IEEE Canadian Review

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IEEE Canada

39th Annual Canadian Conference on Electrical and Computer Engineering (CCECE 2026)

May 18-20, 2026, Le Westin, Montreal, Quebec, Canada

The 39th IEEE Canadian Conference on Electrical and Computer Engineering (CCECE 2026) will be held in Montreal, Quebec, Canada from May 18 to 20, 2026. CCECE provides a forum for the presentation of electrical and computer engineering research and development from Canada and around the world. Papers are invited, in French or English, for the following symposia.

- **Circuits, Devices, Photonics and Systems**
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  Chair: Dr. Qiang Ye, University of Calgary
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- **Marine Systems and Technology**
  Chair: Dr. Oscar De Silva, Memorial University
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- **Space Systems**
  Chair: Dr. Robin Chhabra, Toronto Metropolitan University
  Co-Chair: Dr. Raghvendra Cowlagi, Worcester Polytechnic Institute
- **History of Technology**
  Chair: Dr. David Michelson, University of British Columbia
  Co-Chair: Dr. Scott Campbell, University of Waterloo

NOTE: *Selected papers accepted in this conference will be proposed for publication in the IEEE Canadian Journal of Electrical and Computer Engineering, after another round of review. This would require a substantial extension to the conference version.*

Questions or Comments

For any questions or comments, please contact the Conference General Chair: Amir G. Aghdam. Tel: (514) 848-2424 Ext. 4137, Email: amir.aghdam@concordia.ca

President's Message/Message du Président

Tom Murad
P.Eng., Ph.D., F.E.C., F.EIC, SMIEEE

2024–2025 IEEE Canada President and Region 7 Director
2024–2025 Président de l'IEEE Canada Directeur de la Région 7

Dear IEEE Canada colleagues, this Fall/Winter 2025 edition of *IEEE Canadian Review* is a unique one, being the special 100th edition; therefore, I feel so privileged personally to contribute to this edition by sharing my conclusive ideas at the end of my term as IEEE Canada president.

At this point in time, most of IEEE Canada's volunteers, whom I had the honor to work with in the last two years as president and the two years before as president-elect, may conclude that my leadership approach was about establishing the spirit of "positive change," especially after enduring the COVID-19 pandemic and its negative impacts. During the positive change journey that we went through, I had to keep emphasizing the major pillars of my vision and plans repeatedly. The pillars that I sincerely believe in and tried to implement are simply transparency, diversity, and fairness. With that, we can reach our goal as the "organization for all," where all members have

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Dr. Tom Murad

Chers collègues d'IEEE Canada, Cette édition Automne/Hiver 2025 de la *Revue canadienne de l'IEEE* est véritablement unique, puisqu'il s'agit de son 100e numéro spécial. Je me sens donc particulièrement privilégié de pouvoir y contribuer en partageant mes réflexions finales à l'issue de mon mandat en tant que président d'IEEE Canada

À ce stade, la plupart des bénévoles d'IEEE Canada, avec qui j'ai eu l'honneur de travailler au cours des deux dernières années en tant que président, ainsi que durant les deux années précédentes comme président désigné, pourraient conclure que mon approche de leadership visait avant tout à instaurer un esprit de « changement positif », en particulier après avoir traversé la pandémie de COVID-19 et ses répercussions négatives. Tout au long de ce parcours vers le changement positif, j'ai dû réitérer à plusieurs reprises les principaux piliers de ma vision et de mes plans. Les piliers auxquels je crois profondément et que j'ai tenté de mettre

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the equal opportunity to contribute, innovate, celebrate, and take credit for its success and growth. I find it very beneficial to elaborate on my understanding of these pillars, their importance, and why I chose to focus on them among many other professional leadership values that I figured from day 1 needed to be promoted and emphasized.

"Transparency" can mean different things depending on the context. However, in general, it means the practice of being open, honest, and easy to understand. It involves sharing information clearly and not hiding important details. Transparency means making decisions, processes, and data available so that people can see how things work and hold leaders accountable. Transparency in organizations refers to how openly a company or institution shares information about its decisions, processes, performance, and practices with its members and other stakeholders. It's a foundational element of trust and accountability. With that, we should benefit from higher trust and morale, stronger alignment with

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en œuvre sont tout simplement la transparence, la diversité et l'équité. Grâce à eux, nous pouvons atteindre notre objectif d'être « l'organisation pour tous », où chaque membre dispose d'une égalité d'occasions pour contribuer, innover, célébrer et être reconnu pour le succès et la croissance de notre communauté. Je trouve particulièrement utile d'exposer ma compréhension de ces piliers, leur importance et les raisons pour lesquelles j'ai choisi de les mettre au premier plan parmi les nombreuses autres valeurs professionnelles de leadership qui, dès le premier jour, m'ont semblé devoir être encouragées et mises en évidence.

La « transparence » peut prendre différentes significations selon le contexte. Toutefois, de manière générale, elle renvoie à une pratique fondée sur l'ouverture, l'honnêteté et la clarté. Elle implique de communiquer l'information de façon explicite, sans dissimuler d'éléments importants. La transparence consiste à rendre accessibles les décisions, les processus et les données, afin que chacun puisse comprendre le fonctionnement de l'organisation et tenir ses dirigeants responsables. Dans les

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organizational goals, more informed decision making, fewer rumors and less confusion and conflict, and reduced risk of misconduct or fraud, all leading to improved reputation and stakeholder confidence.

"Diversity" in general refers to the presence of differences among people within a group, organization, or society. It includes visible and invisible characteristics, perspectives, and experiences. Diversity is valuable because it strengthens creativity, innovation, decision making, and fairness. A professional organization benefits from diversity because it represents an entire profession—not just a small subset. Diversity ensures legitimacy, innovation, fairness, and equal opportunity across the profession. This essentially includes

- *Demographic diversity*: That is, representation across race and ethnicity; gender and gender identity; age groups (including students and early-career professionals); disability status; culture, nationality, and language; and socioeconomic background.
- *Professional diversity*: That is, differences in job roles and specialties, years of experience, work settings (private, public, nonprofit, and academia), geographic regions, and educational backgrounds.
- *Cognitive diversity*: That is, differences in perspectives, problem-solving styles, values and priorities, and lived experiences. This is especially valuable for committees, leadership teams, and boards.

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organisations, la transparence désigne la manière dont une entreprise ou une institution partage ouvertement l'information concernant ses décisions, ses processus, sa performance et ses pratiques avec ses membres et autres parties prenantes. Elle constitue un élément fondamental de la confiance et de la reddition de comptes. Grâce à elle, nous pouvons bénéficier d'un niveau de confiance et de moral plus élevé, d'un meilleur alignement avec les objectifs organisationnels, d'une prise de décision plus éclairée, d'une réduction des rumeurs, de la confusion et des conflits, ainsi que d'un risque moindre d'inconduite ou de fraude — autant de facteurs qui contribuent à renforcer la réputation de l'organisation et la confiance de ses parties prenantes.

La « diversité » désigne, de manière générale, la présence de différences entre les personnes au sein d'un groupe, d'une organisation ou d'une société. Elle englobe des caractéristiques visibles et invisibles, ainsi que des perspectives et des expériences variées. La diversité est précieuse, car elle renforce la créativité, l'innovation, la prise de décision et l'équité. Une organisation professionnelle tire profit de la diversité parce qu'elle représente l'ensemble d'une profession — et non seulement un petit sous-groupe. La diversité garantit la légitimité, l'innovation, l'équité et l'égalité des chances à travers toute la profession. Elle comprend essentiellement:

- *Diversité démographique* : c'est-à-dire la représentation de différentes origines raciales et ethniques; des genres et identités de genre; des groupes d'âge (y compris les étudiants et les

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IEEE Canadian Review
La revue canadienne de l'IEEE

IEEE Canadian Review is published three times per year: Spring, Summer, and Fall.

Its **principal objectives** are:

- To inform Canadian members of IEEE on issues related to the impacts of technology and its role in supporting economic development and societal benefits within Canada.
- To foster growth in the size and quality of Canada's pool of technology professionals to serve our increasingly knowledge-based economy.

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President's Message/Message du Président

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A professional organization that prioritizes diversity achieves higher member trust and satisfaction; better, more-balanced decisions; a stronger voice in policy and regulatory discussions; a more vibrant and innovative professional community; and greater credibility with the public and employers

"Fairness" is also a broad concept, but at its core it means treating people in a just, impartial, and consistent way. It's

A professional organization benefits from diversity because it represents an entire profession—not just a small subset.

about ensuring that decisions, opportunities, and rules are applied equally and without favoritism or bias. However, in professional organizations like IEEE, it is about ensuring that all members, leaders, and stakeholders are treated equitably, judged by consistent standards, and given equal access to opportunities because these organizations often influence careers, credentials, and professional reputation, and it is essential for credibility and trust. This in fact leads to higher member trust and satisfaction; better reputation with the public and employers; stronger and more diverse leadership; reduced conflict, politics, and favoritism; more effective advocacy for the profession; and increased member engagement and participation. Lack of fairness in a professional organization can have serious and long-lasting consequences for members, leaders, the organization's reputation, and even the profession that it represents. This ultimately includes loss of trust, loss of people, loss of reputation, and loss of effectiveness. In summary, a professional organization cannot fulfill its mission if members perceive it as biased or unjust.

The positive change journey is practically full of challenges facing any passionate leader who seeks genuine implementation of the aforementioned pillar values, some of these may be

- structural and resource barriers due to a lack of proper funding, staff, or infrastructure, which can limit the ability to implement programs (e.g., high fees or travel costs that prevent diverse members from participating in governance or events). This may reduce access for underrepresented members and hampers transparency initiatives.
- communication gaps when members may not receive timely or clear updates on decisions, policies, or opportunities, (e.g., decisions made behind closed doors without public summaries or explanations). This may be perceived as a lack of transparency and fairness, even if processes exist.
- tokenism reflected by efforts to increase diversity that may focus on appearances rather than meaningful inclusion (e.g., appointing a single person from a minority group to leadership roles without giving them real influence). This leads to members from underrepresented groups feeling undervalued; therefore, real diversity and inclusion goals are unmet.
- resistance to change, essentially from long-standing leaders or influential members who may resist new policies,

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professionnels en début de carrière); des statuts liés au handicap; des cultures, nationalités et langues; ainsi que des milieux socioéconomiques.

- *Diversité professionnelle :* c'est-à-dire les différences liées aux rôles et spécialités professionnelles, aux années d'expérience, aux milieux de travail (secteurs privé, public, sans but lucratif et milieu universitaire), aux régions géographiques et aux parcours éducatifs.
- *Diversité cognitive :* c'est-à-dire les différences de perspectives, de styles de résolution de problèmes, de valeurs, de priorités et d'expériences vécues. Cette forme de diversité est particulièrement précieuse pour les comités, les équipes de direction et les conseils d'administration.

Une organisation professionnelle qui accorde la priorité à la diversité obtient un niveau plus élevé de confiance et de satisfaction de la part de ses membres, prend des décisions plus judicieuses et équilibrées, exerce une influence plus forte dans les discussions politiques et réglementaires, favorise une communauté professionnelle plus dynamique et innovante et renforce sa crédibilité auprès du public et des employeurs.

L'« équité » est également un concept vaste, mais, au cœur, elle signifie traiter les personnes de manière juste, impartiale et cohérente. Il s'agit de veiller à ce que les décisions, les occasions et les règles soient appliquées de façon égale, sans favoritisme ni parti pris. Toutefois, dans des organisations professionnelles comme l'IEEE, l'équité consiste à garantir que tous les membres, dirigeants et parties prenantes soient traités équitablement, évalués selon des critères constants et aient un accès égal aux occasions, car ces organisations influencent souvent les carrières, les titres professionnels et la réputation, ce qui rend l'équité essentielle pour la crédibilité et la confiance. Cela conduit en réalité à une plus grande confiance et satisfaction des membres, à une meilleure réputation auprès du public et des employeurs, à un leadership plus solide et plus diversifié, à une réduction des conflits, des jeux politiques et du favoritisme, à une défense plus efficace de la profession, ainsi qu'à une participation et un engagement accru des membres.

Le parcours du changement positif est, en pratique, jalonné de nombreux défis pour tout dirigeant passionné qui cherche à mettre en œuvre de manière authentique les valeurs fondamentales mentionnées précédemment. Parmi ces défis, on peut citer:

- Les obstacles structurels et liés aux ressources, dus à un manque de financement adéquat, de personnel ou d'infrastructures, ce qui peut limiter la capacité à mettre en place certains programmes (par exemple, des frais élevés ou des coûts de déplacement qui empêchent des membres issus de milieux diversifiés de participer à la gouvernance ou aux événements). Cela peut réduire l'accès pour les membres sous-représentés et freiner les initiatives de transparence.
- Les lacunes en matière de communication, lorsque les membres ne reçoivent pas en temps opportun ou de manière claire les mises à jour concernant les décisions, les politiques ou les occasions (par exemple, des décisions prises à huis clos sans résumés ou explications publiques). Cela peut être perçu comme un manque de transparence et d'équité, même si des processus existent.
- Le tokénisme, ou diversité de façade, qui se manifeste lorsque les efforts visant à accroître la diversité se concentrent

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fearing loss of control or disruption of established norms (e.g., reluctance to publish decision-making processes or rotate committee memberships). This definitely slows down implementation of transparent procedures, diversity initiatives, and fair processes.

- cultural and geographic diversity challenges due to the fact that members/volunteers come from different regions, professional cultures, or linguistic backgrounds, leading to standard policies that may unintentionally favor certain groups, making inclusion harder.
- unconscious bias related to decisions about leadership roles, awards, or membership that may be influenced by implicit preferences for familiar people or networks (e.g., repeated selection of board/committee members from the same demographic or professional circle). This essentially undermines fairness and diversity even when policies are in place.
- balancing transparency with confidentiality when some information, such as personal member data or sensitive disciplinary actions, cannot be made fully public (e.g., a leadership team may avoid sharing details about specific cases, leaving members suspicious), resulting in leaders over-restricting information, reducing perceived transparency.
- inconsistent application of policies such as rules for elections, certifications, or disciplinary actions that may be applied unevenly (e.g., favoring certain candidates for awards or leadership roles despite established criteria). This definitely undermines fairness and credibility.
- a short-term focus that is experienced when a leadership team may prioritize immediate organizational needs over long-term cultural change (e.g., focusing on revenue generation or program expansion rather than leadership development for underrepresented members). This may stall, even for a while, any efforts toward transparency, diversity, and fairness.
- measuring success when metrics for transparency, diversity, and fairness can be complex and qualitative (i.e., unclear benchmarks for "inclusive culture" or "perceived fairness" among members). This makes it difficult to track progress and hold leadership accountable.

Multiple measures and trials were practiced to overcome these challenges, or most of them, including the following:

- *Leadership commitment*: Strong, visible buy-in from top leaders to model values.
- *Education and training*: Workshops on unconscious bias; diversity, equity, and inclusion; and fair decision making.
- *Clear policies and metrics*: Documented procedures, measurable targets, and regular audits.
- *Member engagement*: Involve members in designing and evaluating initiatives.
- *Incremental implementation*: Introduce changes gradually to reduce resistance.
- *Transparent communication*: Share rationale for decisions, successes, and setbacks.
- *Regular evaluation*: Monitor progress, solicit feedback, and adapt strategies.

As I have mentioned in a few previous articles, implementing these values among others has definitely led into a noticeable

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davantage sur l'apparence que sur une inclusion véritable (par exemple, nommer une seule personne issue d'un groupe minoritaire à un poste de direction sans lui accorder une réelle influence). Cela conduit les membres issus de groupes sous-représentés à se sentir dévalorisés; par conséquent, les objectifs réels de diversité et d'inclusion ne sont pas atteints.

- La résistance au changement, provenant essentiellement de dirigeants en poste depuis longtemps ou de membres influents qui peuvent s'opposer aux nouvelles politiques, craignant une perte de contrôle ou une remise en question des normes établies (par exemple, une réticence à publier les processus décisionnels ou à faire tourner les membres des comités). Cela ralentit indéniablement la mise en œuvre de procédures transparentes, d'initiatives en matière de diversité et de processus équitables.
- Les défis liés à la diversité culturelle et géographique, en raison du fait que les membres et bénévoles proviennent de différentes régions, cultures professionnelles ou origines linguistiques, ce qui peut conduire à l'adoption de politiques standard qui favorisent involontairement certains groupes et rendent l'inclusion plus difficile.
- Les biais inconscients, qui influencent les décisions liées aux rôles de leadership, aux distinctions ou à l'adhésion, lorsqu'elles sont affectées par des préférences implicites envers des personnes ou des réseaux familiers (par exemple, la sélection répétée de membres de conseils ou de comités provenant du même groupe démographique ou du même cercle professionnel). Cela compromet fondamentalement l'équité et la diversité, même lorsque des politiques existent.
- L'équilibre entre transparence et confidentialité, lorsque certaines informations — telles que des données personnelles de membres ou des mesures disciplinaires sensibles — ne peuvent être rendues entièrement publiques (par exemple, une équipe de direction peut éviter de partager les détails de cas particuliers, ce qui suscite la méfiance des membres). Cela conduit parfois les dirigeants à restreindre excessivement l'information, réduisant ainsi la transparence perçue.
- L'application incohérente des politiques, telles que les règles relatives aux élections, aux certifications ou aux mesures disciplinaires, qui peuvent être appliquées de manière inégale (par exemple, favoriser certains candidats pour des distinctions ou des rôles de leadership malgré des critères établis). Cela compromet indéniablement l'équité et la crédibilité.
- Une focalisation à court terme, qui se manifeste lorsqu'une équipe de direction privilégie les besoins immédiats de l'organisation au détriment d'un changement culturel à long terme (par exemple, se concentrer sur la génération de revenus ou l'expansion de programmes plutôt que sur le développement du leadership chez les membres sous-représentés). Cela peut freiner — même temporairement — les efforts visant à renforcer la transparence, la diversité et l'équité.
- La mesure du succès, lorsque les indicateurs de transparence, de diversité et d'équité sont complexes et de nature qualitative (c'est-à-dire des repères flous pour définir une « culture inclusive » ou une « équité perçée » par les membres). Cela rend difficile le suivi des progrès et la responsabilisation du leadership.

Diverses mesures et initiatives ont été mises en œuvre pour surmonter ces défis — ou la plupart d'entre eux — notamment:

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positive change, not only at the Region (IEEE Canada) level, but rather was reflected on the other operational units: local Sections and Chapters and all affinity groups. This was evident, specifically during the past two years, in the level of membership contribution and the quality of the grass roots involvement in driving the local activities.

The most evident impact was on the local student branches/Chapters and the Young Professionals Committee, representing our IEEE organization's future leaders, and materialized in their innovative activities and events. Examples of these include the IEEE Student Professional Awareness Conference in 2024 and 2025 in Ottawa, a formal networking event that provided students, academics, and industry professionals with an opportunity to network and bridge the gap between classrooms and boardrooms, thereby empowering attendees to build professional connections and form a bond.

Also, the IEEE Canadian Students and Young Professionals Congress, a major national event held 12–14 September 2025 in Toronto, focused on tech, innovation, career development, networking, and leadership for students and young professionals across Canada and featured workshops, CEO talks, competitions, and a career fair.

Later in 2025, the 2025 IEEE Industry Academia Handshake Convention, organized by Lakehead University's Barrie STEM Hub and the IEEE Lakehead University Student Branch, was a dynamic two-day event that brought together students, entrepreneurs, and industry professionals to bridge the gap between academic innovation and industrial implementation. The event provided a collaborative platform where students could engage with industry professionals through keynote talks, hands-on workshops, hackathons, panel discussions, and competitions. Participants explored real-world challenges and built professional networks that will spark innovation and future collaborations. IEEE Canada even offered travel grants to selected attendees to help cover transportation and accommodation costs, to support student participation.

Another major area of growth and rising stars is the IEEE Canada Women in Engineering organization, which I am proud to announce has active local branches in all Canadian 22 Sections, accommodating the largest number of volunteers in IEEE Canada's History. We anticipate further growth and diversity in the years to come. What's more noticeable is the growth of women leaders in the board, Executive Committee, and operational and standing committees as well as the local Sections' and Chapters' leadership roles.

I am also excited to announce that in 2025 IEEE Canada experienced a unique growth in our publications and communications operational committees, where we have announced in a most democratic selection process, two esteemed and highly qualified female academics to lead *IEEE Canadian Journal of Electrical and Computer Engineering* as well as *IEEE Canadian Review*, in addition to a very active communication team for our social media, website, and newsletter activities.

On the technical conferences front, 2025 was a very successful year as well, where our IEEE Canada Conference

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- *Engagement du leadership:* Une adhésion forte et visible des principaux dirigeants afin d'incarner les valeurs.
- *Éducation et formation:* Ateliers sur les biais inconscients; la diversité, l'équité et l'inclusion; et la prise de décision équitable.
- *Politiques et indicateurs clairs:* Procédures documentées, objectifs mesurables et audits réguliers.
- *Engagement des membres:* Impliquer les membres dans la conception et l'évaluation des initiatives.
- *Mise en œuvre progressive:* Introduire les changements graduellement pour réduire la résistance.
- *Communication transparente:* Partager les raisons des décisions, les réussites et les difficultés rencontrées.
- *Évaluation régulière:* Suivre les progrès, recueillir les commentaires et adapter les stratégies.

Comme je l'ai mentionné dans quelques articles précédents, la mise en œuvre de ces valeurs, parmi d'autres, a indéniablement conduit à un changement positif notable, non seulement au niveau de la Région (IEEE Canada), mais également au sein des autres unités opérationnelles: les Sections locales, les Chapitres et l'ensemble des groupes d'affinité. Cela s'est manifesté, en particulier au cours des deux dernières années, par le niveau de contribution des membres et par la qualité de l'engagement de base dans la conduite des activités locales.

L'impact le plus évident s'est fait sentir au sein des branches et chapitres étudiants locaux ainsi qu'au sein du comité des Jeunes Professionnels, qui représentent les futurs leaders de notre organisation IEEE. Cet impact s'est traduit par la nature innovante de leurs activités et de leurs événements. Parmi les exemples marquants figurent les éditions 2024 et 2025 de la conférence IEEE Student Professional Awareness, tenues à Ottawa: un événement de réseautage formel offrant aux étudiants, aux universitaires et aux professionnels de l'industrie une occasion de créer des liens et de combler l'écart entre la salle de classe et la salle de réunion, permettant ainsi aux participants de développer des relations professionnelles et de tisser des liens durables.

De même, le Congrès canadien des étudiants et des jeunes professionnels de l'IEEE, un événement national majeur tenu du 12 au 14 septembre 2025 à Toronto, a mis l'accent sur la technologie, l'innovation, le développement de carrière, le réseautage et le leadership pour les étudiants et jeunes professionnels de tout le Canada. Il a présenté des ateliers, des allocutions de chefs d'entreprise, des compétitions ainsi qu'un salon de l'emploi.

Plus tard en 2025, la Convention *IEEE Industry–Academia Handshake 2025*, organisée par le Barrie STEM Hub de l'Université Lakehead et la branche étudiante IEEE de l'Université Lakehead, a constitué un événement dynamique de deux jours réunissant étudiants, entrepreneurs et professionnels de l'industrie afin de combler l'écart entre l'innovation académique et sa mise en œuvre industrielle. L'événement a offert une plateforme collaborative permettant aux étudiants d'interagir avec des professionnels de l'industrie à travers des conférences principales, des ateliers pratiques, des hackathons, des tables rondes et des compétitions. Les participants ont pu explorer des défis réels et développer des réseaux professionnels qui stimuleront l'innovation et de futures collaborations. IEEE Canada a même offert des bourses de déplacement à certains participants sélectionnés pour les aider à couvrir les frais de transport et d'hébergement, afin de soutenir la participation étudiante.

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(President's Message cont'd from p. 6)

Advisory Committee (CONAC) managed, obviously with our respective conferences chairs, to host all three IEEE Canada's Flagship Region Conferences (the 2025 IEEE Canadian Conference on Electrical and Computer Engineering, 2025 Canadian Electrical Power and Energy Conference, and Anthem 2025 in Vancouver, Waterloo, and St. John's, respectively), in addition to the multi-Region 2025 International Humanitarian Technologies Conference in Edmonton as well as hosting the 2025 International WiSEE Conference in Halifax. I am also excited to share that we have just formed the 2026 CONAC organization with a diversified team under the leadership of a new, highly experienced and qualified female academic member, with higher expectations to deliver further higher-quality technical conferences in Canada.

So let us lead by example by empowering those who are ready to carry the mission forward.

Finally, I have to share with full pride our observation that in 2025 we had the largest number in recent IEEE Canada history of new technical Society Chapters and student Chapters within the local Sections, which is considered, in my opinion, clear evidence of the creation of a new wave of interest within our membership in all levels to create further platforms for their activities and contribution to the journey within their local communities. In addition, in early 2025, we celebrated, for the first time in decades, the creation of our 22nd local Section in the Okanagan region, B.C. All these signs are positive metrics proving that we are moving in the right direction.

To reemphasize what we have been promoting in the past few years, this is how, I believe, that we build sustainable teams and communities and resilient and professional organizations, leading to a future that belongs to *everyone*. So let us lead by example by empowering those who are ready to carry the mission forward. Because when we invest in leaders who believe in principles and values, focusing on transparency, diversity, and fairness, it is my opinion that we don't just preserve our legacy but rather multiply its impact.

With that, and in closing, we are wrapping up 2025 with all the signs of positive achievements and growth, with our dedicated and hard-working team of volunteers and contributors, and planning various exciting events for 2026. The IEEE Canada Board and I encourage you all to continue being a part of this exciting journey, and joining our fabulous team to enrich our experiences and achievements for further and better success and growth.

I have already passed the torch during our last board meeting to my successor, Dr. Wahab Al-Muhtady, whom I wish all the best in his new role contributing to the historical journey of IEEE Canada with his unique knowledge and experience. I would also like to welcome our new IEEE Canada president-elect (2026–2027), Dr. Ekram Hussain, to the Three Presi-

(Continued on p. 8)

(Message du Président suite de p. 6)

Un autre domaine majeur de croissance et de rayonnement est l'organisation IEEE Canada (*Les femmes en ingénierie – Women in Engineering*), qui — j'en suis particulièrement fier — compte désormais des branches locales actives dans les 22 Sections canadiennes, réunissant le plus grand nombre de bénévoles de toute l'histoire d'IEEE Canada. Nous prévoyons une croissance et une diversification encore plus importantes dans les années à venir. Ce qui est encore plus remarquable, c'est l'essor du nombre de femmes leaders siégeant au conseil d'administration, au comité exécutif, dans les comités opérationnels et permanents, ainsi que dans les rôles de leadership au sein des Sections et des Chapitres locaux.

Je suis également heureux d'annoncer qu'en 2025, IEEE Canada a connu une croissance remarquable au sein de ses comités opérationnels dédiés aux publications et aux communications. À l'issue d'un processus de sélection hautement démocratique, deux universitaires éminentes et hautement qualifiées ont été nommées à la tête du *Journal canadien de génie électrique et informatique de l'IEEE* ainsi que de la *Revue canadienne de l'IEEE*. À cela s'ajoute une équipe de communication particulièrement dynamique, responsable de nos activités sur les réseaux sociaux, de notre site Web et de notre bulletin d'information.

Sur le plan des conférences techniques, l'année 2025 a également été couronnée de succès. Notre Comité consultatif des conférences d'IEEE Canada (CONAC), en collaboration étroite avec les présidents des conférences respectives, est parvenu à organiser les trois conférences phares de la région IEEE Canada — la *Conférence canadienne annuelle sur le génie électrique et informatique (CCECE 2025)*, la *Conférence canadienne sur l'électricité et l'énergie 2025* et *Anthem 2025* — tenues respectivement à Vancouver, Waterloo et St. John's. À cela s'ajoutent la *Conférence interrégionale sur les technologies humanitaires internationales 2025* à Edmonton ainsi que l'accueil de la *Conférence internationale WiSEE 2025* à Halifax. Je suis également heureux d'annoncer que nous venons de constituer l'organisation CONAC 2026, dotée d'une équipe diversifiée placée sous la direction d'un nouveau membre universitaire, hautement expérimenté et qualifié. Nous nourrissons de grandes attentes quant à sa capacité à offrir des conférences techniques de qualité encore supérieure au Canada.

Enfin, je tiens à partager avec une grande fierté le constat qu'en 2025, nous avons enregistré — au sein des Sections locales — le plus grand nombre, dans l'histoire récente d'IEEE Canada, de nouveaux chapitres techniques de Sociétés ainsi que de chapitres étudiants. Cela constitue, à mon avis, une preuve claire de l'émergence d'une nouvelle vague d'intérêt parmi nos membres, à tous les niveaux, désireux de créer davantage de plateformes pour leurs activités et leur contribution au sein de leurs communautés locales. De plus, au début de l'année 2025, nous avons célébré, pour la première fois depuis des décennies, la création de notre 22e Section locale dans la région de l'Okanagan, en Colombie-Britannique. Tous ces signes représentent des indicateurs positifs démontrant que nous avançons dans la bonne direction.

Pour réaffirmer ce que nous avons défendu au cours des dernières années, c'est ainsi, à mon sens, que nous bâtissons des équipes et des communautés durables, ainsi que des organisations résilientes et professionnelles, ouvrant la voie à un avenir qui appartient *à toutes et à tous*. Engageons-nous donc à montrer l'exemple en donnant les moyens d'agir à celles et ceux qui sont prêts à porter la mission plus loin. Car lorsque nous investissons

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President's Message/Message du Président

(*President's Message cont'd from p. 7*)

dents Leadership team, which will work with the Steering/Executive Committees and the board to maintain the success and growth of this organization. We are looking forward to having your trust and support and enjoying together the journey of IEEE Canada's future. ■

Tom Murad, P.Eng., Ph.D., F.E.C., F.EIC, SMIEEE
2024–2025 IEEE Canada President
2024–2025 Region 7 Director
IEEE Canada 2026–2027 Past President/Region 7 Past Director

(*Message du Président suite de p. 7*)

dans des leaders qui croient aux principes et aux valeurs, et qui placent la transparence, la diversité et l'équité au cœur de leurs actions, nous ne faisons pas que préserver notre héritage: nous en multiplions l'impact.

Pour conclure, nous achevons l'année 2025 avec de nombreux signes de réalisations positives et de croissance, portés par notre équipe dévouée et travailleuse de bénévoles et de collaborateurs, tout en préparant divers événements enthousiasmants pour 2026. Le Conseil d'IEEE Canada et moi-même vous encourageons vivement à continuer de faire partie de cette belle aventure et à rejoindre notre formidable équipe, afin d'enrichir nos expériences et nos réalisations pour un succès et une croissance encore plus grands.

J'ai déjà passé le flambeau, lors de notre dernière réunion du conseil, à mon successeur, le Dr Wahab Al Muhtady, à qui j'adresse tous mes vœux de réussite dans ses nouvelles fonctions. Grâce à son expertise et à son expérience unique, il contribuera à poursuivre le parcours historique d'IEEE Canada. Je souhaite également la bienvenue à notre nouveau président élu d'IEEE Canada (2026–2027), le Dr Ekram Hussain, au sein de l'équipe de direction des Trois Présidents. Il travaillera avec les comités de pilotage et exécutif ainsi qu'avec le conseil pour maintenir le succès et la croissance de notre organisation. Nous comptons sur votre confiance et votre soutien, et nous nous réjouissons de poursuivre ensemble le chemin vers l'avenir d'IEEE Canada. ■

Tom Murad, Ing., Ph.D., F.E.C., F.EIC, SMIEEE
Président d'IEEE Canada (2024–2025)
Directeur de la Région 7 (2024–2025)
Président sortant d'IEEE Canada (2026–2027) / Directeur sortant de la Région 7

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A Few Words From the Editor-in-Chief / Quelques mots du rédacteur en chef

Jahangir Khan, Ph.D., P.Eng., SMIEEE
mjakhan@ieee.org

With this edition of *IEEE Canadian Review* (*ICR*), we proudly celebrate the 100th anniversary of its publication. What began as a periodic review of Canadian technological innovations—hence the name *Canadian Review*—has grown into a magazine with a far broader scope. Today, *ICR* not only publishes forward-looking content in both fundamental science and applied sectors but also connects more closely with its member base by regularly featuring community news, event announcements, benevolent initiatives, and even lighthearted humor.

Six years ago, *ICR* transitioned from a print-only publication to a digitally focused magazine, further expanding its reach. Since the late 1980s, *ICR* has served as the flagship publication of IEEE Canada (Region 7). It is worth emphasizing that such a continuous and comprehensive record of one region's technological journey is truly unique within the broader IEEE community.

Responding to an open call for participation, this edition brings together a remarkable collection of special articles. The "President's Message" [A1] reflects on Dr. Tom Murad's tenure as IEEE Region 7 president while commemorating *ICR*'s 100th publication milestone. His thoughtful reflection on IEEE Canada's past, present, and future reminds us that our region—and IEEE as a whole—continues to thrive in its mission of advancing technology for the benefit of humanity.

This issue also features Ajay Lotan Thakur's insights on artificial intelligence-native software products [A2]; Stephen Makonin's perspectives on artificial general intelligence [A3]; Saiful Hoque and colleagues' exploration of smart textiles [A4]; David Michelson's reflections on *ICR*'s 100th edition, radio science, and history [A5]; and Terrance Malkinson's prolific commentary on career opportunities in Canada [A6]. Together, these contributions offer a rich assortment of thought-provoking material.

This edition also marks a transition in *ICR*'s editorial leadership. With great pleasure and excitement, we announce the appointment of Dr. Sharareh Taghipour as the new editor-in-chief, beginning in January 2026.

Over the past six years, I have had the honor and privilege of working alongside many dedicated authors, volunteers, and contributors, including Terrance Malkinson, David Michelson, Gautam Srivastava, David Whyte, Daryoush Shiri, David

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Figure 1: IEEE Canada President Tom Murad presents Jahangir Khan with the Service Award at the Fall 2025 IEEE Canada Board Meeting.

Figure 1: Le président d'IEEE Canada, Tom Murad, remet le *Service Award* à Jahangir Khan lors de la réunion du conseil d›IEEE Canada à l'automne 2025.

Avec cette édition de la Revue Canadienne de l'IEEE (RCI), nous célébrons fièrement le 100e anniversaire de sa publication. Ce qui avait commencé comme une revue périodique consacrée aux innovations technologiques canadiennes — d'où le nom *Revue canadienne* — s'est transformé au fil du temps en un magazine à la portée beaucoup plus large. Aujourd'hui, la RCI publie non seulement du contenu prospectif dans les domaines de la science fondamentale et des secteurs appliqués, mais entretient également un lien plus étroit avec sa communauté de membres en présentant régulièrement des nouvelles locales, des annonces d'événements, des initiatives bienveillantes et même une touche d'humour.

Il y a six ans, la RCI est passée d'une publication exclusivement imprimée à un magazine principalement numérique, élargissant ainsi considérablement sa portée. Depuis la fin des années 1980, la RCI constitue la publication phare d'IEEE Canada (Région 7). Il convient de souligner qu'un tel dossier continu et exhaustif retraçant le parcours technologique d'une région est véritablement unique au sein de l'ensemble de la communauté IEEE.

En réponse à un appel ouvert à contributions, cette édition réunit une remarquable collection d'articles spéciaux. Le « Message du Président » [A1] revient sur le mandat du Dr Tom Murad à la présidence de la Région 7 de l'IEEE, tout en soulignant le jalon historique que constitue la 100e publication de la RCI. Sa réflexion éclairée sur le passé, le présent et l'avenir d'IEEE Canada nous rappelle que notre région — et l'IEEE dans son ensemble — continue de prospérer dans sa mission de faire progresser la technologie au service de l'humanité.

Ce numéro présente également les analyses d'Ajay Lotan Thakur sur les logiciels natifs à l'intelligence artificielle [A2], les perspectives de Stephen Makonin sur l'intelligence artificielle générale [A3], l'exploration des textiles intelligents menée par Saiful Hoque et ses collègues [A4], les réflexions de David Michelson sur la 100e édition de la RCI, la science radio et l'histoire [A5], ainsi que les commentaires éclairants de Terrance Malkinson sur les perspectives de carrière au Canada [A6]. Ensemble, ces contributions composent un ensemble riche et stimulant qui invite à la réflexion.

Cette édition marque également une transition au sein de l'équipe éditoriale de la RCI. C'est avec grand plaisir et beaucoup d'enthousiasme que nous annonçons la nomination de la Dre Sharareh Taghipour au poste de rédactrice en chef, à compter de janvier 2026.

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A Few Words From the Editor-in-Chief / Quelques mots du rédacteur en chef

(A Few Words From the Editor-in-Chief cont'd from p. 10)

Green, Matthew Wilder, Dario Schor, and many others. I am deeply grateful to the *ICR* editorial team and IEEE Publications staff—Christine Torrento, Katie Sullivan, Geri Krolin-Taylor, and Peter Touhy—for their unwavering support. I also extend my sincere appreciation to Maike Luiken as well as the presidents, administrators, secretaries, and countless Region 7 volunteers, whose guidance and encouragement made this journey both seamless and rewarding. The support from our advertisers, including AMBA, EIC, and Telus, has also been invaluable. On a more personal note, I was deeply honored and humbled to receive the special Service Award at the Fall 2025 IEEE Canada Board Meeting, presented by our president, Dr. Murad.

As I pass the torch, I wish Dr. Taghipour and her team every success in leading *ICR* into its next chapter. I hope that you enjoy this special edition of *ICR*. Please share your thoughts and comments—we value your voice. Wishing everyone a prosperous 2026. ■

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(Quelques mots du rédacteur en chef suite de p. 10)

Au cours des six dernières années, j'ai eu l'honneur et le privilège de travailler aux côtés de nombreux auteurs, bénévoles et collaborateurs dévoués, parmi lesquels Terrance Malkinson, David Michelson, Gautam Srivastava, David Whyte, Daryoush Shiri, David Green, Matthew Wilder, Dario Schor, et bien d'autres encore. J'exprime ma profonde gratitude à l'équipe éditoriale de la RCI ainsi qu'au personnel des Publications de l'IEEE — Christine Torrento, Katie Sullivan, Geri Krolin Taylor et Peter Touhy — pour leur soutien indéfectible. J'adresse également mes sincères remerciements à Maike Luiken, ainsi qu'aux présidents, administrateurs, secrétaires et aux innombrables bénévoles de la Région 7, dont les conseils et l'encouragement ont rendu ce parcours à la fois fluide et enrichissant. Le soutien de nos annonceurs, notamment AMBA, EIC et Telus, a également été inestimable. Sur un plan plus personnel, j'ai été profondément honoré et touché de recevoir le prix spécial *Service Award* lors de la réunion du conseil d'IEEE Canada à l'automne 2025, remis par notre président, le Dr Murad.

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A Few Words From the Editor-in-Chief / Quelques mots du rédacteur en chef

(A Few Words From the Editor-in-Chief cont'd from p. 11)

Appendix: Related Articles

[A1] T. Murad, "[President's Message]," *IEEE Canadian Rev.*, vol. 37, no. 3, pp. 1–8, Fall/Automne 2025, Winter/Hiver 2026, doi: 10.1109/MICR.2025.3649939.

[A2] A. L. Thakur, "AI-native software products: Transforming network operations and beyond," *IEEE Canadian Rev.*, vol. 37, no. 3, pp. 14–16, Fall/Automne 2025, Winter/Hiver 2026, doi: 10.1109/MICR.2025.3632590.

[A3] S. Makonin, "The Embui Protocol: Designing a merit-based universal basic income to complement artificial general intelligence for human advancement," *IEEE Canadian Rev.*, vol. 37, no. 3, pp. 23–26, Fall/Automne 2025, Winter/Hiver 2026, doi: 10.1109/MICR.2025.3632588.

[A4] M. S. Hoque and A. Yadollahi, "Smart textiles for health care in the era of 6G and the Internet of Things," *IEEE Canadian Rev.*, vol. 37, no. 3, pp. 20–22, Fall/Automne 2025, Winter/Hiver 2026, doi: 10.1109/MICR.2025.3632589.

[A5] D. G. Michelson, "Celebrating the 100th issue of IEEE Canadian Review," *IEEE Canadian Rev.*, vol. 37, no. 3, pp. 17–19, Fall/Automne 2025, Winter/Hiver 2026, doi: 10.1109/MICR.2025.3644047.

[A6] T. Malkinson, "Engineering: A sustainable career with infinite possibilities within Canada," *IEEE Canadian Rev.*, vol. 37, no. 3, pp. 27–31, Fall/Automne 2025, Winter/Hiver 2026, doi: 10.1109/MICR.2025.3644046.

(Quelques mots du rédacteur en chef suite de p. 11)

Alors que je passe le flambeau, je souhaite à la Dre Taghipour et à son équipe plein succès dans la conduite de la RCI vers son prochain chapitre. J'espère que vous apprécierez cette édition spéciale de la RCI. N'hésitez pas à partager vos impressions et commentaires — votre voix compte pour nous. Je souhaite à toutes et à tous une année 2026 des plus prospères. ■

Annexe: Articles Connexes

[A1] T. Murad, "[Message du Président]," *IEEE Canadian Rev.*, vol. 37, no. 3, pp. 1–8, Fall/Automne 2025, Winter/Hiver 2026, doi: 10.1109/MICR.2025.3649939.

[A2] A. L. Thakur, "AI-native software products: Transforming network operations and beyond," *IEEE Canadian Rev.*, vol. 37, no. 3, pp. 14–16, Fall/Automne 2025, Winter/Hiver 2026, doi: 10.1109/MICR.2025.3632590.

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[A4] M. S. Hoque and A. Yadollahi, "Smart textiles for health care in the era of 6G and the Internet of Things," *IEEE Canadian Rev.*, vol. 37, no. 3, pp. 27–31, Winter/Hiver 2025, doi: 10.1109/MICR.2025.3632589.

[A5] D. G. Michelson, "Celebrating the 100th issue of IEEE Canadian Review," *IEEE Canadian Rev.*, vol. 37, no. 3, pp. 17–19, Fall/Automne 2025, Fall/Automne 2025, Winter/Hiver 2026, doi: 10.1109/MICR.2025.3644047.

[A6] T. Malkinson, "Engineering: A sustainable career with infinite possibilities within Canada," *IEEE Canadian Rev.*, vol. 37, no. 3, pp. 27–31, Fall/Automne 2025, Fall/Automne 2025, Winter/Hiver 2026, doi: 10.1109/MICR.2025.3644046.

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AI-Native Software Products: Transforming Network Operations and Beyond

by Ajay Lotan Thakur

Since the release of OpenAI's ChatGPT, the adoption of artificial intelligence (AI) across the software industry has accelerated rapidly. Products are increasingly branded as "AI-capable" or "AI-integrated," with companies eager to demonstrate performance gains and enhanced functionality. However, the concept of being AI-native remains ambiguous and often contested. Clear definitions are required to distinguish between products that merely embed AI features and those architected from the ground up with AI as a core design principle.

Today, software systems are rarely considered complete without some level of AI integration. This trend is reshaping user experience as interactions evolve from conventional interfaces to natural language-driven models. Recent advances, such as large language models (LLMs) for reasoning and agent-based orchestration, illustrate the shift from simple generative AI to complex, context-aware systems, such as AI-driven network management platforms. This article explores the meaning of AI-native software (product) design and examines its visible impact on customers, with references to products where relevant.

Defining AI-Native Software Products

An AI-native software product can be characterized as one that either embeds AI capabilities directly or is designed to integrate seamlessly with the surrounding AI ecosystem. Unlike conventional products that may bolt on machine learning (ML) modules, AI-native systems are architected with extensibility as a first principle. This is essential because the AI ecosystem is evolving rapidly, and only systems with modular and adaptable designs will remain relevant. AI-native is not just about adding a chatbot to a website or including a minor AI/ML feature; it extends far beyond these superficial integrations.

One defining aspect of AI-native products is the ability to generate high-quality, structured *observability data*. Logs, telemetry, and performance traces must be produced in a form that requires minimal preprocessing, enabling downstream models to fine-tune or train efficiently.

Equally important are *programmable hooks and control points* that allow the system's behavior or performance to be dynamically modified by AI agents. For example, autonomous networking platforms can adapt traffic flows or allocate resources in real time, such as Aether's Smart5G project, which aims to create ML-driven energy-saving solutions for mobile networks.

Furthermore, AI-native platforms increasingly integrate *site reliability engineering (SRE) automation* by default. This reduces operational complexity while opening opportunities for new business models. Some companies are delivering independent SRE platforms that can be integrated as add-ons to existing products.

Several examples illustrate this trend. Start-ups like Traversal have developed products that debug network issues with AI agents. Traditional vendors, such as Cisco, offer AI Assistant, a conversational AI tool that optimizes network management, automates routine tasks, and provides proactive troubleshooting to improve performance and reduce downtime.

Ultimately, AI-native software products aim to improve operational efficiency, enable intent-driven design, and reduce lifecycle costs, all while maintaining adaptability to the rapidly evolving AI landscape.

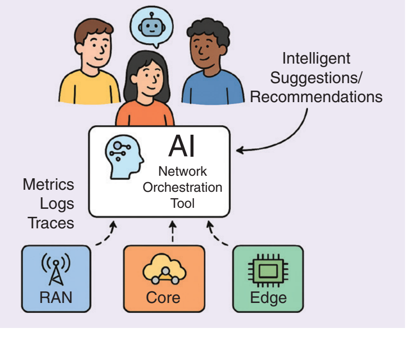

Figure 1: An AI product collects telemetry data and provides insights. RAN: radio access network.

Limitations of Traditional Software

Traditional, rule-based systems were designed for predictable environments. They depend on configuration-driven decisions, where operators must carefully plan and implement changes through rigid procedures. In modern large-scale networks, this approach quickly shows its limits. Systems cannot adapt to complex or unforeseen scenarios, and even small changes carry disproportionate costs and risks. Human errors, in particular, can have major consequences, such as the 14 July 2025 outage of Cloudflare's 1.1.1.1 public Domain Name System resolver, which was traced back to a configuration mistake.

Unlike conventional products that may bolt on machine learning modules, AI-native systems are architected with extensibility as a first principle.

These challenges are magnified in telecommunications. Networks must contend with shifting traffic patterns, the explosive growth of Internet of Things and 5G devices, and the rising demand from data centers powering AI workloads. Manual interventions simply do not scale. Even though monitoring and upgrade tools exist, they still rely on manual debugging and configuration, creating slow, inefficient cycles. As a result, operators often avoid reconfigurations unless absolutely necessary, leading to rigid deployments and long release cycles. Introducing new products only adds complexity as there is no simple way to orchestrate automation across the system.

AI-native platforms change this equation. By leveraging intelligent agents and LLMs, they can automate decision making, reduce manual touchpoints, and relieve the growing pressure on production and SRE teams.

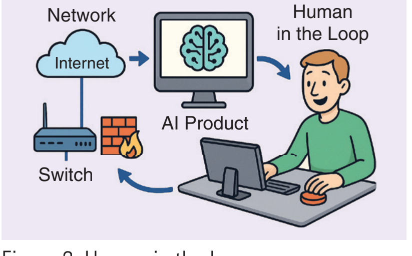

Figure 2: Human in the loop approves a recommendation from an AI product.

Architecture Considerations

An AI-native product is designed to seamlessly interact with an agent-based platform that manages the network, exposing the right interfaces for agents, LLMs, observability, and configuration endpoints. Key aspects of such an architecture can be viewed in terms of basic and advanced capabilities.

The basic capabilities are

- *Configuration*: Complex configurations should be enabled through natural language. For example, LLMs can work alongside MCP servers within the product to automate setup. Based on user requirements, the product can recommend resources such as CPU, memory, and network, with further optimization achieved via closed-loop control.
- *Documentation*: Documentation should be RAG-integrated, with an interactive chatbot on the documentation site that goes beyond keyword search to provide examples and answer operator queries.
- *Monitoring*: Dashboards and health visualization should be simplified using natural language queries. For instance, users could request specific network views without navigating multiple interfaces. Observability data should be structured for easy preprocessing and direct integration into MLOps pipelines.

The advanced capabilities are

- *SRE automation*: The product should incorporate an SRE platform to detect and, where appropriate, automatically remediate issues, while respecting operator preferences for control.
- *Network optimization*: Agents should leverage observability and configuration data to dynamically optimize performance, ensuring efficient resource utilization.

Ultimately, an AI-native product combines these capabilities to deliver intelligent, autonomous, and operator-friendly network management.

Technical Architecture Considerations

Adopting *cloud-native and microservice* principles can greatly simplify product management and operations, even if they are not strictly required at the outset. Flexibility is especially important for LLM integration: enterprises should be able to switch between models easily and decide where the LLM is hosted. Equally critical is robust error handling, for example, when an LLM enforces rate limits on queries.

Real-time analytics and feedback loops are central to decision making. Human-in-the-loop functionality provides essential oversight for critical actions, while integrated data pipelines and ML models enable rapid refinement of system behavior. This ensures that the product adapts continuously to live network performance and evolving user requirements.

Data sovereignty must remain a top priority, with strict adherence to locality and privacy regulations. In parallel, explainable AI is vital so that all AI-driven decisions are auditable and transparent, supporting regulatory compliance and strengthening user trust in automated systems.

Broader Implications of AI in the Product Lifecycle

AI-native goes far beyond its use at runtime. Every product moves through multiple phases, including inception, deployment, and maintenance, and AI can add value at each stage. Although this article focuses primarily on runtime AI, its influence extends much further.

For instance, AI can assist in writing product documentation, breaking down requirements into smaller tasks, and even generating software based on those task definitions. It can also create testing code to validate the quality of AI-generated software. Documentation becomes more accessible through AI-powered chatbots, while runtime metrics and logs can be analyzed by AI to deliver actionable insights. These insights help engineering and product teams to better understand user feedback and adapt more effectively.

It is increasingly clear that AI is permeating nearly every aspect of the product lifecycle, and users are adopting AI-driven tools for daily tasks at an accelerating pace.

Conclusion

The best use of AI is from day one, leveraging it to rapidly create prototypes and gather feedback from key stakeholders. AI should not be limited to one-off tasks; instead, it should enable a closed-loop process: gather user feedback, update the product to enhance the experience, and roll out improvements continuously. Reliability, scalability, and explainability must remain top priorities.

***Data sovereignty* must remain a top priority, with strict adherence to locality and privacy regulations.**

Clear explanations of AI-driven decisions build user confidence and accelerate adoption of AI tools.

AI-native software is increasingly becoming a necessity. Traditional software development is often too slow to keep pace with evolving user requirements. With AI, it is possible to meet customer needs more rapidly, maintain networks at peak efficiency, and experiment with multiple approaches simultaneously to collect user feedback without significant time investment. While the initial investment in AI-native design may appear high, the long-term benefits such as reduced operational costs, streamlined workflows, and improved efficiency make it a compelling approach. We are entering an era where creativity will define progress, and those who leverage it effectively will succeed. Above all, ensuring that the behavior of the end product is explainable should remain the number one priority. ■

Acknowledgment

The figures were generated using ChatGPT. ChatGPT was used to paraphrase the content after the first draft.

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Celebrating the 100th Issue of IEEE Canadian Review

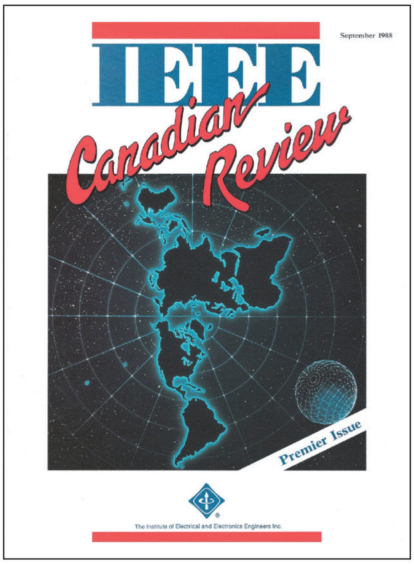
by David G Michelson

IEEE Canada Historian
Chair, IEEE History Committee

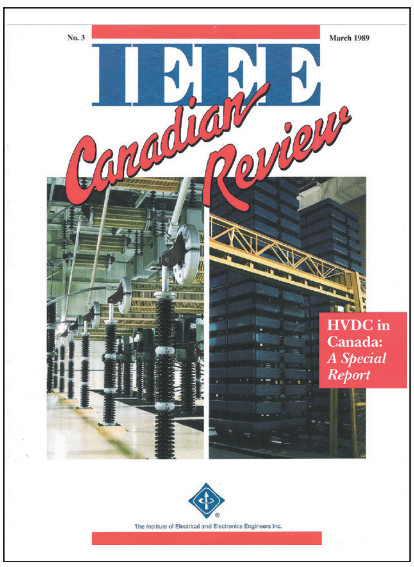
Anniversaries are the perfect excuse to look back and take stock, and the 100th issue of *IEEE Canadian Review* (*ICR*) is no exception. The story of *ICR* began as Robert T. H. (Bob) Alden began his term as director of IEEE Region 7 in 1988. After he teamed up with Richard J. Marceau, progress was rapid and the first issue of *ICR* appeared in September 1988. Since then, the magazine has provided members of IEEE in Canada with a uniquely Canadian perspective on the opportunities and impacts of developments within IEEE's fields of interest. We are fortunate that several of those involved in the formation and early days of the magazine took the time to record the details in the form of both editorial notes and first-hand histories [1], [2], [3], [4].

During its run to date, *ICR* has been led by a succession of 10 editors whose title was originally described as the managing editor and, since Issue 58 (Summer 2008), as the editor-in-chief. They are:

- Richard Marceau: issues 1–8 (1988–1990)
- Anthony R. Eastham: issues 9–11 (1990–1991)
- Théodore Wildi: issues 12–16 (1992–1993)



Front cover of ICR, Issue 1.



Front cover of ICR, Issue 3.

Front cover of ICR, Issue 50.

- Paul Freedman: issues 17–23 (1993–1996)
- Vijay K. Sood: issues 24–50 (1996–2004)
- Eric Holdrinet: issues 51–65 (2005–2011)
- Amir Aghdam: issues 66–68 (2011–2012)
- Wahab Hamou-Lhadj: issues 69–72 (2012–2014)
- Bruce Van-Lane: issues 73–81 (2015–2018)
- Jahangir Khan: issues 82–100 (2020–2025).

Although many aspects of the magazine have changed since the first issue rolled off the presses so many years ago, it is a testament to the vision of the magazine's founders that *ICR* has remained essentially true to the vision that they articulated at the outset and remains

IEEE Canadian Review began as a high-quality print publication that replaced the Region 7 newsletter.

- to inform Canadian members of IEEE on issues related to the impacts of technology and its role in supporting economic development and societal benefits within Canada.
- to foster growth in the size and quality of Canada's pool of technology professionals to serve our increasingly knowledge-based economy.

A Brief History of *ICR*

ICR began as a high-quality print publication that replaced the Region 7 newsletter. It was the first magazine to be produced by an IEEE Region. From the outset, it has been delivered to approximately 15,000 IEEE members in Canada as a member benefit, with paid subscriptions available to others. Originally intended to be a quarterly publication, it quickly assumed its current rate of three times per year. The first several issues were exactly 20 pages in length but gradually began to increase in multiples of four (to match the requirements of magazine production). Today, some special issues, e.g., Issue 92 (Summer 2023) on "Naval and Maritime Technology in Canada," have been as long as 56 pages.

Progress in the early days was rapid. Under the first managing editor, Marceau, Issue 1 included article abstracts in both languages, Issue 4 contained the first full-page advertisement, Issue 5 carried the first full article in French, and so on. Under the fifth and longest-serving editor, Sood, the look and feel of the magazine was refreshed and Issue 34 saw a change in font and format for the name of the magazine. Special issues (and the opportunities to provide multiple perspectives on important topics) have become an increasingly important part of *ICR* over the years.

Until 2015, the editor of *ICR* was always an IEEE Canada volunteer. Starting with Issue 73 in 2015, Van-Lane became the magazine's first professional editor, with his company, Communications Matters, responsible for production. The transition from a default print edition to a default digital edition in mid-2018 resulted in a brief publication pause. Publication resumed with Issue 82 in Winter 2020, with Khan serving as the new editor-in-chief and production shifting to IEEE Publishing in New Jersey.

A Brief History of IEEE Canada

The history of *ICR* is tightly tied to the long quest to establish a distinctly Canadian entity that would provide a unified voice for electrical engineers in Canada. The merger of the American Institute of Electrical Engineering (AIEE) and the Institute of Radio Engineers (IRE) in 1963 had helped somewhat. Under the merger, AIEE District 10 and IRE Region 8 had merged to form IEEE Region 7 which, by 1969, had roughly 8,000 members. However, two other organizations with significant numbers of members, the Electrical, Communications, and Automation Divisions of the Engineering Institute of Canada (EIC), with approximately 2,000 members, and the Canadian branches of the U.K.-based Institution of Electrical Engineers, with roughly 1,200 members, competed with IEEE for both members and the right to be recognized as the Canadian voice of the profession.

In September 1969, an informal meeting was held at the International Electronics Conference in Toronto to discuss options to resolve the matter, but little progress was made. In 1973, the Engineering Institute of Canada formed the Canadian Society for Electrical Engineering (CSEE) as a constituent Society of EIC. In 1976, CSEE launched the *Canadian Electrical Engineering Journal*. In 1988, CSEE launched the Canadian Conference on Electrical Engineering (CCEE). In 1990, these would become the Canadian Society for Electrical and Computer Engineering (CSECE), the *Canadian Journal on Electrical and Computer Engineering* (*CJECE*), and the Canadian Conference on Electrical and Computer Engineering (CCECE), respectively.

By 1988, IEEE Region 7 had more members than CSEE but was seen by many as a mere extension of its U.S.-based parent. It was against this backdrop that Alden saw the opportunity to launch a magazine that would help Region 7 develop a uniquely Canadian identity, complement the offerings of the CSEE, and restart the discussion concerning a possible merger with CSEE. In Issue 3 (March 1989) of *ICR*, Alden asked 15,000 readers whether a single Canadian electrical engineering society was an achievable goal [5].

Within five years, the answer was a resounding yes, and on 1 January 1994, the CSEE and IEEE Region 7 merged to form IEEE Canada. CSECE's journal and conference became part of IEEE Canada, and IEEE Canada became a constituent Society of the Engineering Institute of Canada. Thanks in part to *ICR*, what had seemed impossible in 1969 had finally happened. The continued vitality of IEEE Canada, CJECE, and CCECE more than 30 years after the merger are a testament to the vision of both organizations. ■

About the Author

David G. Michelson is the IEEE Canada historian and chair of the IEEE History Committee. An active contributor to the history of technology for more than two decades, he has been a member or corresponding member of the IEEE History Committee since 2012 and is responsible for one quarter of the 18 IEEE Milestones that recognize Canadian technology achievements. He is also a member of the Society for the History of Technology (and its Special Interest Group on Telecommunications History) and a member of the History and Archives Committee of the Engineering Institute of Canada. His research interests in this area include the historiography of contemporary science and technology, the development and impact of Canadian science and technology since the First World War, and the development and impact of both wireless technology and space technology since the First World War. He can be contacted at dmichelson@ieee.org or historian@ieee.ca.

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IMPORTANT UPDATES

IEEE Canadian Review (*ICR*) is now a "default-digital" publication.

What does this mean?

- All IEEE Canada members will receive *ICR* in digital formats, either through the website or through the IEEE app.
- Members who have explicitly requested not to receive electronic communication will not receive the digital copies. Default mail delivery of print copies will be discontinued to those members in the future. Members are encouraged to opt in for print copies or modify their electronic communication preferences to receive digital copies.
- A print copy will be delivered only to those full-grade members who request it. This will be provided free of additional costs (included in the annual membership fee). Members can opt in for print or digital copies through IEEE membership renewal web page.

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Smart Textiles for Health Care in the Era of 6G and the Internet of Things

by Md. Saiful Hoque
and Azadeh Yadollahi

Clothing is often described as a "second skin," providing comfort and aesthetic expression while maintaining close and continuous contact with the human body [1]. This intimate interface makes textiles an ideal platform for embedding biomedical sensing and therapeutic functions. Since the early 2000s, R&D in smart textiles has shifted toward health-care applications, leading to garments that are capable of monitoring vital signs and supporting clinical interventions. The integration of these medical textiles with digital health technologies is and will be redefining how health care is delivered by allowing continuous, unobtrusive, and patient-centered monitoring in everyday life.

Unlike rigid wearable devices, smart textiles offer distinct advantages for a broad spectrum of users, including children and older adults (see Figure 1). First, the inherent flexibility and conformability of textile fibers and functional polymers enable garments to adapt seamlessly to the body's natural movements, which eliminate the need for conscious adjustment or external effort. Second, textiles are inherently lightweight yet can exhibit remarkable mechanical strength, surpassing even that of steel on a weight-to-strength ratio, thus minimizing the risk of the discomfort, skin irritation, or mechanical interference often associated with rigid wearables. Third, the extensive surface area of textiles allows a larger sensing interface, which enhances data acquisition, robustness, and reliability across multiple body sites, supporting more comprehensive physiological monitoring. Finally, when designed into everyday clothing, smart textiles integrate unobtrusively into daily life, leading to higher levels of user acceptance, long-term adherence, and clinical applicability.

With the advancement of the Internet of Things (IoT), data generated from smart textiles can be transmitted in real time to smartphones or cloud-based platforms for real-time analysis. This capability has given rise to an emerging ecosystem of textile-integrated wearable IoT health devices that enable remote patient monitoring, facilitate early detection of health issues, and support personalized medicine. Industry forecasts highlight the rapid growth of this sector: the global smart textile market was valued at approximately US$7.8 billion in 2024 and is projected to expand to US$51 billion by 2029 [2]. Canada is also a significant contributor to this trend, with its smart textile market valued at US$223.3 million in 2024 and expected to grow at a compound annual growth rate of 25.8%, reaching an estimated US$912.1 million by 2030 [3]. As we stand on the cusp of 6G wireless networks, this short review examines the state of the art in smart health-care textiles, how 6G and advanced IoT will propel the field forward, and what innovations and challenges lie ahead.

Smart Textiles in Health Care: State-of-the-Art Technologies and Challenges

The revolution of smart textiles, from fiber development to fully finished garments, has transformed conventional clothing into functional clothing, made possible through close interdisciplinary collaboration among engineers, clinicians, and researchers that has propelled progress in this sector at a geometric pace. Conductive fibers made from metals, nanomaterials, or polymers are now converted into flexible textiles, which allows sensors, actuators, and data transmission throughout garments [4]. At the same time, self-powered textiles that use piezoelectric and triboelectric nanogenerators are harnessing body motion as an energy source [5]. Moving beyond passive sensing, next-generation smart garments have active functions such as therapeutic delivery, temperature regulation, and fluid monitoring for patients with conditions like heart failure [6], [7], [8], [9].

Data from smart textiles are increasingly integrated with artificial intelligence and analytics to denoise the data and enable advanced health insights. Advanced machine learning algorithms are being used to analyze these large sets of data to detect patterns or early warning signs. For example, researchers have developed a flexible sensor patch that measures electrocardiograms, respiration, skin temperature, and sweat humidity on the skin, with smartphone-based edge computing algorithms that detect arrhythmias, coughs, and falls in real time [10].

With the advancement of the Internet of Things, data generated from smart textiles can be transmitted in real time to smartphones or cloud-based platforms for real-time analysis.

Despite these rapid advancements, challenges remain in areas like durability (e.g. washability of electronic components), power management, mass production, standardization, and validation across larger patient cohorts [11], [12], as shown in Figure 2. Accordingly, current research is exploring solutions such as robust washable electronic circuits, integrated energy-harvesting storage systems, self-healing materials, and the reliable clinical potential of smart textile technologies.

6G Networks and the Future of IoT Textile Wearables in Health Care

Although 5G networks have begun to address needs for high data rates and low latency in the Internet of Medical Things (IoMT), 6G networks are anticipated to further revolutionize this field [13]. The Internet of Wearable Things will markedly benefit from 6G technologies, which are being designed to support long-range, low-power communication; ultra-reliable low-latency connections; and even in-network intelligent computing for data processing at the network edge [14]. In a medical context, this means that smart textiles and wearables will communicate faster and more reliably than ever. Real-time patient monitoring will be enhanced by 6G's ability to transmit data instantaneously. The ultralow latency and high reliability of 6G are especially important for telemedicine that can accelerate the intervention or instant alerts to first responders and even support remote examinations or guided therapies, such as rehabilitation with haptic feedback suits. 6G's massive device connectivity capability also means that the IoMT can scale up dramatically. Finally, with the capacity of 6G networks and the IoT, the application of smart textiles in health care can be limitless.

Future Directions and Recommendations

Although smart textiles for health care have advanced rapidly, several challenges remain before their widespread adoption in clinical and everyday settings. Addressing these challenges requires not only technical improvements but also coordinated efforts across research, policy, and industry. The following key directions highlight priorities that can guide future development and successful integration of smart textile wearables into health-care systems:

- *Interdisciplinary collaboration*: Achieving smart textile health-care breakthroughs requires close collaboration across engineering, materials science, data science, and medicine. Joint research and industry partnerships are needed to ensure that designs satisfy technical constraints and clinical needs simultaneously. Breaking down silos will accelerate innovation and help establish common standards.
- *Policy and ethical frameworks*: Clear regulatory guidelines and standards should be developed for textile-based medical devices to ensure safety, efficacy, and data privacy. Policies must address certification of these wearables and mandate strong data protection for

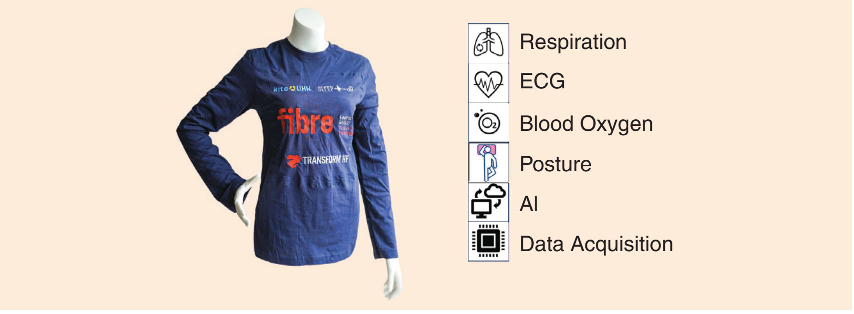

Figure 1: A smart textile prototype designed for continuous monitoring of physiological signals and capable of advancement through 6G network integration.

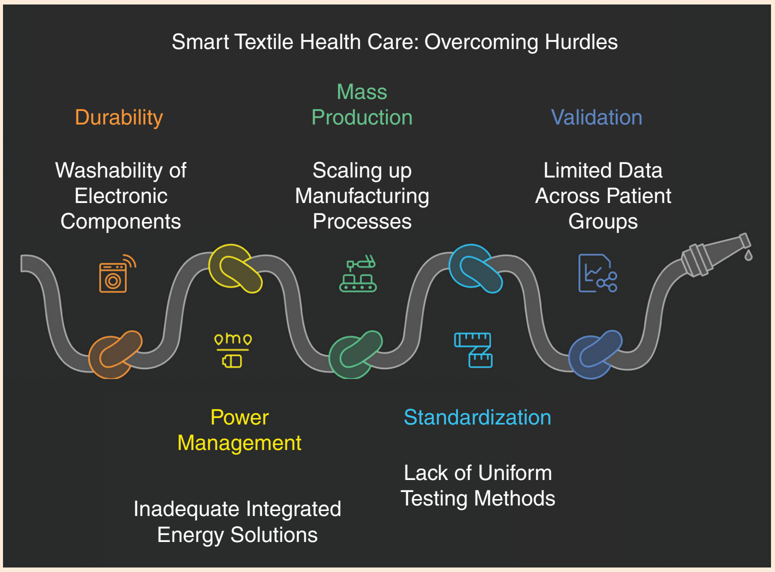

Figure 2: Key challenges of smart textiles, including durability, power management, data privacy, and large-scale deployment.

patient information [15]. Ethical frameworks are also vital.

- *Commercialization challenges*: To move from lab prototypes to real-world use, smart textiles must be robust, user friendly, and cost-effective. Manufacturers should focus on improving durability and wearability and simplifying use. Demonstrating clinical value through robust studies will encourage adoption by health-care providers. Building user trust by proving reliability and protecting privacy is equally important for widespread deployment.

To move from lab prototypes to real-world use, smart textiles must be robust, user friendly, and cost-effective.

Conclusion

Smart textiles integrated with 6G and IoT technologies are poised to redefine health care by enabling continuous personalized monitoring and timely interventions. Fabric-based sensors can seamlessly gather vital health data and transmit them in real time, and upcoming 6G networks will further amplify these capabilities with ultra-fast, ubiquitous connectivity. We also highlighted innovative trends such as self-powered e-textiles, on-device data processing, stronger data security, and new materials that are making smart textile wearables more comfortable and reliable. There are challenges ahead, from ensuring privacy and safety to achieving large-scale production and user adoption. However, interdisciplinary collaboration and supportive policies can help overcome these hurdles. The health-care community, technology developers, and policy makers are called to action to work together in advancing smart textile solutions. ■

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The Embui Protocol: Designing a Merit-Based Universal Basic Income to Complement Artificial General Intelligence for Human Advancement

by Stephen Makonin

It is apparent that artificial general intelligence (AGI) and large language models (LLMs) are and will increasingly displace traditional labour. Some might urgently advocate the need for a universal basic income (UBI). Rather than viewing UBI as a static entitlement, this article proposes a dynamic, merit-based system that rewards individuals for their meaningful contributions to societal progress and AGI development. Drawing on metadata attribution, Shareability Index (S-index)-inspired metrics, and scalable activity-based tiers, The Embui Protocol outlines a policy framework to ensure equitable compensation, dignity through participation, and alignment of human effort with the advancement of AGI toward humanwide betterness.

Introduction: Rethinking UBI in the Age of AGI

We are entering an era where machines can write, reason, and respond in ways once limited to human intelligence. AGI and its practical cousin—LLMs—are reshaping industries, redefining productivity, and raising existential questions about the role of human labour. Automation is no longer about replacing muscle; it is replacing cognition, creativity, and coordination.

Discussions about UBI have gained popularity as a defence against these disruptions, offering a government safety net to cushion the socioeconomic fallout. However, most UBI models are set amounts and passive recurring payments (i.e., social system entitlements). They focus on subsistence rather than empowerment and risk reinforcing dependency on a government social service. We believe that UBI needs to promote contribution to reinforce self-worth and the feeling of accomplishment.

This article proposes an alternative: a merit-based UBI framework that actively rewards individuals for contributing to the very systems that are reshaping our world. By leveraging AGI systems to evaluate and attribute human inputs—such as volunteerism, prompt engineering, and think-tank solutions—we can create a feedback loop that not only compensates but inspires. This approach, *The Embui Protocol*, reimagines UBI not as a static entitlement, but as an engine of participatory advancement.

Embui Etymology

Embui (pronounced *uhm·byu*) is the acronym for *merit-based universal income*. A take on the word *imbue* (i.e., swapping of the "i" and the "e"), a verb meaning to fill something, typically a person or object, with a particular feeling, quality, or idea. In this case, human effort *imbues* AGI betterment.

The Case for Merit-Based UBI

UBI, rooted in merit, recognizes the intrinsic value of being good or worthy—not in a moralistic sense, but in measurable, socially impactful ways. Unlike current models that treat all recipients equally regardless of activity, a merit-based system acknowledges effort, expertise, and contribution (Figure 1).

Analogous systems already exist. Open source developers gain reputation through GitHub contributions.

UBI, rooted in merit, recognizes the intrinsic value of being good or worthy—not in a moralistic sense, but in measurable, socially impactful ways.

Stack Overflow users earn reputation points through helpful answers. Wikipedia editors are acknowledged for curating knowledge. These platforms have proven that recognition can drive meaningful participation—even without monetary reward.

Evidence from UBI experiments further strengthens this view. In Finland's UBI pilot, participants reported higher levels of happiness and trust without reducing their work participation [1]. Likewise, experiments in Kenya and India show improvements in well-being and social participation when people receive unconditional income [2]. A study by Hidalgo et al. [3] found that neither UBI nor taxation on robots reduced workers' motivation to exert effort—indicating that basic income can coexist with ongoing productive engagement.

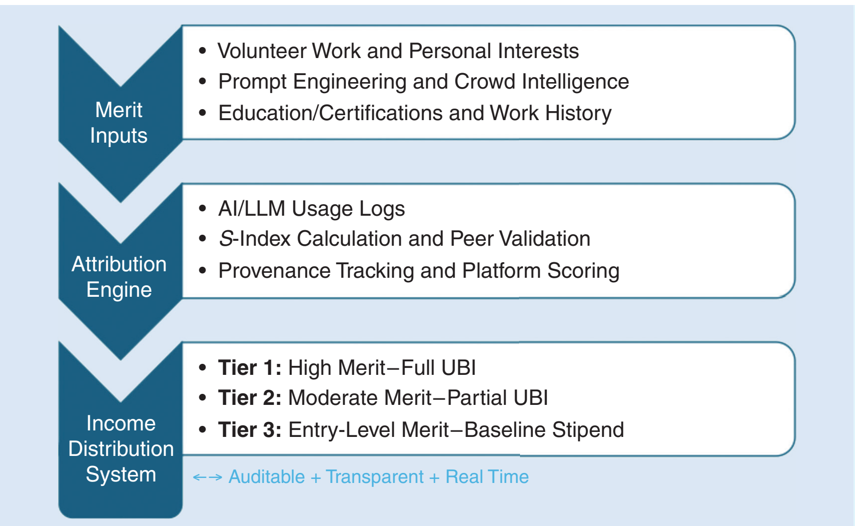

Figure 1: The Embui Protocol: inputs, attribution, and income flow. AI: artificial intelligence.

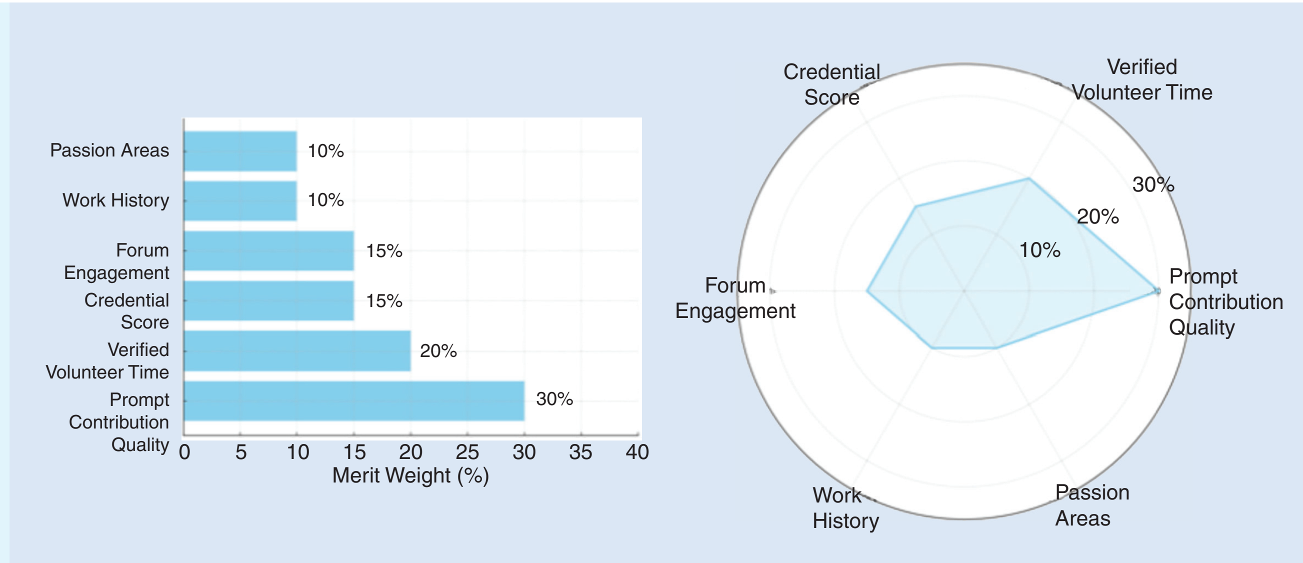

Figure 2: A sample merit portfolio composition for The Embui Protocol.

With AGI and LLMs increasingly trained on human-created data and prompts, there is a clear opportunity: those who help build, refine, or contextualize these models should be rewarded for their labour and insight. This aligns economic reward with intellectual contribution and democratizes participation in the future of intelligence.

Merit-based UBI ensures dignity. It provides a pathway for individuals to continue contributing—even after traditional employment becomes scarce—by valuing their ideas, guidance, and domain knowledge in shaping artificial intelligence (AI) systems.

Defining "Merit" in the AGI Ecosystem

Merit is a measure of being good or worthy, which can increase over time based on activities that align with societal progress and responsible AGI development. For an AGI to be equitable, merit must be quantifiable, transparent, and inclusive. Three key merit channels emerge:

1. *Volunteerism*: This is contributions to education, social services, environmental sustainability, and other altruistic activities that enhance communal well-being. According to the United Nations [4], volunteer work globally contributes the equivalent of 2.4% of world gross domestic product, demonstrating enormous—often unpaid—societal value.
2. *Prompt engineering*: This is writing, refining, and testing prompts that improve LLM performance, safety, and interpretability. Federiakin et al. [5] define prompt engineering as a critical 21st century skill, highlighting its growing role in both personal and professional contexts.
3. *Crowd intelligence*: This is participation in collabourative problem-solving platforms, such as open think tanks, scientific prediction markets, or idea incubators.

Merit must be tracked via metadata. Just as Git commits or academic citations trace intellectual lineage, AGI systems must include attribution layers—tracking who influenced what and how. A modified version of the S-index [6] could measure how widely and usefully a person's contributions are used in AI outputs, policy recommendations, or community tools.

Economic literature has also advocated treating user-generated data and intellectual contributions as labour. Arrieta-Ibarra et al. [7] argues that users who contribute to digital platforms should be compensated fairly for the data they provide, laying the groundwork for compensating prompt engineering and other digital labour.

Income Tiers and Scaling Mechanism

A key distinction of The Embui Protocol is that UBI is not one size fits all. It scales based on a combination of dynamic and historical factors: *current participation* functionality that can track verified, high-quality engagement in platforms that support AGI, social good, or open data; *past achievements* awareness of educational credentials, certifications, work history, and open source or scientific contributions; *volunteer record* documented service of pro-social behaviour; and *personal interests* settings for alignment with long-term learning goals, domain-specific expertise, or creative pursuits.

By compensating humans for their insight, creativity, and care, we steer AGI toward amplifying the best of humanity, rather than making these types of productivity obsolete.

In 2019, Guzman et al. [8] published the CarbonKit framework, which introduced an *eco-currency* (i.e., tradable alternative carbon currency) that users earn by reducing their personal carbon footprint through actions like opting for public transit, lowering home energy use, and meeting step-count goals, with balances redeemable for low-emission products, tax rebates, or in-kind incentives.

Each individual's "merit portfolio" (Figure 2) would be updated in real time and evaluated by transparent AI-driven systems trained to identify authentic, impactful efforts. Peer-review mechanisms, public dashboards, and open source auditing tools would ensure accountability and fairness.

This tiered model (Figure 1) respects the diversity of contribution: not everyone has the same resources, but everyone can participate meaningfully.

Infrastructure Blueprint: What Needs to Exist

Implementing a merit-based UBI requires a robust technological and institutional foundation having the following features:

- *Digital identity frameworks* to verify credentials (e.g., blockchain-based or IEEE-issued digital badges) to ensure authenticity.
- *Metadata-aware LLMs* with next-generation models that retain prompt lineage and attribute influence with granularity.
- *Contribution platforms* that use secure, decentralized hubs where users can submit prompts, solutions, or volunteer logs.
- *Evaluation engines* for AI systems that assess quality, originality, and societal impact based on open metrics that are auditable with trackable history.

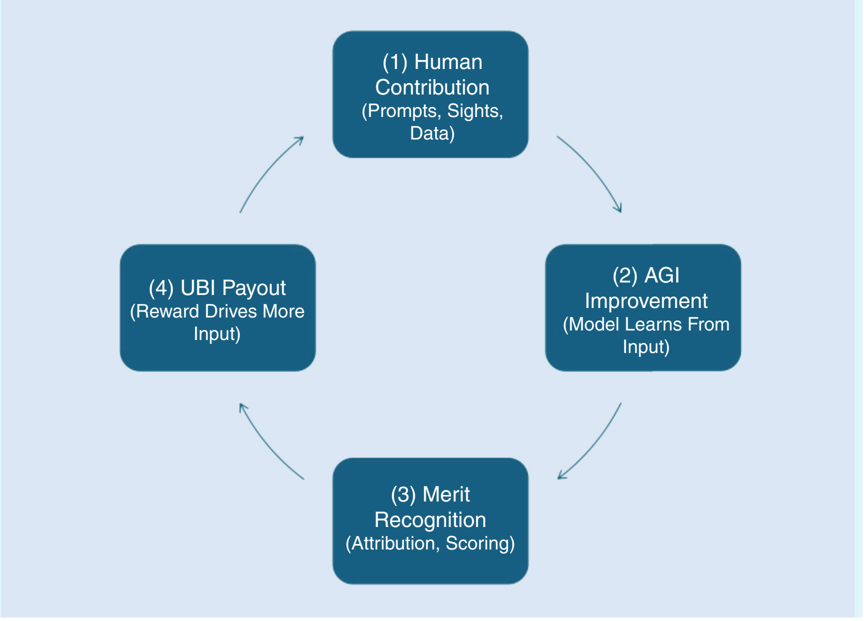

Figure 3: AGI–human alignment via The Embui Protocol.

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- *Payment layers* that provide crypto-agnostic or fiat-compatible smart contracts for distributing micro-UBI disbursements based on accumulated merit.

These components must be interoperable, inclusive, and governed by an independent standards body—potentially under IEEE's Technology and Society umbrella—to ensure ethical oversight and global applicability.

Societal Outcomes and AGI Alignment

A meritocratic UBI framework does more than redistribute wealth, it realigns incentive structures toward human flourishing (Figure 3). It encourages

- *Lifelong learning*: Citizens are rewarded for engaging in ongoing skill development and knowledge contribution.
- *Collabourative intelligence*: Think-tank models replace siloed competition with transparent, collective problem-solving.
- *Ethical AGI shaping*: AI systems evolve based on well-attributed, community-sourced knowledge and values.
- *Inclusion*: Historically marginalized communities gain access to recognition and income by participating in nontraditional ways.

Research by Eloundou et al. [9] estimates that up to 80% of jobs may be affected by LLMs like Generative Pretrained Transformer 4, with nearly one-fifth potentially seeing more than 50% task replacement. Such findings underscore the urgent need for alternative compensation models tied to intellectual contribution and insight.

The World Bank's 2019 World Development Report has already recommended decoupling social support from formal employment in light of these shifts—further legitimizing merit-based UBI as a forward-thinking solution [10].

By compensating humans for their insight, creativity, and care, we steer AGI toward amplifying the best of humanity, rather than making these types of productivity obsolete.

Policy Recommendations and Path Forward

The IEEE Technology and Society community has a pivotal role in building out and developing this new paradigm [11]. The recommended next steps include the following five key tasks:

1. Develop a prototype merit-tracking framework using IEEE digital badges and metadata standards.
2. Launch a call for contributors to pilot merit attribution in prompt engineering, open source AI, and volunteer platforms.
3. Propose policy standards for AGI developers to integrate attribution-aware architectures.
4. Create open datasets that track impact and influence of prompts and ideas within LLM training cycles.
5. Engage with governments and nongovernmental agencies to co-develop hybrid funding models for scaled UBI deployment.

The transition to a post-labour economy is inevitable [12]. The question is not *if*, but *how* we will support the dignity, creativity, and insight of those displaced. The Embui Protocol offers a way forward: a society where income follows merit, merit fuels AGI, and AGI propels humanity forward. ■

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Engineering: A Sustainable Career With Infinite Possibilities Within Canada

by Terrance Malkinson

Engineering is the practice of using natural science, mathematics, and the engineering design process to solve problems, increase efficiency, increase productivity, and improve systems. Engineering has existed since ancient times when humans invented devices to make their lives easier.

An engineer is a practitioner of engineering. The word engineer is derived from the Latin words ingeniare ("to contrive, devise") and ingenium ("cleverness"). An engineer is a professional because their education and training permits them to apply the scientific method to the analysis and solution of engineering problems.

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There are many branches of engineering, each of which specializes in specific technologies and products. Engineers have an in-depth knowledge in one area and a basic knowledge of related areas. The qualifications of a licensed professional engineer typically include a four-year bachelor's degree in an engineering discipline, and passage of engineering board examinations.

Engineering professional societies maintain a code of ethics, which members pledge to uphold.

Engineering professional societies maintain a code of ethics, which members pledge to uphold. Engineers are governed by statute, whistleblowing, product liability laws, and the principles of business ethics.

Modern engineering comprises many subfields, and new fields of interest are emerging with increasing frequency. This is why engineering is a career with infinite possibilities. Engineering is a career path that will never become obsolete or replaced by technology such as artificial intelligence.

Canadian Engineering Leads the World and Makes the World Better

Canada has a long history of engineering innovation, yielding impactful, game-changing technologies and discoveries that have shaped our world. We have demonstrated a quiet confidence rooted in Canadian ingenuity that has enabled many individuals to meet and exceed expectations and solve problems. We have contributed through technological breakthroughs, economic advancements, well-crafted policy adoption, and futuristic global leadership that has global impact and that the world depends upon.

Within the pages of our 100 issues of *IEEE Canadian Review* over the past 37 years, Region 7 has communicated many of the achievements of Canadian engineers. The mission statement of *IEEE Canadian Review* provides the following objectives:

- To inform Canadian members of IEEE on issues related to the impacts of technology, its role in providing economic and societal benefits within Canada, and policy issues around its adoption.
- To recognize the achievements of the people within IEEE Canada as represented through their diverse technical and non-technical activities, events, and awards.
- To foster growth in the size and quality of Canada's pool of technology professionals.
- To support initiatives and organizational objectives of the IEEE Canada leadership team.
- To reach out to members of Canada's broad technology community—spanning industry, academia and government.

We must continue to effectively communicate our achievements vigorously to the public. The *IEEE Canadian Review* editors welcome your submissions and will work with you to assist in crafting your article.

A Selective Compendium of the Diversity of Canadian Engineering and Science Achievements

The following 25 achievements represent only a few of many Canadian success stories. Some are well known, others are unsung contributions to the world. This is not meant to be a comprehensive list; rather, they were chosen as being representative of the diverse range of fields, opportunities, and career possibilities that engineering offers. Some may initially appear to have little connection to engineering, however, upon reflection, they do, which again is indicative of the diverse range of fields available when you choose a career in engineering.

Revolutionizing Manufacturing: The Robertson Screw

The square-headed Robertson screw, patented in 1908 by Canadian inventor Peter Lymburner Robertson, revolutionized the manufacturing and construction industries. The square-drive recess resists cam-out and centres the screw, enabling one-handed operation and reducing assembly time by up to 75% when compared with other screws. It provides a better grip, reduced slipping, and is easier to drive than other screws. The driver grips firmly without downward force, and fatigue and injury rates in production lines drop, giving this simple invention an ergonomic benefit. The Robertson screw is recognized as one of Canada's most practical and enduring engineering contributions.

No Broken Eggs: The Egg Carton

Invented in 1911 by Joseph Coyle, a newspaper editor in Smithers, BC, the egg carton emerged from a discussion between a hotel owner and a farmer over broken eggs during delivery. Coyle's recyclable paper-pulp cushioning matrix design revolutionized egg transport and became the global standard. Not to be limited by eggs, the pulp-molding innovation now protects everything from electronics to medical vials, growing into a global biodegradable packaging sector.

Seeing the Invisible: The Electron Microscope

Brantford-born physicist James Hillier and Albert Prebus co-developed North America's first electron microscope, at the University of Toronto in 1938. This breakthrough instrument used beams of electrons instead of light to magnify objects. This improved the resolution of microscope moves beyond what is possible with light microscopy, opening new frontiers in medicine, biology, materials science, and advancements in nanotechnology. This positioned Canada as a leader in high-resolution imaging. Hillier later helped commercialize the system at RCA, and the microscope won global acclaim, earning Hillier the prestigious Albert Lasker Award.

Moving the Snow: The Snowblower

Arthur Sicard of Montréal invented the snowblower in 1925, essential for removing heavy snow efficiently and enhancing winter mobility. Sicard sold his first snow remover to the city of Outremont in 1927. His design featured an auger and fan system capable of throwing snow more than 25 m. His design became a global standard. The snowblower is a Canadian invention that makes life easier.

Transportation in the Snow: The Snowmobile

Starting in 1935, Joseph-Armand Bombardier, with his track-and-sprocket snow coach, created a mobility machine that could transport people over snow. In 1959, he introduced the personal Ski-Doo, a compact snowmobile that transformed travel across snowy regions worldwide and facilitated Arctic exploration. Using an integration of lightweight engines and rubber tracks, this vehicle could traverse deep snow. Today, it is used by search-and-rescue teams, law enforcement, outdoor adventurers, and recreational users. The snowmobile was a solution tailored to Canada's climate that had global relevance.

Robots in Orbit: Canadarm

The Canadarm was a robotic arm developed by Spar Aerospace in partnership

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with the Canadian Space Agency. In 1981, the 15.2-m robotic arm made its debut aboard NASA's space shuttle *Columbia*, changing the way that we explore space. It was a critical tool in satellite deployment, unloading cargo and in the construction and maintenance of the space station. Its success led to the development of Canadarm2, proving the excellence of Canada's contribution to space exploration. Terrestrial spin-offs include image-guided surgical manipulators and remote mine-site handling equipment, improving precision and worker safety.

Programming: Java

James Gosling, a Calgarian who studied computer science at the University of Calgary, invented Java in 1995 while working for Sun Microsystems. Designed to be platform independent, it has become one of the world's most widely used programming languages. Java became the backbone for software, Android development, and Internet applications. Java's write-once, run-anywhere design enabled cross-platform applications ranging from mobile apps to enterprise systems. This Canadian contribution has reshaped digitization.

Immersive Learning Through Giant Screens: IMAX Technology

Developed by Canadians Graeme Ferguson, Roman Kroitor, and Robert Kerr, IMAX redefined the movie-going experience. IMAX quickly became the standard for large-scale filmmaking and has become a global force. They created an immersive cinematic experience featuring a 10-fold image area over standard cinema with ultrahigh resolution and powerful sound. It is used in documentaries, science films, and by Hollywood producers. Custom-built theaters turned every viewing experience into a spectacle. NASA adopted the technology for astronaut training. IMAX's reach now extends to theatres worldwide, proving that Canadian innovation could dominate globally thanks to the Canadian visionaries who redefined the visual experience.

A Lifesaver: Insulin

Insulin was discovered by Canadian scientists Frederick Banting and Charles Best in 1921 at the University of Toronto and is considered historically to be one of the most important medical breakthroughs. Under the guidance of John Macleod and biochemist James Collip, they isolated insulin and proved that it could control diabetes—a disease that was often fatal. The hormone therapy, first tested on a dog, reduced pediatric mortality by more than 90% within a decade, transforming diabetes into a manageable condition. This discovery helped place Canada among the world leaders in medical research, demonstrating a legacy of Canadian medical ethics and scientific rigor. Their discovery earned Banting and Macleod the 1923 Nobel Prize in Physiology or Medicine. Notably, they sold the patent to the university for US$1, believing that profiting from a lifesaving drug was unethical.

Developed by Canadians Graeme Ferguson, Roman Kroitor, and Robert Kerr, IMAX redefined the movie-going experience.

Fastener: The Zipper

Although early versions of the zipper were invented in the United States, it was Gideon Sundbäck, a Swedish Canadian engineer living in Ontario, who perfected the modern design in 1913. Electrical engineer Sundbäck was working for the Universal Fastener Company in St. Catharines, ON, when he came up with the idea for the "Hookless Number 1." The Swedish-born innovator refined his design and created the first modern zipper, which he patented in 1914. Sundbäck's invention combined utility with ease, replacing buttons and laces across everything from jackets to luggage.

Aeronautics: The Avro Arrow

In the 1950s, there was a growing concern that Soviet bombers would attack North America through the Canadian Arctic. So, in 1953–1954, the Royal Canadian Air Force commissioned Avro to design and build the *Arrow*, an all-weather interceptor meant to fly higher and faster than any aircraft in its class. Avro became a dominant force in Canadian aerospace. By 1957, Avro employed more than 20,000 people, making it one of the largest companies in the country. First flown in 1958, the *Arrow* could hit speeds of 2,450 km/h at altitudes of more than 50,000 ft. It was poised to challenge Soviet bombers head on during the Cold War. Yet, in a political twist that still baffles historians, the project was abruptly canceled in 1959. All design plans and prototypes were destroyed. The *Arrow* remains a symbol of what Canada could achieve when aiming high, literally, and a poignant reminder of a missed aerospace revolution.

Construction: The Paint Roller

Norman Breakey of Toronto invented the paint roller in the 1940s. This time-saving marvel provided the smoothest of paint finishes. Breakey began producing rollers locally, but with no patent, his design was copied widely. Although Breakey didn't get rich, his invention transformed the construction industry, saving time, labor, and reducing injury.

Nuclear Reactor: The CANDU

CANDU reactors were first developed in the late 1950s and 1960s from a partnership among Atomic Energy of Canada Limited, the Hydro-Electric Power Commission of Ontario, Canadian GE, and other companies. Canada's CANDU reactor is one of the safest and most reliable nuclear energy systems in the world. Its unique heavy-water design allows it to use natural uranium, eliminating the need for enriched fuel, reducing fuel costs. First deployed in the 1960s, CANDU units have logged more than 600 reactor years of operation on four continents, providing low-carbon baseload power. They also play a role in producing medical isotopes, which are critical for cancer treatment. This Canadian engineering achievement has contributed to global clean energy development while reinforcing Canada's leadership in peaceful nuclear innovation.

Satellite Communications: Telesat

Telesat began in 1969 as Telesat Canada, a Crown corporation. Telesat Canada launched *Anik A1* in 1972 as the world's first domestic communications satellite in geostationary orbit. It was capable of providing satellite television and communication services to remote parts of Canada. This bridged the urban–rural digital divide and paved the way for global advances in satellite-based broadcasting. Telesat demonstrated how Canadian companies can overcome geographic challenges with cutting-edge technology and help democratize access to information.

Cooking Oil: Canola

Canadian agricultural scientists developed canola from rapeseed to create a cooking oil that was low in saturated fat and free from harmful substances.

The crop became one of Canada's top exports and now supplies the world with healthy vegetable oil. This innovation improved public health and gave farmers a high-yield, climate-resilient crop. Canola is grown on millions of hectares globally, thanks to the Canadian-led re-engineering of a maligned plant into a dietary staple.

Cardiology: The External Pacemaker

Canadian engineer John Hopps, of Winnipeg, along with surgeons at the University of Toronto's Banting Institute, achieved a medical milestone in 1950. This discovery was the creation of a lifesaving device for people with heart conditions and laid the foundation for modern implantable pacemakers. Working with Wilfred Bigelow and John Callaghan, Hopps designed the world's first portable artificial external pacemaker. Tested and first used on humans in 1951, it sent electric pulses via a catheter electrode, laying the groundwork for modern implantable pacemakers. This prototype delivered timed electrical impulses, facilitating rhythm management for arrhythmia patients. Subsequent miniaturization yielded implantable devices, with millions of pacemakers implanted annually. Hopps's work also launched biomedical engineering as an important and continuing Canadian discipline. Although he never patented it, Hopps's innovation became a lifesaving global standard. This Canadian pioneering innovation remains a milestone in medical technology.

Communications: Telephone

Although Alexander Graham Bell later became a U.S. citizen, the telephone was invented in Brantford, ON, in 1874 while Bell lived and worked in Canada. Bell was born in Scotland but did all his telephony engineering in Brantford. This Canadian base provided the intellectual freedom and environment essential for his breakthroughs. The first successful voice transmission occurred on Canadian soil. Although the patent was eventually filed in the United States, Bell's achievement fostered in Canada catalyzed a communications revolution.

Smartphone: BlackBerry

BlackBerry, created by Research In Motion in Waterloo, revolutionized mobile communication, integrating secure e-mail and messaging into a portable device. It became the "go-to" device for professionals worldwide. Cofounded by Mike Lazaridis, BlackBerry took off in 1999 with its thumb-friendly keyboard and encrypted communication. BlackBerry smartphones were among the first phones to have secure e-mail, QWERTY keyboards, and advanced messaging. It changed the way that businesses communicated, setting the stage for what later became the smartphone industry. BlackBerry was Canada's first step into mobile technology. BlackBerry's innovations in mobile security and business communication remain unmatched. The brand's rise and pivot to cybersecurity shows Canadian engineering leadership.

Canadian engineer and railway planner Sir Sandford Fleming divided the world into 24 time zones, bringing order to global timekeeping.

Time: Standard Time Zones

Canadian engineer and railway planner Sir Sandford Fleming divided the world into 24 time zones, bringing order to global timekeeping. His system, adopted at the 1884 International Meridian Conference, divided the globe into 1-h-based zones, making train schedules, global commerce, and coordinated international cooperation possible. The introduction of standard time zones in 1879 ensured consistency and has been globally adopted. The system enabled Canada to lead the way in shaping the modern world's approach to timekeeping. His vision and Canadian-designed system brought precision to clocks worldwide.

Computers: D-Wave Quantum Computers

D-Wave, a Burnaby-based company, was the first to commercially sell quantum computers. D-Wave shipped the world's first commercial quantum computer in 2011. Although traditional computers use bits, quantum computers utilize qubits to solve complex problems more efficiently. D-Wave's machines have been used by NASA, Lockheed Martin, and Google. This pioneering futuristic role will keep Canada at the forefront of a transformative computer engineering technology.

Communication: Wireless Radio

Pioneered by Canadian inventor Reginald Fessenden in 1900, wireless radio communication laid the foundation for modern broadcasting and telecommunications. He was the first to successfully transmit a human voice over radio waves, laying the groundwork for amplitude modulation and frequency modulation radio, radar, and even modern wireless networks. Although others commercialized radio technology, Fessenden's breakthroughs in Canada set the stage for global advancements in wireless communication.

Materials: Plexiglas

Plexiglas, a shatter-resistant glass alternative made of polymethyl methacrylate, was developed by Canadian chemist William Chalmers in the 1930s. Its lightweight and strength characteristics made it indispensable in the aviation, automotive, and medical industries. Canada's contribution to its development was critical in creating groundbreaking material that would evolve into a global mainstay of industrial and consumer goods.

Illumination: Electric Light Bulb

Thomas Edison is often credited with the invention of the light bulb, but Canadian inventors Henry Woodward and Mathew Evans patented an earlier version in 1874. Their design used carbon rods inside a nitrogen-filled glass bulb, significantly advancing electric lighting. Unable to commercialize their invention, they sold the patent to Edison, who refined and mass produced it. Canada played a crucial role in its development, lighting the way for the future.

Transportation: The Confederation Bridge

The Confederation Bridge is a box girder two-lane bridge carrying the Trans-Canada Highway across the Abegweit Passage of the Northumberland Strait, linking Prince Edward Island with New Brunswick. Opened on 31 May 1997, the 12.9-km bridge is Canada's longest and the world's longest over ice-covered water. It is a multispan balanced cantilever bridge with a post-tensioned concrete box girder structure. Most of the curved bridge is 40 m above water, and there is a 60-m-high navigation span for ship traffic. The bridge rests on 62 piers, of which the 44 main piers are 250 m apart. Construction was a joint venture of Ballast Nedam, GTMI, Northern Construction, and Strait Crossing Inc. Construction started in the fall of 1993 and the official opening took place on 31 May 1997

Tower: The CN Tower

The CN Tower is a 553.3-m-high communications and observation tower in Toronto, ON, and was completed in

1976. The CN Tower held the record for the world's tallest freestanding structure for 32 years, from 1975 to 2007. It houses several observation decks, a revolving restaurant, and an entertainment

The CN Tower held the record for the world's tallest freestanding structure for 32 years, from 1975 to 2007.

complex. The design includes a single continuous hexagonal core, with three support legs blended into the hexagon below the main level, forming a large Y-shape structure at the ground level. The CN Tower was built by Foundation Company of Canada, with Canron of Etobicoke handling the steel and antenna fabrication work. Construction began on 6 February 1973, with massive excavations at the tower base for the foundation, and continued upward using innovative engineering techniques. The CN Tower opened on 26 June 1976.

Conclusion

As stated at the beginning, this compendium represents only a few of many Canadian engineering success stories. Some are well known, others are unsung contributions to the world. They were chosen as being representative of the diverse range of fields, opportunities, and career possibilities that engineering offers. The author welcomes suggestions of Canadian engineering success stories for inclusion in future *IEEE Canadian Review* issues.

Founded in 1884, IEEE is the world's largest technical professional association. It is a global network of more than 486,000 engineering and science, technology, engineering, and mathematics professionals across a variety of disciplines whose core purpose is to foster technological innovation and excellence for the benefit of humanity. Through its technical Societies, conferences, technical standards, journals, and magazines, it exists to facilitate your success. Its 2025–2030 strategic plan (www.ieee.org/about/ieee-strategic-plan) details how it will move forward. Its education and career portal (www.ieee.org/education-career) provides you with tools and resources to support you at every stage of your professional journey. ■

About the Author

Terrance Malkinson graduated from the University of Calgary in 1971 with a B.Sc. degree and earned his Information Technology Professional Certificate and his B. Tech. degree in 1999 and 2001, respectively, from the Southern Alberta Institute of Technology (SAIT). Immediately upon university graduation, he was recruited to join the University of Calgary as one of the founding members of the Faculty of Medicine. Over 26 years, he advanced up the technical ladder to positions of senior research practice, management, and educational leadership, supporting many graduate students and advancing medical knowledge. Following his service at the University of Calgary, he worked at the General Electric Company (GE) as a manager and documentation specialist throughout GE's North American operations. He is involved in a number of roles within the advanced technology and education sectors locally, nationally, and internationally. He is a Senior Life Member of IEEE. He has authored more than 610 earned and well-respected research publications and presented the results of original basic and applied research at numerous local, national, and international professional meetings. He mentors undergraduate students, graduate students, postdoctoral fellows, academic staff, visiting scientists, and industry leaders. He was a member of the Editorial Advisory Board of The Institute (2010–2014), and vice-chair of communications for IEEE-USA (2004–2010). He was a pioneer in lifelong learning, advancing his career by pursuing continuing education opportunities at leading institutions. Of particular significance in his life was participation in many wilderness adventure leadership programs facilitated by Outward Bound Canada. He was elected to the Board of Governors of the IEEE Engineering Management Society (2004–2007) and was editor of *IEEE Engineering Management* (2003–2007). He is an associate editor and contributor to *IEEE Canadian Review* (1998–present). In honour of his lifelong and many contributions to the University of Calgary, the Calgary community, and the advancement of scientific and business knowledge, he was inducted into the Order of the University of Calgary in 1997. He was recently named SAIT Polytechnic's 2024 Distinguished Alumni in recognition of his demonstrated leadership skills, exceptional achievements in business and industry, outstanding contributions to the community, and a history of support for education. In 2025, he was named a Compelling Calgarian.

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History Matters

by David G. Michelson
IEEE History Committee Chair and IEEE Canada Historian

Our sense of who we are, our values and beliefs, and our ambitions for the future are guided in large part by the stories and anecdotes concerning the past that we share with each other. In this light, history may be viewed as a formal process by which we preserve, organize, and interpret the stories that both matter to us and define us.

Although historical fact is immutable, historical evidence is inherently fragile and often irreplaceable. Accordingly, efforts to preserve and interpret the past are among the most valuable of legacies.

IEEE HISTELCON 2025

Engineers play a vital role in preserving and interpreting the historical record concerning technology. Informal historical accounts are often incomplete, inaccurate, and lacking in objectivity. A missing detail may be replaced by informed speculation that might seem logical and sound plausible but actually be incorrect. Worse, the narrative may be altered, either innocently or deliberately, to align with a preconceived notion or belief. The purpose of the IEEE History of Electrotechnology Conference (HISTELCON) is to bring together engineers; historians; researchers in science, technology, and society; archivists; and museum curators to address the challenging tasks of both preserving and understanding the history of technology.

The 2025 edition of HISTELCON was held in Bonn, Germany, from 30 September to 2 October. The most recent in a series of biennial history of technology conferences that have been sponsored by IEEE Region 8 since 2008, HISTELCON 2025's theme was "Knowing the Past for Preparing the Future." Cochaired by Wolfgang Koch of Fraunhofer FKIE, Hugh Griffiths from University College London, and Jan Haase of Nordakademie, and hosted by Fraunhofer FKIE and the University of Bonn, the conference emphasized that

> *"the history of HighTech is not a look back into dusty archives, but a toolbox for shaping the future. Particularly in times of military threats, economic uncertainty, and ecological crises, reflections on the history of technology will help to exploit opportunities, recognize risks, make smarter decisions and secure technological independence. Those who learn from the history of technology also learn to shape technological progress responsibly, to protect freedom and democracy in the age of HighTech, to promote prosperity in a targeted manner, and finally to enable cultural development and a dignified life."*

The technical program comprised a series of roundtables, plenary talks, and contributed papers from the history of technology community. The opening roundtable (see Figure 1) was moderated by Koch and featured Kathleen Kramer (IEEE President), Steed Søndergaard (NATO Chief Scientist), General Michael Traut (German Space Command), Jürgen Dickmann (Mercedes Benz), Jürgen Bestle (CTO, Hensoldt Group), and David Michelson (IEEE History Committee chair) as panelists. The ideas generated during the discussion were taken up and fleshed out in three plenary sessions focusing on global uncertainty, quantum technology, and artificial intelligence, and a roundtable on digital technologies for modern radar. The conference organizers deserve full credit for organizing an extremely successful event.

Figure 1: The opening roundtable, "Knowing the Past for Preparing the Future," featured (from left) Kathleen Kramer (IEEE president), Steed Søndergaard (NATO chief scientist), General Michael Traut (German Space Command), Jürgen Dickmann (Mercedes Benz), Jürgen Bestle (CTO, Hensoldt Group), and David Michelson (IEEE History Committee chair). Wolfgang Koch (FKI Fraunhofer) served as moderator.

The Past and Future of HISTELCON

Since its inception in 2008 until now, IEEE HISTELCON has been a flagship conference of IEEE Region 8. The conference has been held in Paris (2008), Madrid (2010), Pavia (2012), Tel Aviv (2015), Kobe, Japan (2017), Glasgow (2019), Moscow (2021), Florence (2023), and Bonn (2025). As the history of technology becomes an evermore important part of IEEE's portfolio, Region 8 elected to transition IEEE HISTELCON into a global conference. It will now be held annually under the combined stewardship of Regions 7, 8, 9, and 10. In particular, the next two editions of the conference will be held in Tokyo (2026) and Ottawa (2027). In both cases, the IEEE History Center and IEEE History Committee will serve as technical cosponsors.

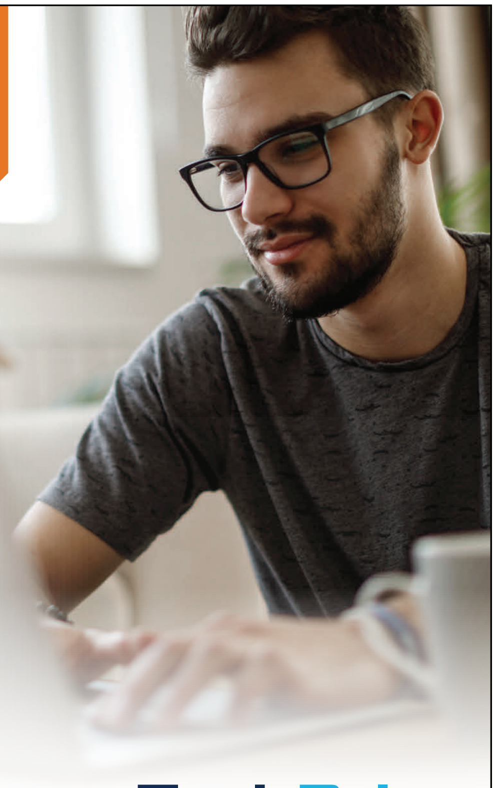
Contributing to IEEE HISTELCON 2027

An important goal of the IEEE History portfolio is to encourage, recognize, and support the historical scholarship that reveals the full story of the history of technology and replaces fiction with fact. Ultimately, discovery and innovation are human activities that are fueled not just by technical skill and insight but by the full range of human emotion and experience. If theory and experiment, or perhaps, alternatively, concept and practice are two axes against which progress in engineering and technology are measured, then surely history is the third axis that reveals the human side of the enterprise. It is no accident that public policy tends to be set by those with a humanities rather than an engineering background. Accordingly, participating in the study of the history of technology can be a valuable way for engineers to earn the confidence of policy makers and join the discussion.

The call for papers and session proposals for IEEE HISTELCON 2027 will be issued in mid-2026. We have already approached other Canadian organizations with an interest in this topic, including Library and Archives Canada, Ingenium, the Engineering Institute of Canada's History and Archives Committee, and the Canadian Science and Technology Historical Association and invited them to participate and contribute. Any organization or individual with an interest in the history of technology and its implications is most welcome to join. In the meantime, we hasten to note that the IEEE Canadian Conference on Electrical and Computer Engineering (CCECE) will host a History of Technology track in 2026. Potential contributors to IEEE HISTELCON 2027 are encouraged to submit a paper to IEEE CCECE 2026 and join us in Montréal the year before. ■

About the Author

David G. Michelson is the IEEE Canada historian and chair of the IEEE History Committee. He will serve as general chair of IEEE HISTELCON 2027 to be held in Ottawa. An active contributor to the history of technology for more than two decades, he has been either a member or corresponding member of the IEEE History Committee since 2012 and is responsible for one-quarter of the 18 IEEE Milestones that recognize Canadian technology achievements. He is also a member of the Society for the History of Technology (and its Special Interest Group on Telecommunications History) and a member of the History and Archives Committee of the Engineering Institute of Canada. His research interests in this area include the historiography of contemporary science and technology, the development and impact of Canadian science and technology since the First World War, and the development and impact of both wireless technology and space technology since the First World War. He can be contacted at dmichelson@ieee.org or historian@ieee.ca.



In Praise of CANDU

by Mitchell Shnier

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CANDU (Canada Deuterium Uranium) is the technology developed by Canadians that currently powers all of the nuclear generating stations in Canada and also powers some of the nuclear generating stations in five other countries.

CANDU is world class compared to other even newer technologies because CANDU has the following attributes:

- It has many openings for sensors and reactor control and shutdown on the top of the unit rather than the bottom, which avoids the risks of leaks of highly radioactive water.
- It protects, and ensures free movement of, the crucial reactor adjuster and shutoff rods rather than exposing them directly to being damaged or jammed during the replacement of fuel bundles.
- It has a fail-safe shutdown system that only relies on gravity, rather than requiring water stored at greater than 1,000 pounds per square inch and the operation of high-pressure valves.
- It is refueled during normal operation while it produces power, rather than requiring weeks of shutdown and opening the reactor pressure vessel.
- Once the CANDU fueling machine is loaded, refueling is done by a single operator in the control room, rather than requiring many people working on a gantry crane directly above the open reactor pressure vessel, who need to precisely and manually hoist and maneuver 12-ft-high, 600-pound fuel cells.
- It has two cooling loops, instead of one, so that the steam turbine is not exposed to the reactor's highly radioactive water, and so that maintenance is simplified. And this adds another level of isolation between the highly radioactive water and the lake cooling water.
- It provides Canada with energy sovereignty.

Here is how CANDU's design accomplishes this, and why Canadians have so much to be proud of.

Energy Sovereignty and Security

CANDU fuel bundles are completely mined and manufactured in Canada, so we're not dependent on any other countries to generate our electricity.

- Most other reactor designs, such as the small modular reactor (SMR) that Ontario Power Generation (OPG) is currently constructing at their Darlington site, require enriched uranium, and Canada does not have the capability to enrich uranium.
- OPG has announced that the enriched uranium for the Darlington SMR will be supplied by companies in the United States and France.
- So in addition to paying others for work that could be done locally and the much longer supply chain, if there were any shipping, regulatory, or other problem receiving this enriched uranium fuel, the SMR could not generate electricity.

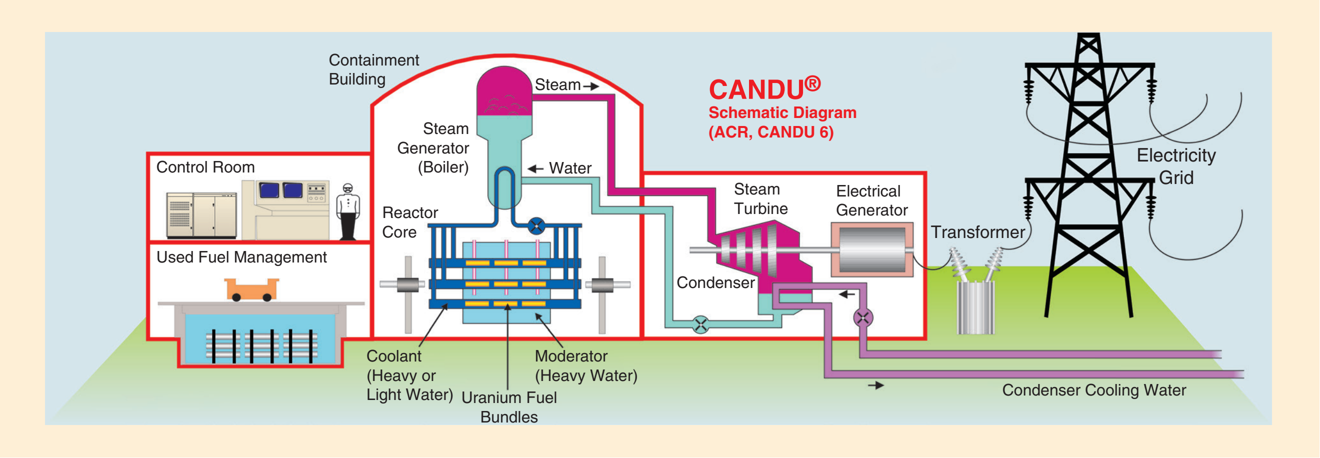

Figure 1: CANDU schematic diagram. The calandria is the cyan square in the Containment Building. The Primary cooling loop is shown in dark blue, and the Secondary cooling loop is shown in green and magenta. The control rods are the pink vertical lines in the calandria. The fueling machines are shown in grey on either side of the calandria, one machine pushes a new fuel bundle into the horizontal pressure tube, and the fueling machine on the other side receives the spent fuel bundle that is pushed out. (Courtesy of NuclearFAQ.ca.)

Leak Avoidance

One of the methods that CANDU uses to adjust and control the nuclear reaction is to lower adjuster rods (and the very similar mechanism to stop the nuclear reaction uses shutoff rods). These are shown as the pink vertical lines in Figure 1. These rods are lowered from winches on the reactivity mechanism deck (which is a thick slab of reinforced concrete above the calandria), down through pipes, which are called *thimbles* (above the calandria) and *guide tubes* (within the calandria). The guide tubes are located between the calandria tubes (in which there are pressure tubes, and in those are the fuel bundles). The calandria tubes are shown as the horizontal yellow lines in Figure 2.

The active component of these adjuster and shutoff rods is cadmium, which absorbs neutrons, and this slows or stops the nuclear reaction. These rods are precisely adjusted to control the nuclear chain reaction, or fully inserted to stop the reaction.

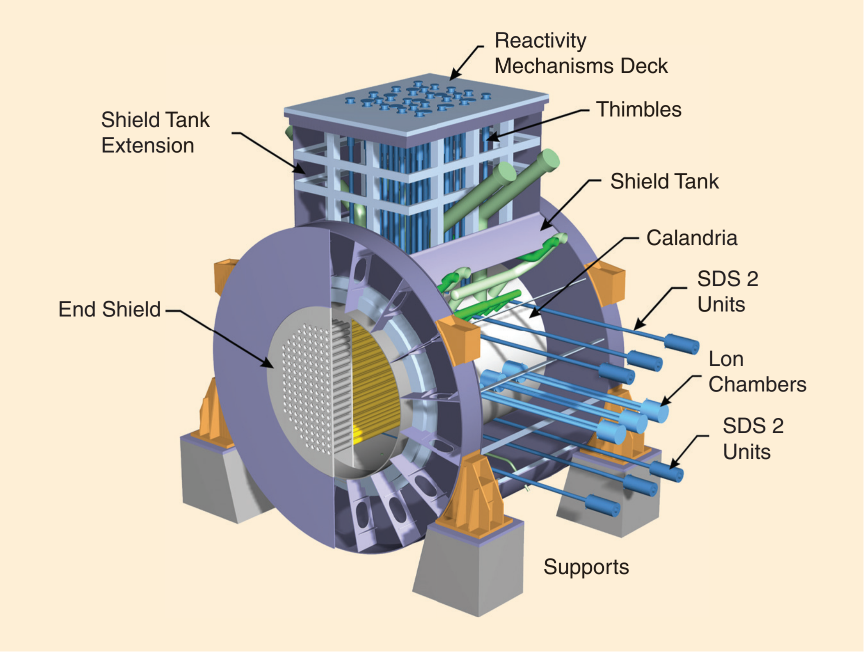

Figure 2: CANDU calandria. Above the calandria is a reactivity mechanism deck, which is a thick concrete slab on which the hoist for each adjuster rod and shutoff rod is mounted. Using a stainless steel cable, the winch has an electric motor (with an electromagnetic clutch for the shutoff rods) to lower and hoist the rods through a thimble (above the calandria) and a guide tube (through the calandria) between the fuel bundles. The fuel bundles are in a pressure tube, which is in a calandria tube; these are shown as the yellow horizontal lines.

- Other designs, such as the SMR, use control rod blades to control the nuclear reaction, and these are pushed up by pistons that penetrate through the bottom of the reactor pressure vessel, as shown at the bottom in Figure 3. This requires openings (actually, 57 openings, one for each control rod and piston) in the bottom of the reactor pressure vessel, and these penetrations create significant risk of leaking radioactive water. This risk is made even worse because the water in the SMR is at a pressure of more than 1,000 pounds per square inch (compare this to typical automobile tires at 32 pounds per square inch, which is roughly the pressure in a CANDU calandria), and the water in an SMR reactor pressure vessel is at a temperature of more than 250 °C. Maintaining and replacing the required seals around these pistons is a significant technical and operational challenge, which CANDU avoids.
- In addition to the 57 openings for the control rod drive mechanisms, the bottom of the SMR reactor pressure vessel also has penetrations for the cables to the many sensors, which are interspersed among the fuel bundles, as shown by the yellow circles and red squares in Figure 4. When these sensors need to be replaced, there is yet another risk of leaks. CANDU avoids all this as sensor cabling does not penetrate the bottom of the calandria, and the CANDU calandria does not have such high pressures and temperatures.

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CANDU Adjuster Rods and Shutoff Rods (and SMR Control Rods)

As the CANDU adjuster rods and shutoff rods are lowered through pipes (the thimbles and guide tubes noted earlier), the rods are protected from interference or damage.

- For the SMR, the control rod blades are in direct contact with the fuel bundles. So every time that these fuel bundles are replaced, it risks anew damaging or binding the control rod blades, and being able to freely move these control rod blades is crucial to both the control and shutdown the SMR's nuclear reaction.
- The configuration can be seen in Figure 4, which shows an overhead cross-section view of the SMR reactor core. The 240 uranium fuel bundles, shown as dark-green squares, are oriented vertically (the fuel bundles are approximately 6 in wide × 6 in deep, and are approximately 12 ft high). The control rod blades are the dark-green crosses, and these are raised and lowered in the spaces between the fuel bundles.
- A photo of the end of an SMR control rod blade is shown in Figure 5: it has a central stainless steel cruciform (a "cross" shape), with laser-welded stainless steel tubes extending further from each fin (the tubes contain the neutron-absorbing material).
- SMR control rod blades are held in position by the fuel bundles, so dummy spacers need to be temporarily inserted in place of some removed fuel bundles to ensure that control rod blades don't tilt out of position when adjacent fuel bundles are removed.
- That is, the SMR does not have built-in fool-proof protection of the crucial control rods from damage or misalignment during refueling, but the CANDU design does.

Fail-Safe Versus "Fail-Complex" Design

The most important requirement for a nuclear reactor is being able to stop the nuclear reaction no matter what may go wrong. Not only are the CANDU emergency shutoff rods (shown in pink in Figure 1) protected in thimbles and guide tubes, but the hoist from which each rod is suspended has an electromagnetic clutch. When power is removed from this clutch, the shutoff rod drops, by both gravity and with extra push by a compressed spring. Removing power—and the shutoff rod dropping through a dedicated guide tube—is simple and guaranteed to work.

- Other designs, such as the SMR, have to push their control rod blades up into the reactor pressure vessel from the bottom, as shown in Figure 3. So not only is this pushing up against the weight of the control rod, but it is also pushing against the 1,000-pounds-per-square-inch pressure in the reactor pressure vessel. For this purpose, the SMR has "scram accumulators," which must always have water at even higher pressure, and has remotely activated

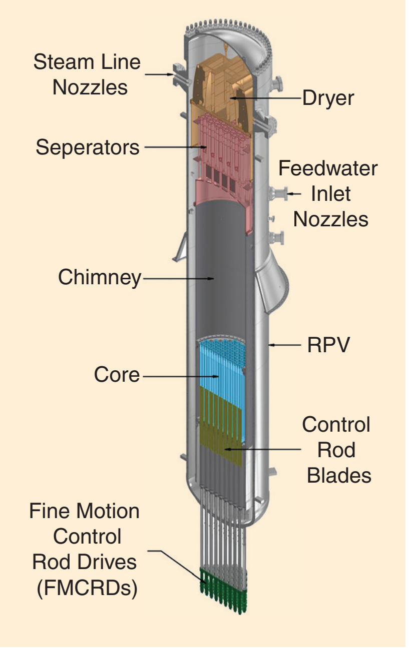

Figure 3: The cut-away elevation view of the BWRX-300 SMR reactor pressure vessel (RPV). The control rods are vertical blades with a "cross" cross section at the bottom of the RPV. These are pushed up into the reactor core, between the fuel bundles, by pistons that enter through the bottom of the RPV.

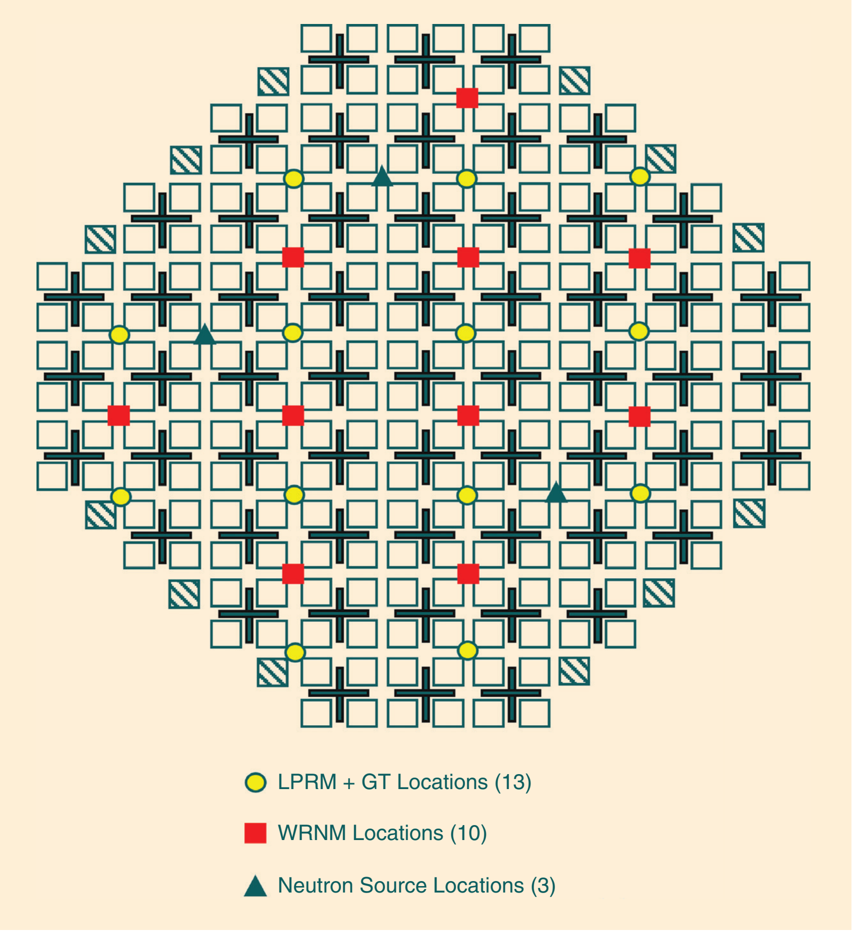

Figure 4: The plan view of the BWRX-300 reactor core. This is a view as if looking down into the reactor core, showing the cross section of the core. The squares are the (approximately) 6 in × 6-in fuel bundles (which are 12 ft high), and in the spaces between are sensors that monitor the nuclear reaction; shown in yellow are 13 vertical instrument tubes containing strings of local power range monitors (LPRMs) and gamma thermometers, in red are the 10 wide range neutron monitor (WRNM) detectors, and in green are three neutron source locations; these are likely only needed to assist with reactor start-up.

high-pressure valves for this shutdown system to work.

- That is, rather than CANDU's fail-safe shutdown, the SMR's emergency shutdown is "fail-complex," requiring stored and maintained very high-pressure water and remotely actuated valves.

Leak Containment

As shown in Figure 1, CANDU's calandria is entirely above grade. This facilitates detecting and dealing with any leaks.

- By contrast, the blasting and excavation for the Darlington SMR's pressure vessel extends to 115 ft below grade, shown by the cylindrical part of the reactor building, which extends below grade in Figure 6. You can imagine this depth as an underground car park that goes down more than 12 levels. And the bottom of this will be 65 ft below the water level of the directly adjacent Lake Ontario. At the bottom of this deep excavation needs to be means to deal both with leaks of the 1,000-pounds-per-square-inch radioactive water from the reactor pressure vessel—and also water infiltration as this is right beside—and 65 ft below the water level of Lake Ontario.
- Nuclear waste management plans would never put even lower-level radioactive waste this close to a lake, which provides drinking water to millions of people, yet the SMR design puts the highest-level radioactive sources below water level and directly adjacent to Lake Ontario.
- Eventually, all of this will need to be decommissioned. Removing such highly radioactive materials, which are below the water level of Lake Ontario—which is just 160 m away—would risk contamination.
- Another complication of the SMR reactor building requiring blasting bedrock and excavating 115 ft below grade, is as the plan is to later build three additional SMR units, this additional blasting bedrock risks damaging the directly adjacent other nuclear reactors.

CANDU fuel bundles are completely mined and manufactured in Canada, so we're not dependent on any other countries to generate our electricity.

Isolation of Radioactive Water

To generate electricity, first, a nuclear reactor heats water enough to create steam, which turns a turbine, and this turbine rotation is coupled to turn an electrical generator. A CANDU reactor does this using two cooling loops: as shown in dark blue in Figure 1, the primary cooling loop brings the water heated in the calandria pressure tubes to pipes running through a steam generator, and then the primary cooling loop pipes bring this (now cooled by the condenser) water back to the calandria to be heated again (there are actually four steam generators per reactor). The secondary cooling loop is completely separate water, as shown in green in Figure 1. This secondary cooling loop water in the steam generator is heated by the blue pipes, which creates the steam shown in magenta, and this steam turns the steam turbine. That is, the radioactive water from the calandria never goes to the steam turbine.

- For an SMR, as shown in orange in Figure 7, the steam from the reactor pressure vessel goes directly to the steam turbines. That is, the SMR has no secondary cooling loop. Therefore, radioactive water runs through the turbine so that it is much more difficult to service the turbines, and if there is a leak between this cooling loop and the condenser, which is cooled by water from Lake Ontario, then radioactive water could be released into the lake.

Refueling During Reactor Operation

The most important metric for any generating station is its "capacity factor,"

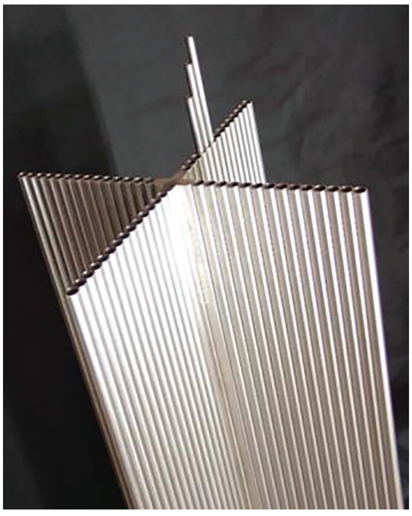

Figure 5: BWRX-300 control rod. The control rod cross section is a cruciform ("cross" shape, an extruded "X"), the core is stainless steel, with 14 stainless steel tubes laser welded along the full length of each of the four fins of the core so that the control rods are actually four blades at 90° angles, 12 ft long (which is the full height of the fuel in the core). The tubes contain neutron absorber material.

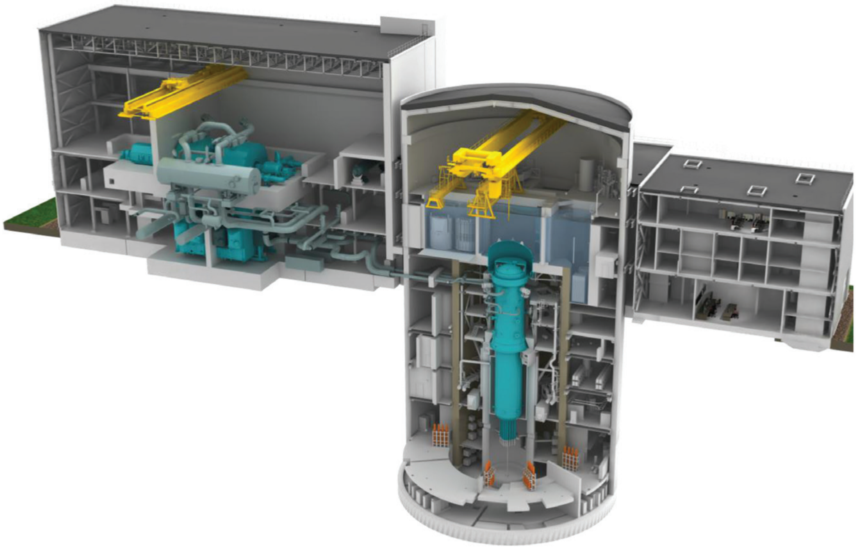

Figure 6: The BWRX-300 SMR station cut-away elevation view. The reactor building is cylindrical and extends 35 m (115 ft) below grade. The RPV is shown in cyan, in the centre of this reactor building. To refuel, the containment head and the RPV head (the top covers), and then the steam dryer and steam separators must be removed, then the water level inside the RPV must be increased so that when the 12-ft-long used fuel is removed, it remains fully below water level.

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which is the percentage of the time that it generates power: more power means more revenue, so the higher the better. CANDU reactors are refueled while they are in full operation, so refueling does not reduce their capacity factor. Also, if there are problems with a fuel bundle, this can be handled while the reactor is in full operation. As shown by the grey fueling machines on either side of the calandria in Figure 1, CANDU refueling is done from the sides of the calandria; one fueling machine pushes a new fuel bundle horizontally into a pressure tube, and another fueling machine on the other side of the calandria receives the spent fuel bundle that is pushed out the receiving side of the pressure tube.

- But SMRs must be shut down for 10–15 days for refueling as this first requires removal of the containment head and the reactor pressure vessel head (shown in cyan in Figure 6), then the steam dryer and steam separator (shown in Figure 3) are removed. That is, refueling requires disassembling much of the reactor pressure vessel, which requires many people with diverse skills, much time and expertise, and some urgency as there's no revenue during refueling.

Remotely Controlled Refueling

CANDU refueling is done by a pair of fueling machines. Once they are loaded with fuel bundles, a single operator in the control room remotely performs the entire operation.

- However, for an SMR, after the reactor pressure vessel is opened, several operators are required on and near the gantry crane bridge, which is shown in yellow at the right of Figure 6 (and from this a telescoping mast is lowered to reach down to attach to the handle of a fuel bundle to hoist it up and out of the reactor core).

CANDU reactors are refueled while they are in full operation, so refueling does not reduce their capacity factor

- This means that the SMR fueling operators on the gantry crane will be above the open reactor pressure vessel, which is 14 ft wide, with the fuel bundles 125 ft below them. These operators must be extremely careful not to drop anything as it may be impossible to retrieve, which could prevent the fuel bundles from seating properly.
- The fuel bundles weigh more than 600 pounds each, and by looking down and using video cameras, the operator must accurately maneuver the gantry crane mast to the specific fuel bundle, then secure the mast's grapple to the fuel bundle's handle and lift, and rotate and move the fuel bundle, all while being careful not to bump it on anything. There are YouTube videos that show all this (search for "BWR refueling"); it is a very manual process, requiring many skilled people and much coordination, compared to the single remote operator, and automatic computer control for CANDU refueling.

Electrical Generating Capacity

At the OPG's Darlington generating station, each of the four CANDU units generates more than 850 MW of power.

- By contrast, the Darlington SMR will have an output of approximately 300 MW, less than half of each of the CANDU reactors.
- In addition to charging electric vehicles, another major new need for electrical power is large data centres. For

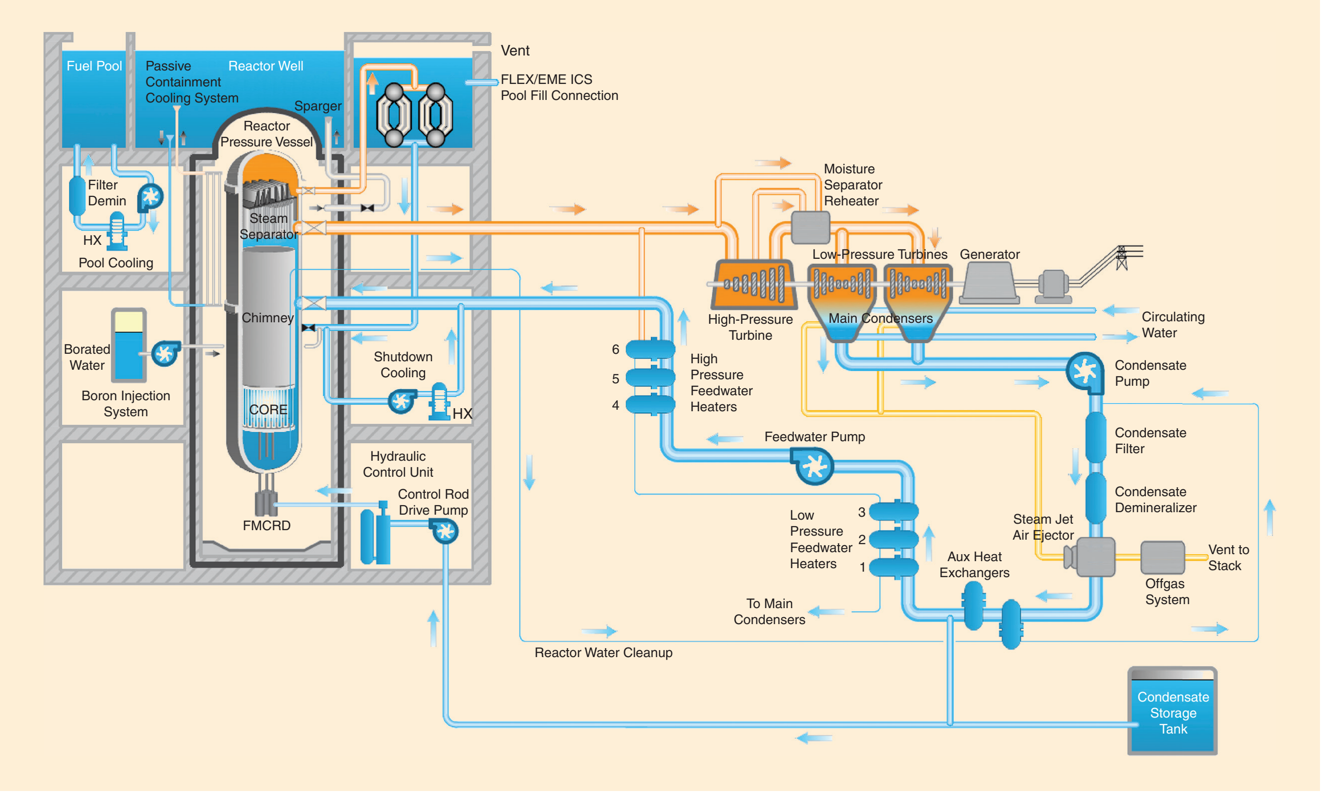

Figure 7: BWRX-300 SMR schematic, showing single-loop cooling. The radioactive steam from the RPV is shown in orange, exiting horizontally from near the top and going directly to first the high-pressure turbine, and then to low-pressure turbines. After being cooled by water from Lake Ontario, the cooling loop water is returned to the RPV.

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example, at the southeast corner of Highway 401 and Islington Avenue in Toronto, Microsoft is currently building a large data centre, designated as YTO 40. Exclusively for this new data centre, Hydro One constructed on site a new transformer station that has a capacity of 160 MVA. So, OPG's new SMR would not have enough power for even two such data centres, but one CANDU generating station could power more than five.

Energy Supply Chain

For decades, hundreds of Canadian companies have been developing and learning nuclear physics and metallurgy, designing and writing the software, manufacturing and supplying thousands of components, and providing specialized services to support Canada's many CANDU reactors. This has helped build Canada's technical competence, supported Canada's economy, and provided export opportunities.

- But OPG's SMRs are designed by GE Vernova Hitachi Nuclear Energy Americas LLC, which is a collaboration between U.S.-based company GE Vernova and Japan-based Hitachi, Ltd. Although they do have a Canadian construction presence for the OPG project, this will not develop the intellectual property, skills, and export opportunities that CANDU has.

Technical Details Matter

As technical people, we know that details are important. And these details show that we can be proud of CANDU nuclear reactors, which have been proven by their decades of safe and reliable operation. ■

About the Author

Mitchell Shnier (mitchell_shnier@ieee.org) received his B.A.Sc. degree in electrical engineering from the University of Toronto in 1979. He has done data communications consulting work in many fields and is a published author, inventor, and instructor. He is a Life Senior Member of IEEE.

The International Union of Radio Science (abbreviated URSI, after its French name, Union Radio-Scientifique Internationale) has a long history of cooperating with IEEE to advance international cooperation in the study of electromagnetic fields and waves. This month's column focuses on the ongoing quest to develop better and more efficient schemes for radiocommunication in Canada's North.

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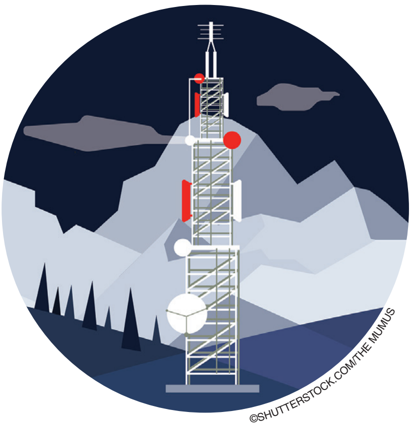

The Challenge of Communications in Canada's North

As governments seek to exercise control and influence over their territories and counter the influence of those who would challenge them, communications infrastructure has always played a defining role. Historically, development of communications infrastructure has been the result of both 1) competition between nations and efforts to assert sovereignty and 2) cooperation between public and private interests and efforts to support the needs of commerce and industry. Nowhere has this been truer than in Canada's North. At the 2025 IEEE International Symposium on Antennas and Propagation and North American Radio Science Meeting (IEEE AP-S/URSI 2025) that was held in Ottawa from 13 to 18 July 2025, the opening plenary session focused on "The Challenge of Communications in Canada's North: Past, Present & Future" and featured presentations by myself, LCol Ellick Pau of the Canadian Armed Forces–Joint Task Force North in Yellowknife, and Denis Couillard of ULTRA Intelligence & Communications in Montréal.

Although wireless communications in the South has reached a high level of maturity during the past 20 years, the same cannot be said for wireless communications in the North.

The session opened by noting that the earliest attempts to use radiocommunication to bridge the vast distances in the North date back to the early 20th century with high-frequency (shortwave) radio networks deployed by the Hudson's Bay Company and later the Royal Canadian Corps of Signals. Construction of the Distant Early Warning System in the 1950s ushered in a second round of innovation that focused on the use of troposcatter systems to provide long-distance links with greater reliability than high-frequency systems based on ionospheric propagation can provide, especially at high latitudes, but with less expense than line-of-sight very high-frequency or microwave radio networks would entail. For some low-bandwidth applications, digital communications systems based on meteor scatter propagation has been found to be effective. The launch of Anik in 1972 ushered in a third round of innovation based on satellite communications that provided Northern settlements with their first reliable and high-bandwidth connectivity to the South. However, the relatively low elevation angles of geostationary satellites when observed from high latitudes represents a significant challenge and renders them unusable. Deployment of satellites in alternative orbits, e.g., pairs of satellites in highly inclined and highly elliptical Molniya or Tundra orbits, or constellations of satellites in low-Earth orbit, address some of the limitations of geostationary satellites but at some expense.

The session continued by noting that we often refer to Canada's North, but there are many different versions of the North depending on the definition one adopts. The narrowest definition refers to the Canadian Arctic, that portion of Canada that lies above the Arctic Circle, i.e., that portion of Canada that lies north of the 66° 34' N. A slightly broader definition refers to Canada's Arctic Region, a slightly larger area that is defined by the 10 °C mean isotherm in July. By contrast, Northern Canada is based on political boundaries and usually refers to that portion of Canada that lies north of the 60th parallel and includes the Yukon, the Northwest Territories, and Nunavut. These three territories cover almost half of Canada's total land area but are home to less than 0.5% of our population. Some will refer to the barren grounds and tundra, shown as light blue in the map in Figure 1, as the Arctic and the taiga and boreal forest shown in dark blue as the Sub-Arctic. The Conference Board of Canada's Centre for the North, the Northern Development Ministers Forum, and Statistics Canada describe Northern Canada as the three territories plus the northern portions of seven provinces, as shown in the map in Figure 2.

The National Research Council of Canada is the adhering body for Canadian membership in URSI and appoints the members of the Canadian National Committee of URSI.

For more information about URSI International, please visit http://www.ursi.org/. For more information about URSI Canada, please visit http://www.ursi.ca/.

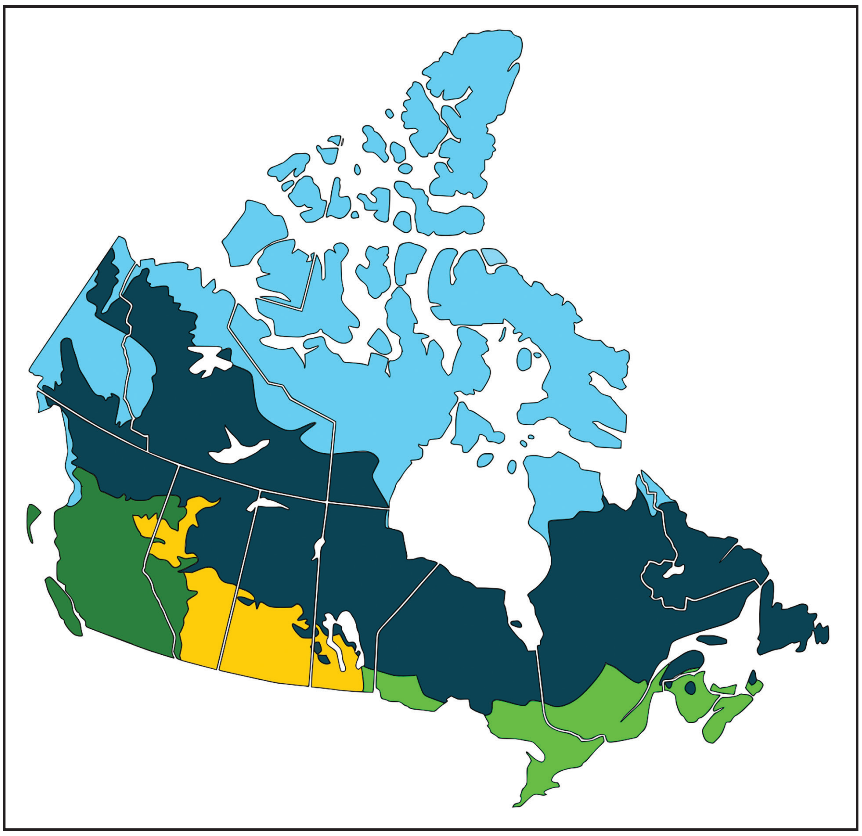

Figure 1: Barren grounds and tundra are shown in light blue, and the taiga and boreal forest in dark blue.

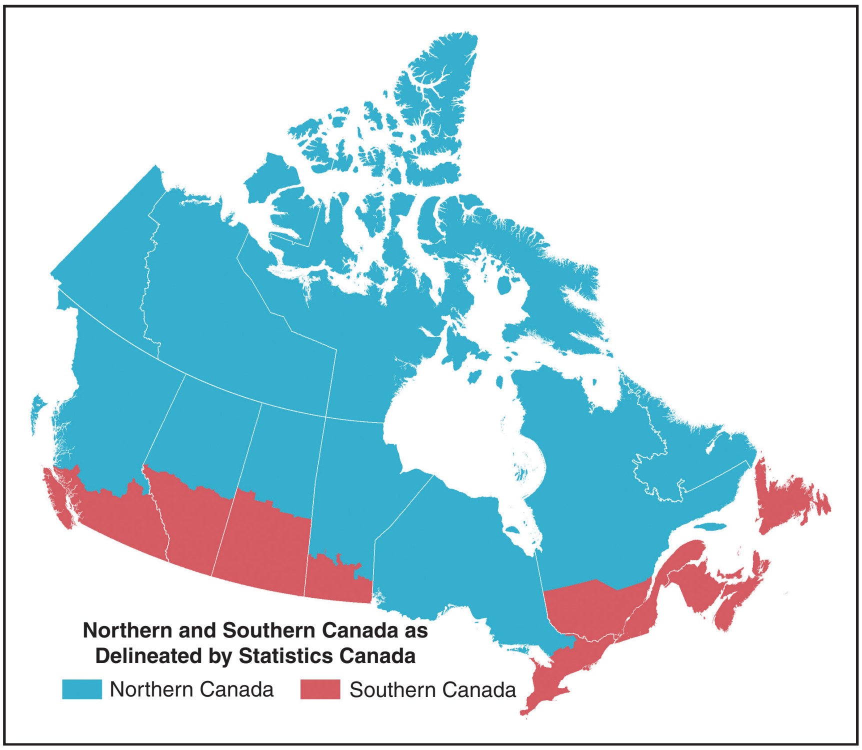

Figure 2: The three territories and northern portions of seven provinces are defined as Northern Canada for northern development purposes.

Regardless of the precise definition, Canada's North is a challenging environment within which to deploy wireless communications systems compared to the South. The distances in the North are vast but wireless propagation over long distances is particularly fraught. Ionospheric disturbances make long-distance high-frequency systems even less reliable in the North than they are at lower latitudes. As noted earlier, satellites in geostationary orbit drop ever lower in elevation as one goes northward and are unusable in the High Arctic. The critical mass of subscribers that financially support common carrier operations in the South is missing in the North. Battery-operated systems do not function well in the extreme cold. Although wireless communications in the South has reached a high level of maturity during the past 20 years, the same cannot be said for wireless communications in the North.

Modern geopolitics have exposed the shortcomings and vulnerability of space-based systems in general and particularly for applications that support sovereignty and security in the North. This has rekindled interest in developing alternative methods for implementing systems that operate under beyond-line-of-sight conditions:

- Near vertical incidence skywave (NVIS) systems transmit high-frequency signals, typically between 1 and 8 MHz, nearly straight up into the ionosphere, where they are refracted and return to a receiver on the ground, creating reliable, local communication over distances of several hundred kilometers. Although NVIS is impacted by unique arctic conditions like auroral activity and polar cap absorption, modern digital techniques can be used to ease the task of selecting the appropriate frequency of operation and implementing adaptive techniques to maintain link reliability. However, there is relatively little experience and intuition regarding their operation in the North to guide development of modern systems.
- Troposcatter systems transmit ultra-high-frequency signals, typically between 500 MHz and 2 GHz, in a

beam aimed just above the horizon. The signals are scattered by turbulence in the troposphere and picked up by a distant receiver. They provide a viable alternative to microwave relay networks and, once again, modern digital techniques can be used to ease the task of implementing adaptive techniques to maintain link reliability. However, much of the experience and intuition regarding the operation of troposcatter links in the North has been lost since the vast majority were decommissioned a half century or more ago.

The session closed with a summary of the contributions that Canadian Marconi Company, a predecessor organization to ULTRA – Intelligence and Communications, has made to wireless communications in Canada's North over the past century and call to the Canadian Radio Science community to take up the challenge of helping to unleash a new round of innovation in wireless communications that uses modern digital techniques to overcome the limitations of past generations of wireless systems and to support Canada's efforts to assert its sovereignty and provide security in the North. ■

About the Author

David G. Michelson is president of the Canadian National Committee of the International Union of Radio Science (2018–2026). He has led the Radio Science Lab at the University of British Columbia, Department of Electrical and Computer Engineering, since 2003. His current research focuses on short-range/low-power wireless networks for industrial vertical and transportation applications and satellite networks for communications and remote sensing. Prof. Michelson currently serves as a member of the Board of Governors of the IEEE Vehicular Technology Society and as principal investigator of the ALEASAT and Pathfinder CubeSat projects. He is licensed in Canada (basic, advanced, and digital) as VA7DM and in the United States as NC7V (extra class). He is an ISED-accredited amateur radio examiner.

The IEEE 20th International Symposium on Antenna Technology and Applied Electromagnetics

The IEEE 20th International Symposium on Antenna Technology and Applied Electromagnetics (ANTEM) was successfully held in St. John's, Newfoundland and Labrador (NL), during 20–23 July 2025. In the past four decades, ANTEM has offered a premier forum on antennas, propagation, applied electromagnetics, remote sensing, telecommunication, and so on. It used to be a biennial conference organized by a permanent committee from the University of Manitoba. In 2018, it was formally transferred to IEEE Canada and became one signature conference of IEEE Canada's. Due to the COVID-19 pandemic, ANTEM 2019 was held virtually, then it was paused until this year for several reasons. This was the first time that ANTEM was held in St. John's, a city of historic significance in the field of electromagnetics and communications. It was here, in 1901, that Guglielmo Marconi recorded the first transatlantic radio signal, sent from Poldhu, U.K., and received at the city landmark of what is now the Signal Hill National Park (see Figure 1).

ANTEM 2025 was organized by the IEEE NL Section and technically sponsored by IEEE Canada, the IEEE Antennas and Propagation Society (AP-S), and IEEE Microwave Theory and Technology Society (MTT-S) and financially sponsored by Memorial University, Solace Power, the IEEE Geoscience and Remote Sensing Society, C-CORE, IEEE Women in Engineering (WIE), Newfoundland and Labrador Hydro, FORTIS, the Institution of Engineering and Technology, and River Publisher. This symposium consists of 17 regular sessions, five plenary talks, one Distinguished Lecturers (DL) workshop, one panel session, and one exhibitor presentation session. Eighty-seven people from 10 countries registered for the conference, and Dr. Tom Murad attended on behalf of IEEE Canada.

Figure 1: Signal Hill, St. John's.

The DL session, which was organized and chaired by Dr. Levent Sevgi, was held at Memorial University (see Figure 2). Four DLs (Dr. Sevgi, Dr. Eng Leong Tan, Dr. Qammer Abbasi, and Dr. George Shaker) made wonderful presentations on various topics. Following it, the Icebreaker Reception at the Whale Atrium of Memorial University enabled old friends and new faces of ANTEM to connect while enjoying delicious food, as shown in Figure 3.

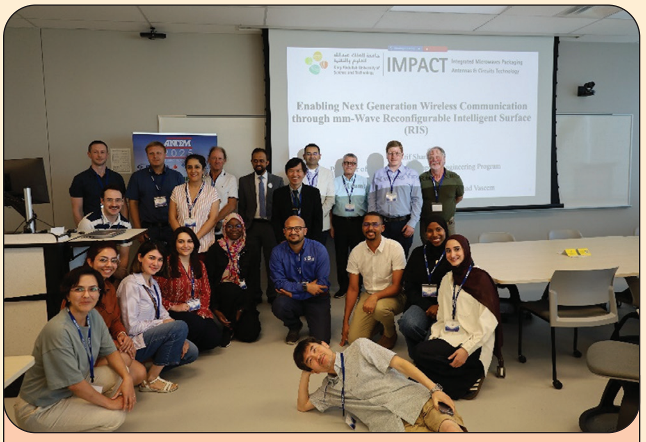

Figure 2: Photo of the DL session.

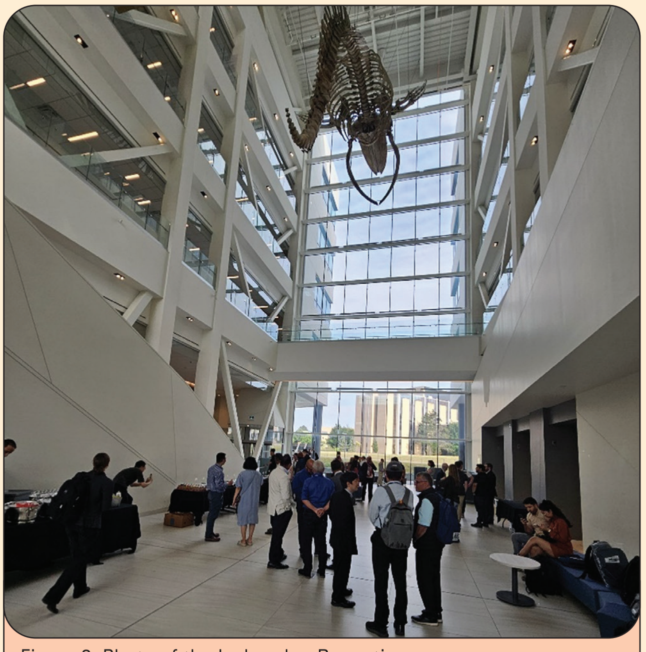

Figure 3: Photo of the Icebreaker Reception.

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Figure 4: Dr. Branislav Notaros gives his plenary talk.

Figure 6: Photo of the "Ask Us Anything" workshop.

Figure 5: The award ceremony at the symposium banquet.

Figure 7: ANTEM 2025 Organizing Committee members.

At the Opening Ceremony, conference General Chair Dr. Weimin Huang, Cochair Dr. Eric Gill, IEEE NL Section Chair Dr. Xianta Jiang, and Technical Program Committee Chairs Drs. Dustin Isleifson and Shaker sent welcome messages to the attendees. As ANTEM creator, Dr. Lot Shafai introduced the history of the conference. Then, Dr. Branislav Notaros, president of the AP-S, started the first plenary talk, titled "Antenna Technology and Applied Electromagnetics: From Computational and Design Methodologies to Biomedical and Sensing Applications" (see Figure 4). The other four plenary speakers were Atef Elsherbeni, Dr. Sevgi, Dr. Jennifer Bernhard, and Dr. Zhizhang (David) Chen.

ANTEM 2025 accepted 69 technical papers, which were scheduled into 17 regular sessions, and it also organized two paper competitions: the Best Student Paper competition and the WIE Paper competition. Based on the research novelty and quality of the papers, the first, second, and third student paper prizes went to Zhiding Yang (Memorial University), Alexander Mackay (University of Toronto), and Mohammad Marjani (Memorial University), respectively. Two honorable mention student paper awards were received by two Memorial graduate students: Thakshila Thilakanayake and Xin Qiao. The first, second, and third WIE paper prize winners were Shirin Ramezanzadehyazdi (University of Manitoba), Mehri Ziaee Bideskan (University of Calgary), and Thi My Chinh Chu (Blekinge Institute of Technology), respectively. Fatiah Balogun (University of Manitoba) and Zahra Lasemiimeni (University of Calgary) took WIE Honorable Mention awards. The paper awards (see Figure 5) were handed out at the symposium banquet, which concluded with fun music and dancing.

The panel session "Ask Us Anything" was dedicated to students who want to seek career advice, explore educational paths, gain field insights, and/or ask tailored questions of the panelists. This interactive workshop (see Figure 6) provided practical guidance to shape their careers and foster on-going engagement with MTT-S activities. The panelists were Dr. Erin Kiley and Dr. Chen.

On the final day of conference, attendees said farewell to each other after a lunch of tasty fish and chips made from fresh local cod. Numerous pieces of positive feedback from attendees indicated that ANTEM 2025 was a great success. I sincerely thank all the Organizing Committee members (see Figure 7) for their tireless input and excellent contribution. The next ANTEM is penciled in for 2027, and we look forward to meeting you then.

—Weimin Huang, ANTEM 2025 General Chair

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IEEE Canada

39e Conférence canadienne annuelle sur le génie électrique et informatique (CCECE 2026)

18-20 Mai, 2026,
Le Westin, Montréal, Québec, Canada
https://ccece2026.ieee.ca

La 39e Conférence canadienne de l'IEEE sur le génie électrique et informatique (CCECE 2026) se tiendra à Montréal, Québec, Canada du 18 au 20 mai 2026. La CCECE offre une tribune pour la présentation de la recherche et du développement en génie électrique et informatique du Canada et du monde entier. Les communications sont les bienvenues, en français ou en anglais, pour les colloques suivants :

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- **Histoire de la technologie**
  Président: Dr. David Michelson, University of British Columbia
  Vice-Président: Dr. Scott Campbell, University of Waterloo

REMARQUE : *Certains articles acceptés lors de cette conférence seront considérés pour publication dans l'IEEE Canadian Journal of Electrical and Computer Engineering, après une autre ronde d'examen. Cela nécessitera une extension substantielle de la version présentée lors de la conférence.*

Questions ou commentaires

Pour toute question ou commentaire, veuillez contacter le président général de la conférence : Amir G. Aghdam. Tel: (514) 848-2424 Ext. 4137, Courriel: amir.aghdam@concordia.ca

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