can replace each analog voice channel with a digital one and increase the capacity of that particular channel number by a factor of six. This results in a system consisting of both analog and digital voice channels, and an analog control channel. Similarly, if in a particular cell all the analog VC's are replaced by digital ones, then the call handling capacity of that cell is increased six times.

Adapting to the digital trend

Because today's mobile phones are analog and because conversion to digital technology requires an outlay of capital both for the operators and the subscribers, the move to digital cellular telephony will be done in two phases. Phase one will see mobile phone manufacturers introduce dual mode mobile phones which will be able to use both analog and digital voice channels, but only analog control channels. Cellular operators on their part will replace some of their analog VC's with digital ones, thus accomodating both dual mode and analog subscribers.

In phase two, the analog voice and control channels will disappear completely in favor of their digital counterparts. Today's analog-only mobile stations will also become redundant just like the long-playing record has given way to digital compact disks.

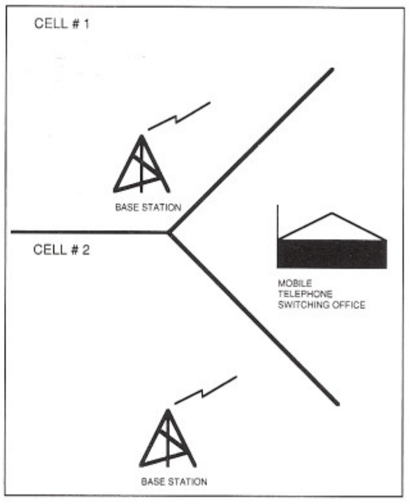


Figure 1 A cellular system composed of two cells.

Locating and handoff

The principles of locating and handoff remain the same as in the analog case (c.f. IEEE Canadian Review, September 1990). A BS must be able to perform locating on both analog and digital VC's. If locating is intended for an analog VC then, as today, the signal strength receivers inside a BS will tune to that voice channel and measure the carrier signal strength, provide the measurements to the MTSO and the MTSO will choose the cell that is best suited to carry the conversation.

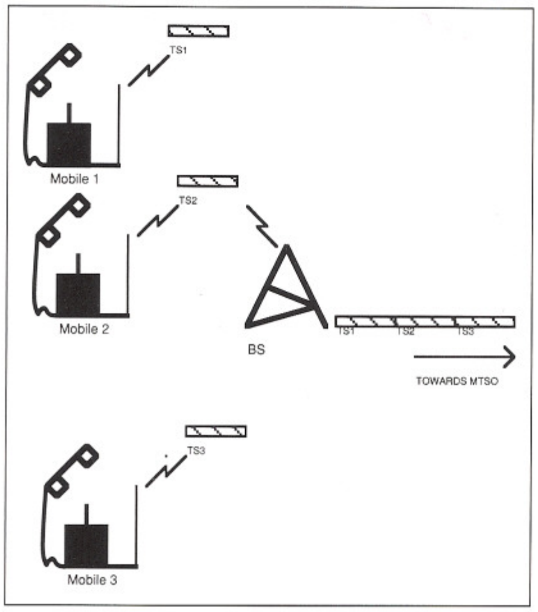


Figure 2 Three mobile telephones transmitting in three different time slots. The base station accumulates the three different bursts and sends them to the Mobile Telephone Switching Office MTSO.

Similarly, in the digital case, a special device known as a *verification module* will be used to tune into the mobile phone's particular time slot and read the TS bit information. It will count how many wrong bits (known as the *bit error rate* or BER) the particular time slot contains. However, there is a slight complication in the digital locating case. Since the information in a particular time slot is coded, the call can be maintained only as long as the BER is at a level that permits the mobile phone to perform proper decoding. If the BER exceeds a certain limit, the call will be automatically dropped without warning, since digital decoding will be impossible. It is therefore necessary to continually monitor digital calls and the moment the BER exceeds a preset threshold, to initiate a handoff. If a handoff is not initiated, the call will be suddenly dropped even though the speech quality may still be acceptable.

Continual BER measurements may take a lot of MTSO time, time that may be used to do other things such as setting up new calls. In order to avoid this, the measurement burden will be passed on to the mobile station in the form of *Mobile Assisted Handoff* (MAHO).

In MAHO, the base station uses the control channel to order the mobile phone to perform BER measurements on a certain set of frequencies. The base station supplies these frequencies to the mobile phone. Once the mobile phone performs these measurements it transmits the results to the MTSO via the BS. The MTSO then decides whether or not to initiate a handoff. Hence, while the mobile station is measuring BERs, the MTSO can devote its time to performing other functions.

Conclusion

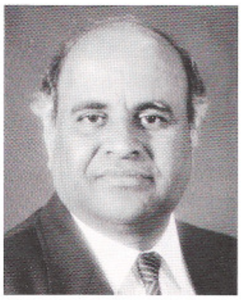
Telephony has always been described as evolving and never undergoing a revolution. This means that each new telephone system should be backward compatible with existing systems so that a customer will have sufficient time to adapt to any new technology. Thus, digital technology will be phased in so that system capacity will be increased without disrupting the high quality of service that analog subscribers are used to. ■

About The Author

Tony Hontzeas received his Bachelor of Engineering degree (Computer Option) from McGill University in 1986 and is presently employed as senior engineer with Ericsson Communications Inc. in Town of Mount Royal, Quebec, Canada.

TEN CANADIANS HONOURED BY THE IEEE IN 1992

NINE FELLOWS + THE NICOLA TESLA AWARD – CONGRATULATIONS !

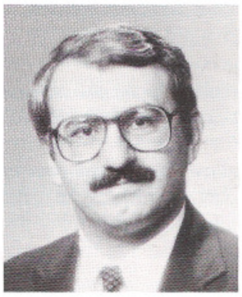


Vijay K. Bhargava, S70 M74 SM82 F92, Professor, Electrical and Computer Engineering, University of Victoria, B.C., **for leadership in the development and applications of error control coding devices**.

Steven A. Boggs, M80 SM89 F92, Director, Research & Corporate Development, Underground Systems Inc, Toronto, **for understanding of the dielectric behaviour of SF6 gas-insulated substations.**

G. S. Peter Castle, S66 M68 SM77 F92, Professor, Electrical Engineering, University of Western Ontario, London, Ontario., **for the practical application of electrostatic forces in industry and agriculture**.

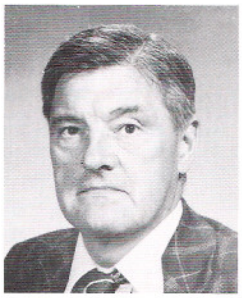
Francisco D. Galiana, M72 SM85 F92, Professor, Electrical Engineering, McGill University, Montreal, Québec, **for sustained innovations in power flow and contingency analysis for power systems planning and operation.**



Mohsen Kavehrad, S75 M78 SM86 F92, Professor, Electrical Engineering, University of Ottawa, Ontario, **for digital communications applied to indoor wireless communication and optical networking.**

John S. MacDonald, S57 M59 SM78 F92, Chairman, MacDonald Dettwiler, Richmond, B.C., **for leadership in the development of techniques in terrestrial monitoring**.

Boris Mokrytzki, SM89 F92, Manager, Research & Development, Siemens Electric Ltd, Brampton, Ontario., **for developments in pulse-width modulation techniques for semiconductor inverters for large ac motors.**



Lawrence Young, SM67 F92, Professor, Electrical Engineering, University of British Columbia, B.C., **for understanding of the growth and** properties of anodic, thermal and plasma oxides.

Phoivos D. Ziogas, S75 M78 SM89 F92, Professor, Electrical Engineering, Concordia University, Montreal, Québec, **for solid-state power converter topologies.**

Thomas H. Barton, Emeritus Professor of Electrical Engineering, University of Calgary, has been awarded the 1992 IEEE **Nikola Tesla Award for the practical application of the generalized theory of electrical machines to A.C. and D.C. drives.**

OTHER AWARDS AND DISTINCTIONS

At the December 6 Advisory Committee meeting of the IEEE Professional Communications Society, **Ron Blicq,** Winnipeg Section, was presented with the Society's first President's Award, in recognition of his many contributions to the Society over the past two years. The Society for Technical Communication also named Ron as one of the 12 Associate Fellows for 1992, the only Canadian to receive such an honour.

George Vaillancourt, Senior Member of IEEE and researcher with the Service Mesures et informatique at Hydro-Québec, was recently appointed as standards coordinator for the Transformer Committee of the Institute. His responsibilities will include liaison with the technical committees of the Power Engineering Society and with the IEEE Standards Board.