IEEE Canadian Review

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Spring/Printemps 2023 — No. 92

Spring Sparks 2023

Federated Learning Architecture

Prime Pairs, Quadruples and Octuples

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Robert (Rob) Anderson
P.Eng., SMIEEE

2022–2023 IEEE Canada President and Region 7 Director
2022–2023 Président de IEEE Canada et Directeur de la Région 7

Welcome to the Spring 2023 edition of *IEEE Canadian Review*. This is my second year as IEEE Canada president/Region 7 director. I want to take the opportunity to look back in history, update on some active projects, and introduce a major new initiative. I look forward to working with this IEEE Board of Directors to address the postpandemic world. My biggest observation from the "new" world is that it has dramatically changed people's priorities on what volunteer activities they will support. There has been an increased focus on making a sustainable future for all life on Earth.

In the postpandemic world, people are interested in getting back to networking and being part of a community. This is not surprising after being confined to our homes for several years. The importance of community and making a difference to something with purpose and value is at the forefront of a lot of members' minds. During the COVID-19 pandemic, IEEE Canada started training sessions to ensure that our Section chairs, the

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Bienvenue a l'édition printanière 2023 de la Revue canadienne de l'IEEE. C'est ma deuxième année en tant que président de l'IEEE Canada/directeur de la région 7. Je saisis cette occasion pour faire le point sur certains projets en cours et vous présenter une nouvelle initiative d'envergure. Je me réjouis à l'idée de travailler avec le Conseil d'administration de l'IEEE pour faire face au monde post-pandémique. Ma principale observation du «nouveau» monde, c'est qu'il a radicalement changé les priorités des gens en ce qui concerne les activités de bénévolat qu'ils appuieront. Une importance accrue a été accordée à la création d'un avenir durable pour toutes les formes de vie sur Terre.

Dans le monde post-pandémique, les gens souhaitent retourner au réseautage et faire partie d'une collectivité. Ce n'est pas surprenant après avoir été confiné à nos maisons pendant plusieurs années. L'importance de la communauté est de faire une différence pour quelque chose qui a un but et une valeur est au centre des

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volunteer leaders in your local community, are properly trained to meet members' needs and do so in as efficient manner as possible. I am pleased to report that we have completed the third year of this training. In addition, the number of attendees at these training workshops jumped dramatically this year.

I had mentioned purpose in the previous paragraph. IEEE is in a unique position to bring technical resources and solutions to the climate change crisis. IEEE has made governance changes to bring our humanitarian efforts under an organizational unit and begun to work with other agencies around the world to address this issue. Every member is invited to make a difference to build a sustainable future for humankind; no, for all life on planet Earth. Late last year, IEEE Canada began to form a policy committee, which will bring together our focus on policies for climate change, education activities, and science and technology.

Section Congress is a triannual face-to-face event where the Sections chairs and senior leadership of IEEE gather.

Continuing the theme of "purpose," IEEE Canada (Region 7) will be hosting Sections Congress 2023 in Ottawa from 11 to 13 August. Section Congress is a triannual face-to-face event where the Sections chairs and senior leadership of IEEE gather. This year's theme for the conference is "Enabling Leaders to Build a Sustainable Future."

Sections Congress will provide for dynamic and engaging sessions that will allow for the exchange of ideas and best practices.

IEEE Canada had its Winter 2023 Caucus and Board Meeting on 22 February 2023. The meeting was held virtually, where the tone for the year was defined. This year, the Region will have to look at ways to be more innovative, which includes taking some risks, being better at communications, cooperating more at the national level, and collaborating to deliver upcoming projects. One of those projects will be revitalization of our webpage. Planning has already begun on this project, and we have a process that will hopefully engage as many members as possible from across the country. The rest of the meeting schedule for the year starts with the face-to-face Spring Caucus and Board Meeting in Toronto from 31 March to 2 April, and it will end with the face-to-face Fall Caucus and Board Meeting in October (location to be finalized). In addition to these meetings, there will be a summer virtual meeting where IEEE Canada will hear recommendations from the Nominations and Appointment Committee for 2024 committee chairs.

IEEE Canada will again host our premier conferences face-to-face. The Canadian Conference on Electrical and Computer Engineering (CCECE) will take place in Regina from 24 to 27 September. The theme for this year's conference is "Engineering and Technology for a Better Tomorrow." For more information on

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préoccupations de nombreux membres. Durant la pandémie de COVID-19, l'IEEE Canada a commencé à offrir des séances de formation pour s'assurer que les présidents de section, les leaders bénévoles de votre collectivité locale, sont dûment formés pour répondre aux besoins des membres et le font le plus efficacement possible. Il me fait plaisir d'annoncer que nous venons de terminer la troisième année de cette formation. De plus, le nombre de participants à ces ateliers de formation a fait un bond considérable cette année.

J'ai fait allusion à l'objectif au paragraphe précédent. L'IEEE est idéalement positionnée pour apporter des ressources techniques et des solutions à la crise du changement climatique. L'IEEE a apporté des changements de gouvernance en vue d'intégrer nos efforts humanitaires dans une unité organisationnelle et a commencé à collaborer avec d'autres organismes du monde entier afin de résoudre ce problème. Chaque membre est invité à faire une différence pour construire un avenir durable pour l'humanité et pour toute vie sur la planète Terre. À la fin de l'année dernière, l'IEEE Canada a commencé à mettre sur pied un comité d'orientation qui mettra l'accent sur les politiques relatives aux changements climatiques, les activités d'éducation et les sciences et technologies.

Le Congrès des sections est un événement triennal en face-à-face où les présidents des sections et la haute direction de l'IEEE se réunissent.

Dans la foulée du thème «But», l'IEEE Canada (Région 7) accueillera le Congrès des sections 2023 à Ottawa du 11 au 13 août. Le Congrès des sections est un événement triennal en face-à-face où les présidents des sections et la haute direction de l'IEEE se réunissent. Le thème de la conférence de cette année est «Donner aux chefs de file les moyens de bâtir un avenir durable».

Le Congrès des sections offre des sessions dynamiques et engageantes pour échanger les idées et les pratiques exemplaires.

IEEE Canada a tenu son caucus hivernal 2023 et sa réunion du conseil d'administration le 22 février 2023. La rencontre a eu lieu virtuellement, donnant le ton de l'année. Cette année, la région devra trouver des façons d'innover davantage, notamment en prenant certains risques, en améliorant les communications, en coopérant davantage à l'échelle nationale et en collaborant pour réaliser les projets à venir. L'un de ces projets sera la revitalisation de notre site Internet. La planification de ce projet a déjà commencé, et nous avons un processus qui, nous l'espérons, mobilisera autant de membres que possible d'un bout à l'autre du Canada. Le reste du calendrier des réunions pour l'année commence par la réunion printanière du caucus et du conseil à Toronto, du 31 mars au 2 avril et se conclura par le caucus d'automne et la réunion du Conseil en octobre (emplacement à déterminer). En plus de ces réunions, une réunion virtuelle estivale se tiendra au cours de laquelle l'IEEE Canada recevra les recommandations du Comité des nominations et désignations pour les présidents des comités de 2024.

L'IEEE Canada accueillera à nouveau ses principales conférences en personne. La Canadian Conference on Electrical and Computer Engineering (CCECE) se tiendra à Regina du 24

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this conference, please visit https://ccece2023.ieee.ca/. Planning is also underway for the Electrical Power and Energy Conference (EPEC). This conference is currently scheduled to take place in October.

IEEE Canada is continuing to expand its relationships with industries and other professional organizations. In the past, we have collaborated with the Canadian Academy of Engineering. This year, we are looking at the Intelligent Transportation Societies. These are largely made up of civil engineers, but with the explosion of electric vehicles and autonomous vehicles, there is an opportunity to bring IEEE's fields of interests together with the transportation sector. Talks on how to collaborate are underway, and we are looking at participating at some events this year.

I am also pleased to report that we have broken the 10-year trend in membership decline. IEEE Canada saw decreases in full dues-paying members but saw increases in all membership levels, with a total increase of 0.2%. The biggest increase was in undergraduate student membership. Many international students returned to their Canadian colleges following the COVID-19 pandemic. This year, IEEE has continued to offer students and graduate students a 50% discount on their IEEE membership dues. Please use the coupon code FUTURE50 on renewals and new memberships.

I would also encourage members and nonmembers to check with your favorite technical Societies as they may offer companion promotions. I encourage all the Section chairs to inform their student branches of this discount so that students can take advantage of this offer to join/renew their membership.

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au 27 septembre. Le thème de la conférence de cette année est «Ingénierie et technologie pour un avenir meilleur». Pour en savoir davantage sur cette conférence, veuillez consulter le site https://ccece2023.ieee.ca/. La planification est également en cours pour la Conférence sur l'électricité et l'énergie. Cette conférence est actuellement prévue pour octobre.

IEEE Canada continue d'étendre ses relations avec l'industrie et d'autres organismes professionnels. Auparavant, on a travaillé avec l'Académie canadienne du génie. Cette année, nous nous intéressons à des compagnies de transport intelligent. Ceux-ci sont largement composés d'ingénieurs civils, mais avec l'explosion des véhicules électriques et des véhicules autonomes, il y a une occasion de rapprocher les domaines d'intérêt de l'IEEE avec le secteur des transports. Les discussions sur la manière de travailler ensemble se poursuivent, et nous envisageons de participer à certains événements cette année.

J'ai également le plaisir de signaler que nous avons renversé la tendance à la baisse des adhésions au cours de la dernière décennie. IEEE Canada a enregistré une diminution du nombre de membres contributeurs, mais une augmentation de tous les niveaux d'adhésion, avec une augmentation totale de 0,2%. L'augmentation la plus marquée concerne le nombre d'étudiants de premier cycle. De nombreux étudiants internationaux sont revenus dans leurs collèges canadiens au lendemain de la pandémie de COVID-19. Cette année, l'IEEE a continué d'offrir aux étudiants et aux diplômés une remise de 50% sur leurs contributions à l'IEEE. Veuillez-vous servir du code de promotion FUTURE50 pour les renouvellements et les nouvelles adhésions.

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Attendees at the IEEE Canada Spring Board meeting held on March 31–April 2, 2023 in Toronto, ON.

(President's Message cont'd from p. 3)

Again, this year, both IEEE Member and Geographic Activities and IEEE Canada have decided to use the available funds from 2020 to fund new and innovative projects to promote memberships. All Sections, affinity groups, and committees are encouraged to take this opportunity to leverage these project funds for various promotional activities as well as to attract and retain our memberships.

The health and safety of our members and volunteers remain our top priority. Therefore, we encourage everyone to monitor the federal, provincial, and local health policies and guidelines for any updates. Stay safe and healthy, and I hope the first quarter of 2023 has treated you well. ■

Robert (Rob) Anderson, P.Eng., SMIEEE
2022–2023 IEEE Canada President
2022–2023 Region 7 Director

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J'encourage aussi les membres et les non-membres à vérifier auprès de vos sociétés techniques préférées dans la mesure où elles peuvent offrir des promotions complémentaires. J'encourage tous les présidents de section à informer leurs sections étudiantes de cette réduction afin que les étudiants puissent profiter de cette offre pour se joindre ou renouveler leur adhésion.

Cette année encore, les membres et les activités géographiques de l'IEEE ainsi que l'IEEE Canada ont décidé d'utiliser les fonds disponibles à partir de 2020 pour financer des projets nouveaux et novateurs visant à promouvoir les adhésions. Toutes les sections, les groupes d'affinité et les comités sont encouragés à saisir cette occasion pour tirer parti de ces fonds de projet pour diverses activités promotionnelles ainsi que pour attirer et conserver nos membres.

La santé et la sécurité de nos membres et de nos bénévoles demeurent notre priorité absolue. Par conséquent, nous encourageons tout le monde à suivre l'évolution des politiques et des lignes directrices fédérales, provinciales et locales en matière de santé. Demeurer en sécurité et en santé, et j'espère que le premier trimestre de 2023 vous a été bénéfique. ■

Robert (Rob) Anderson, ing., SMIEEE
Président de l'IEEE Canada 2022–2023
Directeur de la région 7 de l'IEEE 2022–2023

IEEE Canadian Review
La revue canadienne de l'IEEE

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

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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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Jahangir Khan, Ph.D., P.Eng., SMIEEE
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Dear IEEE Canada members and readers everywhere,

I hope you enjoyed the Fall 2022 edition of *IEEE Canadian Review*. The Spring 2023 edition comes with a set of regular columns, feature stories, community news, and award recognitions. I am glad to see a restart of the columns by Dario Schor and Gautam Srivastava.

The last few months have had nothing short of technologically intriguing issues: debates over the power of artificial intelligence (AI) and use of chat-bots, breakthroughs in fusion reactions, and

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Chers IEEE Canada membres et lecteurs,

J'espère que vous avez apprécié l'édition d'automne 2022 de la revue canadienne de l'IEEE. L'édition du printemps 2023 est accompagnée d'une série de chroniques, de comptes rendus, de nouvelles communautaires et prix de reconnaissance. Je me réjouis que Dario Schor et Gautam Srivastava reprennent leurs colonnes.

Depuis quelques mois, d'intrigantes questions technologiques ont été soulevées: discussion sur la puissance de

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new awareness over balloons in our skies, are just a few to mention. *IEEE Canadian Review* is keen to publish articles on these topics. If you are reading this, please consider submitting articles in line with ethically designed AI, defense reconnaissance technology, or nuclear fusion advancements.

The IEEE Region 7 Spring 2023 Board Meeting provided a great opportunity to reconnect and regroup with volunteers, guests, and officers. The COVID-19 pandemic had put a hold on such gatherings for several years. Now that the restrictions are over, this provided a much-needed thrust toward IEEE Canada activities.

The IEEE Region 7 Spring 2023 Board Meeting provided a great opportunity to reconnect and regroup with volunteers, guests, and officers.

IEEE Canadian Review mourns the loss of life in Turkey and Syria caused by the recent earthquake. If you are affected, our thoughts and prayers are with you.

Enjoy the Spring edition of *IEEE Canadian Review*. Please share your thoughts and suggestions as you read. I can be reached at mjakhan@ieee.org. ■

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l'intelligence artificielle (IA) et l'utilisation des agents conversationnels, les percées dans les réactions de fusion et la prise de conscience des ballons dans notre ciel ne sont que quelques exemples. La revue canadienne de l'IEEE tient à publier des articles sur ces sujets. Si vous lisez ceci, songez à soumettre des articles en ligne sur les avancements dans la conception conforme à l'éthique de l'AI, les techniques de reconnaissance ou les progrès de la fusion nucléaire.

La réunion du Conseil d'administration de la Région 7 de l'IEEE au printemps 2023 a été l'occasion idéale de renouer avec les bénévoles, les invités et les dirigeants. La pandémie de COVID-19 a retardé ces réunions pendant de nombreuses années. Maintenant que les restrictions ont été levées, cela a donné aux activités de l'IEEE Canada un élan dont elles avaient grandement besoin.

La réunion du Conseil d'administration de la Région 7 de l'IEEE au printemps 2023 a été l'occasion idéale de renouer avec les bénévoles, les invités et les dirigeants.

La revue canadienne de l'IEEE pleure les pertes de vie en Turquie et en Syrie causées par le récent tremblement de terre. Si vous êtes touchés, nos pensées et nos prières se tournent vers vous.

Profitez de l'édition printanière de la revue canadienne de l'IEEE. En lisant ce numéro, n'hésitez pas à partager vos idées et suggestions. On peut me contacter au mjakhan@ieee.org. ■

2023 IEEE Vancouver Section Annual General Meeting

On Saturday, 25 March 2023, the Vancouver Section held its Annual General Meeting (AGM) and Gala event (see Figure 1). The event was a major success, bringing together more than 100 members, guests, and friends of the Section. This marked the return to an in-person event for the first time since 2019, following three years of virtual-only AGMs without corresponding galas. Attendees were glad to be in person once again, enjoying the company of friends and colleagues as well as a fantastic buffet dinner.

In addition to the traditional reports associated with the AGM business, the event also included

- a student poster competition
- an address by IEEE Canada President Rob Anderson
- the announcement of Vancouver Section Awards
- recognition of one member's 50-year IEEE anniversary
- the announcement of Vancouver Section Scholarship Awards (see Figure 2)
- a unique keynote conversation featuring Shivam Kishore, from the United Nations.

Figure 1: Attendees at the 2023 IEEE Vancouver Section AGM and Gala held Saturday, 25 March 2023.

Figure 2: Scholarship winners at the 2023 IEEE Vancouver Section AGM and Gala event.

Section Chair Jacqueline Nichols and Past Section Chair Matthew Wilder thanked the AGM sponsors for their generous support.

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Some Observations on Prime Pairs, Quadruples, and Octuples

by Jon Rokne

In this article, computers are used as a tool for experimental mathematics with the aim of establishing hypotheses in the form of interesting, but finite, number patterns or sequences that are, however, conjectured to continue to infinity, where "Experimental mathematics is the modus operandi of using computers for generating insight into pure mathematics" [3]. A more extensive definition of experimental mathematics is also found in [3].

However, the following definition for experimental mathematics that is found in [4] is outside the scope of the article: "This new branch is defined less by its subject matter, and more by its use of computer assisted reasoning. Experimental mathematics uses a variety of computer assisted approaches to verify or prove mathematical hypotheses."

In the abstract domain, we can talk about sequences of numbers that are generated according to a pattern. If the sequences generated are finite, then the question often arises as to whether they can be continued to infinity. For example, the even numbers form a sequence because every second number in the sequence of increasing natural numbers is even. In this case, the sequence is infinite. For other sequences, a kind of order might be observed

without being able to provide proof that the sequence is infinite. In this note, we consider some new finite sequences that are computationally observed, and we may conjecture that they extend to infinite sequences in some cases. Andrews [1] notes, "However, the computer's most important role has been to provide numerical data from which one may guess the truth of a theorem."

Prime Pairs

An interesting concept in the abstract domain is the notion of primes. These are the natural numbers that have no divisors except for one and itself. Already in the antiquity, it was verified that there is an infinite number of primes. Following this, a number of variations of the proof has been found. For typical proofs, see [5].

In practice, given a prime pair, we can most likely computationally produce a new prime pair, provided we have a powerful-enough computer.

Along with prime numbers, there is the notion of prime pairs. That is, a set of two primes that differ by an integer factor of two. A recent proof that verifies that there are an infinite number of prime pairs is discussed in [10]. A simple existence proof along the lines of the proof of the infinite sequence of primes does not exist, however. In practice, given a prime pair, we can most likely computationally produce a new prime pair, provided we have a powerful-enough computer.

Various aspects of primes and sequences of primes have been discussed by many authors. For some recent discussions, see [3], [7], and [10]. In the following, further aspects of primes are introduced that are valid for finite ranges with hypotheses for validity for the unbounded case.

Let $(n-1, n+1)$ be a prime pair for some n. Then, n is defined to be the *dcentre* of the prime pair. It is well known that the *dcentre* for a prime pair n is divisible by six so that $n = 6 * m$, where m is an integer, which we call the reduced *dcentre* or the *drcentre* for n. The *dcentre* or the *drcentre* provide a unique number identifying the prime pair.

There are further groupings of primes. Two groupings that will be discussed here are quadruple and octal primes.

Quadruples

Quadruple primes are two pairs of double primes, $dcentre_l$ and $dcentre_r$, where $dcentre_r - dcentre_l = 15$, $(dcentre_l > 12)$, and where it is computationally verified up to a large, but finite limit that 15 is the minimum distance possible between two double primes. The centre of a quadruple prime is defined as $qcentre = (dcentre_l + dcentre_r)/2$. Similar to the double-prime case, we also define the reduced quadruple prime centre as $qrcentre = qcentre/15$, having computationally observed that the *qcentre* is divisible by 15.

Octuples

Octuple primes are two pairs of quadruple primes, $qcentre_l$ and $qcentre_r$, where $qcentre_r - qcentre_l = 30$ under the computationally verified assumption that 30 is the minimum distance possible between two quadruple primes. The centre of an octuple prime is an octuple prime centre defined as $ocentre = (qcentre_l + qcentre_r)/2$, and the reduced centre for octuple primes is $orcentre = ocentre)/30$, having computationally observed that the *ocentre* is divisible by 30.

For an integer $n = f_1^{m_1} * \ldots * f_j^{m_j}$, we use the notation $n = ((f_1, u_1),..., (f_j, u_j))$ to denote that it has prime factors f_1 to f_j with respective multiples u_1 to u_j. That is, if $n = 36$, then it can be written as $n = ((3, 2); (2, 2))$. Normally, the factors are ordered so that $f_1 < f_2 < \ldots < f_j$.

An interesting feature of natural numbers is that they form many observable, finite patterns. For example, consider the sequence 5, 11, 17, 23, 29. This is a finite pattern of primes formed by the numbers $6n - 1$ for $n = 1,\ldots, 5$. Having observed this pattern, one might easily conjecture that the sequence $6n - 1$ would continue to produce primes for $n > 5$. Clearly this fails, given that $n = 6$ results in 35, which is not a prime number. For other patterns that may or may not be infinite, see [10] and [11].

In the following, some computationally observed results on primes, prime pairs, prime quadruples, and prime octuples up to large but finite limits are provided. These results are conjectured to be valid for the infinite case as well.

Table 1: The number of primes and prime pairs for two ranges.

Number Range	Number of Primes	Number of Prime Pairs	Frequency
Range 6–10^6	78,498	8,169	0.008
Reduced range 1–(10^6/6)	15,225	1,856	0.011

Table 2: A short sequence of prime pairs with *drcentre* factorizations.

drcentre $m = n / 6$	*dcentre n*	*drcentre* Prime	*drcentre* Even	*drcentre* Odd
103	618	103	Not	Not
107	642	107	Not	Not
110	660	Not	((2, 1), (5, 1), (11, 1))	Not
135	810	Not	Not	((3, 3), (5, 1))
137	822	137	Not	Not
138	828	Not	((2, 1), (3, 1), (23, 1))	Not
143	858	Not	Not	((11, 1), (13, 1))
147	882	Not	Not	((3, 1), (7, 2))

Table 3: The number of prime pairs for the quotient *drcenter* = *m* = *n*/6.

	m Prime	*m* Even	*m* Composite Odd
The number of *m* corresponding to prime pairs	558	4,121	3,489
The number of new prime pairs	104	1,899	—

Table 4: The number of prime pairs for centres formed by the product two ($m = n * 6$).

Original Index	Range When Multiplied by 6	Prime Pairs Found	Second Set	Third Set
1–166,666	1–10^6	8,169	655	34

In Table 1, the number of primes, prime pairs, and the frequency of prime pairs are shown for the range 1, … , 10^6. Note that the frequency of prime pairs is reduced for the larger number range.

Now consider the reduced centre m = *drcentre* for the prime pairs. There are three cases for m. It can be a prime, an even integer, or an odd composite integer. Table 2 lists a typical short sequence of prime pairs, showing examples of the three possible factorizations of the *drcentre*.

Note that the numbers n in Table 2 are even, however, the last digit is only one of 0, 2, 8, with 4, 6 not appearing. This has been computationally verified up to a large integer, and it is conjectured to be true for all prime pairs.

If the m = *drcentre* for a prime pair is prime, then the following question can be asked: Is either $(m, m + 2)$ or $(m - 2, m)$ a prime pair? The answer is that this is true for some values of n. Example: n = 155,082 = 6*25,847, and hence, m = 25,847. In this case, (25,847, 25,849) is a prime pair.

Table 5: An example of a prime pair generating prime pairs.

drcentre	Number Tested	Prime Pair Found	Second Pair	Third Pair
23	138	138	828	4,968

Table 6: Select quadruple primes.

qcenter	*drcentre = m = dcentre /6*	*n = dcentre*	Prime *drcentre*	Even *drcentre*	Odd *drcentre*
15,645	2,607	15,642	Not	Not	((3, 1), (11, 1), (79, 1))
—	2,608	15,648	No	((2, 4), (163, 1))	Not
15,735	2,622	15,732	Not	((2, 1), (3, 1), (19, 1), (23, 1))	Not
—	2,623	15,738	Not	Not	((43, 1), (61, 1))
169,065	2,677	16,062	2,677	Not	Not
—	2,678	16,068	Not	((2, 1), (13, 1), (103, 1))	Not

Table 7: QPRIME.

qcentre	*Prime 1, 1*	*Prime 1, 2*	*dcentre 1*	*Prime 2, 1*	*Prime 2, 2*	*dcentre 2*	*qrcentre*	*Factored qrcentre*	*qrcentre Prime?*
105	101	103	102	107	109	108	7	((7, 1))	True
195	191	193	192	197	199	198	13	((13, 1))	True
825	821	823	822	827	829	828	55	((5, 1), (11, 1))	False
1,485	1,481	1,483	1,482	1,487	1,489	1,488	99	((3, 2), (11, 1))	False
1,875	1,871	1,873	1,872	1,877	1,879	1,878	125	((5, 3))	False
2,085	2,081	2,083	2,082	2,087	2,089	2,088	139	((139, 1))	True
3,255	3,251	3,253	3,252	3,257	3,259	3,258	217	((7, 1), (31, 1))	False
3,465	3,461	3,463	3,462	3,467	3,469	3,468	231	((3, 1), (7, 1), (11, 1))	False
5,655	5,651	5,653	5,652	5,657	5,659	5,658	377	((13, 1), (29, 1))	False
9,435	9,431	9,433	9,432	9,437	9,439	9,438	629	((17, 1), (37, 1))	False

Table 8: An example of a large octuple prime.

Centres	Factored	Reduced Center	Left Prime	Right Prime
dcentre=557,458,632	((2, 3), (3, 3), (19, 1), (41, 1), (3,313, 1))	92,909,772	557,458,631	557,458,633
qcentre=557,458,635	((3, 1), (5, 1), (37,163,909, 1))	37,163,909	—	—
dcentre=557,458,638	((2, 1), (3, 1), (11, 1), (587, 1), (14,389, 1))	92,909,773	557,458,637	557,458,639
ocentre=557,458,650	((2, 1), (3, 2), (5, 2), (7, 1), (37, 1), (4,785, 1)	18,581,955	—	—
dcentre=557,458,662	((2, 1), (3, 1), (17, 1), (5,465,281, 1))	92,909,777	557,458,661	557,458,663
qcenter=557,458,665	((3, 1), (5, 1), (43, 1), (864,277, 1))	37,163,911	—	—
dcentre=557,458,668	((2, 2), (3, 2), (13, 2), (59, 1), (1,553, 1))	92,909,778	557,458,667	557,458,669

Table 9: An example of an octuple prime with an extra prime at *n*=3,919,229.

Centres	Factored	Reduced Center	Left Prime	Right Prime
dcentre=3,919,212	((2, 2), (3, 3), (11, 1), (3,299, 1))	653,202	3,919,211	3,919,213
qcentre=3,919,215	((3, 1), (5, 1), (261,281, 1))	262,181	—	—
dcentre=3,919,218	((2, 1), (13, 1), (653,203, 1))	653,203	3,919,217	3,919,219
ocentre=3,919,230	((2, 1), (3, 2), (5, 1), (7, 1), (6,221, 1))	130,641	—	—
dcentre=3,919,242	((2, 1), (3, 1), (653,207, 1))	653,207	3,919,241	3,919,243
qcenter=3,919,245	((3, 1), (5, 1), (11, 1), (23,753, 1))	261,283	—	—
dcentre=3,919,248	((2, 4), (3, 2), (17, 1), (1,601, 1))	653,208	3,919,247	3,919,249

Table 10: Some further large octuple primes where the *ocentre* is divisible by 210.

ocentres	Reduced *ocentre*	Factored *ocentre*
3,501,128,190	116,704,273	((2, 1), (3, 1), (5, 1), (7, 1), (16,672,039, 1))
4,184,384,610	139,479,487	((2, 1), (3, 1), (5, 1), (7, 1), (43, 1), (463,387, 1))
4,334,286,180	144,476,206	((2, 2), (3, 1), (5, 1), (7, 2), (1,474,247, 1))
4,967,697,420	165,589,914	((2, 2), (3, 2), (5, 1), (7, 2), (53, 1), (10,627, 1))
5,008,732,890	166,957,763	((2, 1), (3, 1), (5, 1), (7, 1), (431, 1), (55,339, 1))
5,074,178,550	169,139,285	((2, 1), (3, 1), (5, 2), (7, 1), (4,832,551, 1))

If m is an even integer, is $(m - 1, m + 1)$ a prime pair? The answer is, "Yes, for some values of n." Example: $n = 98,712 = 6 * 16,452$. Then, $m = 16,452$ is the centre of the prime pair (16,541, 16,543).

If m is an odd composite integer, then neither $m - 1$ nor $m + 1$ can be the centre of a prime pair. Example: $n = 85,830 = 6*14,305$ and neither 14,304 nor 14,306 can be centre of a prime pair as 14,305 is composite.

In Table 3, the number of prime pairs for the different cases of the quotient $m = drcenter$ are listed as well as the number of prime pairs that are generated by m, as explained previously.

Now consider multiplying the integers 1, 2, 3,…166,666 by six and then asking for the resulting prime pairs. The results are given in Table 3. As expected, the number of prime pairs from the original index multiplied by six is the same number as for the original range 1,… 10^6. For the second set of results, the question is asked as to whether there are prime pairs formed by multiplying the original prime pairs by six. The result is 655 such prime pairs. Repeating the process once more, the number of new prime pairs is 34 (see Table 4).

An example of a prime pair generating several new prime pairs via the reduce prime centre is given in Table 5.

In a list of prime pairs, there are some pairs for which the ns differ by six. Equivalently, the values of m are consecutive in this case. These pairs are pairs of prime pairs and called *quadruple primes*. Some of these pairs are listed in Table 6.

It is notable that the last digits of the ns of the pairs of prime pairs are two for the first one and eight for the second one in Table 6. From this, it follows that the patterns of the last digits of the quadruple primes are 1, 3 and 7, 9. The last digits of the *drcentre*s are either 2, 3 or 7, 8. This has been verified for n up to $6 * 10^6$. Also, it is noted that the *qcentre* is divisible by 15 starting from the quadruple prime 11, 13, 17, 19.

The aforementioned discussion is conjectured to be true for all such pairs. We now compute the *qcentre* and *qrcentre* of quadruple primes (see Table 7).

If we calculate up to the limit $2*10^6$, we get 106 quadruple primes with prime *qrcentre* and 905 quadruple primes with composite *qrcentre*.

An interesting feature of natural numbers is that they form many observable, finite patterns.

We now try to find if there are octuple primes. Assuming that the minimum distance between *qcenter*s is 30, only very large quadruple primes are found (see Table 8). When checking for such a set of primes up to $6*10^9$, we find that there are 48 such sets where some of the sets have an extra prime close to the octuple centre: for a very large octuple prime (see Table 9). There are few octuple primes.

We note that the ocentres are all divisible by $210 = 2*3*5*7$ (see Table 10). An unlikely conjecture would therefore be the existence of 16 fold primes composed of two octuple primes whose centres are separated by 210. No such set of primes has been observed computationally.

Many of the observed properties are a consequence of the Sieve of Eratosthenes [9]. ■

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The Evolution of Security and Privacy in Federated Learning Systems

Gautam Srivastava, Ph.D., SMIEEE

In my previous article, the focus was on issues related to security, privacy, and trust in the Internet of Things (IoT) [1]. Since then, as expected, technology has advanced and, in some way, the IoT has transitioned into subdomains like the Internet of Medical Things, Internet of Vehicles, and many others. Further, research into smart cities, simply put, the urban area that uses sensors and other means to collect data, has taken off.

Federated Learning

Smart cities have grown enormously in popularity as the data collection techniques and options for data degeneration themselves have become so diverse. However, a common issue as always is the hesitancy to share data due to ongoing concerns with data privacy. The mainstream media does not help; every week there is a new piece on a data breach and how users' data are now on the dark web for sale. This has led to ideas around data silos, that is, data collections that are not easily accessible outside of a specific group. There have been many attempts to thwart data privacy threats, with one standing tall among others, namely, federated learning (FL). FL has shown a certain level of superiority as it allows local workers to work together, independently overcoming the need to share sensitive personal information with regard to local data. The IEEE Standards Committee approved an "*architectural framework and application of Federated machine learning*" in 2018. Since then, a heavy amount of effort has been put into bringing FL technologies forward in many different domains.

Nothing is ever as good as it seems at its onset. Although there is power in FL's ability to conquer data silos, there have also been key threats exposed through research in regard to security and privacy. As with any learning technology, training becomes a key aspect. As such, these independent workers who create the strength of FL, if adversarial or malicious, could in turn affect the confidentiality, integrity, and availability of said data contaminating the model.

To provide some background for our novice readers, the two main parts of FL are the central server and local clients (workers) (see Figure 1). An adversary could compromise either the local workers individually or even the central server. The local workers are creating what is called *local updates*, which are then combined centrally into the global model. As such, an adversary could manipulate the global model by controlling the local updates that are collected centrally. This in turn would create a lower accuracy of what the global model represents, or even leave a backdoor open for an adversary to use as he or she sees fit. Furthermore, with respect to the predicting portions and model training itself, an adversary could potentially infer information about other local workers that are working honestly, which may potentially include both attribute and membership inference. Even though researchers have worked painstakingly hard to design FL models using privacy-preserving algorithms and differential privacy (DP), we have still seen successful attacks on FL [2].

FL is a machine learning (ML) system where many clients collaborate for the training of a model under direct supervision by a central server. The data used in training remain locally with the local workers. There are two main types of workers: cross silo and cross device. Cross-silo workers fall into the category of larger institutions, which have the usual high storage and high computational capabilities. In contrast, cross-device workers are constrained, usually referring to mobile devices or other IoT devices. As an aside, there is current work on a fully decentralized version of FL (removing the central server) that makes use of blockchain, but such systems are still in their preliminary stages. It is the centralized version of FL where more concrete security and privacy issues exist at this time.

Types of FL

FL centralized models are first locally trained on the worker's side, and then, that information is combined at the central server. The global model that is created at the central server is created after many parameter and gradient updates. Unlike one of its predecessors, known as *distributed ML*, one fact that stands out is that the central server does not have any access to the local worker data. In turn, both nonindependent and identically distributed (non-i.i.d.) as well as i.i.d. data distribution models are available. A few

"types" of FL that stem from these decisions include federated transfer learning (FTL), vertical FL (VFL), and horizontal FL (HFL). FTL is best suited for instances with scenarios involving few sample IDs and a lot of feature overlap. VFL, in contrast, is best suited for schemas with fewer overlapping features and where the local workers have identical sample IDs. Finally, HFL is best suited to applications where there is minimal sample repetition and a high number of overlapping features.

The term *privacy computing* is in reference to the range of information systems that are able to analyze data while still making sure that data providers are secure against leaks in private information. The notion of "data availability while lacking visibility" comes from privacy computing, which includes FL and many others, including DP and trusted execution environment (TEE). As mentioned earlier, FL is basically a further enhancement of distributed ML that adds in privacy techniques. Some other examples of privacy computing are TEE, which is a hardware privacy computing technique, and also DP, which provides an in-depth mathematical version of privacy. There is also secure multiparty computing, which uses cryptography to provide measures for privacy computing. It is often imperative to use a few of these technologies in tandem while analyzing data to ensure the rigor needed for the security and privacy of the data being analyzed.

There are three main challenges when dealing with FL systems. Those challenges include security and privacy threats, communication, and finally, heterogeneity. The attacking potential in FL has grown tremendously due to the natural distribution characteristics inherent in these systems. For example, the susceptibility of malicious/adversarial workers that may attempt to steal data and/or honest worker information is something that needs to be solved for future systems. Furthermore, groups of adversarial workers could collude, which would really damper any usable results from the global model. In terms of communication, an ongoing roadblock for FL is the high communication needs between workers and the central server. Local workers need to stay in constant contact with the central server, and as such, unstable connections as well as the constrained nature of cross-device workers can lead to issues. Research into transmission efficiency while maintaining the quality of the global model is an important research topic. Both model compression and the use of sparse matrices have shown promise in improving communication issues. The last known issue in FL is in regard to heterogeneity. As is evident from earlier, there is a diverse and complex collection of local workers that work to create global models. Inherently, there are concerns around the efficiency of these workers, convergence quality of the global model, and also mutual trust among local workers. In all practical applications of FL, the systems must coordinate in a heterogeneous manner between differences among the workers, such as device storage, communication, and computational limits and make sure all local workers are aware of model requirements as they can change over time. The current research trend is toward recognizing these issues and pursuing solutions in three directions, namely, the model, data, and device levels.

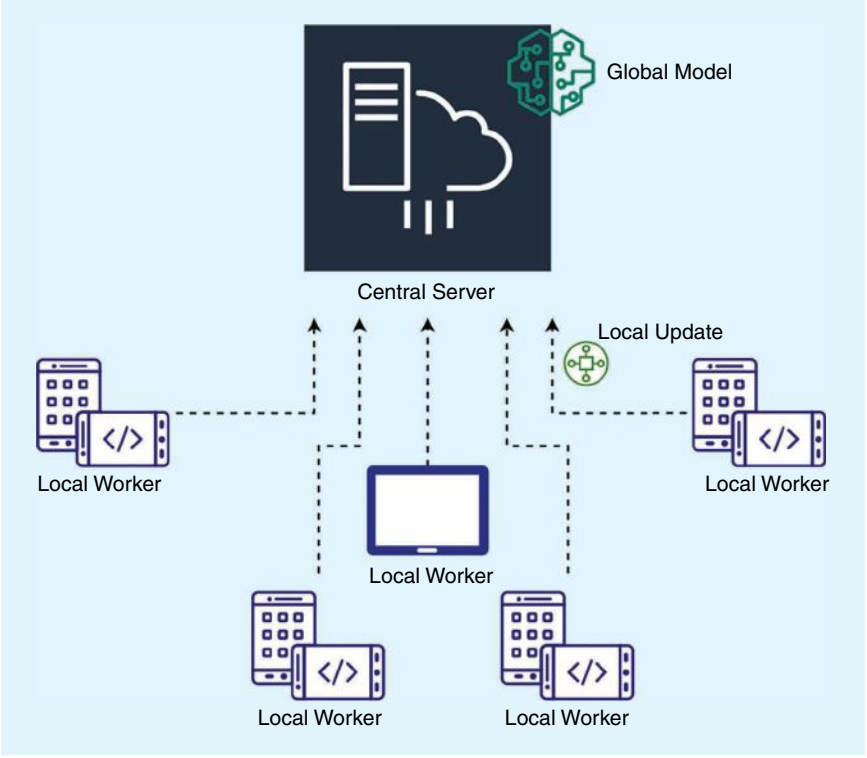

Figure 1: An FL architecture.

An article by me would be incomplete without a plug for blockchain technology, which was foreshadowed earlier. In an effort to thwart known issues of security and privacy in FL, fully decentralized systems may provide a viable avenue. Blockchain can provide a level of protection against malicious local workers by providing an authentication mechanism for workers, which also improves data privacy and strength of the global model. Recent work on DeepChain, proposed in [3], is a good starting point for these decentralized FL systems. Based on a combination of blockchain technology and privacy-preserving algorithms, the future of FL can strive to be a fully decentralized learning system, enhancing trust issues that tend to exist in collaborative computing. ■

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Growing up in the 1980s, I did not witness the glory of the Apollo program and often wondered if and when humans would go back to the moon. Well, it's finally happening. In this article we look into why now and what is Canada's role in lunar exploration.

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Why Go Back to the Moon?

Up until 2022, the plot of human and robotic lunar missions over time was dominated by a large peak marking the Space Race, and a very small resurgence in the mid-2000s when China and India entered the game. For the most part, the post-Apollo era was dedicated to low-Earth orbit missions with the Shuttle, building and commissioning the International Space Station (ISS), and the commercialization of space applications. In fact, due to the cost and technical challenges, only China was able to successfully land on the moon, while others like Israel, India, and Japan are still hoping their next attempt won't end up crashing onto the surface.

However, NASA's direction changed in 2010 when the Authorization Act directed them to pursue missions beyond low-Earth orbit [1]. Initially, the Obama administration set asteroids as the priority, but this was later altered by the Trump administration to use the moon as a stepping stone on the "Journey to Mars" [2]. A decade later, the American investment is finally paying off. More than 20 missions, including many international collaborations, will be launched over the next three years. It is safe to say, the moon is back! But why now?

The moon is back in the spotlight thanks to the 1998 Lunar Prospector mission discovery that there is water in the polar craters. This water not only serves as a vital resource for sustaining life, but it also holds exciting possibilities for commercial applications. Water molecules can be broken down and used for breathable air and, more importantly, rocket propellant [3]. The combination of liquid hydrogen and an oxidizer, such as liquid oxygen, results in a high-specific impulse fuel that has powered rockets for decades. This means that future interplanetary missions would not need to carry all the propellant at liftoff and instead would refuel around the moon, making the overall missions lighter (i.e., cheaper) and safer compared to heavy liftoffs.

The moon is back in the spotlight thanks to the 1998 Lunar Prospector mission discovery that there is water in the polar craters.

Let's be realistic; the first lunar gas station is still a few years away. The concept faces two significant challenges: first, the market for refueling in space may not be established for many years, and second, it would necessitate a substantial investment over an extended period. This puts the onus on government agencies to lead the way and invest in the initial infrastructure. The problem is that very few space agencies have the means to launch their own lunar mission.

In fact, even NASA's budget, the largest among space agencies, is still very limited. Consider this: at the height of the Apollo missions, NASA received a significant portion of the U.S. federal budget, accounting for 4.5%, thanks to public support and the geopolitical climate [4]. Unfortunately, after the successful return of Armstrong, Aldrin, and Collins, public interest waned and NASA's budget decreased, reaching a steady 0.5% of the federal budget in the 2010s. Given the number of different programs supported by NASA, the stagnant funding, and an unpredictable political environment, it is hard to fathom how one could achieve such a long-term and ambitious goal, which begs the question: What is the secret formula that is fueling the comeback?

As it turns out, the key difference is NASA's approach. In the past, the agency would have owned the entire design process and the intellectual property, meaning that any private stakeholders would essentially be working on cost-plus contracts building parts to NASA's specifications. However, as part of the philosophy enacted in the 2010 Authorization Act, NASA was to also offer fixed-price contracts (i.e., seed money) to kick-off long-term commercial operations in space [1]. This way, the private sector would work to high-level mission and safety requirements, keep the intellectual property, and ultimately be able to sell its products and services to other customers. This new approach promotes a free market that cultivates innovation and cost savings, which are not traditionally associated with government bureaucracies.

The dual approach is very evident in the American human spaceflight agenda as NASA is both leading the Artemis program while also investing in contracts that emerged from the Commercial Orbital Transportation Services (COTS) program over the last decade [1], [3]. This level of redundancy ensures that, unlike what happened with the Shuttle program, the United States will have options even if one of the spacecraft is grounded or decommissioned. Technically speaking, the COTS program was meant for low-Earth orbit, but the investment has invigorated the private sector, enabling it to also develop capabilities for more. Perhaps the best example is how NASA helped fund SpaceX's Falcon 9, then allowing SpaceX to apply those principles for its own Falcon Heavy and Starship rockets.

The success of COTS opened the door to similar ventures for robotics missions via the Commercial Lunar Payload Services (CLPS) program, which aimed to establish FedEx-like services to deliver payloads to the moon [1], [3]. Eventually, the program will make the moon more accessible, thus accelerating plans

for a lunar gas station. Many of the planned missions for the next few years will be CLPS technology demonstrations that include soft landings, power generation, in situ resource utilization, and autonomous mobility.

Outside of the United States, the Chinese and Indian space agencies are developing their own rovers and have goals for human space missions. In the private sector, two former Google Lunar XPRIZE competitors, SpaceIL in Israel and iSpace in Japan, are hoping for a soft landing to deploy rovers on the moon for science and prospecting purposes. Moreover, Japanese billionaire Yusaku Maezawa has already secured the first private crewed flight, the dearMoon mission, which will fly around the moon with a crew of artists aboard the SpaceX Starship spacecraft.

Where Is Canada in All This?

Building on previous contributions to the Shuttle and the ISS, the Canadian Space Agency (CSA) and MDA are designing the Canadarm3 (Figure 1) for Artemis' Lunar Gateway station [3], [5]. The arm will help assemble the station, capture visiting vehicles, assist astronauts during spacewalks, and enable scientific experiments in lunar orbit. Similar to the Canadarm2, the new robotic arm will move around the exterior of the station anchoring itself to power and data connectors, while also having the possibility of attaching a smaller and more dexterous arm or specialized tools. However, unlike its predecessor, the arm will take advantage of advances in artificial intelligence to support autonomous operations. It is hard to do justice to the Canadarm3 project in this article, so look forward to a column dedicated to the design of the arm in the near future.

In exchange for providing the Canadarm3, Canada will receive two astronaut flights to the moon on the Orion reusable crewed spacecraft [5]. Canadian Astronaut Jeremy Hansen will be a part of the Artemis II mission, the first flight back to the moon since 1972, which will fly around the moon no later than May 2024. Equivalent to the Apollo 8 flight that gave us the Earthrise photo, the capsule will take the astronauts around the moon and back to Earth.

Figure 1: An artist's rendition of the Canadarm3 attached to the Lunar Gateway around the moon. (Credits: CSA, NASA.)

In preparation for crewed flights to deep space, Canada is also leading the Health Beyond initiative to develop capabilities for remote health care. Five companies are working to design prototypes for a scalable and integrated system known as the *Connected Care Medical Module*, which can detect, diagnose, treat, and/or monitor health conditions on site.

Technically speaking, the COTS program was meant for low-Earth orbit, but the investment has invigorated the private sector, enabling it to also develop capabilities for more.

The goal is to deploy these modules in remote communities in Canada to help improve access to health care while also testing the capabilities to support future long-duration space missions.

In addition, taking advantage of the CLPS program, the CSA established its own Lunar Exploration Accelerator Program (LEAP) to help fund Canadian missions to the moon [5]. As part of this program, they selected Canadensys Aerospace Corporation to build the first Canadian lunar rover [5]. Aside from testing new technologies, the 30-kg robot will explore the lunar south pole, conduct geology and mineralogy experiments, and assess lunar-surface radiation to help in future crewed missions. The rover is expected to launch in 2026.

Concluding Remarks

The infrastructure is in place to develop a lunar outpost for commercial purposes that can enable deep space exploration. Although some nations are working independently, a program of this magnitude requires international collaborations and Canada has positioned itself as a key player. Let's keep exploring! ■

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About the Author

Dario Schor is at Magellan Aerospace, Winnipeg, MB. He is also pursuing a space studies Ph.D. degree at the University of North Dakota. He obtained his B.Sc. and M.Sc. degrees in computer engineering from the University of Manitoba in 2008 and 2013, respectively, before attending the 2013 Space Studies Program from the International Space University in Strasbourg, France. He has served in various roles within IEEE Canada and the Winnipeg Section. He can be reached by email at schor@ieee.org.

New IEEE History Committee Initiatives

by David G. Michelson
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 and define us.

While 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. In this column, we consider recent changes to the IEEE Milestones program, and establishment of a new IEEE History Coordination Subcommittee.

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Recent Changes to the IEEE Milestones Program

In 1983, IEEE established the Milestones program to recognize significant achievements within IEEE-designated fields (as defined in the IEEE Bylaws, section I-104) that took place more than 25 years prior. Milestone proposals may be submitted by any IEEE member but must pass a detailed and rigorous review by the History Committee before they are submitted to the IEEE Board of Directors for final approval.

Milestones are intended to take both members of our profession and the general public back to a time and place when the world changed because an important device, system, process, model, algorithm, or architecture was introduced that changed the way engineering is done and which had significant downstream impacts. Milestone proposals must make the case for the novelty, ingenuity, and utility of the achievement but must also capture something of what transpired and why, and hopefully reveal details that would otherwise not be apparent.

Requirements for the Milestone proposal have evolved over time as successive History Committees have reflected on the experience of the program to date. Uppermost in the minds of History Committee members is the need to dispel the notion that Milestones are awards and to reinforce the notion that they recognize the historical significance of a technical achievement, rather than the person or place.

One recent change concerns the use of names in Milestone citations. In late 2022, the History Committee amended an earlier policy against including names in the 60–70-word Milestone citation that appears on the bronze Milestone plaque. Previously, names could only be cited after becoming a part of the generally used name of an achievement, e.g., Maxwell's equations," "Lempel–Ziv algorithm," "Morse telegraph," and "Yagi antenna."

The amended policy allows names to be included when the proposal includes detailed, clearly stated, and incontrovertible evidence, particularly historical evidence and documentation, that one or more persons were central to the achievement and deserve to be singled out beyond others, and that the list is comprehensive and does not omit anyone who should be explicitly credited on the plaque.

The History Committee is aware that most technical innovation is the result of collaboration and wants to be very careful not to perpetuate the myth of the lone or heroic inventor. It has charged the Milestones Subcommittee with responsibility for reviewing proposals to include names in the citation prior to its being submitted to the History Committee for approval and may ask for changes that correct any shortcomings or oversights within the proposal as a whole.

Establishment of an IEEE History Coordination Subcommittee

Numerous IEEE organizational units (OUs), IEEE members, private and public sector organizations, and other technical heritage organizations have an interest in, are pursuing activities related to, or have expertise relevant to, the history and historiography of IEEE and the profession, but most work independently and in relative isolation.

In response, the IEEE History Committee has recently formed a History Coordination Subcommittee that will recommend, promote, and support 1) development and sharing of history-related resources and best practices across IEEE, and 2) collaboration and coordination of history activities among IEEE OUs, individual IEEE members, and other external and technical heritage organizations.

Requirements for the Milestone proposal have evolved over time as successive History Committees have reflected on the experience of the program to date.

I have been appointed as the founding chair of the new subcommittee. Our responsibilities include

- maintaining awareness of history-related activities across IEEE, identifying opportunities to provide support, encouraging collaboration, coordinating efforts where needed, leveraging successful activities, merging efforts, and launching activities, with the goal of strengthening and harmonizing IEEE history efforts as well as promoting collaboration and coordination with other technical heritage organizations (e.g., the American Institute of Physics, American Society of

Mechanical Engineers, American Society of Civil Engineers, and so on)

- gathering inputs and perspectives from IEEE members, geographic and technical OUs, private and public sector leaders, and other technical heritage organizations that will assist the History Committee in developing its strategic directions and multiyear road map
- facilitating history presentations at meetings of other IEEE OUs, including the IEEE Board of Directors, Divisions, Regions, Sections, and Societies
- recruiting Milestones advocates and expert reviewers for Milestone proposals using the pool of corresponding members, i.e., past History Committee members; liaisons from other IEEE boards or committees; history activities coordinators (or similar positions) within Divisions, Regions, Societies, Councils, Sections, or other OUs; IEEE Milestone proposers and historians from sister Societies (e.g., the American Society of Civil Engineers, American Society of Mechanical Engineers, and American Institute of Mechanical Engineers); or historians from museums/archives or similar historical organizations
- encouraging IEEE OUs to maintain their histories on the Engineering and Technology Wiki, and to submit past newsletters, historical photographs, archival documents, and information on past award winners to the IEEE History Center.

Support from Regions, Technical Societies, and Councils will obviously be key in achieving our goals. We hope to make rapid progress in getting the IEEE History Coordination Subcommittee underway during the remainder of 2023. ■

About the Author

David G. Michelson is the IEEE Canada historian and chair of the IEEE Canada History Committee. An active contributor to the history of technology for two decades, he has been a member or corresponding member of the IEEE History Committee since 2012 and is responsible for more than one quarter of the 17 IEEE Milestones that recognize Canadian technology achievements. As a member of the IEEE History Committee, he is the founding chair of its History Coordination Subcommittee, a member of its Milestones Subcommittee, 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 Second World War, and the development and impact of both wireless technology and space technology since the Second World War. He can be contacted at dmichelson@ieee.org or historian@ieee.ca.

Dr. William Chisholm Receives the 2022 IEEE Dielectrics and Insulation Society Caixin Sun and Stan Grzybowski Lifetime Achievement Award

Dr. William (Bill) Chisholm has been awarded the 2022 IEEE Dielectrics and Insulation Society Caixin Sun and Stan Grzybowski Lifetime Achievement Award "for contributions to overhead high voltage line reliability and safety."

Dr. Chisholm, based in Toronto, was nominated and selected to receive this award, reflecting his outstanding career in research, engineering, and innovation. The nomination letter mentioned his contributions to 16 of the 19 IEEE International Conference on High Voltage Engineering and Applications (ICHVE) topics of interest, including lightning, electrical insulation, grounding, and dynamic line rating. The nomination specified his roles in achieving a global consensus for the selection of insulators and live-line tools for cold weather conditions in IEEE Standard 1820-2020. Dr. Chisholm's award lecture, "Capacitance and Resistance Duality, Applied to Lightning Backflashover Estimation," was presented online on 26 October 2022 and hosted from Chongqing, China.

The IEEE Caixin Sun and Stan Grzybowski Awards were established in 2017 through an agreement between the IEEE Dielectrics and Electrical Insulation Society and ICHVE. The funds were contributed by the Caixin Sun Foundation of Education at Chongqing University, China. Each award consists of a subsidy of US$5,000 and a plenary lecture given at ICHVE.

Dr. Chisholm received his B.A.Sc. (engineering science) and M.Eng. degrees from the University of Toronto in 1977 and 1979, respectively, and his Ph.D. degree in electrical engineering from the University of Waterloo, Canada, in 1983.

IEEE Canada congratulates Dr. Chisholm for his work and achievements.

Radio Science in Canada

by David G. Michelson

The task of resolving questions raised by and developing the technical basis for decisions taken at the WRC falls upon the ITU-R SGs.

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 URSI-International Telecommunications Union (ITU) Inter-Union Working Group (IUWG) that has been formed to strengthen the URSI-ITU relationship and which is being led by Canada.

David G. Michelson
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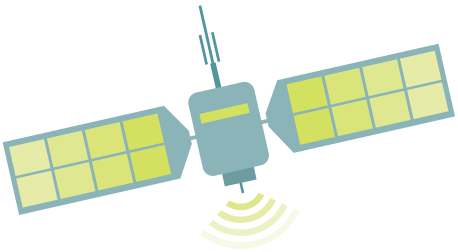
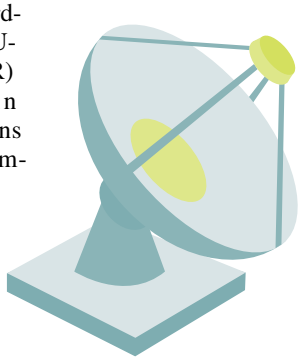
DRAFTING A BLUEPRINT FOR ENHANCED URSI/ITU COOPERATION

As noted in our last column, wireless technologies have become increasingly complex and demand for the wireless spectrum has become increasingly urgent. Accordingly, the work of the ITU-Radiocommunication (R) Study Groups (SGs) in helping to resolve questions raised at World Radiocommunication Conferences (WRCs), the body responsible for the Radio Regulations, the international treaty that governs the use of radio-frequency spectrum and satellite orbits, has greatly increased.



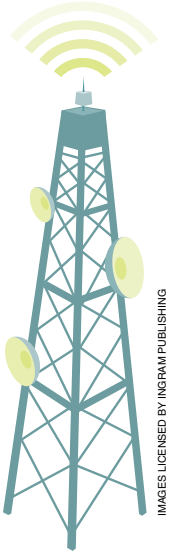


The task of resolving questions raised by and developing the technical basis for decisions taken at the WRC falls upon the ITU-R SGs. ITU-R SGs are venues for ITU members to work collaboratively to address and seek consensus on issues such as the efficient management and use of the radio-frequency spectrum and orbit resources, radio systems' characteristics and performance, spectrum monitoring, emergency radiocommunications for public protection and disaster relief, interference-free radiocommunications, radio and TV broadcasting, and new radio technologies.

During the first several months of 2023, the new URSI-ITU IUWG, led by Prof. David G. Michelson of the University of British Columbia, will consult with stakeholders within the URSI, ITU, and relevant member communities as it seeks to devise ways for URSI to more effectively support the ITU-R SGs in their important task. This effort has been described as the most important advance in URSI-ITU cooperation in more than three decades. Prof. Michelson will present the working group's initial strategic plan to the URSI Council for approval in Sapporo, Japan, in August 2023.

STRUCTURE OF THE ITU-R SGs

ITU-R currently operates six SGs: SG 1, Spectrum Management; SG 3, Radiowave Propagation; SG 4, Satellite Services; SG 5, Terrestrial Services; SG 6, Broadcasting Service; and SG 7, Science Services. SGs are generally organized into working parties (WPs), which address specific subject matter.



- SG 1 is organized into three WPs: WP 1A, Spectrum Engineering Techniques; WP 1B, Spectrum Management Methodologies and Economic Strategies; and WP 1C, Spectrum Monitoring.
- SG 3 is organized into four WPs: WP 3J, Propagation Fundamentals; WP 3K, Point-to-Area Propagation; WP 3L, Ionospheric Propagation and Radio Noise; and WP 3M, Point-to-Point and Earth-Space Propagation.
- SG 4 is organized into three WPs: WP 4A, Efficient Orbit/Spectrum Utilization for FSS and BSS; WP 4B, Systems, Air Interfaces, Performance and Availability Objectives for FSS, BSS and MSS, Including IP-Based Applications and Satellite News Gathering; and WP 4C, Efficient Orbit/Spectrum Utilization for MSS and RDSS.
- SG 5 is organized into four WPs: WP 5A, Land Mobile Service Above 30 MHz (Excluding IMT); Wireless Access in the Fixed Service; Amateur and Amateur-Satellite Services,

WP 5B, Maritime Mobile Service Including Global Maritime Distress and Safety System; Aeronautical Mobile Service and Radiodetermination Service, WP 5C, Fixed Wireless Systems; HF and Other Systems Below 30 MHz in the Fixed and Land Mobile Services, and WP 5D, IMT Systems.

- SG 6 is organized into three WPs and one task group (TG): WP 6A, Terrestrial Broadcasting Delivery; WP 6B, Broadcast Service Assembly and Access; WP 6C, Programme Production and Quality Assessment; and TG 6/1, WRC-23 Agenda Item 1.5.
- SG 7 is organized into four WPs: WP 7A, Time Signals and Frequency Standard Emissions: Systems and Applications (Terrestrial and Satellite) for Dissemination of Standard Time and Frequency Signals; WP 7B, Space Radiocommunication Applications: Systems for Transmission/Reception of Telecommand, Tracking and Telemetry Data for Space Operation, Space Research, Earth Exploration-Satellite, and Meteorological Satellite Services; WP 7C, Remote Sensing Systems: Active and Passive Remote Sensing Applications in the Earth Exploration-Satellite Service and Systems of the MetAids Service, as Well as Space Research Sensors, Including Planetary Sensors; and WP 7D, Radio Astronomy: Radio Astronomy and Radar Astronomy Sensors, Both Earth-Based and Space-Based, Including Space Very Long Baseline Interferometry.

More than 5,000 specialists, from administrations, the telecommunications industry as a whole, and academic organizations throughout the world, participate in the work of the SGs. SGs and their WPs tend to meet in Geneva annually for between one and two weeks according to regular schedules developed by the ITU-R SGs department.

ITU-R outcomes take the form of global standards (recommendations), reports, and handbooks on radiocommunication matters. The collaborative process of reaching a consensus on the content of these outcomes is similar to those employed by other standards development organizations such as IEEE. Upon agreement of the member states, some recommendations may be incorporated into the Radio Regulations by reference and become binding. Accordingly, particular care must be taken in formulating and updating the recommendations.

ITU-R outcomes take the form of global standards (recommendations), reports, and handbooks on radiocommunication matters.

STRUCTURE OF THE URSI SCIENTIFIC COMMISSIONS

URSI is organized into 10 scientific commissions: Commission A, Electromagnetic Metrology; Commission B, Fields and Waves; Commission C, Radiocommunication Systems and Signal Processing; Commission D, Electronics and Photonics; Commission E, Electromagnetic Environment and Interference; Commission F, Wave Propagation and Remote Sensing; Commission G, Ionospheric Radio and Propagation; Commission H, Waves in Plasmas; Commission J, Radio Astronomy; and Commission K, Electromagnetics in Biology and Medicine.

URSI outcomes include research papers published in *Radio Science* and *Radio Science Letters*, and conference papers presented at the triennial URSI Atlantic and Pacific Radio Science Meetings and General Assembly and Scientific Symposia and published in the corresponding conference proceedings.

MAPPING ITU-R SGs ONTO URSI SCIENTIFIC COMMISSIONS

The first step is to map the structure of the ITU-R SGs onto the structure of URSI's Scientific Commissions. During a recent meeting of the URSI-ITU IUWG leadership in Geneva, David Botha, counselor for SG 3, proposed the following mapping:

- *Commission A*: Electromagnetic Metrology (of interest to WP 1A, WP 1C, WP 3J, and WP 7A)
- *Commission B*: Fields and Waves (of interest to WP 3J)
- *Commission C*: Radiocommunication Systems and Signal Processing (of interest to WP 1A, WP 1B, WP 4A, WP 4B, WP 4C, WP 5A, WP 5B, WP 5C, WP 5D, WP 6A, WP 7B, and WP 7C)
- *Commission D*: Electronics and Photonics
- *Commission E*: Electromagnetic Environment and Interference (of interest to WP 1A, WP 1B, WP 1C, and WP 3L)
- *Commission F*: Wave Propagation and Remote Sensing (of interest to WP 3J, WP 3K, WP 3M, and WP 7C)
- *Commission G*: Ionospheric Radio and Propagation (of interest to WP 3L)
- *Commission H*: Waves in Plasmas
- *Commission J*: Radio Astronomy (of interest to WP 7D)
- *Commission K*: Electromagnetics in Biology and Medicine (of interest to WP 1C and WP 6A).

The simplest possible engagement would have ITU-R simply share lists of open questions with the URSI scientific commission leadership and hope that researchers would step forward to participate in SG activities. However, the URSI-ITU IUWG envisions a more structured engagement that would align with URSI's mission to "stimulate and coordinate studies of the scientific aspects of telecommunications using electromagnetic waves." We will share details in our next column. ■

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/.

About the Author

David G. Michelson is president of the Canadian National Committee of the International Union of Radio Science (2018–2024) and chair of the URSI-International Telecommunications Union Inter-Union Working Group. He has led the Radio Science Lab at the Department of Electrical and Computer Engineering. University of British Columbia (UBC), since 2003. His current research focuses on short-range/low-power wireless networks for industrial vertical and transportation applications, millimetre-wave channels and systems, and satellite networks for communications and remote sensing. Prof. Michelson serves as a member of the Board of Governors of the IEEE Vehicular Technology Society, as a member of the Steering Committee of the National Institute of Standards and Technology-sponsored NextG Channel Model Alliance, as director of the AURORA Smart Transportation Testbed, and as principal investigator of the Campus as a Wireless Living Lab project at UBC.

We Just Couldn't Resist ...

David Green
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On the 25th anniversary of Lady Diana's death, there was a little-known writing competition. Writers and artists from across the Commonwealth were asked to submit tributes to the late princess. A submission could take any verbal form and would be evaluated by a panel of judges from all walks of life. The winner would be able to read or perform his or her work of art at a private ceremony and receive a grand prize of £100,000 personally from Prince William—first-born son of the late Lady Diana—and his family.

The touching tributes came in from all across the globe: Kenya, St. Lucia, Botswana, Canada, New Zealand, and many more. The judges volunteered long hours to pare down the enormous volume of submissions to ever-smaller sets of worthy contenders.

IMAGE LICENSED BY INGRAM PUBLISHING

Finally, it came down to two tributes: a lovely solo song from Anne Newton of the United Kingdom, and a well-crafted poem from Catherine Halfyard of Australia. There was a panel of 15 judges who weighed these two entries. They went around the table asking for votes: Ms. Newton's song or Ms. Halfyard's poem. After the 14th judge, it was tied 7–7. It all came down to Sofia, an electrical engineer from Canada. When asked for her vote, Sofia responded that they should both present their heart-felt tributes and each receive £50,000. The rest of the judges were baffled, and asked why she couldn't just pick one winner.

She replied, "Because I believe that a Di Ode should consist of an Anne Ode and a Cath Ode." ■

Dr. Wolfgang Hoefer Receives the 2022 Career Award From the IEEE Microwave Theory and Technology Society

Dr. Wolfgang Hoefer received the IEEE Microwave Theory and Technology Society's 2022 Career Award, with the award being presented at the International Microwave Symposium Awards Banquet in Denver, Colorado, last year. The award cites Dr. Hoefer "for a career of leadership, meritorious achievement, creativity and outstanding contributions in the field of microwave theory and techniques."

The Microwave Career Award Recognizes a career of meritorious achievement and outstanding technical contribution by an individual in the field of microwave theory and techniques.

Wolfgang J.R. Hoefer, Life Fellow, IEEE, Professor Emeritus, received his Dipl.-Ing. diploma (RWTH Aachen, Germany), D. Ing. degree (University of Grenoble, France), and an honorary Dr.-Ing. degree (TU Munich, Germany). He joined the University of Ottawa, Canada, in 1969 and was chair of electrical engineering from 1978 to 1981. From 1992 to 2006, he held the NSERC Industrial Research Chair in RF Engineering at the University of Victoria, Canada, and led the Computational Electromagnetics Research Laboratory. Subsequently, he was a principal scientist and department director at the A*Star Institute of High-Performance Computing, Singapore, from 2009 to 2012.

Read more about Dr. Hoefer by visiting his website at https://wolfganghoefer.com/. IEEE Canada congratulates Dr. Hoefer for his work and achievements.

IEEE Canadian Foundation
VT Travel Grants

IEEE Canada Vehicular Technologies Awards

This program of the IEEE Canadian Foundation provides two travel grants each year, each not to exceed $1,200. The Grant supports Canadian students at any level with attending and presenting papers at national or international IEEE Vehicular Technology (VT) conferences, or adjacent conferences with VT topics. The opportunity to present a paper in person, meet leaders in the field, mingle with student peers, connect with people in industry, and represent Canadian knowledge and achievement all enhance the recipient's profile and make a positive showing of Canadian contributions to the field.

VT and IEEE Canada Invest in the Future

The Vehicular Technologies Conference '98 "Pathway to a Global Wireless Revolution" held at the Westin Hotel Ottawa 18–21 May 1998 generated a surplus, a portion of which was given to IEEE Canada with the stipulation that the funds be used for the benefit of students. IEEE Canada presented the first pair of awards in 2003, then transferred the funds as a directed gift to the IEEE Canadian Foundation to continue these annual awards.

Build Sustainable Benefit From Successful Events

Engage event organizers, sponsors, and IEEE Canada—if they are agreeable—and consider establishing a fund at the IEEE Canadian Foundation to provide sustainable support to your affinity group, students, Society Chapter(s), Section, or Region in Canada.

IEEE Canada Power Quality Scholarship—Also Built on Success

The IEEE Canada Power Quality Scholarship, operated by the IEEE Canadian Foundation, provides one scholarship per year valued at $1,500. The IEEE Sections in Alberta (Northern Canada and Southern Alberta) organized the "Annual Alberta Exposition and Conference on Power Quality Issues" in 1988. The conference ran successfully from 1988 to 1995 and, during that time, generated a considerable surplus. The organizers of the conference wanted to set up an annual Power Quality Scholarship, which would be available to an IEEE student member in full-time attendance at either the University of Alberta or University of Calgary. The trustees of the conference transferred these funds as a directed gift to the IEEE Canadian Foundation to establish and administer this scholarship. The conference was supported by utility producers and large-scale industrial/commercial consumers of electricity in Alberta, hence the focus on that province.

Learn More

To learn more and apply for the VT Travel Grants and Power Quality Scholarship, visit https://www.ieeecanadianfoundation.org/EN/vt_award.php and https://www.ieeecanadianfoundation.org/EN/pq_award.php, respectively. To explore how your group can create sustainable benefits, contact the IEEE Canadian Foundation at icf-president@ieee.ca.

2022 VT Travel Grants—Recipients Reflect

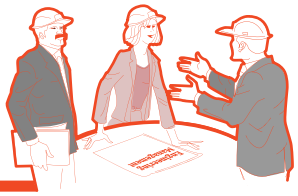
"The IECON (Industrial Electronics, Control, and Instrumentation) conference organized by the IEEE Industrial Electronics Society is one of the largest international conferences held. The 48th IECON conference was held in Brussels, Belgium, October 2022, which is a melting pot of several cultures. Being able to attend the conference has given me the opportunity to present my work to the world and interact with some of the greatest minds across the globe. I am grateful to the IEEE Canadian Foundation, who provided a great opportunity to not only network with researchers but also to explore a new culture through the IEEE Canada Vehicular Technologies travel grant."

—Anindita Golder

"First, I would like to extend my warm regards to the donor supporters and IEEE Canadian Foundation for the travel grant. The generous gift enabled me to present and promote my research ideas and concept to the engineering community and specifically to the researchers and industries in the domain of transportation electrification. Furthermore, IECON gathered more than 1,000 attendees in person, consisting of researchers, professors, and industry experts from around the world. It provided me with a platform for discussing my research ideas and issues. Further, I have also discussed with industry experts on the open research areas and the challenges that automotive industries are now facing. The feedback received helps me in fine-tuning my research goals to ensure the practical viability of my research outcomes. Furthermore, the professional network that I built will also help me in finding a suitable position immediately after completing my Ph.D. Last but not the least, I have received the Students and Young Professionals Award, and this travel grant enabled me to receive the award in person during the IECON."

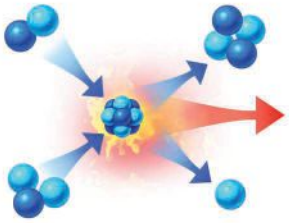
—Akash Samanta

Biz Tech Report



by Terrance Malkinson

The U.S. Department of Energy has announced a breakthrough in nuclear fusion achieved by scientists at the Lawrence Livermore National Laboratory in California. Nuclear fusion is a process where two lighter elements combine to make a heavier element. The seemingly insurmountable challenge is how to produce more energy than it takes to create the energy (www.cbc.ca/news/science/nuclear-fusion-explainer-1.6684298). The excess energy is considered "clean" as there are no harmful by-products. Although in this case the energy produced was small, roughly 3 mJ, it is important because the process used only 2 mJ. This moves the world closer to the possibility of zero-carbon energy. In Canada, private companies like General Fusion (www.generalfusion.com) are involved in developing and commercializing fusion energy to transform the global energy system.



The Kicking Horse Canyon section of the Trans-Canada Highway extends 25 km between Golden and the western boundary of Yoho National Park. Constructed in the 1950s, it has a tortuous path, long transit time, and very high accident rate. The highway carries more than 10,000 vehicles a day during the summer. Thirty percent of the traffic consists of commercial vehicles. The multiyear Kicking Horse Canyon Project involves upgrading this 25-km section to a four-lane, 100-km/h standard. This involves realigning multiple curves, a median barrier, and creating wide shoulders to accommodate cyclists; mitigating rock fall and avalanche hazards, bridges, rock-catchment ditches, and other measures including wildlife-exclusion fencing and wildlife-passage opportunities (www.globalnews.ca/video/8738388/drone-footage-shows-massive-construction-project-in-kicking-horse-canyon/). Construction is expected to be completed in the winter of 2023–2024. Innovative engineering was necessary to overcome the unpredictable challenges of the deep canyon; steep, mountainous unstable terrain and weather.

A new attraction has opened at Niagara Falls, allowing visitors to explore the tunnel created by an electricity-generating company many years ago to harness hydropower from the fast-flowing water (www.cnn.com/travel/article/niagara-falls-tunnel/index.html). The power station, which operated from 1905 until 2006, diverted water from the Niagara River to run electrical generators that electrified the region. The 670-m tunnel built more than a century ago on the Canadian side reveals the massive scale of this early-Canadian engineering marvel. It once held 71,000 gallons of water moving at 9 m/s. It is almost 8 m tall and 6 m wide. It took thousands of workers four years to excavate the shale beneath the main generating room using lanterns, dynamite, pickaxes, and shovels. The walls contain four layers of brick and 18 in of concrete surrounded by shale. The tunnel exits onto a river-level viewing platform that is almost at the base of Horseshoe Falls.

The 670-m tunnel built more than a century ago on the Canadian side reveals the massive scale of this early-Canadian engineering marvel.

Two of Canada's most recognizable science journalists are transitioning into retirement after long and distinguished careers communicating science to the public.

- After 44 years of hosting CBC's "The Nature of Things," David Suzuki, a genetic scientist by training, is retiring (www.cbc.ca/news/science/david-suzuki-retires-the-nature-of-things-1.6625011). As a science communicator and environmentalist, Suzuki earned a reputation for speaking his mind. He wants Canadians to know that science is important. He believes that the key to addressing climate change is getting people to shift how they think about nature. There is no separation between us, the air, and nature. Suzuki, a third-generation Japanese Canadian, spent a part of his childhood in a Canadian internment camp during WWII. This is part of the reason why social justice and environmental activism are important to him. Even in retirement, he will continue speaking his mind on important issues.
- Bob McDonald hosted CBC "Quirks & Quarks" for 30 years starting in 1992 (www.cbc.ca/radio/quirks/bob-mcdonald-looks-back-at-30-years-of-hosting-quirks-quarks-1.6631534). The program focuses on science discoveries of the week. These include a wide assortment of topics emanating from scientific journals and news from industry, universities, and research labs. He learned early on that good journalism is about listening and focusing on the guests' story, making it understandable to his audience.

Both journalists are sincerely appreciative of all the scientists who have been generous with their time and shared their stories with the public. Both of these CBC public information programs will be continuing on with new hosts. Communication of science to the public in terms that it can understand is extremely important as scientific exploration is critical to maintaining and increasing our standard of living globally.

As our climate changes, accurately tracking severe weather is critical. Weather radar shows precipitation in real time, allowing meteorologists to better

predict and issue warnings for flooding, thunderstorms, hail, and other severe events. Canada's newest weather radar site located near Fort McMurray, AB, commissioned in September, is seen as an important component in the weather and climate forecasting system. The installation will expand radar coverage over northeastern Alberta and northwestern Saskatchewan (www.cbc.ca/news/canada/edmonton/canada-s-newest-weather-radar-in-alberta-begins-operation-here-s-why-that-s-important-1.6608516). This installation is part of a US$140 million nationwide project to upgrade and replace the aging radar network with dual-polarization radar that will double the severe-weather detection range. Canada's weather radar network consists of 33 sites across the country, and complete upgrading is forecasted to be complete by March 2023.

The Canadian Hydrogen Intensity Mapping Experiment (CHIME), located near Penticton, BC, became operational in 2017. In October 2022, the CHIME team of roughly 100 professionals received the Natural Sciences and Engineering Research Council of Canada's Brockhouse Canada Prize for Interdisciplinary Research in Science and Engineering, which includes a US$250,000 grant (www.cbc.ca/news/science/chime-nserc-award-1.6627533). This award will facilitate the work of Canada's largest radio telescope in uncovering the secrets of the universe. Indeed, when the new telescope was unveiled in 2017, only 30 fast radio bursts from beyond our Milky Way galaxy had been detected. Today, CHIME has detected roughly 3,000.

The Square Kilometre Array (SKA) project (www.skao.int); (www.skatelescope.org/the-ska-project) is an international project to build the world's largest radio telescope. With more than a square kilometre of collecting area, the SKA represents a huge leap forward, bringing together the world's best scientists, engineers, and policy makers. Sixteen member countries, including Canada, are participating in the design and development of the SKA. The final product will consist of thousands of dishes and up to a million low-frequency antennas. These will enable astronomers to monitor the sky with unprecedented detail. South Africa will host the core of the high- and midfrequency dishes. Western Australia will host up to a million low-frequency antennas. Construction of the SKA began in 2021. Science observations are expected to start by the end of the decade. Scientists and engineers are working on a dual-supercomputer system 25% more powerful than any current supercomputer. New network technology will transmit data at a rate 100,000-times faster than the current broadband speed.

The Canada Infrastructure Bank has made a deal with Ontario Power Generation to provide US$970 million to build the country's first small modular reactor (SMR) (www.cbc.ca/news/politics/cib-funds-smr-to-cut-emissions-1.6628801). This will fund construction of a 300-MW SMR next to the existing 3,500-MW Darlington Nuclear Generating Station in Ontario. This deployment will enhance Canada's leadership in nuclear technology, creating sustainable jobs and reducing emissions. SMRs have smaller footprints and shorter construction schedules than traditional nuclear generating stations. Similar SMR projects in Saskatchewan, New Brunswick, and Alberta are forecast.

The Canadian CubeSat Project (CCP) (www.asc-csa.gc.ca/eng/satellites/cubesat) is providing postsecondary institutions with the opportunity to engage their students in a space mission. Teams of professors and students are offered the opportunity to design and build their own miniature satellite, called a *cubesat*. In May 2018, the Canadian Space Agency (CSA) announced the selection of the winning proposals, awarding a total of 15 grants. Thirty-seven organizations are participating in the CCP, thanks to interregional, interprovincial, and international collaborations. Student teams across Canada are busy designing and building their cubesats. CSA experts as well as representatives from the Canadian space industry will mentor students to optimize their success. Once tested, the cubesats will be launched to and deployed from the International Space Station, likely in 2023. Student teams will operate their cubesats, conducting science according to the objectives of their missions. The main objectives of the CCP are to 1) increase students' interest in space careers, 2) develop students' expertise in space domains, 3) give students hands-on experience, and 4) advance space science and technology.

After 53 years and more than 1,570 planes, the last Boeing 747 left

About the Author

Terrance Malkinson (malkinst@telus.net), the author of more than 600 peer- and editorial-reviewed earned publications, is now retired. His diverse career path includes 26 years in medical research as a founding member of the Faculty of Medicine at the University of Calgary and a three-year appointment as a business manager with the General Electric Company followed by a one-year applied research appointment with SAIT Polytechnic. He is an alumnus of continuing professional education programs with Outward Bound International, Banff Center for Management, the Massachusetts Institute of Technology, and the University of Colorado. During his long career, he has advanced both basic and applied medical, health and wellness, scientific, and engineering knowledge. He has trained and mentored undergraduate, graduate, and postdoctoral students as well as staff in the business sector and government. He is a 45-year, Life Senior Member of IEEE. He has served in many professional public and private governance and publication roles. He is the recipient of several peer-selected earned awards including, induction into the Order of the University of Calgary, IEEE achievement medals, and APEX awards for publication excellence. In retirement, he vigorously continues basic and applied research with an extensive portfolio of projects. He is a manuscript reviewer and a special topic editor for several journals. Other passions include communicating emerging technologies to the public, investigative journalism, philanthropy, and mentorship. His current research interests in emerging technologies and health and wellness extend to being an accomplished multisports triathlete, including, among other events, the completion of 11 full-distance Ironman Triathlons.

the assembly line in Washington State on 7 December 2022 (www.cnn.com/2022/12/06/business/last-boeing-747/index.html). Boeing delivered its first 747 passenger jets in December 1969. The jumbo jet, with its distinctive second-floor bulge, is the most notable and popular plane Boeing has ever built, and a spectacular engineering achievement. Since 1990, the 747 has served as Air Force One. The passenger versions of the plane could carry between 400 and 500 passengers. Today, there are only 44 passenger 747s and 314 freighter 747s in service.

NASA completed its first planetary defense test to determine that if an asteroid was ever on a trajectory to impact Earth, whether its path could be changed (www.cbc.ca/news/science/nasa-dart-mission-successful-orbit-1.6612806). The Double Asteroid Redirection Test spacecraft slammed into an asteroid 11 million-km away at 22,500 km/h on 26 September and succeeded in shifting its orbit even more than expected. This mission successfully tested NASA's ability to be ready for such a catastrophic event should it ever be needed. In this case, the asteroid posed no threat to Earth.

Transport Canada will begin enforcing the use of electronic logging devices (ELDs) for specified commercial vehicle drivers, such as long-haul truckers, on 1 January 2023 (www.cbc.ca/radio/spark/trucking-eld-workplace-surveillance-1.6680568). The federal regulation covers only commercial trucks and buses that cross provincial and territorial boundaries. ELDs are seen as a way to make roads safer by keeping truckers accountable to their allowed hours of service. Under federal hours of service rules, drivers are not allowed to drive more than 13 h in a day. The devices can also track information such as vehicle location and speed. The Canadian Trucking Alliance, a group representing trucking associations across the country, says that it is supportive of this mandate. ELDs have been mandatory in the United States since 2017.

On 15 November 2022, the United Nations recognized that the global population reached eight billion people. Its Population Prospects (population.un.org/wpp/) report forecasts reaching 10.4 billion people in the 2080s, remaining at that level until 2100. Darrell Bricker and John Ibbitson, who cowrote "Empty Planet: The Shock of Global Population Decline" in 2019, believe that 8 and 9 billion is where we are going to end up by the end of the century. Projections of the future differ slightly but most agree that the population will level off some time in the relatively near future. Some forecast a decline in world population, with many choosing to have smaller families. A smaller global population may result in an improved environment and lower the risk of famine. A decline in births and an aging population may present economic challenges. This is something that government policy makers will need to be mindful of. ■

Canadian editors and volunteer leaders at the 2023 Panel of Editors (POE) meeting held in Chicago, IL USA from 27 to 29 April 2023.

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