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Rebirth of The IEEE Technology and Engineering Management Society

Guest Editorial

Priorities for federal government infrastructure spending

2015 MGA Award Recipient

World View

Canadian remote sensing at home and abroad

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Witold Kinsner
PhD, PEng, FEIC, FEC

2016-2017
IEEE Canada President and Region 7 Director

Warm welcome to all IEEE Canada members, volunteers, activists, both young and seasoned!

As you know, IEEE Canada (Region 7, or R7) changes its leadership in even years. After two years as President Elect, I will continue working hard to help IEEE Canada grow, working together with the Past President, Amir Aghdam from the Montreal Section, the President Elect, Maike Luiken from the London Section, as well as IEEE Canada's Executive Committee, Steering Committee, Area Chairs, Group Committee Chairs, Committees, and 21 Sections.

I would like to thank Amir Aghdam for his tireless effort to make IEEE Canada a better organization over the previous two years. His accomplishments will have a lasting value. I also wish to recognize the innumerable contributions of Keith Brown, who completed his term as Past President in December. Keith served on the IEEE Canada Board for 10 consecutive years, elected as Chair of Northern Canada Section in 2005. He was appointed Canada Central Area Chair in 2007, and then elected as IEEE Canada Vice-President/President Elect in the fall of 2009.

We are also grateful to Ashfaq (Kash) Husain from the London Section for his excellent service as the Treasurer of IEEE Canada. He has now taken the position of Administrator, previously carried out very diligently by Cathie Lowell for so many years. Cathie will now be responsible for registration at Region 7 and other conferences in Canada. Rasheek Rifaat from the Southern Alberta Section has been appointed Treasurer of IEEE Canada. Thanks also go to Raman Paranjape from the South Saskatchewan Section who was the IEEE Canada Secretary for the last two years. He was replaced by Scott Melvin from the Canadian Atlantic Section.

(Continued on page 4)

Bonjour à tous les membres, bénévoles et militants d'IEEE Canada!

Comme vous le savez, la direction d'IEEE Canada (région 7) change aux années paires. Après deux années passées à titre de président désigné, j'ai l'intention de continuer à travailler fort pour favoriser la croissance d'IEEE Canada, et cela de concert avec le président sortant, Amir Aghdam (section de Montréal), la nouvelle présidente désignée, Maike Luiken (section de London), ainsi que le comité exécutif, le comité directeur, les présidents des zones, les présidents des comités, les comités et les 21 sections d'IEEE Canada.

Je tiens à remercier Amir Aghdam pour son dévouement à faire d'IEEE Canada une meilleure organisation. Ses réalisations auront des bienfaits durables. J'aimerais aussi souligner les innombrables contributions de Keith Brown, qui terminait en décembre son mandat de président sortant. Keith a siégé au conseil d'administration d'IEEE Canada pendant dix années consécutives, ayant été élu président de la section du Nord du Canada en 2005, président de la zone Canada Central en 2007, puis vice-président/président désigné d'IEEE Canada à l'automne 2009.

Merci, par ailleurs, à Ashfaq (Kash) Husain (section de London) pour avoir rempli avec brio son rôle de trésorier d'IEEE Canada. Il est désormais administrateur, un rôle occupé fort diligemment par Cathie Lowell pendant nombre d'années. Cathie s'occupera désormais des inscriptions aux conférences de la région 7 et d'ailleurs au Canada. C'est Rasheek Rifaat (section d'Alberta-Sud) qui est notre nouveau trésorier. Merci aussi à Raman Paranjape (section de Saskatchewan-Sud) pour avoir été notre secrétaire ces deux dernières années; il a été remplacé par Scott Melvin (section de l'Atlantique canadien).

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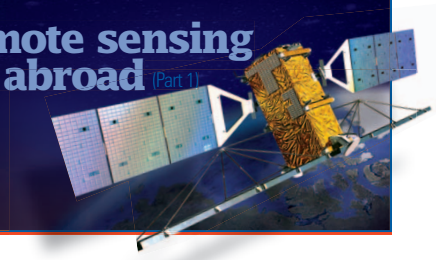
World View Canadian remote sensing at home and abroad (Part 1)

Canada's world-leading spaceborne radars give planners and decision makers a unique capability to monitor our ocean territories, aid in resource development and assess humanitarian needs.



(President's Inaugural Message cont'd from page 3)

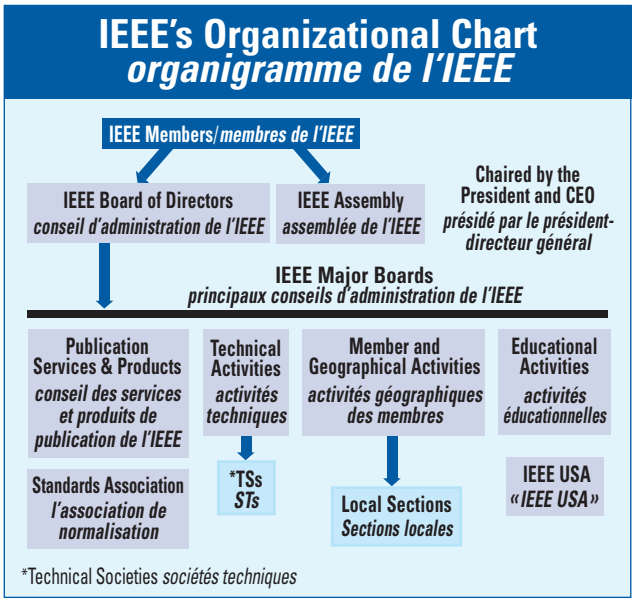
IEEE Canada has many important committees, some with newly-appointed Chairs. I will discuss their roles and accomplishments in future messages.

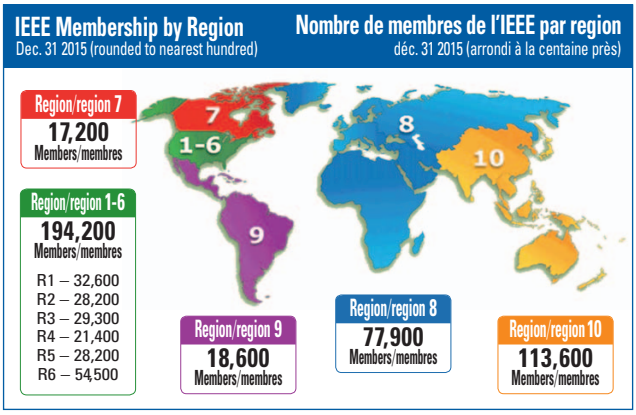
Our current priorities have been set so as to address various challenges, including (i) reconnecting industry to IEEE in a meaningful relationship, (ii) engaging Young Professionals and Women in Engineering at several levels, (iii) engaging pre-university students in Engineering, Technology and Science through humanitarian projects, (iv) developing inter-region collaboration, (v) communicating among our academic, industrial and government members through the *IEEE Canadian Review* (*ICR*) magazine, the IEEE Canada Newsletter (ICN), and local correspondents and media, and (vi) responding effectively to grand challenges.

IEEE has been a competent, influential, and glorious organization for years. In 2015, IEEE had over 426,000 members in over 160 countries, 46 technical societies and councils, over 1,600 conferences in more than 80 countries, and published over 170 top-cited journals and magazines, and developed over 1,600 standards and projects, and has nearly 4 million technical documents in the IEEE Xplore Digital Library. We have over 300 sections in the 10 geographic Regions.

The global structure of IEEE includes: Technical Activities (societies, councils and technical committees; society publications; conferences committee; conference events; conference proceedings; chapters; and the future directions committee), Publication Services and Products (IEEE Press, IEEE Spectrum, Proceedings of the IEEE, The Institute, and governing policies for all publications), Standards Association (Industry Standards and Technology Organization, ISTO; Standards working groups, and IEEE Registration Authority), Educational Activities (EA Committees: Continuing Professional Education, Engineering Accreditation Activities, and Pre-University Education, and TryEngineering.org), Member and Geographic Activities (Regions, Sections, and Chapters; Student Branches; Affinity Groups: Young Professionals, Women in Engineering; Consultants Network; and Life Members), in addition to the Corporate and IEEE-USA structure.

The Board of Directors meets to get familiar with the critical activities in the ten Regions and to discuss positive (and negative) issues facing the organization. The Board works together to succeed by combining complementary skills and knowledge to conceive and implement creative solutions.





The current IEEE President, Barry Shoop, suggests that to be effective in growing a better IEEE, we must be fiercely loyal, and identify, cultivate, and mentor the next generation of leaders.

(Message inaugural du Président suite de page 3)

IEEE Canada compte de nombreux comités importants, certains ayant maintenant de nouvelles personnes à leur présidence. Je parlerai de leur rôle et de leurs réalisations ultérieurement.

Nos priorités actuelles épousent nos différents défis, à savoir : (i) réconcilier l'industrie avec l'IEEE et donner vie à une relation fructueuse; (ii) mobiliser des jeunes professionnels et des femmes travaillant dans le domaine du génie; (iii) mobiliser des étudiants préuniversitaires en génie, technologie et science dans le cadre de projets humanitaires; (iv) favoriser la collaboration interrégionale; (v) communiquer avec nos membres universitaires, industriels et gouvernementaux par l'entremise de La revue canadienne de l'IEEE, des bulletins de nouvelles d'IEEE Canada ainsi que des correspondants et des médias locaux; et (vi) relever efficacement des défis de taille.

L'IEEE est une organisation compétente, influente et prodigieuse depuis nombre d'années. En 2015, elle comptait au bas mot 426 000 membres dans 160 pays, comptait 46 sociétés et conseils techniques, avait donné 1 600 conférences dans 80 pays, avait publié 170 revues professionnelles renommées, avait élaboré 1 600 normes et projets, et avait archivé près de 4 millions de documents techniques dans sa bibliothèque numérique Xplore. L'IEEE regroupe plus de 300 sections dans 10 régions géographiques.

Outre la structure administrative de l'organisation, l'IEEE comprend : des activités techniques (sociétés, conseils et comités techniques; publications des sociétés; conférences, travaux connexes et actes; chapitres; comité des orientations futures); des produits et services de publication (IEEE Press; IEEE Spectrum; Proceedings of the IEEE; The Institute; politiques de gouvernance pour toutes les publications); une association de normalisation (Industry Standards and Technology Organization, ISTO; groupes de travail sur les normes; IEEE Registration Authority); des activités éducatives (comités de formation professionnelle continue; accréditation en génie; éducation préuniversitaire; TryEngineering.org); ainsi que des activités de membres et des activités régionales (régions, sections et chapitres; branches étudiantes; groupes d'affinités : jeunes professionnels et femmes en génie; réseau de consultants; membres à vie).

Le conseil d'administration se réunit pour être au fait des activités essentielles des dix régions et discuter des enjeux positifs (et négatifs) touchant l'organisation. Les membres du conseil collaborent en alliant leurs compétences et connaissances complémentaires pour concevoir et mettre en œuvre des solutions créatives.

Pour mieux atteindre notre objectif de développer l'IEEE en qualité, le président actuel de l'IEEE, Barry Shoop, nous invite à redoubler de loyauté tout en repérant, formant et inspirant les leaders de demain.

To do so, we should:

- Know the IEEE's mission, core values, policies, programs, services, trends, strengths and needs;
- Make knowledge-based/data driven decisions;
- Embrace a culture of inquiry and learning;
- Be open to innovative solutions all the time;
- Be willing to engage in new levels of collaboration;
- Ask yourselves during and after every meeting or activity;
  - "How did we help the members today?"
  - "How did we help the engineering and technology community today?"
  - "How did we help the public today?"

OUR MISSION
to foster technological innovation and excellence for the benefit of humanity.

OUR VISION
"we will be essential to the global technical community and to technical professionals everywhere, and be universally recognized for the contributions of technology and of technical professionals in improving global conditions."

OUR VALUES
trust, growth and nurturing, global community building partnership, service to humanity, and integrity in action.

In order to move towards those goals, IEEE has developed and approved (June 2015) a Strategic Plan 2015-2020 which can be found under the About IEEE section at: http://www.ieee.org/about/ieee_strategic_plan.html

The goals of the plan include: (i) Expand and enable dynamic, nimble, flexible, diverse communities around the world; (ii) Provide technically vital forums related to traditional technologies while focusing on emerging and disruptive technologies; (iii) Lead humanitarian efforts around the world to use technology to solve the world's most challenging problems; and (iv) Leverage IEEE's technology-related insight to address public policy issues.

To support the above goals, the following key initiatives have commenced: (i) Increase our value to professionals working in the industry, particularly younger professionals and entrepreneurs; (ii) Ensure the vitality and relevance of our core activities and increasing value to our members; (iii) Develop programs focused on knowledge and technology related to public policy and humanitarian efforts; and (iv) Evaluate and adapt organizational structures and processes.

The priorities we are setting within IEEE Canada are in alignment with IEEE's Strategic Plan. We can and will earn reputation and respect, keep well-seasoned members, and acquire many new members – but only if we manage a transparent, evidence-based organization capable of delivering and reporting meaningful results.

These observations are presented in my first message to indicate that IEEE Canada's strategy and activities will be consistent with the other nine regions of IEEE. I am very excited to work with all of you to make it a reality.

My future messages will focus on the specific challenges and corresponding initiatives. ■

Respectfully submitted,

Witold Kinsner,
PhD, PEng, FEIC, FEC
2016-2017 IEEE Canada President
2016-2017 IEEE Region 7 Director

NOTRE MISSION FONDAMENTALE
consiste à favoriser l'innovation et l'excellence technologiques au profit de l'humanité.

ÉNONCÉ DE VISION
«Nous entendons jouer un rôle essentiel auprès de la communauté technique mondiale et des professionnels techniques de partout, ainsi que recevoir une reconnaissance mondiale pour les contributions de ces professionnels à l'amélioration des conditions de vie dans le monde.»

NOS VALEURS
Nos valeurs essentielles incluent la confiance, la croissance, l'établissement d'une communauté mondiale, le partenariat, l'aide humanitaire et l'intégrité de nos actions.

À cette fin, il nous faut :

- connaître la mission, les valeurs essentielles, les politiques, les programmes, les services, les tendances, les forces et les besoins de l'IEEE;
- prendre des décisions en nous appuyant sur des connaissances/données;
- encourager une culture favorisant la curiosité et l'apprentissage;
- faire preuve d'une ouverture constante face aux solutions novatrices;
- être prêts à collaborer différemment ou davantage;
- nous poser les questions suivantes pendant et après chaque rencontre ou activité :
  - « Comment avons-nous aidé les membres aujourd'hui? »
  - « Comment avons-nous aidé la communauté du génie et de la technologie aujourd'hui? »
  - « Comment avons-nous aidé la population aujourd'hui? »

En vue d'atteindre ces objectifs, l'IEEE a élaboré et approuvé, en juin 2015, son plan stratégique 2015-2020. Vous pouvez le consulter ici (en anglais seulement) : http://www.ieee.org/about/ieee_strategic_plan.html

Ce plan stratégique poursuit les objectifs suivants : (i) développer des communautés dynamiques, autonomes, vivantes, souples et diversifiées partout dans le monde; (ii) offrir des forums techniques essentiels sur les technologies traditionnelles de même que les technologies émergentes et perturbatrices; (iii) mener des activités humanitaires partout dans le monde en faisant usage de la technologie pour résoudre les problèmes les plus importants de la planète; (iv) tirer profit des connaissances technologiques de l'IEEE pour aborder des enjeux stratégiques publics.

En appui à ces objectifs, les initiatives suivantes ont été amorcées : (i) accroître notre valeur auprès des professionnels de l'industrie, particulièrement auprès des jeunes professionnels et entrepreneurs; (ii) assurer la vitalité et la pertinence de nos activités principales en appuyant notre valeur auprès de nos membres; (iii) élaborer des programmes fondés sur les connaissances et les technologies relativement à des politiques publiques et à des activités humanitaires; (iv) évaluer et adapter les structures et processus organisationnels.

Les priorités d'IEEE Canada cadrent avec les objectifs du plan stratégique de l'IEEE. Nous gagnerons en respect et bâtirons notre réputation à conserver nos membres chevronnés et à en acquérir de nombreux autres, mais à la condition d'être transparents, de nous appuyer sur des données probantes et de livrer et de communiquer des résultats significatifs.

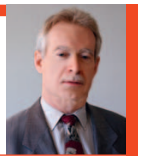
J'ai choisi de présenter ces observations dans mon premier message pour indiquer que la stratégie et les activités d'IEEE Canada concorderont avec celles des neuf autres régions de l'IEEE. Je suis très enthousiaste à l'idée de travailler avec vous tous à la concrétisation de nos projets.

Mes prochains messages porteront sur les défis à relever et les initiatives correspondantes. ■

Votre président,

Witold Kinsner,
Ph.D., ing., FEIC, FEC
Président d'IEEE Canada pour 2016-2017
Directeur de la région 7 de l'IEEE pour 2016-2017

A few words from the Editor in Chief / Quelques mots du rédacteur en chef



Bruce Van-Lane, P.Eng., MIEEE

La traversée prochaine du navire de croisière Crystal Serenity dans le passage du Nord-Ouest canadien a fait briller le caractère unique de la géographie du Canada de la proue à la poupe de notre pays, non sans provoquer une forte houle : quels sont les risques pour les passagers et l'environnement? Certaines précautions ont été envisagées pour calmer la tempête, dont l'achat d'imagerie glaciaire du satellite canadien RADARSAT-2.

La géographie et la destinée du Canada ont toujours été interreliées, et le changement climatique accentue cette réalité. Heureusement, notre passé est jalonné de visions nationales invitant les citoyens à relever les défis. Ce fut le cas au siècle dernier du chemin de fer Canadien Pacifique et de la voie maritime du Saint-Laurent. L'article-vedette du présent numéro explore la façon dont RADARSAT-1 et RADARSAT-2 se sont révélés des ressources inégalées pour la sensibilisation du secteur maritime. Nous abordons aussi les perspectives d'avenir offertes par la mission RADARSAT Constellation, lancée en 2018.

En plein ralentissement économique, le gouvernement fédéral doit agir sur de nombreux plans – alors qu'il entend créer des emplois en renouvelant les infrastructures. Encore et toujours, il lui faudra s'adapter au changement climatique. Plusieurs défendent un investissement à long terme dans le système d'alimentation électrique et, dans cette veine, nous avons invité l'Association canadienne de l'électricité à se prononcer sur la question. Dans ce numéro et les suivants, nous publierons des collaborations spéciales d'associations professionnelles ou d'autres sources pertinentes. Le premier éditorial en collaboration se trouve sur le site http://canrev.ieee.ca. Vos commentaires peuvent être soumis en ligne.

Vous trouverez dans ce numéro les rubriques habituelles de Terry Malkinson ainsi qu'un texte convaincant, corédigé par ce dernier, sur les raisons de se joindre à IEEE Technology et à l'Engineering Management Society.

Bonne lecture! ■

Although the voyage of the cruise ship Crystal Serenity through Canada's northwest passage isn't until August, its proponents sailed into a bit of choppy media coverage recently. Could 1600 passengers and crew be rescued there? Potential environmental impacts? Amongst the precautions cited to calm the waters was the planned purchase of ice imagery from Canada's RADARSAT-2 satellite.

Canada's geography and destiny have always been linked; with climate change, this will become more so. But we have an enviable track record in creating national visions to meet the challenges. In our first century, one can look to the Canadian Pacific Railway and the St. Lawrence Seaway. More recently, first RADARSAT-1 and then RADARSAT-2 have made our maritime domain awareness capability the envy of every country with a coastline, explored in part in this issue's cover story. We also outline the future capabilities of the RADARSAT Constellation Mission, to be launched in 2018.

In an economic slow-down, the federal government is called upon to take action from many quarters. Even more so when it announces an infrastructure renewal program with job creation as one of its aims. Then consider the need for climate change action—again. Add it all up, and some would make the case for government long-term investment in Canada's electricity supply system. We invited the Canadian Electricity Association to do just that. Beginning with this issue, we'll be publishing Guest Editorials on a frequent basis, most often from industry associations. We invite you to comment on-line on the opinions presented; our first Guest Editorial can be found from http://canrev.ieee.ca.

We have our usual insightful columns from Terry Malkinson, and a persuasive overview he has coauthored of why we should join the reborn IEEE Technology and Engineering Management Society.

Enjoy the read! ■

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Biz-tech Report

by Terrance Malkinson

Did you ever wonder what the most influential brands in the country are? Check out the *Canadian Business* feature "25 Best Brands in Canada" [*Canadian Business*. 88 (12) :31-36. Fall, 2015]. Leading the ranking is Mountain Equipment Co-Op, followed by Cirque du Soleil and in third place, WestJet. Profiles of each of the twenty-five best brands are provided. Other interesting special reports from *Canadian Business* include: "Canada's Fastest Growing Companies" [October, 2015. pp.43-87]; "Canada's Top Executives" [November, 2015.pp. 27-32]; "Canada's Best Employers" [December, 2015. pp. 35-43]; "The Power 50" [December, 2015. pp. 45-60]; "Innovators of the Year" [January, 2016 pp. 36-40]; and "The New Establishment" [Winter 2016/2016 pp. 24-45]. The "*Canadian Business* 24th Annual Ultimate MBA Guide" [*Canadian Business*. 8 (12):45-70. Fall, 2015] provides an overview and profiles of MBA and executive MBA programs in Canada. The information is designed to help students decide which education provider is best for them. Leading the ranking by reputation is the University of Toronto's Rotman School of Management, followed by Queens School of Business and Ivey Business School at the University of Waterloo.

One of the many great Canadian success stories is that of Montreal-based Cirque du Soleil [www.cirquedusoleil.com] Sarah Barmak discusses in "The Show is Alive" [*Canadian Business*.8(12): 24-30. Fall, 2015. www.canadianbusiness.com] how with new ownership this Canadian icon now in its fourth decade is re-inventing itself, expanding its wide-ranging creative endeavors while maintaining the essence of what has proven to be successful—invoking the imagination, provoking the senses and stirring the emotions of people around the world.

Those of us whose hair is turning grey sometimes look back nostalgically of the pleasure of collecting and listening to vinyl records. In "The Vinyl Countdown" Jese Snyder discusses the entrepreneur Dean Read's risky business venture as Canada's only record press. [*Alberta Venture* 20-26. August, 2015. www.albertaventure.com]. His goal – to make him one of North America's largest manufacturers of vinyl records at a time when demand is soaring. In 2014 consumers bought four million new vinyl records: a 42% increase from the previous year. He tells his story, the opportunities, the challenges, and prospects for the future. Many audiophiles believe in the quality of the sound emanating from vinyl recordings.

The 70th anniversary of Canada's First Air occurs in 2016. Brian Dunn discusses the history, contributions and futures of Canada's oldest airline still operating under its original name in *Wings*, [pp. 20-23. November/December 2015. www.wingsmagazine.com]. The airline contributes more than $50 Million annually to Canada's northern economy and had sales of close to $260 Million in 2015. Code sharing agreements initiated in July 2015 with Canadian North and Calm Air will help reduce costs, improve efficiencies and service for passengers and cargo in the Canadian north. In the same issue of *Wings* Matt Nicholls contemplates a "View to the Future of Canadian Aerospace" [pp. 25-28] in discussion with the Aerospace Industries Association of Canada's CEO Jim Quick. The Canadian aerospace industry contributes $29B to the GDP and its 700 companies nation-wide employ more than 180,000 people.

First Air contributes more than $50 Million annually to Canada's northern economy and had sales of close to $260 Million in 2015.

The winners of the 2015 Royal Canadian Geographic Society awards share their viewed of the importance of geography and its future in *Canadian Geographic*[136(1):38-43. January/February, 2016.www.canadiangeographic.ca]. They explain the importance of knowing our land; expanding scientific knowledge; understanding climate change; grasping world geopolitics; and love of the Canadian nation, its people, and its history.

In the same issue, five smartphone apps are featured that aid in reducing our individual environmental footprints. A Vancouver-based company, ReCollect, has worked with municipalities from coast-to-coast in engaging citizens more fully with recycling. A simple but very popular feature allows residents to check their collection schedule by entering their street address. The company's "campaign" feature lets city hall staff send out timely notices through emails, tweets, mobile reminders and phone calls. For example, on a windy day, residents can be sent tips on how to pack their blue bins to avoid dispersal of the contents. Service alerts can advise residents about emergency collections in the aftermath of severe storms.

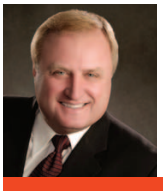
The ReCollect smartphone app lets residents look up their collection schedule and offers advice on windy days

In 2016 the University of Calgary is celebrating its 50th anniversary [www.ucalgarycelebrates.ca] Additionally, Calgary's Southern Alberta Institute of Technology - SAIT Polytechnic is celebrating its 100th anniversary . [www.sait.ca/flipbooks/Centennial-Sponsorship-Brochure/#?page=0]. Both institutions of post-secondary learning; like many others in Canada have been major contributors not just to Canada but globally, with alumni throughout the world, in all business sectors and who are making the world a better place through their intellect and innovation. Canada is very fortunate to have developed some of the most highly respected educational institutions in the world. Students are instructed, and mentored by some of the best educators and researchers in the world. More on this topic in an upcoming issue of the *IEEE Canadian Review*. ■

About the Author

Terrance Malkinson is a communications specialist, business analyst and futurist. His career path includes technical supervisor and medical researcher at the University of Calgary, business proposal manager for the General Electric Company, and research administrator with the School of Health and Public Safety at SAIT Polytechnic in Calgary. He is currently an international correspondent for IEEE-USA *Today's Engineer*, contributing editor for *IEEE Canadian Review*, and a member of the editorial advisory board of IEEE *The Institute*. He was Vice-Chair of the IEEE-USA Communications Committee (2004-2010), and editor-in-chief of IEEE-USA Today's *Engineer Digest* (2004-2008). He was an elected Governor of the IEEE Engineering Management Society as well as past editor of *IEEE Engineering Management*. He is the author of more than 540 earned publications, and an accomplished triathlete. **malkinst@telus.net**

Transformational Infrastructure: **The Work of Nation Building**



By **Hon. Sergio Marchi**
President and CEO, Canadian Electricity Association

Since their election and flowing from their ambitious election platform, the Federal Liberal government has laid out a number of broad public policy goals that align with electricity sector priorities – investing in green infrastructure, commitment to renewables and clean technology, and addressing climate change.

Additionally, the Government of Canada has promised a significant robust investment in the renewal of the country's infrastructure, beginning with Budget 2016, and has set a number of priorities to govern decisions about allocating that investment. One of those priorities was long term, transformational projects.

The Canadian Electricity Association (CEA) believes there are strong public policy drivers to make electricity infrastructure eligible for government investment. The benefits are consistent with priorities identified by the government, beginning in the election campaign through to the present. In fact, the Liberal Party said as much in responding to a CEA federal election questionnaire that was forwarded to all political parties.

Currently, CEA is looking to partner with the federal government to develop an integrated proposal that explores how best to make targeted, longer term investments in electricity infrastructure. We would propose that it do so by focusing on significant "gaps" that currently persist in our governance structures. Let me explain.

Identifying Gaps in the Current System

The primary jurisdiction over electricity is provincial and most investment in electricity infrastructure is funded on a user-pay basis, passed on to ratepayers after approval by arm's-length provincial regulators.

However, there is also a significant federal role in the sector. Be it through the 34 federal departments and agencies with policymaking responsibility and influence or through a historic, though time limited, engagement in accelerating the electricity system's transition to a low-carbon future.

In the past, this division of roles has meant that provincial regulators have tended to focus on immediate costs and needs in order to keep rates to the consumer as low as possible, linking them closely to existing or immediately foreseeable requirements.

In practice, the result has been a 'ratepayer gap', essentially an overall reluctance by regulators to support experimental pilot projects, innovative technologies, renewable and/or green technologies and extension of service to areas without sufficient ratepayer critical mass such as Northern Canada.

Yet, these are all legitimate and significant public issues. Moreover, government agendas are promoting these very aspirations. We should not allow investment and R&D into transformational projects in the production, transmission and distribution of electricity to fall between the cracks.

So, how do we bridge the gap between government ambitions and regulatory decisions? And who should do it?

On the critical, over arching issues facing the country, federal/provincial collaboration and cooperation must prevail. The new federal government has laid out a set of high ambitions – investing in green infrastructure, commitment to renewables and clean technology, and addressing climate change.

It has also demonstrated its willingness to engage the provinces in addressing them. At the 2015 U.N. Conference on Climate Change (COP 21) and following the Paris Agreement, we have seen a concerted national effort to support further de-carbonization. This includes the electrification of transportation which contributes some 25 per cent of the carbon footprint, and greater resilience of critical infrastructure to severe weather impacts.

N.Ed. IEEE Canada members interested in furthering their understanding of the impact of policy decisions on Canada's electricity grid may wish to register with the upcoming IEEE Electrical Power and Energy Conference (EPEC 2016), to be held October 12-14 in Ottawa. One of the 18 mini-symposia will be on the topic of Government Initiatives, Policies and Smart Grids.

Policy Development to Support Energy Transformation

The public policy need and the political will being exhibited in Ottawa presents an opportunity for the federal government to use its spending power to join with provinces in funding (through tax dollars, not ratepayer charges) non-typical and transformative infrastructure projects to fill the gaps. There may also be a role for the private sector in addressing these challenges.

In his Davos speech in January, Prime Minister Trudeau recognized the historic and economic role of electricity:

> **"If we didn't build the public infrastructure in the early 20th century to support mass electrification, only the wealthy would have had heat and running water. And with that, the creation of the middle class – the base of resilient economies – would never have happened"**
>
> **– Prime Minister Trudeau,**
> Davos/World Economic Forum, January 20, 2016

CEA agrees with the Prime Minister's take of history of how our forefathers built for the future.

The Conference Board estimates that we will need to invest some $350B over 20 years to renew Canada's aging electricity systems. Canada is far from alone in confronting this challenge, the US, Europe, and Asia face the very same pressures.

In tackling this obligation, we must embrace innovation as an enabling force that will facilitate our success in securing a reliable and sustainable source of power for Canadians well into the future. We must envision transformational projects and technologies that could be deployed at scale. We must look for new ways to bridge long-standing gaps.

In other words, infrastructure investment with a different mindset, new partnership, and a spirit of national enterprise. We encourage the Prime Minister and other Canadian leaders to recognize, and act on, this historic nation building opportunity. To build a green future for generations to come. ■

About the CEA

Canadian Electricity Association members generate, transmit and distribute electrical energy to industrial, commercial, residential and institutional customers across Canada. Members include integrated electric utilities, independent power producers, transmission and distribution companies, power marketers and the manufacturers and suppliers of materials, technology and services for the industry. ***http://www.electricity.ca/***

CALL FOR PAPERS

EPEC 2016

Electrical Power and Energy Conference

"Smart Grid and Beyond: Future of the Integrated Power System"

October 12-14, 2016, Ottawa, Ontario, Canada

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The annual IEEE Canada Electrical Power and Energy Conference (EPEC 2016) will take place in Ottawa, Ontario, Canada from October 12-14, 2016. As the capital of Canada and located between Toronto and Montreal, Ottawa is easily accessible.

EPEC 2016 is a conference that provides an opportunity for experts from industry, academia, government sector and other interested organizations from Canada and abroad to present and discuss the latest developments in the electric power and energy systems: academic, industrial and government research and development, industrial and business trends and challenges, as well as regulatory and policy aspects. This includes debate on the potential impact of these developments on the society. The conference provides an international forum for the presentation of peer-reviewed papers and presentations on power and energy research and development, applications and their implementations.

Topics: **The EPEC 2016 welcomes submission of papers related to the conference theme including, but not limited to, the following topics**

1. Future Integrated Electric Power System
2. Smart Grids: Existing & Emerging Technologies
3. Communications in Smart Grids
4. Synchrophasors and Protection in Smart Grids
5. Power Electronics, HVDC, FACTS in Smart Grids
6. Renewable Energy: Generation and Integration
7. Energy Storage
8. Electrification of Transportation
9. Microgrids and Remote Communities
10. Smart Grid Standards and Deployment
11. Cyber Security and Power System Security
12. Energy Conservation and Efficiency
13. Nuclear Energy
14. Electricity Markets and Business Models
15. Integrated Energy System Planning
16. Data Analytics in Smart Grids
17. Computational Methods and Reliability
18. Government Initiatives, Policies and Smart Grids

Paper Submission: The format of the paper should follow the IEEE conference paper style. EPEC 2016 will only accept the electronic submission of a full paper in English. Detailed information on the paper format and submission procedure is available: http://epec2016.ieee.ca and the EDAS link for paper submission is: http://edas.info/N21909.

EPEC 2016 proceedings will be submitted to IEEE *Xplore*, and EI Compendex and ISI Proceedings.

Important Dates:

Submission of full papers in PDF	**May 22, 2016**
Submission of workshop & panel session proposals	**May 22, 2016**
Submission of tutorial proposals	**May 22, 2016**
Notification of workshop/panel/tutorial acceptance	**June 05, 2016**
Notification of paper acceptance	**July 05, 2016**
Submission of final camera-ready papers	**July 31, 2016**

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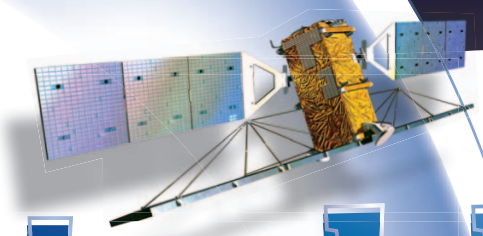


World View

Canadian remote sensing at home and abroad

Kevin Rokosh
The Engineer's Copywriter
Maria Rey
Space Strategies Consulting Ltd.
Director General of Defence Research and Development Canada, Ottawa Lab. (retired)
David G. Michelson
University of British Columbia

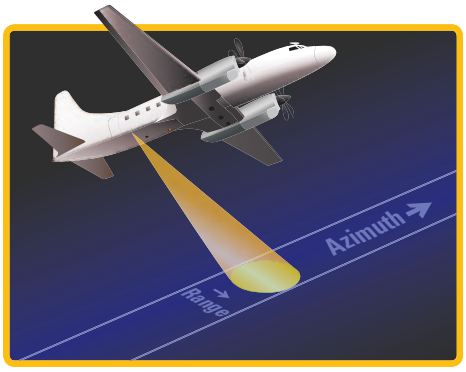
Canada's world-leading spaceborne radars give planners and decision makers a unique capability to monitor our ocean territories, aid in resource development and assess humanitarian needs.

Anytime, anywhere – Earth Imaging using Spaceborne Radar

Since the dawn of the space age, orbiting satellites have provided planners and decision makers with a unique vantage point from which to routinely observe the Earth and gather information for applications as diverse as weather forecasting, crop assessment, strategic surveillance, and geology. Until the late 1970s, however, virtually all Earth observation from space was based on optical images produced from reflected light in the visible and infrared.

While optical imagery from space has proven to be extremely useful, producing it requires both adequate illumination and clear skies. At night, or when clouds, fog or smoke obscure the ground, the quality and utility of such images suffer greatly. Radars provide their own illumination and operate at wavelengths that easily penetrate clouds, fog and smoke, but conventional side looking radars lack the resolution required to generate useful radar images of the Earth's surface from orbit.

The advent of Synthetic Aperture Radars mounted on fast moving airborne platforms introduced the first practical way to generate high resolution two-dimensional radar images of the land below.[1] As in conventional radar images, the intensity of individual pixels corresponds to the radar reflectivity of the scene. Unlike conventional radar images, however, the azimuthal or "along-track" resolution of SAR images is independent of range, yielding the possibility of creating photograph-like images with high resolution.



In Synthetic Aperture Radar (SAR), resolution in the azimuth direction is independent of range. SAR was first developed for airborne application.

Canada has made significant contributions to SAR research, development and application during the past 40 years including development of fundamental SAR image processing techniques and providing SAR image processors and systems engineering expertise to major U.S., European, Asian and other international customers. Since the advent of Canada's RADARSAT program in the mid 1990s, Canada has played a leading role in demonstrating the routine use of SAR imagery in both public and private sector applications.

Today, Canadian decision makers benefit from a wide range of Canadian-produced SAR image products. Marine surveillance and

[1] Polarimetric and interferometric SARs go a step beyond conventional SARs and allow special types of multi-channel or multi-image SAR data to be processed to yield image products useful in the identification of targets, interpretation of target structure, observation of fine ground movement and production of terrain elevation maps. In this manner, the utility of advanced SAR imagery can fundamentally surpass (and complement) conventional optical imagery.

ice-mapping have become routine applications. Geotechnical mapping and environmental monitoring are becoming increasingly important. Humanitarian disaster relief is a less common application — thankfully — but is of immense benefit when needed.

The "Magic" of SAR
(Synthetic Aperture Radar)

The linear path traversed by the simplest form of SAR as it moves along the scene is called the track. Resolution in range or the cross track direction – the direction in which the radar antenna points – is determined by the effective duration of the radar pulse. In this respect, SAR functions in the same manner as conventional radar and conventional pulse compression techniques can be used to improve resolution. A monostatic SAR uses the same antenna for transmission and reception and is sensitive to the diffuse waves reflected back from the target (backscatter response). In bistatic SARs, the transmitting and receiving antennas are separate.[2]

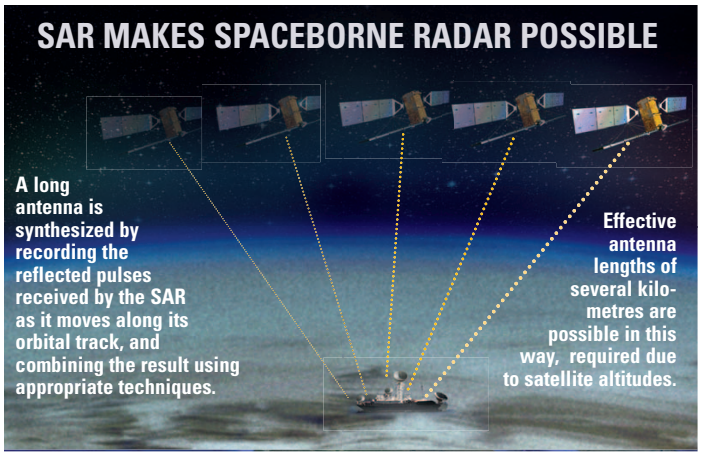
Resolution in the azimuthal or along track direction is determined by the radar antenna's length. It is well known that an antenna's beamwidth becomes finer as the antenna lengthens. There are limits to how long a physical antenna can be realized given the many constraints imposed upon satellite payloads. However, it is possible to synthesize an arbitrarily long antenna by recording the signal received by the SAR as it moves along its orbital track and combining the result using appropriate techniques.

However, a side-looking radar that simply synthesizes a large antenna with a very fine beamwidth using simple beamforming techniques is not sufficient. A simple geometric construction reveals that the width of the pixels in the radar image will increase linearly with the range to the target. Satellite orbits increase that range to hundreds of kilometres and fatally degrade the azimuth resolution. A new approach is required.

Synthetic aperture radar is based upon the observation that the energy from a given point target is spread in both range and azimuth. In SAR image reconstruction, this dispersed energy is collected or focused into a single pixel in the output image using advanced signal processing techniques. The underlying principle also forms the basis for the well known medical diagnostic tool commonly called CAT Scan, short for Computer Aided Tomography, that yields high resolution images of the body using low power X-rays. In radar application, the result is also a high-resolution image. But unlike conventional side-looking radar, the azimuth resolution is independent of range.

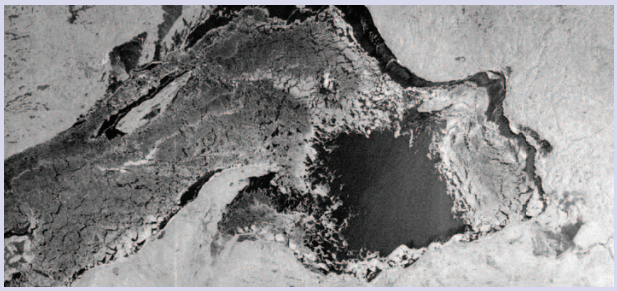
Such fine and uniform resolution in both the azimuth and range directions means that a SAR can create photograph-like images of the landscape, as seen in the RADARSAT-1 image in the sidebar to the right. *This is the magic of SAR*. However, because the location of a point target in a SAR image is based upon the time of flight, not the line of sight as in an optical image, SAR images suffer from a characteristic distortion in which higher terrain appears to be folded towards the observer. This is most apparent in SAR images of mountainous terrain.

[2] They may even be carried by different platforms, either to permit characterization of forward scatter from the target, to allow a secondary receiver to take advantage of existing transmitter in a parasitic mode of operation, or to make it difficult for a third party to detect the receiver.



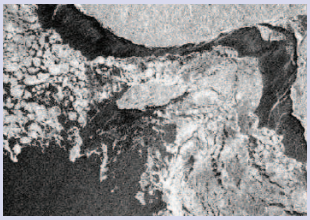
SAR creates photograph-like images

Lake Superior is easily recognized in this RADARSAT-1 image. Taken in late winter, the lake is almost entirely ice covered. The SAR was operating in ScanSAR Wide mode, giving a swath width of 500 km.



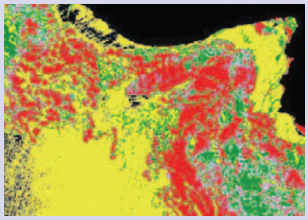
RADARSAT Data © Canadian Space Agency (CSA) 1997

An enlargement of the north shore near the east end of the lake. RADARSAT-1 operated at an altitude of about 800 km. In ScanSAR wide mode, the resolution of pixels in the azimuth direction was about 100 m.



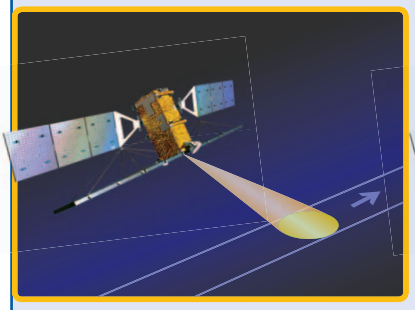
A satellite equipped with conventional real aperature radar operating at the same altitude would yield a resolution in the azimuth direction in excess of 5 km. Very little useful information would be obtainable.

Processing of the RADARSAT-1 image using calibration software and a library of backscatter signatures allows classification of ice coverage. Image created by George Leshkevich and Son Nghiem, 2007 [REF: 1]



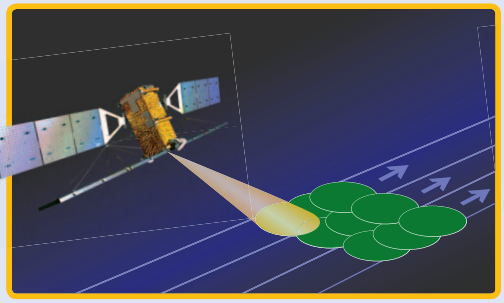
Consolidated ice flows | Brash ice | Stratified ice | Calm water

RADARSAT Operating Modes



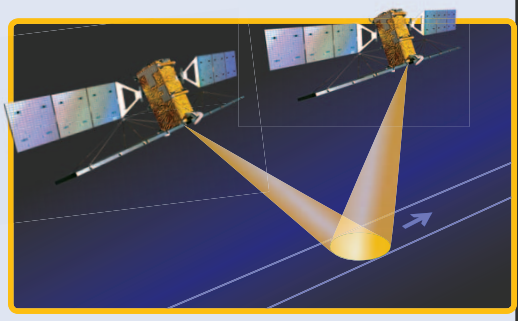
Stripmap Mode

The basic SAR configuration in which the radar antenna is pointed broadside to the direction of travel permits formation of a continuous image of the ground. This is called **Stripmap SAR**. Synthetic aperture radars can be configured to operate in other modes in order to enhance certain aspects of SAR performance.



ScanSAR Mode

In **ScanSAR**, as orginally developed, the radar antenna is electronically steered to different angles in order to illuminate multiple swaths. This permits a wider area to be imaged than is possible in conventional SAR systems. Canada's RADARSAT-2 ScanSAR uses two or more physical beams operated sequentially, each producing separate image blocks that are then electronically merged together.



Spotlight Mode

In **Spotlight SAR**, the radar antenna is electronically steered in order to keep the target in view for a longer period. Because this extends the size of the synthetic aperture, it increases the azimuthal resolution of the image but at the expense of spatial coverage.

A Brief History of SAR

The synthetic antenna concept was first successfully applied to radar by Carl Wiley at the Goodyear Aircraft Corp. in 1953. He used an aircraft for the moving antenna platform and a storage tube display that was configured to mimic a conventional Plan Position Indicator to present the radar returns. SAR literally took flight. [REF: 2]

Early data storage and processing was only practical using Fourier optics. By the mid 1970s, minicomputers with sufficient processing power to process SAR imagery digitally became available. The earliest computer algorithms in this area processed data from airborne SAR, developed by researchers at the Communications Research Centre (CRC) and The Defence Research Establishment Ottawa (now DRDC Ottawa). These algorithms were shared with Canadian industry in keeping with the commercialization mandate of the CRC dating back to its creation in 1969.[3]

In 1978, a Canadian startup company, MacDonald, Dettwiler and Associates, won the race to demonstrate that the general-purpose minicomputers available at the time could be used to reconstruct a viable SAR image from data collected by NASA's SEASAT spaceborne SAR (see IEEE Milestone article in the previous issue). In 1979, a CRC-designed processor yielded the first full-resolution SAR images from SEASAT.

[3] Historically, the vast majority of SAR image reconstruction has been conducted using frequency domain processing where computationally intensive convolution operations are replaced by much simpler multiplications in the frequency domain after application of a Fast Fourier Transform. Canadian SAR researchers played key roles in the development of three of the four common SAR processing algorithms in use today: Range-Doppler, Chirp Scaling, and SPECAN. A fourth, Omega-K, was developed at Politecnico di Milano in Italy. In recent years, advances in computing technology have made it possible to reconstruct SAR images using direct methods such as back projection and thereby avoid the need to satisfy some of the simplifying assumptions inherent to frequency domain approaches.

RADARSAT

In 1990 Canada created the Canadian Space Agency (CSA) within the Department of Industry. The RADARSAT-1 project was not only its first major project, but also the world's first operational civilian SAR satellite mission. Launched in 1995, the spacecraft lasted nearly 18 years and fundamentally changed the nature of Canada's Earth observation program.

Building on lessons learned, Canada developed RADARSAT-2 and launched it in 2007. Continuing Canada's world-leading role in operational SAR solutions, we will be launching the new three-satellite RADARSAT Constellation Mission (RCM) in 2018. [REF: 3, 4, 5, 6]

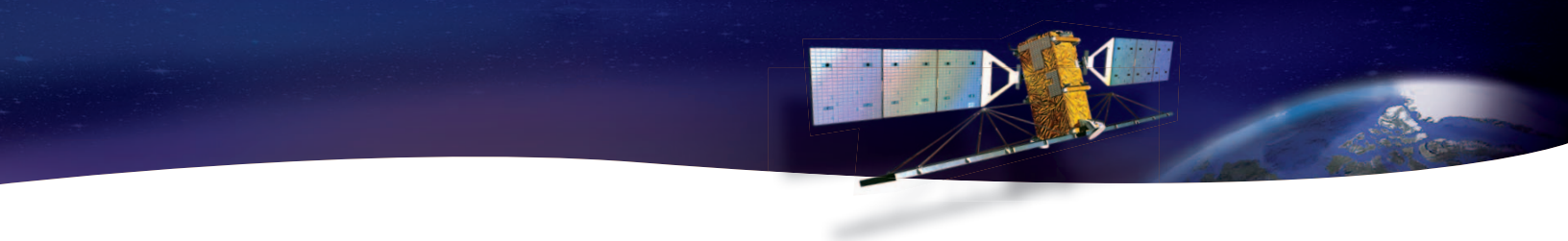
RADARSAT-1

The Canadian spaceborne SAR story began with RADARSAT-1, launched in 1995. The CSA managed the RADARSAT-1 project as a key component of the Canadian space program in the early 1990s. The total development contract was about $620 million (almost $1 billion in today's dollars), and the CSA owned and operated the final system. The major Canadian industrial team members who designed and built RADARSAT-1 for the CSA included

- **SPAR Aerospace (prime contractor, now part of MDA Corp.)**
- **MacDonald, Dettwiler & Associates**
- **COM DEV International Ltd.**
- **CAL Corporation (now part of COM DEV International Ltd.)**
- **SED Systems**
- **Fleet Industries (now Magellan Aerospace Corp.)**
- **IMP Group**
- **FRE Composites**

In exchange for access to SAR data, the National Aeronautics and Space Administration (NASA) supplied the Delta II rocket used to launch RADARSAT-1.

RADARSAT-1 followed a dusk-to-dawn sun-synchronous polar orbit with an altitude of about 800km. It always passed over the same Earth location at the



In 1990 Canada created its Canadian Space Agency (CSA); the RADARSAT-1 project was its first major crown project.

same time of day, which was important for consistent imaging through time and comparison with visible light imagery produced by other platforms. It also meant downlink ground stations had a consistent window of time to receive data sets. Being sun-synchronous also meant the satellite's solar panels were almost always in sunlight, ensuring that RADARSAT-1 ran primarily from solar rather than battery power.

The on-board SAR payload had the following specifications:

- **Frequency band: C-Band,**
- **Centre frequency 5.3 GHz**
- **Bandwidth 30 MHz**
- **Polarization HH (Horizontal transmit, Horizontal receive)**
- **Polarization isolation > 20 dB**
- **Aperture length 15 m**
- **Aperture width 1.5 m**
- **Mass 679 kg**

RADARSAT-1 had seven beam operating modes, with resolutions from 8m to 100m (depending on the mode) but could only look-right from the spacecraft. It would revisit its orbital path every 28 days. However, it could provide daily coverage of the Arctic. This was important, because at the time Canadian Ice Services needed a better method to monitor sea ice. RADARSAT-1 had its basic operating parameters (C-Band, HH polarization) optimized for ice mapping. And using one of its wider but lower resolution beam modes, the SAR could view almost any part of Canada within three days, and places near the equator every six days.

CSA planners had projected a 5-year lifespan for RADARSAT-1. So when it eventually failed in late March 2013, RADARSAT-1 had outlived all expectations. It delivered data products to more than 60 countries. But more important was its legacy as a civilian-based research tool, working hard to advance SAR Earth observation technologies. Though inoperable today, RADARSAT-1 still follows its dusk-to-dawn orbit — one more piece of space junk now.

RADARSAT-2

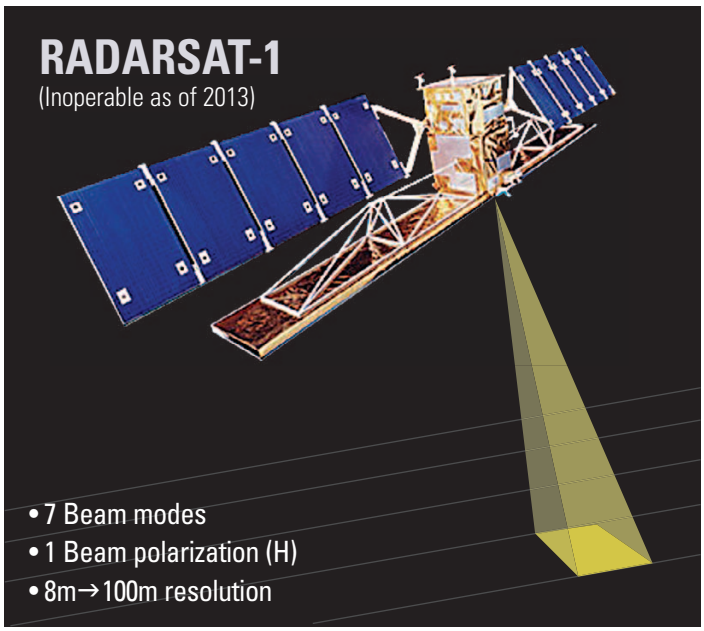
The follow-on CSA project, RADARSAT-2 was a direct descendent of the lessons learned from RADARSAT-1. It was a unique Public-Private Partnership (P3) project between CSA and MDA, with MDA owning and operating the final system. The development contract was approved in 2004 for a total of $528.8 million (about $641 million today) – slightly more than half the cost of RADARSAT-1. The Government of Canada contributed $437.1 million to the project. Though it had no ownership interest in RADARSAT-2, the government did receive about $446 million in data product credits from MDA.

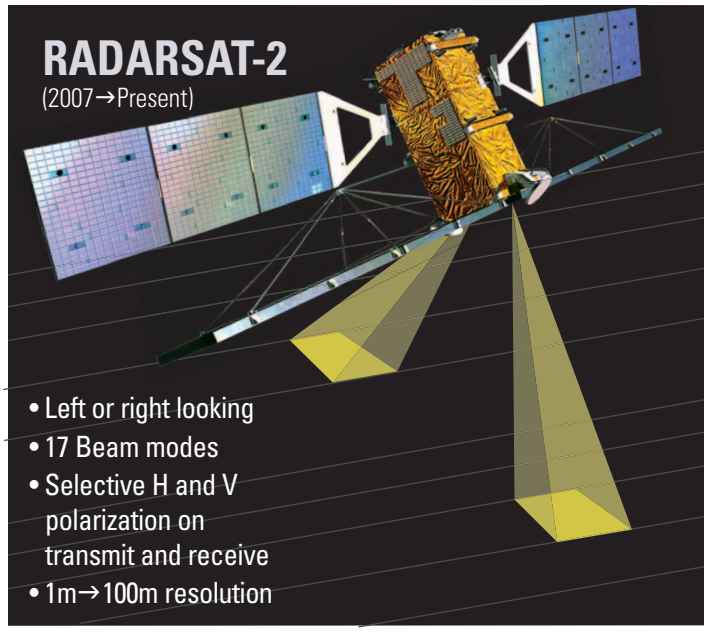
One limitation of RADARSAT-1 was its single polarimetry mode of Horizontal Transmit / Horizontal Receive (HH). Previous work had shown that much more information about the nature of the target can be extracted from radar pulse returns when a system can operate with multiple polarizations in both transmit (TX) and receive (RX). With flexible polarimetry modes, RADARSAT-2 SAR does a better job of discriminating different surface types and can classify terrain more accurately. It is particularly useful for detecting returns from artificial objects, such as ships at sea. Artificial objects tend to incorporate right-angled corners and, as a consequence, generate strong radar reflections with distinctive polarimetric features. [See sidebar on page 18]

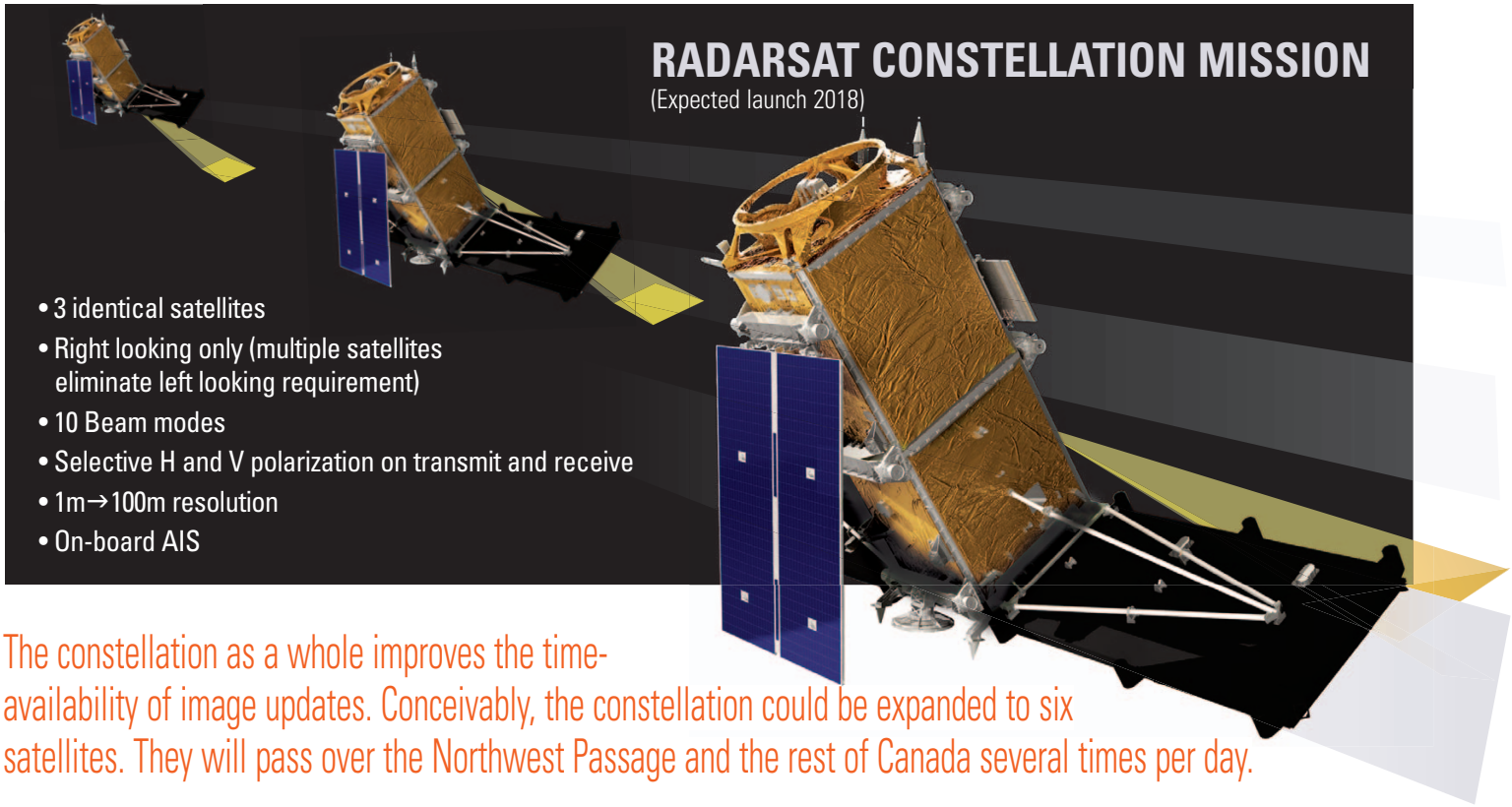
RADARSAT-2 also added routine look-left or look-right capabilities. This meant that from the same orbital path as RADARSAT-1 it could re-visit the same Earth locations more often. More frequent image capture increased the change detection capabilities of the RADARSAT-2 data products.

While RADARSAT-1 relied mostly on analog tape recorders, RADARSAT-2 employed solid-state memory devices for data storage. With solid-state memory came higher reliability and faster access to data.

Finally, RADARSAT-2 could use GPS to geo-locate itself to +/- 60m on orbit in real-time.







The constellation as a whole improves the time-availability of image updates. Conceivably, the constellation could be expanded to six satellites. They will pass over the Northwest Passage and the rest of Canada several times per day.

RADARSAT-2's SAR has the following specifications:

- **Frequency band: C-Band**
- **Centre frequency 5.405 GHz**
- **Bandwidth 100 MHz**
- **TX/RX Polarization HH, VV, HV, VH**
- **Polarization isolation > 25 dB**
- **Aperture length 15 m**
- **Aperture width 1.37 m**
- **Mass 750 kg**

The SAR has 17 beam modes that achieve resolutions from 100m down to 1m. It can look left or right from the spacecraft (but not both sides simultaneously).

Designed to last seven years, RADARSAT-2 has already exceeded its lifespan. It was launched in 2007, but not after some push-back from U.S. government policy. The original plan was to utilize another NASA-led Delta II rocket launch.

But at the time, U.S. government policy evolved to frown upon supporting foreign technology launches that could compete with their own interests – commercial and security. A launch contract was instead awarded to the Russians, and RADARSAT-2 was delivered into orbit on a Soyuz FG rocket.

RADARSAT Constellation Mission (RCM)

For about five years, both RADARSAT-1 and RADARSAT-2 co-existed. This provided an opportunity to combine SAR data from two separate satellites and made it easier to collect interferometric data sets (see sidebar on pg 17 for explanation of InSAR) to be used in the creation of geophysical elevation data for monitoring land structural stabilities. The results showed the value of having a constellation of SAR satellites working cooperatively to image the Earth.

But moreover, the ship detection capabilities of SAR proved to the Department of National Defence (DND) that SAR is a real solution to help monitor Canada's marine traffic, all the way out to 2,000 nautical miles.

Over about five years, beginning in 2005, the Government of Canada spent $216 million on RCM concept studies with MDA Corp. In 2013, the government entered a $706 million fixed-price contract with MDA Corp. to complete operational development of the RCM.

RCM will initially launch three identical SAR satellites in 2018. The final system will be owned and operated by the CSA. The major Canadian contractors delivering the space project are:

- **MDA Corporation**
- **COM DEV International Ltd.**
- **Magellan Aerospace Corp.**

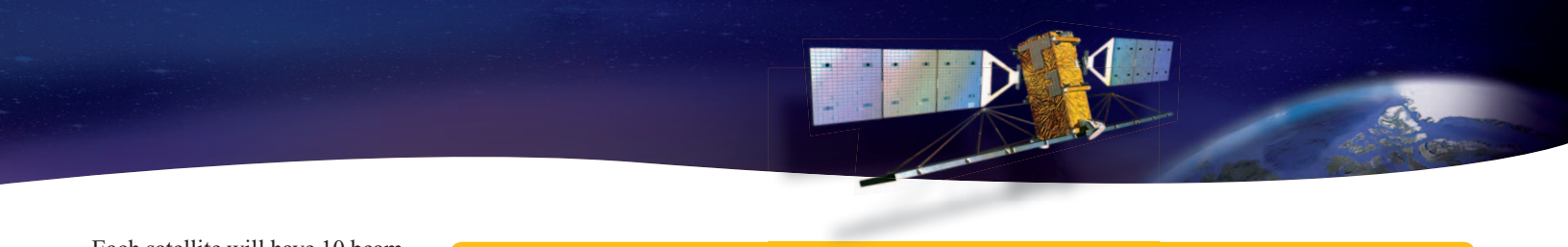
Working as a constellation, these satellites will monitor the Arctic with four overhead passes daily, and will pass over the Northwest Passage and the rest of Canada several times per day.

The constellation will also follow a sun-synchronous polar orbit, but at 586km – lower than RADARSAT-2. Space Exploration Technologies (more commonly known as SpaceX) has been awarded the contract to launch all three RCM satellites on one Falcon 9 launch vehicle.

As a constellation, there's no longer a need to have both left- and right-looking SAR features. The constellation as a whole improves the time-availability of image updates. If required, the constellation could later be expanded to six satellites.

Each RCM satellite will have the following specifications:

- **Frequency band: C-Band**
- **Centre frequency 5.405 GHz**
- **Bandwidth 100 MHz**
- **Polarization HH, VV, HV, VH, Compact Polarimetry (Circular TX, H&V RX)**
- **Polarization isolation > 30 dB**
- **Aperture length 6.75 m**
- **Aperture width 1.38 m**
- **Mass ~400 kg**



Each satellite will have 10 beam modes with resolutions from 100m down to 1m. Its ship detection mode should be able to detect vessels down to at least 25m in size. To support the DND's operational objectives for marine surveillance, the RCM will also have an Automatic Identification System (AIS) payload. [See sidebar to the right]. The SAR and AIS systems can be used in synergy to improve ship detection. SAR can image vessels whose transponder signals are not detected by AIS, and vice-versa.

Automatic Identification System (AIS)

Automatic Identification System (AIS) is a ship-to-ship and ship-to-shore transponder based system of identifying marine vessels. AIS-equipped ships broadcast identification, heading, ship size and type, and hazardous cargo information. Other ships use this to aid in collision avoidance and shore systems use the data to manage maritime control. AIS signals can also be received by satellite, and RCM will have an on-board AIS. With the addition of satellite surveillance, a more complete picture of maritime traffic flow and control can be achieved.

The rules of the International Maritime Organization mandate that most ships greater than 300 gross tonnage operate AIS transponders. Today, more than 60,000 ships worldwide carry AIS transponders. The data AIS provides is valuable to accurately tag and identify vessel traffic identified by space borne SAR. It allows maritime operations controllers like the DND to quickly discern known vessel traffic from unknown, perhaps rogue vessels.

exactEarth Ltd. (jointly owned by COM DEV International Ltd. and HISDESAT Strategic Services, S.A) has a commercially operating constellation of 7 AIS satellites providing global ship detection capability. Since 2012 they have been under contract to provide data to the CSA and DND. [REF: 8]

SAR Data Applications

Canada has three primary interests in using SAR imagery:

- **Maritime surveillance** (ice, surface wind, oil pollution and ship monitoring)
- **Ecosystem monitoring** (agriculture, wetlands, forestry and coastal change monitoring)
- **Disaster management** (mitigation, warning, response and recovery)

Each RADARSAT mission has included project objectives to meet these application demands. And RCM will continue to support these objectives. RCM also continues the research opportunity to expand the scope of applications through further operating mode analysis projects in Canada and around the world. [REF: 7]

Coast-to-Coast-to-Coast – Keeping an Eye on Our Oceans

Continuous monitoring of Canada's vast ocean frontiers would be a tedious, time-consuming impracticality if we did it all at the Earth's surface. With space-based SAR data, even from the first generation RADARSAT-1 system, Canada enhanced its overview of offshore interests.

Marine Surveillance

Canadian expertise in this particular application of SAR actually began emerging in the late 1970s. Defence Research and Development Canada (DRDC), the Science and Technology arm of the Department of National Defence, had been developing high-resolution airborne SAR signal processing algorithms for military coastal surveillance applications. In June 1978, NASA's Jet Propulsion Laboratory launched Seasat, the first Earth-orbiting SAR-equipped satellite designed for remote sensing of the Earth's oceans. Although it functioned for only about three months, Seasat produced a wealth of ocean imagery.

Applying their expertise in airborne SAR surveillance, DRDC scientists were able to exploit the vast number of Seasat images made available, including many of ships and their wakes, imaged in varying ocean conditions. With colleagues from Natural Resources Canada (NRCan) and the Canadian Coast Guard, they began evaluating the use of space-based SAR for monitoring ship traffic off Canada's coasts. So when RADARSAT-1 was being designed, its benefit in this area was well understood.

The later introduction of differently polarized radar pulses greatly enhances SAR vessel recognition capability (see sidebar on pg. 18 for polarization techniques). Reflected cross-polarized backscatters provide well-correlated sea-state wind speeds. The ocean surface appears fuzzy, and ship returns stand out clearly. The resulting picture can be used for monitoring ocean traffic.

The DND has integrated SAR imaging into their Polar Epsilon maritime surveillance system. Ground stations use satellite SAR data to aid the DND with monitoring naval traffic around all of Canada's coastal waters, east, west and north. When combined with AIS ship data, positive maritime ship tracking, of both friendly and rogue vessels, becomes possible. In fact, the DND's next generation Polar Epsilon-2 project will employ the RCM for this very purpose, using the co-located AIS system on board each satellite to enhance the system's capabilities. [REF: 9, 10, 11]

Since SAR imaging produces detailed land maps, the world's coastal areas can be monitored for changes over time too. Observers can routinely map and compare coastal erosion, monitor aquaculture activities and potentially locate productive fishing grounds. Construction of new islands in disputed waters can be detected.

Marine Wind Monitoring

From hurricane monitoring to wind farm site selections, SAR data can be used to build ocean surface wind-speed images.

The radar cross-section (the effective area that an object presents to a normally incident radar pulse) of ocean wave surfaces correlates well with wind speeds. The intensity of the ocean surface returns tends to increase with the wind-state of the ocean. Cross-polarized SAR returns can be used to further refine estimates of the wind state of the sea. The SAR data can be used to build wind maps to help identify the best sea-based locations for wind farms – often a better option than placing them on land. [REF: 12]

Useful for disaster prediction and response, though, are the hurricane maps that can be built. Optically, we rely on mapping the change in cloud cover to predict a hurricane's trajectory. But if wind speed can be correctly extracted from the data within the SAR return

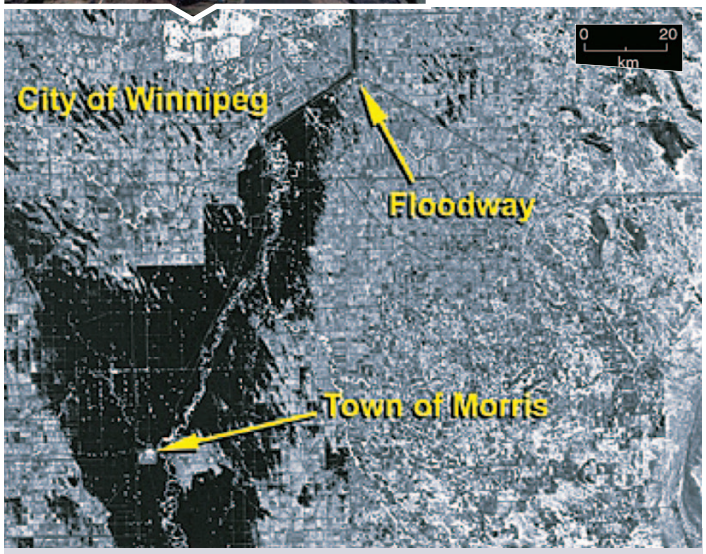
image, then forecasters can more accurately monitor and predict a hurricane's destructive path. SAR can see through the swirling cloud cover down to the ocean surface, and provide a dimension to hurricane analysis that has not been previously available using optical imagery.

Ice Mapping

With our large polar ice areas, shrouded in darkness throughout the winter, SAR imaging provides detailed ice mapping capabilities. RADARSAT-1's design was optimized for this. Experience has confirmed the practicality of using radar data to produce daily ice maps throughout the year and use them to chart safe shipping routes and aid supply trips to offshore exploration, research and drilling operations.

"RADARSAT data has proven to be a very cost-effective way of monitoring ice conditions throughout Canadian waters and has enabled us to expand our service and reduce the Canadian Ice Services budgets by about $6 million dollars a year in terms of data acquisition." - B. Ramsay, Canadian Ice Services [REF: 13]

Processing the intensity of the SAR return data creates ice maps that ships can use to safely navigate our waters. Sea ice reflections are far more coherent than returns from ocean water. Different ice types themselves display measureable reflection characteristics too, especially if cross-polarized backscatter returns are available. [REF: 14] The Compact Polarimetry mode of the RCM provides a promising tool to map large ice-area SAR swaths with very useful ice-type content. [REF: 15]



Upper Image: Red River Floodway, spring 2007. *Photo Credit: Natural Resources Canada 2012, courtesy of the Geological Survey of Canada (Photo 2000-118 by G.R. Brooks)*

Lower Image: RADARSAT-1; dark areas represent flooding. The Floodway was able to provide protection for the city of Winnipeg; a ring dike around the town of Morris keeps the waters at bay. *Photo Credit: RADARSAT Data © Canadian Space Agency (CSA) 1997 ; data enhancement and interpretation by Canada Centre for Remote Sensing*

Making comparative maps of polar ice over months and years also allows us to measure and report the changing effects of global warming. The breadth and depth of our ice will help us know where we stand on the global temperature continuum. From the beginning of our SAR story, Canada has supported these global interests. In 1997, we helped to produce the first seamless image of Antarctica using RADARSAT-1 data. [REF: 16]

Oil Spill Monitoring

Like ice, oil also displays an easily detectable SAR reflection characteristic. Detailed mapping and tracking of oil spills allows accurate deployment of marine clean-up efforts, saving time and possibly saving sensitive coastal areas from environmental disasters.

Land and Environmental Monitoring Lead to Disaster Relief

Poor ambient light, clouds, and difficult physical access create barriers to detailed land mapping. None of these stand in the way of SAR. Radar backscatter returns can be correlated to various land matter, like forests, grasslands, lakes, mountains and urban development.

Land Monitoring and Cartography

The polarization response of a target is sensitive to the structure and spatial arrangement of surface and vegetation features, like forests, grasslands and wetlands. Radar scattering properties can be used to retrieve geophysical and biophysical parameters such as soil dielectric constants, ground surface roughness, slope as well as forest height and biomass.

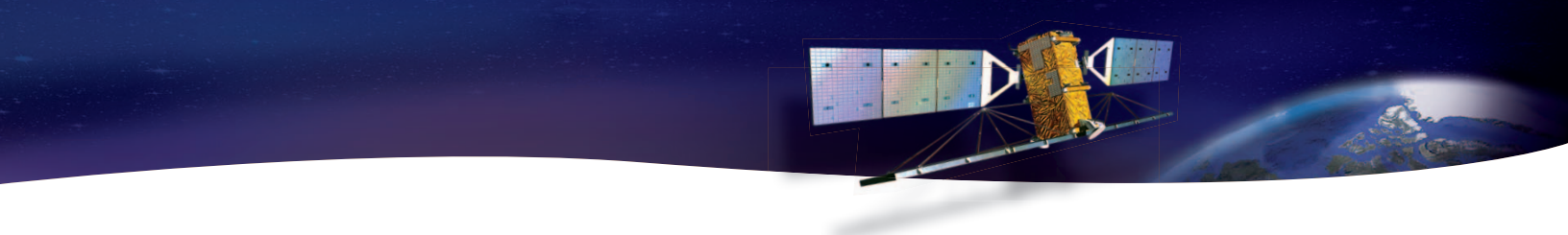
The resulting geophysical and biophysical SAR images can be used to better manage forestry growth and use, agricultural land use, and wetland growth or erosion. These types of SAR images can also be used to monitor land use threats to wildlife, including Polar Bears around Hudson Bay, or Grizzlies in the National Parks. Officials can make better informed land management decisions to protect our wildlife habitats and their biodiversity.

Combining SAR images with optical satellite imagery vastly increases the utility of the data. During Manitoba's "Flood of the Century" in 1997, RADARSAT-1 image data was overlaid on maps of the Winnipeg area. The Canadian Forces were able to see washed-out roads and bridges that couldn't be used. They directed their relief efforts around the obstacles and quickly got aid on the ground to where people needed it. [REF: 17]

Frequent satellite overpasses of a particular location also allow detailed image building. Interferometric SAR (InSAR) can be accomplished using one SAR satellite operating in so-called Spotlight mode: taking many localized snapshots of a smaller area during the satellite's overhead tracking time.

But results are more efficiently obtained—with higher resolution possibilities—if SAR data can be combined from more than one satellite passing overhead in a small time window. From this data a stereographic 3-D image can be built. This produces a detailed Digital Elevation Model (DEM) that can be used to prepare engineering site drawings and opens the possibility to remotely monitor site integrity.

K. Mattar and J. Secker at Defence R&D Canada looked at the feasibility of using RADARSAT Spotlight Mode InSAR data to monitor the landfill integrity at four of Canada's decommissioned Distant Early



Warning (DEW) Line radar sites. These remote sites are strung across the Canadian Arctic from Alaska to Greenland. To maintain Canada's stewardship of the North, we need to monitor these sites for landfill changes like surface slides, soil depressions, water ponding, frost-induced changes and even human alterations. [REF: 18]

Mattar and Secker found the concept is feasible, though it really needs a better coherent repeat imaging cycle than the 24-day cycle offered by RADARSAT-2. The upcoming launch of the RCM will address this shortcoming with its four-day coherent repeat visit interval.

Also, Mattar and Secker propose a method to aid surface deformation monitoring in the future: place radar corner reflectors at key geographic measurement points to "amplify" the return. From such a reflector, a SAR signal return would have an expected constant amplitude and site-surveyed location. Over time, it would be possible to build a centimetre-accurate SAR image of the reflector's location – opening the possibility to detect minor surface movements before they become major catastrophes.

Disaster Management and Humanitarian Relief

Using InSAR, key geographic locations around the globe can be monitored for disaster response. Minute changes in the height of terrain in the vicinity of volcanic structures can be measured, enhanced if necessary with corner-reflector markers. The results can be used by authorities to alert the nearby population of an impending eruption. Similar InSAR mapping can be applied to aid prediction of flash floods and landslides.

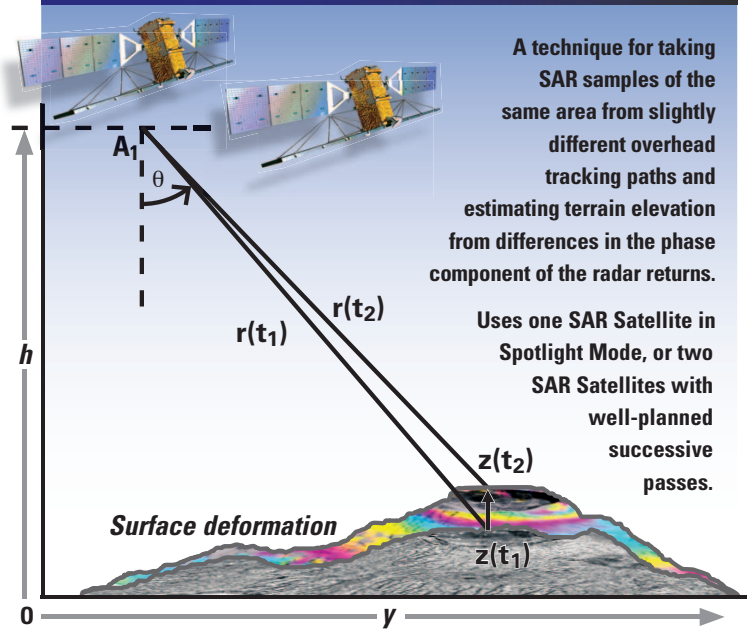
Along the same lines, pipeline corridors can be monitored with SAR images. Geological shifts that might indicate unstable slopes or similar instabilities before a ground team needs to be dispatched. Remote oil pipeline breaks might be seen earlier if sampled with the appropriate beam mode.

Wildfire mapping, hurricane monitoring, catastrophic flooding – if we can't predict the disaster we can use SAR imaging data to support our relief efforts. Pre- and post-tsunami SAR images were used to assess coastline damages and to help direct aid and rescue efforts after the South Asian ocean tsunamis of December 26, 2004.

Already mentioned was the support SAR provided in response to the 1997 Manitoba "Flood of the Century." Earlier, though, RADARSAT-1 images were used to support humanitarian relief assistance during the 1994-1996 Rwandan "Great Lakes Refugee Crisis." Millions of Hutu refugees massed in the Great Lakes region of Africa. Comparing before and after RADARSAT-1 images, ground picture changes were easily seen. This allowed pin-point determination of refugee encampments and even showed new obstacles on nearby airstrips, likely making them unusable to support delivery of humanitarian shipments.

SAR continues to be a key technology for the relief of human suffering. A new SAR satellite program jointly sponsored by NASA and the Indian Space Research Organization (ISRO) — dubbed NISAR — is a good example. With broad capability to measure changes to the earth's surface through polarimetric InSAR, it will assess the extent and severity of damage in natural disasters, and will have a host of other humanitarian applications. A launch date by 2021 has been suggested by the ISRO. [REF: 19, 20]

Interferometric SAR (InSAR)



A technique for taking SAR samples of the same area from slightly different overhead tracking paths and estimating terrain elevation from differences in the phase component of the radar returns.

Uses one SAR Satellite in Spotlight Mode, or two SAR Satellites with well-planned successive passes.

Civil Engineering InSAR Applications

Able to detect changes in elevation in the order of a centimetre or less, InSAR is becoming increasingly important in ensuring the safety of large civil engineering installations. Applications include monitoring movement of bridge footings and pipeline sections, and monitoring the stability of slopes in roads, reservoirs, etc. The increased frequency of InSAR data to be available with RCM will reinforce this trend. Development of such commercially viable data products is key to supporting ongoing remote sensing research.

Spaceborne Earth Observation — Canada's Legacy

The capability for monitoring of Canada's natural resources from space began with the creation in 1971 of the federal government's Canada Centre for Remote Sensing (CCRS), recently renamed the Canada Centre for Mapping and Earth Observation (CCMEO). This coincided with the advent of earth observation satellites such as ERTS (Earth Resources Technology Satellite, later renamed Landsat), which could return high-resolution imagery of the ground in several different optical wavelengths or spectral bands.

Through the CCRS, the newly available data products could be reliably obtained by policy makers, decision makers and the general public. Monitoring and managing of Canada's natural resources were fundamentally changed. Over the next few decades, optical Earth observation satellites proved their value and steadily increased in number, sophistication and capability.

Beginning with the RADARSAT-1 project, the Canadian government has had a specific policy objective to produce and operate the most advanced SAR-based earth observation satellites in the

world. We were the first to market with an operational civilian spaceborne SAR in 1995, and are continuing to lead into the future with RCM.

The sidebar to the right lists the Canadian Government organizations that use RADARSAT-2 data. Each has a mandate that covers wide remote swaths of the Canadian land and ocean scape. This list implies how valuable SAR Earth observation has become to our national interests. Of particular note, Canada today is the global forerunner in space-based Maritime Domain Awareness; although government led, integral to this success is the strong participation of industry and academia.

CSA's RADARSAT-2 Project was a Public-Private Partnership. At the project conclusion MDA became the owner and operator of RADARSAT-2. This put MDA into the business of selling SAR ground station equipment and image data nationally and internationally. However, it's been a business of first educating the users. It is one thing to identify usable SAR data. It's another thing to develop actual user readiness to put that data to work. The market development continues to evolve. For example, MDA has SAR product contracts with the oil industry, European agencies and the US Department of Defence. Canadian SAR expertise has become an international export product.

The RADARSAT family of CSA space missions have fostered the development of the Canadian aerospace industry. The legacy is wide and deep. Canadian universities like University of Toronto, University of Manitoba and University of British Columbia have industry-partnered research and development programs that feed engineering and science talent into the Canadian aerospace industry.

The University of Toronto Institute for Aerospace Studies – Space Flight Laboratory (UTIAS-SFL) has been doing exciting work on micro/nanosatellite spacecraft. These satellites are about half the size of a typical bar fridge, whereas RADARSAT spacecraft are more the scale of a small car. UTIAS-SFL built and launched the twin nanosatellite mission CANX-4 and CANX-5. It successfully proved that two satellites can orbit in close proximity and even maneuver around each other at the same time. Perhaps this points in the direction of Canada's next generation space-based SAR constellation.

In March 2015, Magellan Aerospace and the University of Manitoba (U of M) launched their new Advanced Satellite Integration Facility (ASIF) inside Magellan's Winnipeg buildings. The ASIF can support all three RCM satellites in 6,000 square feet of ISO Class 8 cleanroom space. Magellan will use the ASIF to assemble and test the RCM satellites. And it positions the company to win more national and international satellite assembly projects.

Magellan went beyond providing real estate for the ASIF. They also used $625,000 to create an Industrial Research Chair in satellite development at U of M's Faculty of Engineering. Together, the ASIF and the Chair give faculty and students opportunities for world-class research and hands-on experiences in satellite technology development.

THE TOP 5 Canadian Government organizations that use RADARSAT-2 data* are:

- Canadian Ice Services
- Department of National Defence
- Natural Resources Canada
- Canadian Space Agency
- Canadian Coast Guard (Department of Fisheries and Oceans)

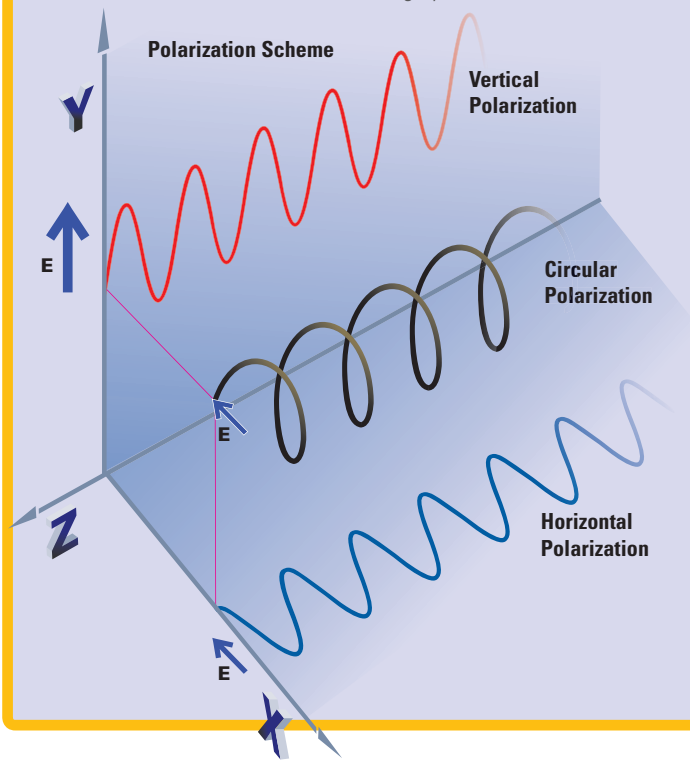
(* as of 2009) [REF: 5]

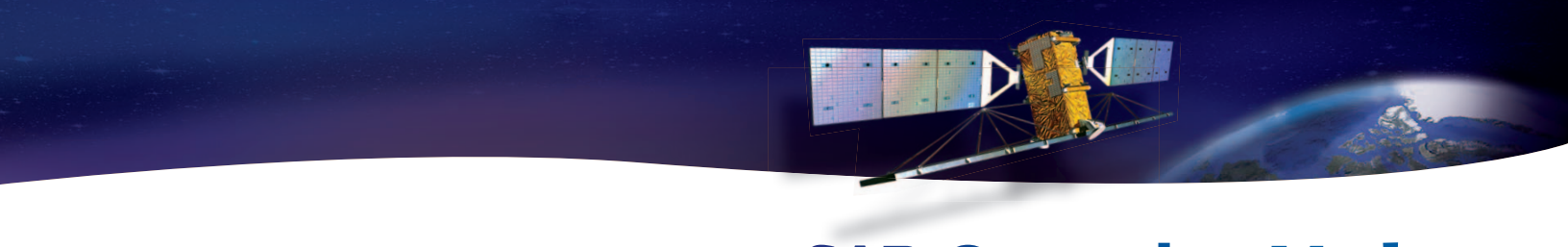
Horizontal-Vertical-Circular EM Wave Polarization

Electromagnetic (EM) waves are polarized in one of three basic senses: horizontal, vertical or elliptical/circular. The amplitude of each polarized EM field vector (E) will oscillate with respect to the normal pointing direction of the antenna. An antenna tuned to transmit in one polarized sense will likewise be tuned to receive that sense. Earth reflections (ground structures, vegetation, ice, ships, varying soil moisture, etc.) provide unique radar reflections based on the incident polarized EM waves.

The polarization state of an electromagnetic wave describes the behaviour of the electric field vector over time as observed at a fixed point in space. Often, the polarization state divides into randomly polarized or /unpolarized/ and fixed or /fully polarized components. The fully polarized component is completely specified by a 2 x 2 complex-valued polarization scattering matrix referred to orthogonally polarized bases, e.g., horizontal and vertical, right and left circular, etc. By comparing the polarization states of the incident and reflected waves, much can be inferred about the geometry and symmetry of the radar target.

Thus, polarization response supports both identification and classification of targets seen in SAR imagery.





The RADARSAT family of CSA space missions have fostered the development of the Canadian aerospace industry. The legacy is wide and deep.

The University of British Columbia has a long history of collaborating with MDA in the areas of SAR image reconstruction and image interpretation. From 1992-2007, MDA sponsored an NSERC Industrial Research Chair in Radar Remote Sensing that was held by SAR pioneer Ian G. Cumming. Many of the graduate students trained under the Chair went on to become MDA employees. More recently, MDA has begun to collaborate with the UBC Radio Science Lab to develop more sophisticated models of radar targets in both terrestrial and maritime environments.

Numerous other universities have also participated in satellite or interplanetary missions including: Alberta (U. of), Athabasca, Calgary (U. of), Dalhousie, Guelph (U. of), Lethbridge (U. of), McMaster, Montréal (U. de), New Brunswick (U. of), Québec à Montréal (U. du), Royal Military College, Saint Mary's, Saskatchewan (U. of), Simon Fraser, Victoria (U. of), Waterloo (U. of), Western Ontario (U. of), and York.

While MDA Corp. plays a leading role in the industry side of Canada's SAR efforts, many other Canadian companies are playing important roles in SAR and in other satellite-related technologies. Examples include: Array Systems Computing, Inc of Toronto, which provides technical investigations and software engineering support services to develop signal processing and display software for SAR and related fields; PCI Geomatics, based in Toronto and Gatineau, which provides specialized tools for processing SAR data in a standard remote sensing or GIS environment.

Moving west, the prairies are home to Saskatoon-based SED Systems, a major supplier of satellite ground stations to the European Space Agency. In B.C., 3V Geomatics of Vancouver provides InSAR data analysis services in support of the oil and gas, mining, infrastructure management, and offshore sectors. Also in Vancouver, UrtheCast Corp., which has announced plans to build, launch and operate the world's first fully-integrated, multispectral optical and SAR commercial constellation of Earth Observation satellites, to be deployed over multiple launches expected in 2019 and 2020.

Continuing Our Proud Heritage of Innovation

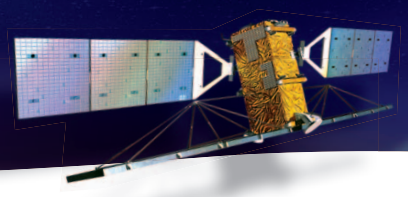
Canadian government agencies, universities and industry have been playing a world-leading role in advancing Earth observation using SAR. For our small population, we have the second biggest country in the world to keep watch over. By building a space-based observation system like RADARSAT to help keep an eye on it all, we've leveraged some of the best engineering talents our country has ever produced.

We are well positioned to take advantage of recent trends in spaceborne remote sensing. With further electronics miniaturization and faster processing speeds, there will be more "small" SAR-equipped satellites (500 kg or less). A whole host of microsatellites are also under development—less capable, yes, but less expensive as well. These will complement traditional large satellites.

SAR Operating Modes and Applications

Application	Geographic Coverage	SAR Polarization Mode	End Use
Ice and iceberg monitoring	Great Lakes, Coastal zones (3 oceans), Shipping lanes	Dual co-cross	Ice Charts
Marine winds	Great Lakes, Coastal zones (2 oceans)	n/a	Weather forecasts
Oil pollution	Shipping lanes, Coastal zones	Dual co-cross	Integrated Satellite Tracking of Pollution (ISTOP), Spill response
Ship detection	1200nm (above 42° N)	Dual co-cross	Domain awareness product
Forestry	Forest areas of Canada	Quad	State of the forest report
Protected areas and wildlife habitat	Parks and sensitive areas	Quad	Change map
Agriculture	Cultivated land in Canada	Quad	Crop classification, crop yield products, tillage practice product
Wetlands	Wetlands in Canada	Quad	Change map
Coastal change	Coastlines 3% highly sensitive	TBD	Change map
Disaster mitigation	Canadian urban areas, Transport and energy corridors	Variable	Risk maps
Disaster warning	River basins, Geohazard risk areas	Variable	Warning bulletins
Disaster response	Global	Variable	Situational awareness; damage assessment
Disaster recovery	Global	Dual co-cross or Quad	Maps

[Information in table extracted from REF: 7]



At the same time, the technological advances mentioned above are opening up new possibilities for satellites in time-sensitive applications such as Maritime Domain Awareness. Until now, raw data has been transmitted to ground stations in a relatively slow process, given the volume of data. Onboard processing of SAR data will mean that immediately useful information can be sent directly to decision makers, rather than waiting for ground stations to first construct the imagery.

Future articles will explore a range of novel satellite trends, including the capabilities of upcoming Canadian nanosatellites (weighing one kilogram or less) and the combining of SAR data with that of other remote sensing technologies. ■

References

[1] G. A. Leshkevich and S. V. Nghiem, "Satellite SAR Remote Sensing of Great Lakes Ice Cover, Part 2. Ice Classification and Mapping," *J. Great Lakes Res.*, vol. 33, pp. 736–750, 2007

[2] C. A Wiley, "Synthetic Aperture Radars – A Paradigm for Technology Evolution," *IEEE Trans. Aerosp. Electron. Syst.*, vol. AES-21, pp. 440-443, May 1985

[3] Canadian Space Agency, "Earth Observation Satellites," [Online], http://www.asc-csa.gc.ca/eng/satellites/default-eo.asp

[4] Treasury Board of Canada Secretariat, "Status Report on Major Crown Projects," [Online], https://www.tbs-sct.gc.ca/dprrmr/2007-2008/inst/csa/st-ts04-eng.asp

[5] Public Works and Government Services Canada, "Evaluation of the RADARSAT-2 Major Crown Project," Project Number: 570-2782-3, September 2009, [Online], http://www.asc-csa.gc.ca/pdf/eng/publications/er-5702-7823.pdf

[6] The Canadian Press, "Controversial Canadian satellite mission to proceed," [Online], http://www.cbc.ca/news/politics/controversial-canadian-satellite-mission-to-proceed-1.1341208

[7] Canadian Space Agency, "The RADARSAT Constellation Mission," April 18, 2013 [Online] http://www.asc-csa.gc.ca/pdf/eng/publications/radarsat-constellation-eng.pdf

[8] H. Ball, *Satellite AIS for Dummies, Special Edition*, John Wiley & Sons Canada, Ltd., 2013.

[9] P. W. Vachon and R. Quinn, "Operational Ship Detection in Canada using RADARSAT," IEEE Geoscience and Remote Sensing Symposium 2014, Québec City, Québec, pp. 998-1001, [Online], http://cradpdf.drdc-rddc.gc.ca/PDFS/unc197/p802388_A1b.pdf

[10] National Defence and the Canadian Armed Forces, "Polar Epsilon Project," [Online], http://www.forces.gc.ca/en/news/article.page?doc=polar-epsilon-project/hnps1uo5

[11] National Defence and the Canadian Armed Forces, Polar Epsilon 2, [Online], http://www.forces.gc.ca/en/business-defence-acquisition-guide-2015/joint-and-other-systems-19.page

[12] P.W. Vachon and J. Wolfe, "C-Band Cross-Polarization Wind Speed Retrieval," *IEEE Geoscience and Remote Sensing Letters*, vol. 8, no. 3, pp. 456-459, May 2011

[13] Canadian Space Agency, "Maritime Surveillance," [Online], http://www.asc-csa.gc.ca/eng/satellites/radarsat/maritime.asp

[14] A. Kaur and S.S. Kang, "Sea Ice Detection using Synthetic Aperture Radar Algorithm in Image Processing," *International Journal of Computer Applications*, vol. 121, no. 13, July 2015

[15] M. Dabboor and T. Geldsetzer, "On The Classification Of Sea Ice Types Using Simulated RADARSAT Constellation Mission (RCM) Compact Polarimetric SAR Parameters," American Society for Photogrammetry & Remote Sensing 2014 Annual Conference, Louisville, Kentucky.

[16] Canadian Space Agency, "Antarctic Mapping Mission (AMM), [Online], http://www.asc-csa.gc.ca/eng/satellites/radarsat1/antarctic.asp

[17] S. Simonovic and T. Birkenstock, Database Subgroup Co-Chairs, "Red River Flooding Final Report," International Red River Basin Task Force of The International Joint Commission, May 2000

[18] K. Mattar and J. Secker, "Coherent Stacks of RADARSAT-2 Spotlight Mode Interferometry Data for Monitoring Arctic DEW Line Clean-Up," IEEE Geoscience and Remote Sensing Symposium 2015, Milan, Italy, pp. 1519-1522, [Online], http://cradpdf.drdc-rddc.gc.ca/PDFS/unc195/p801998_A1b.pdf

[19] NASA, "NASA-ISRO SAR Mission (NISAR)," [Online], http://nisar.jpl.nasa.gov/

20] Geospatial Media and Communications, "NISAR will set standards for future collaborations between NASA and ISRO says Dr. Paul Rosen," April 15, 2016, [Online] https://www.youtube.com/watch?v=WFXV5HMoKIE ■

N.Ed. A five-part series on radar remote sensing was published in the *IEEE Canadian Review* in issues #19 to #23 inclusive (Spring 1994 to Fall 1995). The topics included the latest commercial and government-operated airborne SAR systems, DND's Spotlight SAR project, and the design and capabilities of the then yet-to-be launched RADARSAT-1 satellite. Those interested in the background to Canada's current leadership in remote sensing will find these articles a most worthwhile read.

About the Authors

Kevin Rokosh is a freelance writer who helps engineering and technology companies with their writing projects. He received his BSc in Electrical Engineering from the University of Alberta in 1988 and has been an IEEE member for more than 25 years. He spent his engineering career working on air traffic control radar systems for Transport Canada and Nav Canada. He's also an accomplished road and track cyclist and cycling coach. He can be reached at: copy@Kevin Rokosh.com

Maria Rey is the former Director General of Defence Research and Development Canada, Ottawa Laboratory. First joining Defence Research Establishment Ottawa (DREO) in 1984, her early work was in the area of SAR signal and image processing with an emphasis on RADARSAT 1 and other space-based and airborne imaging radars. In 1995, she founded the Radar Data Exploitation group, leading the development of SAR imagery analysis, including automatic ship and wake

(continued in 4th column...)

David Michelson is with the University of British Columbia, Department of Electrical and Computer Engineering in Vancouver, where he leads the Radio Science Laboratory. He currently serves as the Canadian Representative for Commission F (Radio Wave Propagation and Remote Sensing) of the International Union of Radio Science (URSI) and is Editor of the Wiley/IEEE Press Series on Vehicular Technology. He is a Member of the Boards of

(continued in 4th column...)

Maria Rey bio
...continued

detection off Canada's coasts. She retired from DRDC in 2014 and is now Vice President and Chief Science Advisor with Space Strategies Consulting Limited in Ottawa; contact: maria@sscl.solutions

David Michelson bio
...continued

Governors of both the IEEE Communications and Vehicular Technology Societies. He is immediate past chair of IEEE Canada's Industry Relations Committee; contact: dmichelson@ieee.org

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IEEE Member and Geographic Activities recognizes an outstanding Region 7 volunteer

Tushar Sharma

MGA Young Professionals Achievement Award, 2015

By **Vawn Himmelsbach**

Tushar Sharma was on Facebook when he found out he'd won an MGA Young Professionals Achievement Award for 2015 — after someone posted congratulations."I was a bit shocked," he says. "I hadn't yet read the official email."

But for those who've worked with Sharma, the award is no surprise.

"Tushar was an obvious candidate for this award," says Doug Brooks, Chair of IEEE Southern Alberta Section (SAS). "His high-energy promotion of Young Professional member engagement and development sets a great example across IEEE MGA. He's made outstanding contributions at virtually all levels of the organization."

Sharma first became involved with the IEEE in 2009, as an engineering student in Delhi, India at Guru Gobind Singh Indraprastha University. But when he moved to Canada in 2013 to pursue his PhD at the University of Calgary, he made an immediate impact on IEEE SAS, serving as chair of the Young Professionals Affinity Group, and co-founding a section Special Interest Group on Humanitarian Technology (SIGHT). He has also served as SAS chapter chair of the IEEE Microwave Transmissions and Techniques Society (MTTS), and chair of the section's IEEE MTTS Student Branch.

"I have no hesitation in saying that my personal development has been facilitated by the IEEE," says Sharma. "This group allows you to network, to expand your horizons. It's been a fantastic journey."

When he first joined the Southern Alberta Section, however, the Young Professionals group was dormant — so he set to work. "I believe you cannot attract new members until you show them some benefits," he says.

"Tushar's enthusiasm is infectious. He is able to develop ideas that not only engage IEEE members, but to reach out to non-engineers and get them excited too."

– **Laleh Behjat** Chair of the SAS WIE Affinity Group

The awards and recognition program of the IEEE Member and Geographic Activities Board (MGA) is designed to promote, recognize and reward excellence in the MGA operations and IEEE Geographic Unit Activities (Regions, Geographic Councils and Areas, Sections, Chapters, Student Branches, and Student Branch Chapters).

Building on contacts made through the iRadio Lab at the University of Calgary, Sharma collaborated with Stanford University and NASA to organize a three-day tour by scientists from the NASA Solar Dynamics Observatory – simultaneously supporting International Year of Light 2015. A component of the tour was a pre-university student presentation at Calgary's TELUS Spark science centre: "Fingerprints of the Sun." This is but one of numerous outreach events put together by Sharma with the help of the Astronomy Teacher Training Institute, of which he is a co-founder and its current president.

Sharma's penchant for organizing events certainly spans continents – but also cultures. In collaboration with the University of Calgary's Russian Speaking Student Association, he organized "Yuri's Night," celebrating Yuri Gagarin's achievement as the first human to travel to outer space.

Events such as these revived the SAS Young Professionals group and took it to a level of global standards — winning the IEEE Young Professionals Hall of Fame Award in 2015.

"Tushar's enthusiasm is infectious," says Laleh Behjat, Chair of the SAS WIE Affinity Group. "He is able to develop ideas that not only engage IEEE members, but to reach out to non-engineers and get them excited too." Inspired herself by Sharma, Behjat credits him with convincing her to kick-start the dormant WIE group in SAS.

More recently, Sharma has leveraged his local section/chapter experience in organizing international events through IEEE MTTS. A reception he arranged at the International Microwave Symposium in May, 2015 in Phoenix connected Young Professionals graduate students and industry professionals. In December 2015, he organized and delivered ham radio training for participants in an IEEE MTTS-sponsored conference in Hyderabad, India, as part of the conference's SIGHT activities.

Also worthy of note, Sharma serves as Chair of IEEE Canada's Advertising & Publicity Committee, an appointment recognizing his success in creating awareness within and outside of the IEEE. For Sharma, it's a natural fit. "My section – and all of IEEE – has really backed me," he says. "I want to help others get those benefits."

Sharma gives special credit to two of the Faculty at iRadio Lab at University of Calgary for helping him achieve success: his supervisor, Professor Fadhel Ghannouchi, and post-doctoral fellow, Dr Ramzi Darraji. He also acknowledges the strong support of Dr. James Rautio, founder of Sonnet Software, and chair of the IEEE MTTS Image and Visibility Committee.

"These mentors have all given me extraordinary guidance. I dedicate this award to them, and to all the wonderful IEEE volunteers I've worked with." ■

__Vawn Himmelsbach__ is a freelance writer who has written about business and technology for close to 20 years.

What's New in the Literature?

by Terrance Malkinson

"How the Internet of Things Got Hacked" is the title of an article by Andy Greenberg and Kim Zetterin in *Wired* [Dec. 28, 2015. www.wired.com]. We live in a world of rapidly changing technology and the information technology field is a participant; producing numerous innovative products with embedded connectivity. The explosion of the Internet of Things has raised important issues regarding personal cybersecurity. Technology we strap to ourselves or install in our homes, offices and cars that are connected and controlled by a network can provide opportunities for those who cause harm. These devices can inform others when we're home, what we're saying, who we are saying it to, our finances and even our health to name but a few. Connected devices make us continuously vulnerable to hackers. Even "benign technology" like talking toys or baby monitoring cameras have proven especially vulnerable, because manufacturers don't expect a toy or a baby monitor to interest a hacker. We all need to be vigilant in our connected world. Engineers now need to have a cybersecurity awareness when designing products and services. Very lucrative career opportunities exist for those skilled in cybersecurity.

Reviews of the past year and visions of the future emerge near the beginning of a new year. Top technology in 2016 is the theme of the January 2016 issue of *IEEE Spectrum*[www.spectrum.ieee.org]. A plethora of reports discuss breakthroughs that will make a difference. The 100 greatest innovations of the year are profiled in the December, 2015 issue of *Popular Science*'s "28th Best of What's New", [287(6):19-60 www.popsci.com December, 2015]. Categories of innovations include: entertainment, automotives, gadgets, security, aerospace, software, health, the home, recreation, and engineering. *Scientific American* profiles 10 advances that will improve life, transform computing, and have the potential to make the earth sustainable. [313(6):30-39. December, 2015. www.scientificamerican.com]. Developments including "Eye-Controlled Machines", "Microwave Rocketry", "Injectable Electronic Brain Probes", and "Self-learning Machines" are but a few of these. A subsequent article pp. 40-53 profiles some of the idea and inventions that have changed the world and are chronicled in the *Scientific American* archives from 170 years of publication. The January, 2016 issue of Discover focuses on a review of the year in science ["100 top Stories of 2015". www.discovermagazine.com]. Stories include the stunning first images of the planet Pluto from NASA's deep space probe, the discovery of fossils in an underground cave that could bring information on a new human species, the destruction of cultural artifacts in the Middle East, climate change, new insights on comets by the Rosetta probe, ethical issues associated with altering human DNA, and many, many other stories of interest to all enthusiasts of advancements in science.

Fortune's 2015 business person of the year is Mark Parker; CEO of Nike [*FORTUNE*. 172(7):95-102. December, 2015. www.fortune.com]. Profiled by Adam Lashinsky, Mark has doubled revenues and profits for the footwear and apparel giant accompanied with a six-fold increase in its stock price. The author describes how he accomplished this and how he plans to continue doing so. The article concludes with the statement "at Nike, there is no finish line." Immediately following this article Scott Cendrowski et. al. profiles the other nineteen top business leaders in the ranking [pp. 104-111]. In the cover story of the September 15, 2015 issue of *FORTUNE* [172(4):90-97. September 15, 2015], Krisen Bellstrom et al. list their "Most Powerful Women List." Nineteen of the twenty-seven women profiled are CEO's of Fortune 500 companies.

In a research report published in *Exercise and Sport Sciences Reviews* ["The Role of Exercise-Induced Cardiovascular Adaptation in Brain Health." 43(4):181-189. October, 2015. www.acsm.org] Takashi Tarami and Rong Zhang review scientific evidence that exercise induced cardiovascular adaptations play an important role in improving brain performance, structure, and function. A harmonic relationship exists between the intensity of exercise and brain health. The cover story in the October 2015 issue of *Discover* [pp. 25-35. www.discovermagazine.com] focuses on science and aging. Topics covered include reversing Alzheimer's disease, bionic vision, heart muscle repair, skeletal muscle building, and the aging personality. On the same topic, an article in *New Scientist* by Jessica Hamzelou [Vol 227. #3039. pp. 30-33. September 10, 2015. www.newscientist.com. "Renew Yourself: Why Ageing Isn't Irreversible"] discusses the question could "purging worn-out cells be all that it takes to stay healthy as you age?" In the 2007 film "The Bucket List" Jack Nicholson and Morgan Freeman play men terminally ill with cancer who set out to do all the things they wanted to do before "Kicking the Bucket." We each have our own "bucket list." Jamie Malanowsky provides 25 suggestions for surprisingly new destinations to put on your bucket list in his article "Life List: The 21st Century Don't Kick the Bucket Just Yet!" [Smithsonian. 46(5):25-35. September, 2015. www.smithstonian.com"]. As the author states in his introduction "Get Going," people often procrastinate until it is too late and at the end of their life regret that they will leave with dreams unfulfilled.

It is no secret that in today's 24 x 7 world many people are not getting enough quality sleep. In his article "Sleep On It!" [*Scientific American*. 313(4): 52-57. October, 2015. www.scientificamerican.com] Robert Stickgold discusses the importance of sleep on the health of your brain and body. An excellent review of the damage that a lack of quality sleep causes. References for further reading are provided at the end of the article.

Jacob Aron discusses how we have been able to invent tools that take us beyond our natural abilities and how computer technology is able to change our ability to think, transcending the limits of our current ingenuity. ["Beyond Knowledge: Making Discoveries Beyond the Limits of the Human Mind". [*New Scientist*. pp. 28-31. No. 3036. August 29, 2015. www.newscientist.com]. Central to this is the ability of computational technology to extend our mathematical capabilities. As discussed in the article "the first major computer-assisted proof was published 40 years ago and it immediately sparked a row. It was a solution to the four-colour theorem, a puzzle dating back to the mid-19th century." Continuing on "mathematicians were reluctant to accept this as a proof," due to the possibility of an error in the computer software. The article concludes with the statement, "humans remain the ultimate judge – even if we don't always trust ourselves".

For **Terrance Malkinson**'s biography please see page 7.

The Power of Words

By **Kevin Rokosh**

If you've ever been in a conversation and you didn't quite grasp the meaning of a few words, then you know how frustrating that can be.

Maybe you knew the words, but in that context they meant something different. That's one of the strange things about the English language. The same words can carry quite different meanings.

Let me tell you what happened when a word shifted context when I was tuning up a radar site in the early 1990s.

TRANSPORT CANADA was commissioning the world's first solid state transmitter radar system for civilian air traffic control. Up until this time, radars used tube-based technologies to generate high power radar pulses. Transport's RAMP system used 14 solid state amplifier modules, all running in parallel. A six-foot by three-foot passive slab of micro-strips combined the outputs of these amplifiers into one coherent 28kW pulse.

But the original design of the combiner slab had a flaw. Part of its internal cavity would arc-over and burn up its micro-strip. Raytheon, the system designers, solved the problem and delivered re-worked combiners to the field.

As one of Transport Canada's radar engineers I went to the London (Ontario) radar site to do some set-up work. Ontario Region's lead project technician, Dan Epple, was helping me.

Naturally we still had concerns about the combiner slabs. A failing slab would crackle and pop, sounding like it had slices of bacon frying inside. I suppose a piece of burned out micro-strip didn't look too much different from a slice of crispy bacon either.

Like most radio transmitter installations, the radar site was a noisy place. Huge, loud HVAC units ran noisy blower fans to cool the equipment.

To listen for the crackle and pop of a failing combiner, I had to move in close. I squeezed behind the radar transmitter cabinet, put my ear to the cabinet and listened. Dan was watching from behind my back.

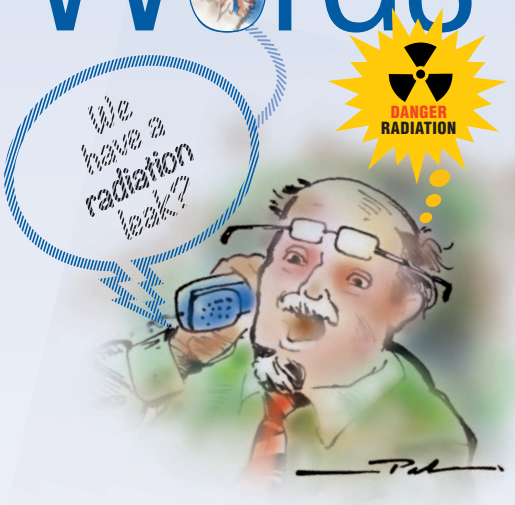
I didn't hear anything from the combiner. But I did hear the sound of snapping static coming from somewhere else. At its top, the combiner slab transitioned to a rectangular waveguide. I reached overhead and put my hand on it.

"Whoa!" Dan shouted. A big white arc of electricity jumped out of a waveguide joint to one of its holding bolts. We had an electromagnetic (EM) radiation leak, almost literally on my hands.

Immediately Dan backed out and shut the system down.

We found a few loose bolts on that waveguide flange joint. We easily tightened them, but couldn't simply turn the system back on and continue our work. We needed an EM field meter to probe around the joint to make sure it wasn't still leaking. An EM field meter is not standard equipment for a radar site. We had to phone around to find one.

Within about two hours, the phone rang at the site and I answered it.



"It's Atomic Energy Canada here. We understand you've had a radiation leak and need some help."

I paused to think about what I just heard. "No, no. Not a nuclear radiation leak. We've had an electromagnetic radiation leak. Very different and not so grave."

It took a little more talking, but I was able to reassure the caller we didn't need any help from Atomic Energy, and thanked him for his concern.

As I recall, by the next day we were able to courier an EM field meter from my headquarters in Ottawa. A little later than expected, we verified that the waveguide joint was well sealed.

…

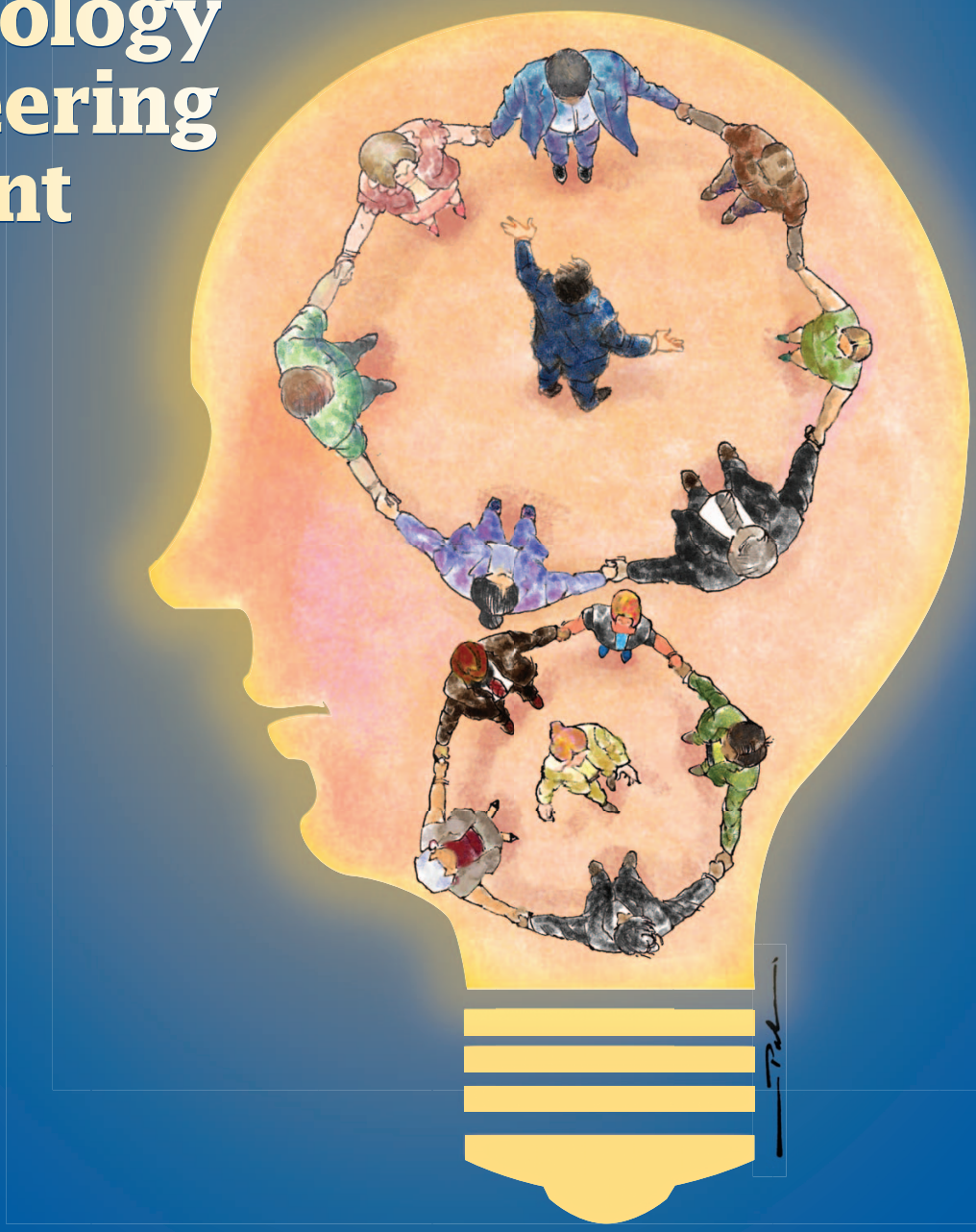
This little story was one of the lessons I learned about the power of words. It helped pique my interest in working more with words. So today, I've moved on from hands-on engineering work. Now I help engineers make themselves clearly understood when communicating to other engineers or industry professionals.

And if I'm ever struggling to explain a critical concept — and need motivation to find just the right words — I recall that day at the London radar site. I remember how I was almost greeted by a posse of hazmat suits at a radar shelter door. All because of a few misinterpreted words! ■

*For **Kevin Rokosh**'s biography please see page 20.*

N.Ed. "Experiential Learning" shares the real-life lessons of our readers that only experience can teach. If you have a tale to tell, then target it to Bruce Van-Lane, Editor-in-Chief, **vanlane@ieee.org**. It can be about your "schooling," or that of a colleague's – all we ask is that it be **true!**

The New IEEE Technology and Engineering Management Society



By **Terrance Malkinson** and **Michael Condry**

January 2016 marked the first anniversary of the rebirth of an IEEE Society — the IEEE Technology and Engineering Management Society (IEEE TEMS). Its roots date back to 1951 to the founding of what was then called the IEEE Engineering Management Society (EMS). This became the Technology Management Council (TMC) in 2007, and in January 2015 transitioned to TEMS (http://ieee-tems.org/). The mission of TEMS is to advance, enhance, and improve essential management and leadership knowledge and skills of IEEE members. Its vision is to be the premier resource of essential management and leadership knowledge. The TEMS value proposition is to:

1. Help IEEE members to maintain essential engineering management skills
2. Support the leadership career path of IEEE members
3. Foster active knowledge transfer between the academic and practicing communities.

The TEMS field of interest encompasses the management sciences and practices required for defining, implementing, and managing engineering and technology. TEMS has chapters in all 10 IEEE regions, and holds an annual international conference.

A common misconception is that management skills are only applicable to those in positions of leadership. In today's global and competitive job market; rapidly changing business environment and world economy; to be successful, every worker must accept responsibility

TEMS Publications

IEEE Transactions on Engineering Management is a quarterly journal published since 1954. It is dedicated to the publication of peer-reviewed original contributions, by researchers and practitioners, regarding the theory and practice of engineering, technology, and innovation management. IEEE-TEM is organized into seven departments: People and Organizations; Research & Development and Engineering Projects; Models and Methodologies; Information Technology; Manufacturing Systems, Technology & Innovation Management, and E-Business.

The *IEEE Engineering Management Review* re-publishes papers and articles and includes original content that serves those who manage technology, engineering and innovation; engineers and non-engineers who hold strategic leadership responsibilities; and upward-bound engineers with an interest in management as a profession.

IEEE TEMS Leader is the society newsletter, published quarterly and distributed electronically to all members. IEEE TEMS Leader shall be an innovative newsletter, essential to the international technical community; providing information and services to practitioners and researchers. Articles emanate from IEEE members sharing what they have learned with other members.


IEEE TEMS LEADER

A Newsmagazine of the IEEE Technology and Engineering Management Society

January, 2016

What's Inside

From Your Editor

Terrance Malkinson

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and take action to manage their job responsibilities, steer their career and balance their personal life. Additionally, insights into why managers make the decisions they do reduces conflicts and misunderstandings in organizations. The reality is that even if you are not a manager, management skills and attitudes will be of enormous benefit to you. Membership in TEMS will benefit your personal and career success.To achieve success in today's competitive and global workplace you need to think futuristically and have a holistic knowledge of the diverse factors that may impact on your life and career. New knowledge and technology quickly disrupts the status quo. Those who do not make the effort to scan the broader environment and adapt to change may unexpectedly find that their job has disappeared and that their skills are no longer needed.

Another excellent way of becoming informed and networking with others who have similar interests to yours is through a new initiative by the IEEE TEMS. Technical Activities Committees (TACs) are groups of individuals with a common technical area of interest that wish to participate in and perhaps lead technical activities and programs of the IEEE and in this case the IEEE Technology and Engineering Management Society (TEMS). TEMS has started this Technical Activities Program to provide a venue for interest, growth, and new directions; addressing the many challenging topics around engineering and technology management, and moving a technical concept to a product. Please see web page http://ieee-tems.org/node/1686 for a complete overview.

As a member of an IEEE TEMS TAC you can engage in discussion, networking, proposing and chairing special sessions in conferences, chairing TEMS conferences, and contributing to publications all focused alongy your technical interests. Each TAC has a leader or "chair" along with a "co-chair." Other positions may be identified by the group's members. Each TAC will have a charter, web page and member lists. Anyone may join a TAC and engage. Some enhanced benefits will require a TEMS membership. Anyone can define a TAC and propose it to the TEMS AdCom for implementation.

We will be allocating some financial resources for TACs, specifically for those that engage in our conferences and publications.

To start this program in 2016 TEMS has defined five TACs and an AdCom member to lead their creation:

- **Social Management – Leslie Martinich** lmartinich@ieee.org
- **Engineering Processes – Axel Richter** axel.richter@ieee.org
- **IT and e-Business – Liang Xi Downey** lxdowney@ieee.org
- **Future of Management – Terrance Malkinson** malkinst@telus.net
- **Technology, Innovation, Entrepreneurship – Michael Andrews** m.andrews@ieee.org

During 2016 the TEMS President-Elect Michael Condry (condry@condry.org) will oversee the entire program and its direction. Each TAC now has its own web

TEMS in Canada

In Canada there are five IEEE TEMS Chapters located in Montreal, Ottawa, Toronto, Winnipeg and Vancouver, and over 27 others world-wide. Your engagement in IEEE Chapters is one of the more important benefits of belonging to the IEEE, providing you with unique learning and networking opportunities. The Vancouver Joint Manager Chapter, (http://vancouver.ieee.ca/content/professional_comm) together with Vancouver Section, is hosting IEEE International Symposium on Ethics in Engineering, Science, and Technology. (http://sites.ieee.org/ethics-conference/).

page describing its charter and how to join. These are also available from: http://ieee-tems.org/node/1686.

The opportunity for members to define additional TACs and make them official by AdCom approval is available to you starting in 2017. To be a chair or co-chair and receive benefits such as travel expense requires TEMS membership. We will be allocating some financial resources for TAC's specifically for those that engage in our conferences and publications. Our new flagship conference TEMSCON is under development. The larger the engagement, the more funding will be provided. We hope to welcome TAC chairs to some of our AdCom discussions and influence the direction of the Society.

This program establishes a key leadership pipeline for members to engage with the IEEE and Society leadership; perhaps even facilitating the transition into a leadership role if desired. Stay tuned to the TEMS website for further announcements on TAC's and visit their websites. We believe our TAC's will grow quickly and many people will become engaged in this member benefit. The concept of TAC's was introduced in the January 2016 issue of *IEEE TEMS LEADER* pages 4-5. [http://ieee-tems.org/leader] ■

Michael Condry *is IEEE TEMS President-Elect; a member of the IEEE Industrial Electronics Society AdCom; the IEEE Industry Summit Chair; and a retired Chief Technical Officer, Global Ecosystem Development, Intel Corporation.*

Terrance Malkinson *is a veteran contributor to the* IEEE Canadian Review*; he has been an associate/contributing editor since 1998. His biography can be seen on page 7.*

IEEE Canadian Review

La revue canadienne de l'IEEE

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