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IEEE Canadian Review

The Spotlight SAR Project
Overview of Protecting Inventions by Patent
Bombardier's New Generation Tilting System

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(ii) Canadian members of the profession and community who are non-members of IEEE;
(iii) the associated academic (i.e. universities, colleges, secondary schools), government and business communities in Canada.

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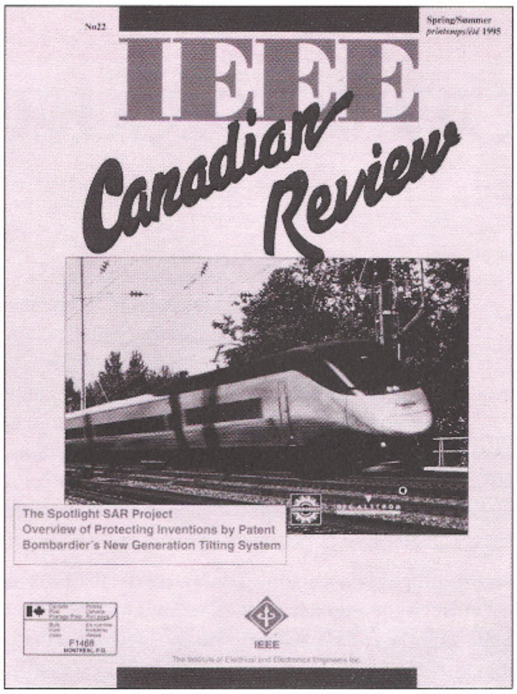
Cover picture

The new Tilting system has a promising future. VIA Rail is presently studying a potential retrofit of the existing tilting system and AMTRAK is requesting proposals for the supply of high-speed tilting trainsets for the Northeast Corridor.

Tableau couverture

Bombardier Eurorail, Bombardier's equivalent of the Transportation Equipment group in Europe, is well informed of the development of the new tilting system. Together, they offer worldwide possibilities to the New Generation Tilting System.



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DIRECTOR'S REPORT/*RAPPORT DU DIRECTEUR*

Ray Findlay

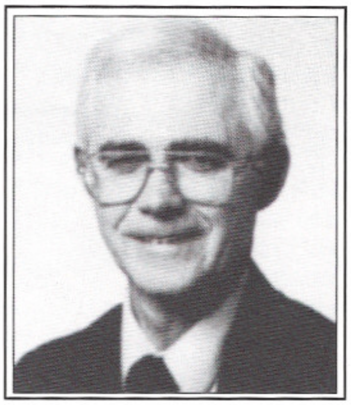
S*ervice to our Members* used to be the motto of IEEE. Many of us who were a part of that grand scheme still believe in it and want to ensure that it continues. In Canada, we plan to do something about it, too. During the coming months we will be embarking on a phone campaign to contact every member in the region. We want to ensure that the information we have about our members is correct. And we want to find out what our members want from IEEE Canada. Excluding students, there are about 14,000 members from across Canada. We hope to talk to each one.

We are compiling a «shadow» data base for IEEE Canada members to run on the Region computer maintained in Ottawa. This database is Oracle-based, as is the IEEE data base. We are sharing information with the IEEE Operations Centre. Our objective is to help the centre run smoother and to provide our members with quality service.

One of the things the Board of Directors is considering right now is the restructuring of the volunteer structure of IEEE. One of the objectives stated is to make the Board more policy oriented rather than process oriented. Some Board members are distressed with the amount of work required of a Board member in the current scheme. They believe that any of the proposed scenarios would reduce the amount of effort required of a Board member. Three possible scenarios for a new structure are presented in the June issue of the Institute. I urge every member to read this item and to express your opinion on it.

One of the issues we in IEEE Canada need to consider is: which structure would best serve our needs, the current one, one of the three alternatives presented, or some other variation of the current structure. In the current structure, I, as your Director, have direct input to the Board of Directors. This would disappear under all three proposed alternative structures. Every model presented would have Board members «elected at large.» I do not believe that a governing body of a democratic organization can govern effectively without responsibility to an established constituency. In the current model the constituencies are clear - ten regional constituencies, and ten technical constituencies. Additional board positions include the Vice Presidents of the six boards, the three presidents, past current and future, and a few others.

Part of the dilemma is whether you think we belong to a US organization with some international members, or whether you think we belong to an international organization based in the United States. All three models might enhance the former. In my view, none of the models presented would enhance the international nature of IEEE. None would have the overall responsibility of interfacing with both the volunteer structure (the Board) and the equivalent departmental structure in the Operations Centre, to ensure that members' needs are met. I keep asking myself, if things are tough now, who will do the work on a Board that has been diminished in size? Whether you agree with my conclusions or not, please consider this matter carefully and make your views know. Send your comments to Henry Shein at IEEE HQ, or at info.oi.plans@ieee.org



L*e service aux membres*, telle semblait être la devise d'IEEE. Bon nombre de ceux qui sont prenants de cette théorie y croient encore et tiennent à s'assurer de sa poursuite. Au Canada, nous comptons également appliquer cette devise. Dans les mois qui suivent, nous entreprendrons une campagne téléphonique durant laquelle nous contacterons chaque membre de la région. Nous voulons d'abord nous assurer que l'information que nous avons sur nos membres est exacte et nous voulons savoir exactement ce à quoi s'attendent les membres d'IEEE Canada. Mise à part les étudiants, IEEE Canada compte environ 14,000 membres à travers le Canada. Nous souhaitons parler à chacun d'entre vous.

Nous sommes à compiler une base de données parallèle des membres d'IEEE Canada pour notre système informatique à Ottawa. Cette base de données est de type Oracle comme celle d'IEEE et ainsi, nous partageons les données avec le centre d'opérations d'IEEE. Notre objectif est de faciliter le travail du centre et de fournir un service de qualité à nos membres.

Présentement, un des éléments mis en question par le conseil d'administration est la structure bénévole d'IEEE. Un des objectifs exprimés est d'amener le conseil à une structure plus directive qu'exécutive. Quelques membres du conseil sont très préoccupés par la quantité de travail demandée aux membres du conseil dans la structure actuelle. Ils croient que l'un ou l'autre des trois scénarios de restructuration proposés dans le numéro de juin de l'Institut, réduirait l'effort demandé aux membres du conseil. J'encourage chaque membre à lire cet article et à exprimer son opinion sur le sujet.

En effet, la question suivante est au coeur du débat : quelle structure répondra le mieux à nos besoins, celle actuellement en place, un des trois scénarios proposés ou encore devrait-on se doter d'une autre option? Présentement, le directeur d'IEEE Canada a une incidence directe sur le conseil d'administration et ce rapport disparaîtrait selon les trois scénarios présentés, chacun proposant que les membres du conseil d'administration soient élus «at large». Je ne crois pas que le corps dirigeant d'un organisme démocratique puisse le gérer correctement sans faire appel aux groupes d'électeurs établis. Selon la structure actuelle, les rôles sont bien définis : dix groupes à caractère régional et dix groupes à caractère technique. De plus, notons les vice-présidents des six comités, les trois présidents (passé, présent et futur) ainsi que quelques personnes supplémentaires. Au fond, IEEE est soit un organisme américain ayant quelques membres internationaux soit un organisme international ayant son siège social aux Etats-Unis, et les trois scénarios favorisent le premier. À mon avis, aucun ne renforce l'essence internationale d'IEEE et par conséquent, aucun n'assure que le service aux membres à travers le monde soit prioritaire. Je me pose donc la question suivante : si les choses sont difficiles actuellement, qu'arrivera-t-il avec un conseil réduit? Que vous soyez d'accord ou pas, je vous invite à y refléchir et à faire connaître votre opinion auprès de Henry Shein au bureau chef d'IEEE ou à info.oi.plans@ieee.org.

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THE SPOTLIGHT SAR PROJECT

An Imaging Radar for the Canadian Military

This is the third article in a series describing Canadian Synthetic Aperture Radar (SAR) activities and initiatives. Previous articles have discussed systems operated by the commercial sector[1] and the federal government[2]. In this issue, we explore SAR from the military perspective.

by Major Pushkar E. Godbole, George T. Haslam, and Dr. Malcolm R. Vant
National Defence

This article describes the "Spotlight SAR Project", an initiative by the Department of National Defence to develop an all weather, long range target classification and surveillance capability for Canada's fleet of CP-140 Aurora Long Range Maritime Patrol Aircraft. The Spotlight SAR project will provide the Canadian Department of National Defence with one of the most sophisticated SAR systems in the world and should help establish Canadian industry as a world leader in this area of surveillance technology.

Cet article décrit le projet portant sur le développement du radar à ouverture synthétique «Spotlight». Cette initiative du département de la Défense nationale a pour but de permettre à la flotte d'aéronef de patrouille maritime CP-140 Aurora de surveiller et de classifier, en tout temps, des cibles d'intérêts à longue distance. Ce projet fournira au département de la Défense nationale l'un des systèmes radars à ouverture synthétique les plus sophistiqués au monde. De plus, ce projet devrait aider a établir l'industrie canadienne comme étant un leader à l'échelle mondiale dans le domaine de la technologie de surveillance radar.

The Spotlight Synthetic Aperture Radar (SAR) project is an initiative by the Department of National Defence to develop a high performance SAR system for the CP-140 Aurora Maritime Patrol Aircraft. The project has been ongoing since the late 1970s and has been continuously pushing the limits of achievable technology. The currently flying version of the Spotlight SAR system is the highest resolution system in Canada. A further improved version is planned to be installed on Canada's fleet of CP-140 Aurora Long Range Maritime Patrol Aircraft.

The CP-140 Aurora is the primary strategic airborne surveillance platform in Canada and is called on to perform a variety of surveillance and sovereignty operations over the Canadian landmass and coastal areas. Typical operations include: patrols over the remote northern areas, support in monitoring and enforcing the 200 mile economic zone, pollution monitoring, and counter drug patrols. The current radar on the CP-140 Aurora, although very capable, is only a detection radar. In the case of sea surveillance, the current radar is designed to detect the presence of extremely small objects at long ranges over the sea. It gives very little descriptive information on the nature of the target which would allow the operator to determine whether it is a fishing boat, military ship, or iceberg.

An imaging radar is extremely well suited to military applications because of its long stand-off range and its inherent ability to operate in all weather, day or night. In a large sparsely populated country such as Canada, territorial surveillance of the land mass and surrounding oceans can be very difficult and costly. An imaging radar acts as a force multiplier since it allows a single aircraft to observe a much greater area than would normally be possible with visual sensors alone. As a result of these benefits, DND embarked on a SAR development program in the late seventies known as the Spotlight Synthetic Aperture Radar Project. The Spotlight SAR will provide a significant improvement over the existing capabilities of the Aurora radar. It will be a highly effective tool for conducting sovereignty operations and surveillance of Canada's three oceans.

Project Chronology

A brief history of the Spotlight SAR project to date is as follows:

- 1978-1984 - Preliminary research and feasibility studies initiated at the Defence Research Establishment Ottawa.
- 1985-1991 - eXploratory Development Model (XDM) Phase culminating in the successful demonstration of a real-time Spotlight SAR capability on the Convair 580 Aircraft operated by the National Research Council's Institute for Aerospace Research.
- 1992-1993 - Definition Studies and continued development of the XDM system. Formal approval of the Advanced Development Model (ADM) Phase was obtained in September 93.
- January 95 - Award of a three year contract to Loral Canada (Ottawa) for the development, production and installation of the Spotlight SAR ADM system on the CP-140 Aurora aircraft. Sub-contractors on the team include Applied Analytics (Toronto), Array Systems Computing (Toronto), International Marine Products (Halifax), Omega-Telemus (Ottawa), and Raytheon Canada (Waterloo, Ont).

Synthetic Aperture Radar (SAR) vs. Conventional Radar

After completion of the ADM Phase, the Spotlight SAR system is

1. Lowry, R. T., M. D. Thompson, and J. B. Mercer. "The STAR-1 Synthetic Aperture Radar". *IEEE Canadian Review*. Fall 1994.
2. Livingstone, C. E. "The CCRS Synthetic Aperture Radar System: a Canadian national Facility". *IEEE Canadian Review*. Winter 1994.

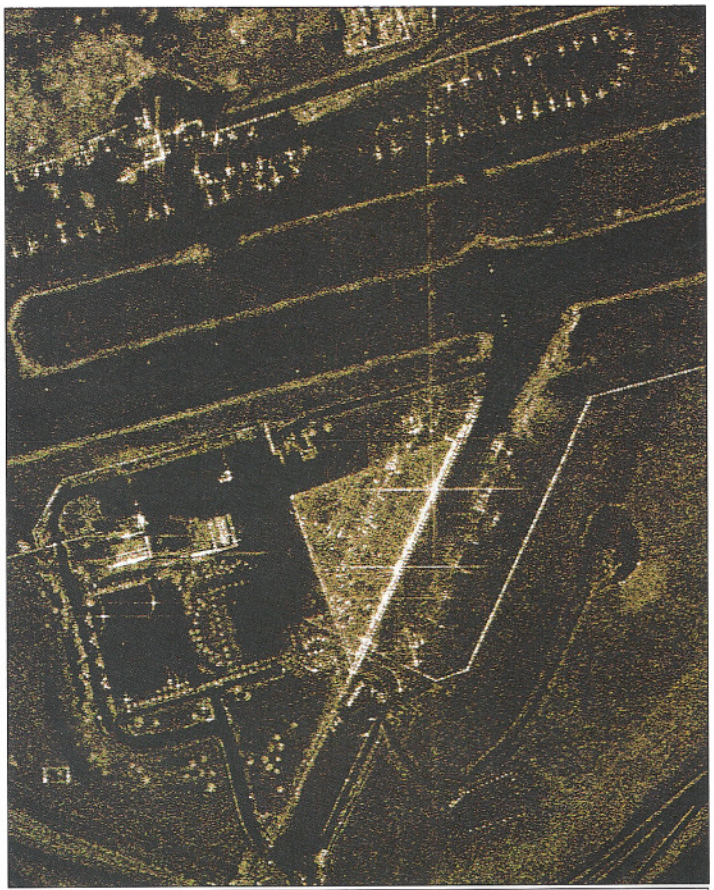


Figure 1: SAR image of the National Aviation Museum

Figure 2: SAR image of the Dunbar Bridge over the Rideau River, Ottawa, Ontario.

expected to be deployed on Canada's fleet of eighteen CP-140 Aurora Aircraft as part of the Aurora Life Extension Project (ALEP). The ALEP project will begin its definition phase later this year and production preparation should commence in late 1996.

A conventional radar, such as the current radar on the CP-140, usually only provides an indication that a target has been detected. This will appear in the form of a low resolution featureless blip on the radar screen. A conventional airborne surveillance radar will typically have a cross-range resolution in the hundreds or thousands of meters while a high performance SAR, such as the Spotlight SAR, can support resolutions less than a meter.

To achieve fine resolution, a SAR simulates (or synthesizes) a very long antenna (or aperture) and hence the name Synthetic Aperture Radar. In the higher resolution modes, the synthesized antenna length can be over a kilometer long, which is well beyond the size any antenna that could be carried on an aircraft.

SAR imagery of terrain often resembles aerial photography. This is particularly true of coarser resolution imagery of vegetation and rural areas. A SAR can operate from a significant stand-off range yet provide an image which, except for the presence of radar shadows, appears as if the sensor were directly overhead. The long range capability of SAR makes it particularly useful to military and para-military applications. A long stand-off range allows the surveillance of hostile territory or targets without having to take the aircraft into the range of hostile missiles, also known as the missile engagement zone. In more benign situations, such as surveillance of the 200 mile economic zone, SAR allows for the surveillance of distant areas without actually having to transit the aircraft to the area of interest. In a conventional radar, a small target such as a ship would appear as a poorly defined blob or blip. Even with an ordinary commercial SAR, a moving ship on the high seas would be a defocussed blob, and not very useful for surveillance. The Spotlight SAR system uses special adaptive algorithms to provide imagery of sufficient resolution and fidelity to allow determination of the class of vessel for sea-going targets.

System Description

The Spotlight SAR system is a multi-mode imaging radar designed to provide a capable and flexible system for military surveillance. The version of the Spotlight SAR system destined for the CP-140 Aurora is designed as an upgrade to the existing Texas Instruments AN/APS-506 radar (also known as the AN/APS-116). The AN/APS-506 is a high performance maritime surveillance radar which is optimized to detect extremely small targets such as submarine periscopes. It has a range of 280 Km and a 500 Kilo-Watt peak power. The Spotlight SAR upgrade will primarily consist of the addition of two signal processing boxes. The modular nature of the Spotlight SAR technology means that it can migrated to other suitable radars. The Spotlight SAR ADM system will make maximum use of ruggedized commercial technology and components will only be built to full military specifications, where necessary.

The Spotlight SAR system supports three primary SAR modes, which are as follows:

Strip Map Mode

This mode is similar to that found in commercial SAR systems [1] and it provides an endless strip of imagery parallel to the aircraft's flight. Providing high resolution imagery in real time at long range requires significant signal processing resources since the data must be processed at a rate that is proportional to the speed of the aircraft.

Figure 3: The CP-140 Aurora Maritime Patrol Aircraft. Canada's fleet of Auroras will be upgraded with the Spotlight SAR system under the Aurora Life Extension Project.

Range Doppler Profiler (RDP) Mode

This mode produces a continuous series of snapshots of moving targets, such as ships. The image exhibits the effects of a combination of the aircraft motion (SAR), and target motion (Inverse SAR) [3]. The predominate direction and type of motion determines what the image looks like. Full compensation for the motion of the aircraft, and automatic focussing and tracking techniques allows imaging of both stationary and moving ships. This mode is significantly better than a simple ISAR mode since it effectively combines SAR and ISAR processing techniques.

Spotlight Mode

In the Spotlight Mode, a target or target area of interest is illuminated by the radar and a snapshot of data spanning the synthetic aperture, is acquired. This allows for long synthetic aperture times required to produce high resolution images. The Spotlight Mode consists of two sub-modes as follows:

- Spotlight Adaptive. This mode is optimized to generate images of moving targets such as ships. As with the RDP mode, the imaging mechanism is a mixture of SAR and ISAR, but here only a single snapshot of the target is taken, which allows greater stealth in image collection and greater use of adaptivity in the signal processing. Again, the aircraft motion is fully compensated.
- Spotlight Non-Adaptive. This mode uses the Spotlight technique but is optimized for producing fine resolution images of non-moving targets such as buildings.

Performance Features

The Spotlight SAR system has been designed to be a flexible yet capable SAR system which can support the unique surveillance requirements of the CP-140 Aurora. To achieve this capability, the Spotlight SAR System incorporates a number of special features:

- Digital Pulse Compression. Pulse compression is widely implemented in radar by means of analogue Surface Acoustic Wave devices. In the Spotlight SAR system, the signal is digitized and the pulse compression is performed in the signal processor. This permits the acquisition of imagery and target signatures with an extremely high dynamic range, helping to ensure that the bright portions of a target can be captured accurately along with smaller objects and details. The system can simultaneously capture features spanning a dynamic range in excess of 100,000,000:1 (> 80 dB).
- Inverse Filtering. This reduces the range sidelobes to near perfect levels. In the Spotlight SAR system, the transmitted wave form is sampled, and its amplitude inverse, phase conjugate, is used as the pulse compression filter. The net result is that the range sidelobes from a very bright target can be reduced to near the theoretical minimum level. This helps remedy the usual problem of sidelobes from a very bright object obscuring nearby smaller objects and also corrects for imperfections in the pulse of the underlying AN/APS-506 radar.
- Active Aircraft Motion Compensation. This involves the use of an antenna mounted strap-down sensor package to precisely measure motions which cause variations in the synthetic antenna. Data from

3. Werner, Donald R. High Resolution Radar. Artec House. 1987. Chapter 7.

the antenna sensor is combined with information from an on-board Inertial Navigation System and a Global Positioning System (GPS) receiver to permit the precise calculation of motion correction vectors which are applied to the radar data. If left uncorrected, these errors would have an effect similar to that of a continuously flexing or distorting antenna. Through a combination of hardware and software techniques, all residual aircraft motions, greater than a fraction of a millimeter, are compensated. This capability is particularly important for aircraft such as the CP-140 Aurora which operate at lower altitudes where turbulence is more pronounced.

- Real Time Processing. The Spotlight SAR algorithms are computationally intensive and require a very powerful signal processor to generate imagery in real-time, in the air. For a long range military aircraft such as the CP-140 Aurora, an on-board image generation capability is critical. The ADM version of the Spotlight SAR will require an airborne signal processor with a throughput of approximately 2.5 giga-flops. The processor will be VME based and will use i860 signal processing chips.
- High Resolution Imagery. The Spotlight SAR system supports five resolutions as indicated below. The values are based on the unweighted impulse response in range and cross range and coarser resolution results when weighting functions are used to reduce sidelobes [4].

Mode	Approximate Resolution
Super-Low	12.0m
Low	3.5m
Medium	1.5m
High	<1.0m
Super-high	<1.0m

Conclusion

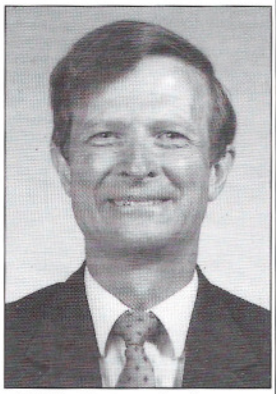
The Spotlight SAR project is an ambitious development effort aimed at satisfying the unique Canadian surveillance requirement with technology that is uniquely Canadian. The Spotlight SAR project will provide the Department of National Defence with one of the most sophisticated SAR systems in the world and will help establish Canadian industry as a world leader in this area of surveillance technology.

4. Skolnik, Merrill I. Radar Handbook, McGraw Hill. 1990. P. 10-31.

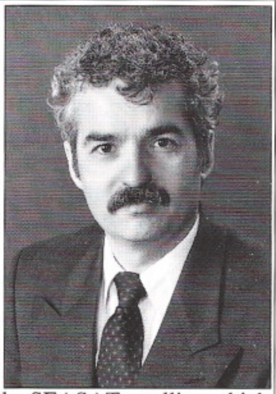
About the authors

Major Pushkar E. Godbole is an Aerospace Engineering Officer with the Canadian Airforce. He graduated from the Royal Military College in 1983 with a degree in Computer Engineering and was stationed with 407 Maritime Patrol Squadron in Comox British Columbia until 1987. He subsequently pursued post graduate studies at Carleton University and graduated with an MEng degree (Electrical) in 1989.

Since that time Major Godbole has been employed on the Spotlight SAR project at National Defence Headquarters in Ottawa and he is currently the Engineering Manager for the Spotlight SAR project.



Mr. Haslam received his B.Sc. degree from Queen's University in 1965 and M.Sc. in Electrical Engineering from Northeastern University in 1969. Prior to joining the Communication Research Centre in 1970, he was a microwave engineer at RCA in Montreal and Microwave Associates in Massachusetts, and a radar systems engineer at Goodyear Aerospace in Arizona. While at Goodyear he was responsible for designing a number of subsystems for synthetic aperture radars. In the early 1970s while at CRC, he worked on an experimental coherent radar for application to northern surveillance. In the mid-70s he led Canadian studies into the processing of SEASAT A SAR data, and conceived the Spotlight SAR concept for the radar onboard the CP-140 aircraft. Later, he was technical manager of the Spotlight SAR exploratory development project. He is currently leading airborne radar surveillance projects in the Airborne Radar and Navigation section at the Defence Research Establishment Ottawa.



Dr. Vant obtained his Bachelor's degree in Electrical Engineering from Carleton University in Ottawa in 1973. He joined Environment Canada in 1974 where he worked on the remote sensing of fresh and sea ice. In 1976, while working for Environment Canada, he completed his Ph.D.in Electrical Engineering at Carleton. In 1976, Dr. Vant joined the DND sponsored Radar Program at the Communications Research Centre in Ottawa. He designed the DND Synthetic Aperture Radar processor for the SEASAT satellite, which in 1979 produced the world's first full resolution SAR images from SEASAT. During the period 1980-1992, Dr. Vant developed several different SAR signal processors for different radar systems, and he was responsible for the signal processing algorithm development and testing for the DND Spotlight SAR Project. During the period 1982-1987, he was also part of the Radarsat Project Technical Office team and had responsibility for the Radarsat Prototype Signal Processor, which eventually became the Canadian Processor for ERS-1. In 1988, Dr. Vant became the Section Head of Airborne Radar at Defence Research Establishment Ottawa (DREO). Since then, the Section has developed programs in Missile Approach Warning, Non Cooperative Target Recognition using Jet Engine Modulation, and Electronic Counter Counter Measures, as well as taking the lead role in Spotlight SAR R&D. In April 1994, Dr. Vant became Director, Research and Development Communications and Space in DND's Chief of Research and Development Headquarters.

OVERVIEW OF PROTECTING INVENTIONS BY PATENT:

Some important recent patent law changes in Canada and the USA

by James Anglehart
Swabey Ogilvy Renault, Montréal

The basics of the patent system are introduced, including what may be patented and the benefit of owning patents. The protection of software is reviewed, and recent changes to US and Canadian patent law are also summarized.

On présente le système des brevets d'invention, ainsi qu'une description de ce qui peut se faire breveter et de l'avantage d'obtenir des brevets. On résume également la protection des logiciels et les modifications récentes aux lois sur les brevets au Canada et aux Etats-Unis.

What does a patent do?

Patents are often seen as something mysterious. Some think that patents are a form of government approval of the merit of an innovation. Others think they are government approval to make and sell an innovation. But in fact, a patent is a legal document that gives you the right to exclude others from making, using or selling a new product or process. A patent starts out as an application filed with the Patent Office (i.e. *patent pending*) which is then examined by the Patent Office before being granted. Patents are an important asset of any technology company, and the rights under a patent can be sold or licensed to others. With some companies, patents are their only significant assets.

How do you know when you have a patentable invention?

You're probably not the stereotypical "inventor" we imagine working in the basement workshop, but if you have already solved a technical problem by designing a new electronic apparatus, process, system or software, you are likely to have invented something. An invention is patentable when any part of it can be described as new and inventive. "New", as you can guess, simply means the part of the product or process has never been done and published before anywhere in the world. "Inventive" does not mean that it must be deserving of a Nobel prize or an IEEE award. Inventive simply means that the part of the invention which is new cannot be deduced from what has been done before in the same area of technology without using any imagination.

A patent search or a literature search in addition to your own knowledge is useful in determining what has already been done in the area. Patent searches can be carried out using on-line databases such as those available through Questel/Orbit (1-800-456-7248) or Dialog (1-800-334-2564) and/or by manually looking through the indexed patents at the Patent Office in Hull, Quebec or Washington, DC. At http://www@uspto.gov on the internet, you will find a variety of information about patents provided by the US Patent and Trademark Office, as well as the Canadian Intellectual Property Office. Full text of only some recent (i.e. 1994) US patents are available for searching and printing, while all US patents relating to AIDS are available for searching. Searching patents by keyword is always less certain than manually looking through all patents in the relevant patent classes to find relevant patents. A registered patent agent will, for a fee (ballpark of $800 to $1200), carry out a search on your invention and provide you with a patentability opinion.

Publish and your patent rights perish.

When you are managing your product development, remember that you lose your right to file a valid patent application in Europe, Mexico, China and most other countries of the world if you publish your invention before you file at least a first patent application.

You will lose your right to file a valid US patent application if, more than one year before filing your US application, you: 1) publish a description of your invention anywhere; 2) offer your invention for sale in the US (even if you do not describe fully your invention to your potential customer); or 3) use your invention in public in the US (public use does not include experimental trials intended to be secret and non-commercial).

In Canada, the patent is granted to the first person to file a patent application for the invention, so it is best not to delay. You will lose your right to file for a valid Canadian patent if you publish or publicly show details of your invention anywhere in the world more than one year before filing your patent application in Canada.

Can you get a patent for software?

In the past, patenting software inventions in the USA was sometimes difficult, if not impossible. Recently, it has been settled under US law that a programmed computer or micro-controller may operate as a new machine or system which is patentable.

Last year Tektronix went to the US Court of Appeals (Case No. 92-1381, July 29, 1994) to fight the US Commissioner of Patents and Trademarks to have its patent application for a digital oscilloscope display rasterizer accepted. Tektronix had noticed that the conversion of a digital oscilloscope trace to a graphics video display often resulted in jagged looking traces. The users of 'scopes are used to smooth analog traces, and therefore a way to make digital traces appear smoother was sought. Mr. Alappat, an employee of Tektronix, discovered that by setting each pixel's intensity as a function of how close each pixel is to the higher precision position of the digital trace, a much smoother appearance was obtained. This means that when the actual position of the trace passed right over a pixel, its intensity was set to a given maximum, and when the trace's actual position passed between two pixels, the chosen pixel was set to have a given minimum intensity. The question put to the Court of Appeals was: "Is the invention merely a new way of calculating intensity values, or is it a new way to display smooth traces in an oscilloscope?" The majority of the judges decided that the invention was not just a method of calculation, and that a patent should be granted.

The Alappat decision stirred things up at the US Patent Office. Recently, proposed Examination Guidelines for Computer-Implemented Inventions were published by the US Commissioner of Patents and Trademarks (see http://www@uspto.gov for a copy). When these new guidelines are revised and accepted, US patent examiners will clearly follow a new, more friendly approach to examining software patent applications.

In Canada, we still do not have a clearly favorable decision by the Courts in support of the patentability of software inventions. Nevertheless, the Patent Office seems to accept patents for programmed computers, and this year set out revised guidelines relating to the patentability of computer related inventions.

However, the program code itself (in any language) is not patentable, but instead is considered a written work protected against copying under the Copyright laws in Canada and in the USA. Copyright is created when the program is written. Registration of a copyright is optional, but an advantage. If someone writes software to do the same task as your software, there is only copyright infringement if your original work has actually been copied. This does not protect the ideas or functions in your software. Protecting the function of an invention is the domain of patents.

Patents have been obtained in both Canada and the USA for software applications. In every case, the patent is carefully drafted to describe a new process or product (machine) which happens to be done or made using programmable hardware. Intuitively, we know that any programmed digital computer for a given application could be replaced by a hard-wired circuit, even if the dedicated circuit would be completely impractical! Your patent should cover your invention whether done using programmed computer components or dedicated circuitry. If you want to confirm whether your software (i.e. programmed system) may be patented, consult a patent agent.

Why should you spend money on a patent if nobody will be able to copy your invention?

You shouldn't. But ask yourself the question again and think about the answer: "Can someone reverse engineer what I have done?" Setting aside professional pride, it is rare when the answer is no. When the answer is yes, you have a *trade secret*, and efforts must be made to keep it secret, including legally binding contracts with employees and any subcontractors or other manufacturers you authorize to use your trade secret. However, a leak would be disastrous.

What's to stop someone from copying my patent anyway?

If your product is on the market and is marked with its patent number, attention will be paid to it. Cautious competitors will steer away from copying the advantages or new features of your product. You will never know how effective your patent has really been in stopping timid competitors from producing a competing product. However, bold competitors may attempt to make a small minor change and then copy the same advantageous features of your product. It's safe to say that any competitor who does not find out what is really protected by a patent before deciding whether or not to manufacture a product is foolish.

Patents almost never protect the whole product. The wise competitor will consult a patent agent to find out what the patent really protects. If your patent is broad and well prepared, there will be little room, if any at all, for your competitors to get around the patent. If your patent is for a specific feature while your product has been very successful because of good marketing, a wise competitor will be able to compete without risking infringement.

If you are faced with a bold infringer who has bigger resources than you do, it's probably impossible to get him to roll over and stop competing with you. Even if the infringement is crystal clear, the simplest court action needed to stop an infringer is beyond the means of almost any individual. This may seem like your worst nightmare. After expending the effort and cost of developing a new product including getting a patent, a belligerent competitor comes along and steals it. But there is a silver lining. Settling a license agreement either with the infringer, or with one of his competitors, is probably within your reach and quite profitable. If there is a good market for your product, and your patent is strong, it will of course also be of value to the bigger players.

Recent Changes in US Patent Law

No more submarine patents.

Under pressure from other GATT member countries, US Patent Law took a step forward into the future on June 8, 1995. US patents will now last 20 years from the date your US patent application is filed, instead of 17 years from the date of grant. This has been the way in Canada since 1989 and in Europe for decades. Recently, for example, Thomson Consumer Electronics of France started suing US manufacturers of compact discs for infringement of its US patents which emerged to the surface between 1989-1992, after having been concealed at the US Patent and Trademark Office since the filing of the original patent application in 1973!

Provisional Patents.

If you are not in a rush to get a patent, and you want your 20 year patent term to end a year later, an unexamined, provisional patent application can be filed at the US Patent and Trademark Office. A year later, the regular patent application can be filed, and the examination procedure will be initiated. Canada will begin to accept the same type of patent applications at some time in the near future. If a provisional patent application's description of the invention is not as complete as a regular patent application, any benefit of the provisional patent application may be lost.

Conclusion.

The patent system in the USA and Canada has significantly changed for the better in recent years. However, the system is still quite complex. If you are ever in doubt whether your product or process can be patented, or whether you will infringe a competitor's patent by proceeding with your project, it is worthwhile to get proper advice before making any important decision.

About the authors

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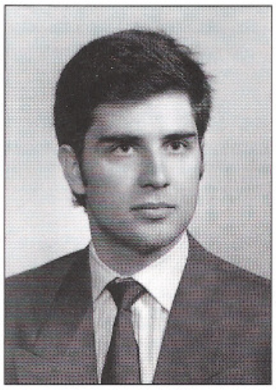

BOMBARDIER'S NEW GENERATION TILTING SYSTEM

by Daniel Lanoix, P. Eng.
Bombardier Inc. Transportation Equipment Group

Bombardier Inc. - Transportation Equipment Group's new generation tilting system is in revenue service every day on three modified LRC cars operated by VIA Rail Canada. This new system, developed in only eighteen months, allows for greater performance achievements comparatively to the previous system. Thanks to a state-of-the-art technology and advanced detection of curves, the system can perform at speeds superior to 240 km/h. Foreseeing the complexity of the project, a methodology for system specifications and software development was implemented which proved to be very efficient. This is the first software project designed and delivered by Bombardier's system engineering group. Its proven success grants the possibility of numerous applications throughout the world.

Le nouveau système d'inclinaison de Bombardier Inc., Groupe matériel de transport, opère journalièrement en service-passager sur trois voitures LRC modifiées de VIA Rail Canada. Ce nouveau système, offrant une performance supérieure, fut développé en dix-huit mois seulement. Grâce à de nouvelles technologies et à la détection avancée de courbes, ce système permet une vitesse opérationnelle supérieure à 240 km/h. En prévision de la complexité du projet, une méthodologie pertinante aux spécifications de systèmes ainsi qu'au développement d'un logiciel fut implanté. Cette méthodologie, s'est avérée dès plus efficace. Le succès de ce projet informatisé, le premier conçu et livré par le groupe de l'ingénierie de système, offre une ouverture accrue du marché mondial ferroviaire nécessitant des mécanismes d'inclinaison

Less than eighteen months following the formation of a design team, Bombardier's new generation tilting system was in operation on three modified VIA Rail LRC cars in revenue service between Montréal and Québec City. The new system was designed based on the experience acquired on the tilt system used by VIA Rail since 1981, on 100 LRC coaches. In revenue service since mid-February 1995, the new tilt system incorporates state-of-the-art technology.

THE AMERICAN FLYER

When travel time must be reduced to compete with airlines, existing tracks must be shared with freight trains, and land or budget prohibit the construction of dedicated high-speed track, one can only turn to tilt technology. For example, AMTRAK's Northeast Corridor links the cities of Washington, New York and Boston. AMTRAK plans to increase its operating speed on the Corridor to 240 km/h through a combination of infrastructure improvements and the purchase of a fleet of twenty-six trainsets composed of tilting cars powered by non-tilting locomotive.

Bombardier and GEC Alsthom, the manufacturer of the TGV high-speed train, have teamed to design and build a high-speed tilting train to meet AMTRAK's requirements. Named the "AMERICAN FLYER", this train combines the high-speed elements of the TGV with Bombardier's new generation tilting system.

TILTING SYSTEM RATIONALE

Tilting passenger car acquisition and maintenance costs are slightly increased in comparison to the cost for a standard passenger car. Tilting, the body of a rail passenger car during curve negotiation, however, offers the possibility of increasing the speed of a trainset in a curve without exceeding the maximum allowed steady state lateral acceleration felt by the passengers. Typically, the centrifugal acceleration must be lower than 1 m/sec^2. This feature reduces the overall traveling time without requiring track modification. Moreover, an effective tilting system greatly improves the passenger ride comfort during curve entry and exit by minimizing the transient accelerations.

The maximum speed allowed in curves is limited by: the maximum tilt angle of the car (typically between 6° and 9°); the maximum steady state lateral acceleration residual; the forces applied to the tracks by the non-tilting locomotive, which is close to two times heavier than a passenger car. The dynamic wheel/rail forces are identical for a tilting or a non-tilting car at a given speed. All forces vary with the square of the speed in a curve.

Safety criteria for passenger cars are related to lateral track panel shift, car overturning, rail rollover, load equalization and wheel climb. A tilt system is most sensitive to the last two items.

THE PRESENT LRC TILTING SYSTEM

The LRC car (see Figure 1), like most passenger cars, is mounted on two trucks, each composed of two axles and four wheels. Each truck has a primary and a secondary suspension mechanism. The present LRC tilting system operates on a per truck basis. Each truck is equipped with an accelerometer installed on the secondary suspension measuring the lateral acceleration seen by the passenger car. The system, when activated, tilts each end of the car in order to eliminate any lateral acceleration measured at each truck. Since the acceleration signature is very noisy, a very low frequency filter must be provided, thus creating a noticeable delay in the tilting command of the car. Depending on the car speed and the track quality, curve entries and exits can, in some cases, affect passenger comfort. Thus, local detection of the centrifugal acceleration has a limited performance. Moreover, this architecture of canceling the lateral acceleration using a closed loop always adds an overshoot entering and exiting a curve due to the slowness of the filtered accelerometer values and the softness of the secondary suspension.

Figure 1. In mid-February, 1995, three LRC cars operated by VIA Rail Canada started their revenue service test period with Bombardier's new tilting system.

Tilting of one end of the car is accomplished by a servo-valve controlling the hydraulic mechanism which in turn tilts the car. The tilting cylinders are located between the primary and secondary suspension mechanisms. The servo-valve is controlled by an analog control circuit. The hydraulic system comprises one hydraulic pump, one oil reservoir, one manifold per truck, safety valves, servo-valves, temperature sensors, four tilting and four centering cylinders. Safety circuitry is provided to ensure that both trucks are tilting within an acceptable range whenever the system is activated. Following a normal de-activation or a fault condition, the car is centered and maintained in that position by four centering cylinders (two per truck).

The tilting system is activated by the locomotive engineer before the train undertakes a run. A cab indication informs the engineer of the tilting system status. When the system is activated, the locomotive engineer can operate the train at higher speed. If the tilting system is deactivated, the train engineer must return to conventional speed in all curves for passenger comfort purposes. The difference between tilting and conventional speeds in high speed curves is typically 35 km/h. It is mandatory for the tilting system, in all cars of a train, to remain operational when running at tilting operating speed.

THE BOMBARDIER NEW GENERATION TILTING SYSTEM

Creating the team

In September 1993, an engineering team was assembled. Its mandate was to design and implement, within an eighteen month period, the prototype of a new advanced detection tilting system that would be installed on VIA Rail Canada LRC cars. The system was to be controlled by microprocessors, use a train network for advanced tilt commands, and provide self-diagnosis on a per car and per train basis. VIA Rail was interested in the new system and, later on, became a partner in the testing of this new system.

The engineering group was divided in two teams: a mechanical/ hydraulic team and a system/electronic/software team. The first step was to determine the exact functional requirements of this new system with respect to the existing LRC system. Bombardier decided to form a new team that would not only design the high level system but would also design, write as well as test all the system application software.

The hardware platform was designed and built by Vapor Canada (Saint-Laurent, Québec). Vapor also supplied some of the firmware drivers.

Foreseeing the complexity of the task, the limited time frame, and based upon the experience acquired from multiple system suppliers on many

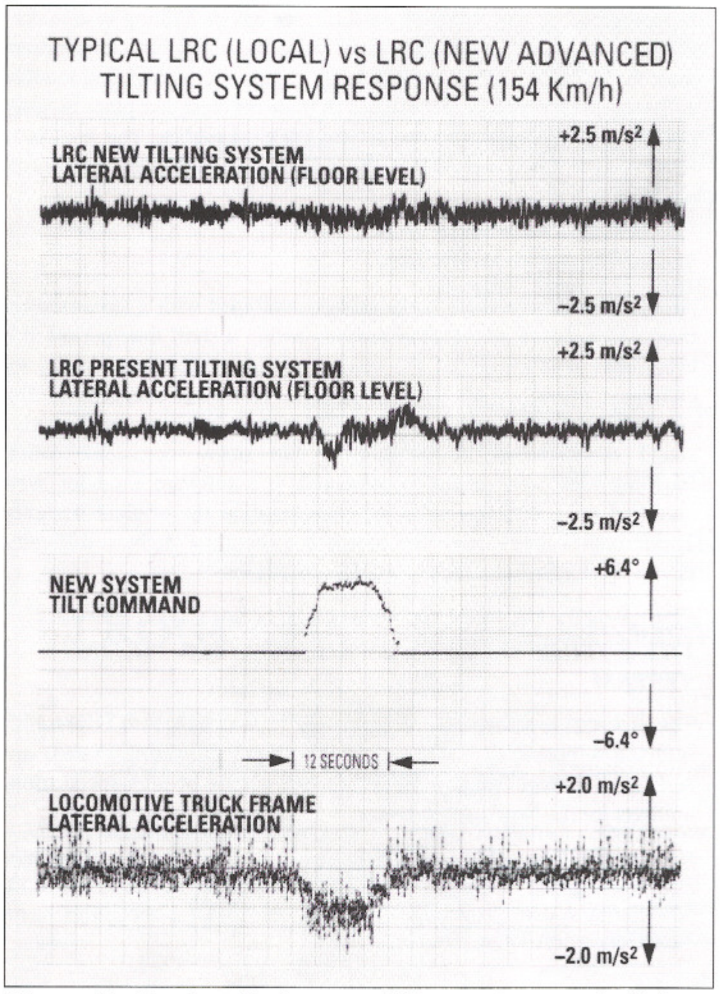

Figure 2. Bombardier's new tilting system control loop architecture. The tilt sensors located on the foremost locomotive truck feed the Master Tilting Controller (MTC) with continuous track data. The MTC computes tilting commands for all the passenger cars. Each Car Tilting Controller (CTC) tilts its car using a feedback control loop based on displacement transducers.

previous contracts, Bombardier implemented a basic methodology for system specifications and software development. Initially with the Centre de recherche informatique de Montréal (CRIM) and subsequently with a consulting firm called Schemacode International, a methodology initially developed by Schemacode was adapted to Bombardier's specific needs. The methodology, which was continuously improved during the project, is still undergoing improvement. Well tailored to Bombardier's needs, the methodology was readily accepted and applied by everyone.

Part of the methodology rests on extensive use of a simulator for lab testing. A full hardware/software functional system simulator (without hydraulics) was built and used initially to validate the new software. This simulator remains in use today to validate the new software releases.

Simultaneously, Hydra-Fab (Laval, Québec) was selected to join the hydraulic team for the new hydraulic components and the fabrication of a realistically sized mock-up for simulation of the complete system. The hydraulic simulator was built with all the necessary mechanisms to tilt a 36 000 kg mass which corresponds to a rail coach with full passenger weight. The simulator allowed for both the validation of the new hydraulic components as well as certain electronic components, without the use of an LRC car.

New generation system architecture and features

The new system architecture offers two major performance improvements over the existing system: an advanced tilt sensing sub-system located on the lead truck of the locomotive as well as an open control loop, respectively to the tilt command computed for each car. (See Figure 2). These two features allow the train to operate at a higher speed, 240 km/h comparatively to 160 km/h. This architecture minimizes the transient acceleration and the corresponding jerk rate throughout rail spiral transitions. Transient accelerations become more significant when high speeds are proposed over existing corridors where spiral transitions are often short in length, and at best may only be designed for current lower speed operations. Other major improvements include key redundancy for specific components, self calibration of sensors, self diagnosis on a locomotive/car /train basis and self-test routines.

The Master Tilt Controller (MTC) processes the data received from the tilt sensor located on the locomotive lead truck. The MTC, knowing the exact configuration of the train (number of cars and their relative position) computes for each car its respective tilting angle command. The MTC supervises all Car Tilting Controllers (CTC) for activating and stopping the system. The tilt sensing components subsystem for each locomotive are continuously monitored by the MTC. Diagnoses are established for each malfunction or abnormal behavior of the system.

Each CTC supervises the functioning of all the different car components. Each car is equipped with one centrally located hydraulic power unit, and a reservoir equipped with temperature, pressure and level controls. Two hydraulic manifolds equipped with hydraulic valves control the tilting cylinders of their respective truck. The use of displacement transducers mounted directly on the tilting cylinders provides for the servo-control feedback.

The tilting system is designed as a fail-safe system such that all key system parameters are continuously monitored. Critical safety functions which are present in the car are performed by non-software related components only. It is here assumed that any software-related component is not safe, thus the system uses last resort electronic software-free circuits to shut-down the hydraulic system. Upon detection of a failure, the system returns to its fail-safe mode and automatically centers the car, using the centering cylinders. These cylinders have a built-in locking mechanism which locks out all tilting motions mechanically.

The team at work

The first months of the project were spent in analyzing the requirements and establishing the architecture. A document was produced specifying all the hardware and software requirements.

Beginning in the winter of 1994 , analyses were still in progress and almost no coding was performed. The software module functions were defined. Software engineers were added to the team. Each system engineer teamed-up with a software engineer. Progress was made with the new hydraulic components on the hydraulic simulator.

Within three months, everything was well analyzed, defined and documented. The first software modules were written and tested on a modular basis with a development machine. More progress was made with the new hydraulic components.

By mid-summer, all the software modules for the CTC were ready. The integration of the CTC modules had begun on the target machine. Within a month, all modules were integrated and functioning. Software validation was performed on the software simulator. No defects were found in the application software. Few requirements were modified. Some defects with the operating system and firmware were found. The hardware was quite stable and required only minor modifications.

Fall brought the first CTC integrated test on a modified LRC car. Test results were conclusive. The MTC software integration started on the software simulator. A full integration of the system was performed on two LRC modified cars. Night run tests between Montréal and Kingston, Ontario, were performed three to four times a week. The tilting system behaved according to the design specifications on the first run. Fine tuning began on the next test run. A third modified LRC was added to the experimental train consist.

Full revenue service operations started on February 12, 1995 between Montréal and Québec City. Minor adjustments were made. Overall, the new system performed extremely well.

Performance analysis

Figure 3 shows partial results of a test performed on three modified LRC cars on June 11, 1995. This figure illustrates the lateral acceleration measured at the locomotive truck, the residual lateral acceleration of one LRC car equipped with this new tilting system, and the lateral acceleration of a standard LRC car. The figure also shows the computed tilting commands for the modified car. The commands are the same for all modified cars except for a respective time delay. The differences in curve entry and exit lateral acceleration transients, between both systems, are evident. Although the existing LRC system is quite acceptable and comfortable, it is operating at its maximum capabilities. The modified LRC cars with this new system offer an unmatched ride quality for the passengers and provides the possibility of operating cars at a much higher speed.

Tilting computing algorithms

Perfect synchronization is achieved by using the locomotive speed and determining the inherent delay of each sensor filtering, network delay, data processing and hydraulic response. A typical locomotive length is 20 m. At 100 km/h, the advanced sensors located on the first locomotive truck provide a 0.72 second advanced information with respect to the curve entry of the first passenger car truck. At 240 km/h, the advanced information time is reduced to 0.3 second. Although 0.3 second seems fairly small, it is far from being negligible. Both the theoretical and actual validation have proven that every tenth of a second is critical to acceleration transitions during curve entry and exit.

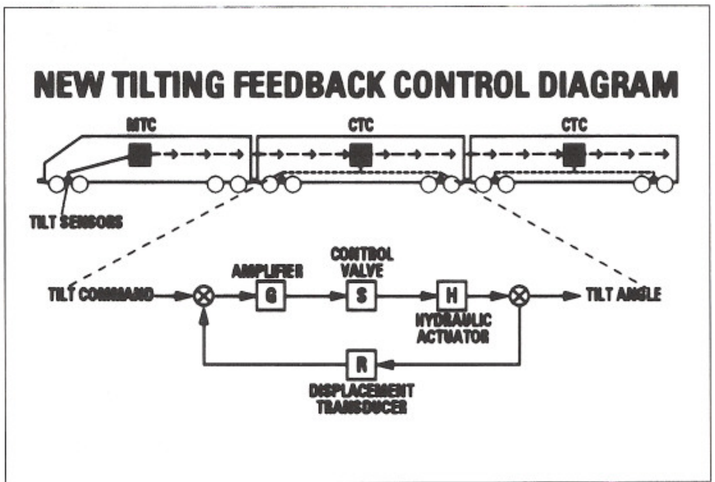

Figure 3. Bombardier's new tilting system test results. Typical system response entering and exiting a curve at 154 km/h for the new tilting system versus the present LRC's system.

Nevertheless, the key to a high performance advance tilting system does not rely on advanced detection only since the algorithm computations must be designed to filter track defects, switches, crossings and roadbed stiffness which vary with the seasons. A trade off must take place between normal performance in curves versus track anomalies. The goal is to minimize car movements due to the tilting commands when the cars are out of curves.

The methodology finally pays

An accurate development methodology combined with a strong design team will result in sound achievements within a short time period. It is everyone's conviction that the success of this project was due to the combined efforts of all team members. However, everyone is also convinced that a budget or a schedule can only be respected through a sound development methodology. On many occasions, where functionalities were added or changed, the software modules were modified by a different software engineer than the original designer. These modifications were accomplished without the slightest difficulty, thanks to standardized coding and documentation.

THE FUTURE OF THE NEW GENERATION TILTING SYSTEM

The new tilting system has a promising future. VIA Rail is presently studying a potential retrofit of the existing LRC tilting system and AMTRAK is requesting proposals for the supply of high-speed tilting trainsets for the Northeast Corridor.

Bombardier Eurorail, Bombardier's equivalent of the Transportation Equipment group in Europe, is well informed of the development of the new tilting system. Together, they offer worldwide possibilities to the New Generation Tilting System.

About the author

Daniel Lanoix is an electrical project engineer, System Engineering, Bombardier's Transportation Equipment Group, based in St-Bruno, Québec. He has the ongoing responsibility of the tilting project for VIA Rail Canada as well as the continuous improvement of the new tilting system. He also supervises the development of electronic door controller and automatic equipment monitoring for the New Jersey Commuter Car contract. Finally, he is also responsible for the advanced engineering of the tilting, monitoring and radio data link systems for the AMERICAN FLYER. Prior to the tilting project, Mr. Lanoix was an electrical project engineer and a system integrator for the Advanced Technology train R-110B developed by Bombardier for the New York City Transit Authority. In 1987, he started with Bombardier on the Disney World Monorail project as a design engineer and subsequently, as an electrical project engineer. After graduating from the Université de Sherbrooke in electrical engineering, Mr. Lanoix worked one year for the Société de Transport de la Communauté Urbaine de Montréal as an electrical project engineer.

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18:00 - 20:00	Inscription et cocktail - Registration and cocktails

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08:00 - 14:00	Inscription - Registration
08:45 - 09:00	Cérémonie d'ouverture - Opening session
09:00 - 10:00	Session plénière - Plenary session
10:00 - 10:20	Pause - Break
10:20 - 12:00	Sessions techniques - Technical sessions
12:00 - 14:00	Dîner-conférence - Luncheon and invited speaker
14:00 - 15:20	Sessions techniques - Technical sessions
15:20 - 15:40	Pause - Break
15:40 - 17:40	Sessions techniques - Technical sessions

JEUDI 7 septembre 1995 - THURSDAY, September 7, 1995

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