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President's Inaugural Message/Message inaugural du Président

Maike Luiken
Ph.D., FEIC, SMIEEE

2018-2019
IEEE Canada President and Region 7 Director

To all IEEE Canada members and friends, I welcome you to this new IEEE year 2018. We are a large community—new and long-time volunteers, supporters and activists, both young and seasoned professionals from industry, academia, education, government, NGOs, consultants and those who are well into their 'official' retirement.

I am honored with the privilege of leading IEEE Canada for the next two years as IEEE Canada President and to represent IEEE Canada (R7) as Director on the IEEE Board of Directors.

During the past two years, as President-Elect of IEEE Canada, I had the privilege to work very closely with and learn from the current Past President Witold Kinsner, Winnipeg Section, and the then Past President Amir Aghdam, Montreal Section.

I would like to thank Witold Kinsner for his tremendous and tireless effort in leading TEAM IEEE Canada during the past two years. We will continue to benefit from his wisdom and experience in his role as Past-President. I also wish to express a great 'thank you' to Amir Aghdam who has completed the six-year commitment he volunteered for in standing for election for IEEE Canada President-Elect/ IEEE Region 7 Director-Elect in 2011. The formation of Windsor

(Continued on page 4)

Je tiens d'abord à souhaiter une excellente année 2018 à tous les membres et amis de l'IEEE Canada, bénévoles de longue date ou fraîchement nommés, partisans et activistes, professionnels novices ou chevronnés, professeurs et chercheurs universitaires, enseignants, fonctionnaires, ONG, cabinets-conseils ou retraités.

J'aurai l'honneur au cours des deux prochaines années de présider l'IEEE Canada et de représenter la Région 7 au conseil d'administration de l'IEEE.

Depuis deux ans, pour me préparer à mes nouvelles fonctions, j'ai eu le privilège, en tant que président désigné, de travailler avec l'actuel président sortant Witold Kinsner, section de Winnipeg, et son prédécesseur Amir Aghdam, section de Montréal.

Je tiens à remercier Witold Kinsner qui a rempli son rôle avec brio. Je suis persuadé que nous nous profiterons encore longtemps de sa sagesse et de son expertise. Je tiens également à rendre hommage à Amir Aghdam qui, pendant six ans, a tout donné à l'organisation, après s'être porté volontaire en 2011 pour remplir la double fonction de président désigné de l'IEEE Canada et de directeur désigné de la Région 7. Il laisse un héritage durable et de nombreuses réalisations, dont la création de la section de Windsor, qui connaît un essor fulgurant. Ces résultats sont le fruit des efforts de toute l'équipe de l'IEEE Canada durant l'exercice 2016-

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Digital Delivery

IEEE's impending adoption of the EU's General Data Protection Regulation temporarily put our plans for email notification on hold. With the way forward now clear, we encourage members to consider switching to digital-only delivery.

canrev.ieee.ca/delivery_options.shtml

President's Message/Message du Président

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

Section — which continues its impressive growth — is amongst his many achievements, leaving a lasting legacy.

None of the above accomplishments would have been possible without all of the TEAM IEEE Canada members of 2016/2017. Thank you all very much for committing your time, your talent, your enthusiasm, your ideas and your creativity for the benefit of the members, volunteers and our communities.

Congratulations to all the new and re-appointed volunteers to the 2018 IEEE Canada Board of Directors and its committees. We welcome President-Elect/Director-Elect Jason Gu, Canadian Atlantic Section, who will lead IEEE Canada in 2020-21. A list of TEAM IEEE Canada, the current IEEE Canada Board of Directors and Committee Chairs, is published on the IEEE Canada website at https://www.ieee.ca/en/administration/list/.

IEEE has developed exciting new tools to find publications and events of interest. The IEEE Event Finder App lists all IEEE registered conferences and/or events listed in vTools and lets you choose your own selection criteria (e.g. location.) The MyExplore App will alert you to new publications in your area of interest. The IEEE App gives you access to trending IEEE news, and finds other app users as well as meet-ups. These apps are available to everyone: members and non-members alike.

Two developments to pay particular attention to:

- On May 25th, the General Data Protection Regulation (GDPR), which applies to EU citizens and to international organizations that are doing business in the EU, takes effect. IEEE staff has been diligently reviewing IEEE practices and processes and making necessary changes to ensure that IEEE is GDPR compliant, as well as providing training for staff and volunteers. This may apply to your business; potential fines are enormous.
- An IEEE Region 7 Training Group has been created in IEEE Collabratec. Resources will be posted for all IEEE volunteers to use; please sign up.

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IEEE Collabratec – a great way to build a community!

Build a community with IEEE members and non-members. Or, use it to create a well-protected group.

Collabratec's **job site** could be the pathway to your next career move.

All IEEE members are now accessible in Collabratec. You can **reach out** to any member you think would be interested in your initiative. Thinking bigger? There are now more than **70,000** non-members participating in Collabratec!

Many IEEE initiatives and groups have Collabratec communities as communication and collaboration platforms. Please check out and participate in initiatives such as:

- Brain,
- Future of Technology,
- HKN,
- Humanitarian Activities,
- IEEE 5G,
- IEEE Digital Reality,
- IEEE Entrepreneurship,
- IEEE Internet of Things,
- IEEE Smart Cities,
- Internet Technology Policy,
- Sustainable Computing,
- Women in Engineering,
- Young Professionals

and many others.
Should you not be able to find the community you are looking for, you can start your own!

(Message du Président suite de p. 3)

2017. Merci à tous d'avoir mis votre temps, votre talent, votre enthousiasme, vos idées et votre créativité au service des membres, des bénévoles et de nos communautés.

Je félicite les bénévoles qui viennent d'être nommés ou qui renouvellent leur mandat au conseil d'administration de l'IEEE Canada et à ses comités pour l'exercice 2018. Je souhaite la bienvenue à Jason Gu, de la section de l'Atlantique, notre nouveau président désigné et directeur désigné, qui dirigera l'organisation en 2020-2021. La liste des membres de l'équipe de l'IEEE Canada, du conseil d'administration actuel de l'IEEE Canada et des présidents des comités est affichée à www.ieee.ca/en/administration/list/. Vous trouverez également sur notre site de nouveaux outils de recherche de publications et d'événements. Ainsi, pour fouiller la liste complète des activités, conférences et autres événements inscrits dans vTools et dénicher les activités qui vous intéressent, vous pouvez configurer l'appli de recherche d'événements (paramètre de lieu p. ex.). Grâce à l'appli MyExplore, vous recevrez des notifications dès la publication d'un article dans votre domaine d'intérêt. Vous pouvez aussi suivre l'actualité de l'IEEE, retrouver des utilisateurs et vous tenir au courant des réunions à partir de l'application IEEE. Le tout est accessible au public et aux membres de l'IEEE.

J'attire votre attention sur deux faits d'actualité :

- L'entrée en vigueur le 25 mai prochain du Règlement général sur la protection des données de l'UE qui s'applique aux citoyens européens comme aux organisations internationales qui font affaire sur le territoire de l'UE. L'IEEE a examiné ses pratiques et pris les mesures nécessaires pour se conformer à ce nouveau règlement et former son personnel et ses bénévoles. Je vous recommande d'en faire autant pour votre organisation, car je vous préviens, les amendes risquent d'être salées.
- La mise sur pied dans Collabratec d'une communauté dédiée à la formation dans la Région 7 où les bénévoles trouveront les outils et les ressources dont ils ont besoin. N'oubliez pas de vous inscrire. Parallèlement, la création de plusieurs nouvelles entités en 2018 dénote l'intérêt grandissant à l'égard de

IEEE Collabratec™
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IEEE Collabratec : la voie vers une communauté de qualité!

Créez une communauté ouverte aux membres et aux non-membres de l'IEEE, ou encore un groupe privé bien protégé.

Le **site d'emploi** de Collabratec est possiblement le tremplin vers la prochaine étape de votre carrière!

Tous les membres de l'IEEE sont maintenant inscrits à Collabratec. Vous pouvez donc leur **proposer directement** vos initiatives. Ce n'est pas assez? Il y a actuellement plus de **70 000** non-membres inscrits!

Plusieurs groupes et projets affiliés à l'IEEE utilisent les communautés Collabratec comme plateforme de communication et de collaboration. En voici quelques-unes, n'hésitez pas à prendre part à la discussion :

- Brain;
- Future of Technology;
- HKN;
- Humanitarian activities;
- IEEE 5G;
- IEEE Digital reality;
- IEEE Entrepreneurship;
- IEEE Internet of Things;
- IEEE Smart cities;
- Internet Technology Policy;
- Sustainable computing;
- Women in engineering;
- Young professionnals.

Si vous ne trouvez pas ce que vous cherchez, n'hésitez pas à créer votre propre communauté!

Interest in IEEE activities in our region is growing with the addition of several new units so far in 2018. The full list can be seen below. These groups will all help better serve our members and our community. We thank the many volunteers that have made their formation possible.

It was my pleasure to announce the above during IEEE Canada's annual spring board meeting and training session, held April 20-22. The IEEE Canada Exemplary Section Awards for 2018 were also announced. Congratulations to: Vancouver Section (Large Section); Kitchener/Waterloo and Southern Alberta Sections (Medium Section); and Victoria and Windsor Sections (Small Section). Many volunteers made the weekend a success. The meeting was enriched by many IEEE international guests, both volunteer and staff.

Strategic Direction for IEEE Canada

In alignment with IEEE's Strategic Plan 2015-2020, and building on the accomplishments of my predecessor Witold Kinsner, I see IEEE Canada's priorities for 2018-19 including:

- A stronger focus on the "North" and working with Canada's Indigenous peoples
- Growing communities of engagement within and around IEEE Canada
- A stronger focus on public visibility and advocacy
- A review of IEEE Canada administrative and organizational processes, in particular communications and data management, and roles and committee structures to ensure efficient support for our Sections, Chapters, Student Branches, Affinity Groups, Student Branch Chapters, SIGHT, TISP and other groups across Canada

I will discuss strategic directions of IEEE Canada in detail in future columns as well as actions taken to achieve them. But the leadership team can't be successful without your input. We have an open mailbox policy for your ideas: please forward to maike.luiken@ieee.org

IEEE Canada is a formidable organization with innumerable committed, talented volunteers. I am very exited to work with all of you on contributing significantly to the Goals and Priorities of IEEE, and IEEE MGA; achieve those of IEEE Canada, and deliver on the IEEE Mission: "IEEE's core purpose is to foster technological innovation and excellence for the benefit of humanity." ■

Maike Luiken, Ph.D., FEIC, SMIEEE
2018-2019 IEEE Canada President
2018-2019 IEEE Region 7 Director

Welcome to IEEE Canada's latest organizational units!
Bienvenue aux nouvelles entités d'IEEE Canada!

- **IEEE Canada**: IEEE Canada Special Interest Group on Humanitarian Technology - SIGHT/
  ***IEEE Canada** : groupe d'intérêt spécial sur la technologie humanitaire*
- **Southern Alberta Section**: University of Calgary Student Branch Chapter of IEEE Photonics Society/
  ***Section du Sud de l'Alberta** : chapitre Photonique, branche étudiante de l'Université de Calgary*
- **Toronto Section**: Industry Applications Society Chapter and Joint Power Electronics/Consumer Electronics Chapter (formerly all three in Toronto Section Joint IA34/PEL35/CE08)/
  ***Section de Toronto** : chapitre Applications industrielles et chapitre mixte Électronique de puissance/Électronique de grand public (auparavant le chapitre mixte IA34/PEL35/CE08)*
- **Canadian Atlantic Section**: Dalhousie University Student Branch Joint Chapter of Industry Applications Society and Power & Energy Society/
  ***Section de l'Atlantique** : chapitre mixte Applications industrielles/Puissance et énergie, branche étudiante de l'Université Dalhousie*
- **Kingston Section**: Queen's University Student Branch Women in Engineering Affinity Group/
  ***Section de Kingston** : groupe d'affinité Femmes en génie, branche étudiante de l'Université Queen's*
- **Victoria Section**: Women in Engineering Affinity Group (formed in late 2017)/
  ***Section de Victoria** : groupe d'affinité Femmes en génie (créé à la fin de 2017)*

notre organisation. Vous trouverez la liste détaillée un peu plus loin. Grâce à elles, nous serons mieux outillés pour servir nos membres et nos communautés. Un merci particulier aux nombreux bénévoles qui ont contribué à leur mise sur pied.

Du 20 au 22 avril dernier, à l'occasion de la réunion du conseil d'administration et des séances de formation, j'ai eu le plaisir d'annoncer ces nouveautés ainsi que les sections de l'IEEE Canada s'étant le plus illustrées en 2018. Félicitations aux lauréates : la section de Vancouver (grande), les sections de Kitchener/Waterloo et du Sud de l'Alberta (moyenne); et les sections de Victoria et de Windsor (petite). Merci aux nombreux bénévoles qui ont fait de cette fin de semaine un succès. Pour couronner le tout, des bénévoles et des membres du personnel de l'IEEE international nous ont gratifiés de leur visite.

Orientation stratégique d'IEEE Canada

À partir de notre plan stratégique 2015-2020 et des réalisations de Witold Kinsner, l'IEEE Canada s'est fixé les priorités suivantes pour l'exercice 2018-2019 :

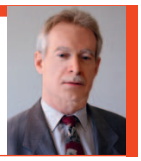
- Faire plus de place au Nord et aux Premières Nations;
- Mobiliser nos communautés à l'interne et à l'externe;
- Gagner en visibilité auprès du public;
- Évaluer nos processus administratifs et organisationnels, en particulier les communications et la gestion des données ainsi que le mandat et la structure des comités pour mieux servir nos sections, chapitres, branches étudiantes, groupes d'affinité, groupes d'intérêt spécial sur la technologie humanitaire, programme des enseignants en service, etc.

J'aborderai plus en détail l'orientation stratégique et le plan d'action de l'IEEE Canada dans mes prochaines chroniques. Dans l'intervalle, la porte de l'équipe de direction est toujours ouverte. Vous êtes la clé de notre réussite; n'hésitez donc pas à faire parvenir vos idées à maike.luiken@ieee.org. Nous avons hâte de vous lire!

L'IEEE Canada est une organisation formidable dont le succès tient à ses innombrables bénévoles. C'est avec beaucoup d'enthousiasme que j'amorce mon mandat. Ensemble, nous ferons avancer les dossiers et les priorités de l'IEEE et du bureau des activités géographiques des membres de l'IEEE, nous atteindrons les objectifs de l'IEEE Canada et mènerons à bien notre mission. « Promouvoir l'innovation technologique et l'excellence pour le bien de l'humanité ». ■

Maike Luiken, Ph.D., FEIC, SMIEEE
Président d'IEEE Canada pour 2018-2019
Directeur de la région 7 de l'IEEE pour 2018-2019

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



Bruce Van-Lane, P.Eng.

Je suis un admirateur de Stephen Hawking. J'admire son cheminement, ses réussites et sa détermination sans borne. Dans la foulée de son décès le mois dernier, j'ai cependant découvert qu'il n'affectionnait pas particulièrement les philosophes. Selon M. Hawking, l'intérêt des philosophes pour la nature de la vérité et de la connaissance est un frein au progrès scientifique et essentiellement une perte de temps. Ayant moi-même « perdu » du temps à réfléchir à des questions similaires, quoique très peu comparé à ceux qui y ont consacré leur vie, j'ai appris que les écoles de pensée, et par conséquent les façons de voir le monde, sont multiples.

Quelques semaines à peine après le décès de M. Hawkings, un scandale éclaboussait Facebook. Alors que la planète découvrait le côté sombre du modèle d'affaires mis de l'avant par l'enfant chéri d'Internet, mes pensées sont revenues à Stephen Hawkings et à ses mises en garde sur les risques éthiques que pose l'IA. Il n'est toujours pas clair dans quelle mesure Facebook savait que ses données étaient utilisées sans le consentement des utilisateurs, et dans certains cas, ce sont des intermédiaires qui étaient gardés dans le noir. Considérant l'ampleur des données visées, il ne fait cependant aucun doute que quelqu'un aurait dû se poser des questions. Impossible de le nier désormais: si l'intelligence est artificielle, la menace pour la gouvernance, elle, est bien réelle.

À titre d'association professionnelle mondiale, l'IEEE prône la prise en compte des considérations éthiques dans toute décision, peu importe le domaine. Si la question vous intéresse, il y a plusieurs façons de contribuer. L'association de normalisation de l'IEEE compte sept projets de normes sur l'éthique des nouvelles technologies. L'une d'elles, la norme IEEE P7002, touche spécifiquement les enjeux éthiques entourant les systèmes et logiciels qui recueillent des renseignements personnels. En outre, vous pouvez aussi joindre la communauté Internet Technology Policy dans Collaboratec.

Je termine en souhaitant la bienvenue à Dave Michelson à titre de rédacteur invité. M. Michelson dirige le laboratoire de science radio de la Faculté de génie électrique et informatique de l'Université de Colombie-Britannique. ■

I'm a fan of Stephen Hawking. At least, mostly. At his passing last month, amongst the many details of his life, his achievement and extraordinary determination, a lesser-known trait caught my attention: he apparently had no use for philosophers. Their preoccupation with issues such as the nature of truth and knowledge were making them obstacles to scientific advancement — a waste of time, he argued. My own training in wasting time this way barely elevates me atop my office chair, compared to the orbits of those he criticized. But I did learn there are many different systems of thought, and hence ways of thinking about the world around us.

It was only a couple of weeks after Hawking's death the Facebook scandal erupted. As the business model of one of tech's brightest stars revealed its darker side, it got me thinking again about Stephen Hawking, who sounded the perils of AI if questions of ethics weren't addressed along the way. The extent to which Facebook knew its data was/might be used in a manner its users hadn't consented to isn't fully clear. And in some instances there were intermediaries who might not have been aware of the intended uses. But given the size of the data set, it might have occurred to some of those involved to ascertain to what ends it would be employed. If it wasn't clear before, it is now — the bot can be more powerful than the bomb.

As a world-wide professional association, IEEE engages its members in how ethics can guide design decisions – be it business models or autonomous vehicles. If you want to help shape the discussion, there are several ways you can become involved. The IEEE Standards Association has seven standards projects to provide ethical guidance for new technologies. One of these, IEEE P7002, specifically addresses ethical issues for systems and software that collect personal data. Also, consider joining the Collabratec Internet Technology Policy Community.

I close this column in welcoming Dave Michelson, as Contributing Editor. Prof. Michelson leads the Radio Science Laboratory at the Department of Electrical and Computer Engineering at UBC. ■

Biz-tech Report

by Terrance Malkinson

On January 2, 2018 the successful completion of the merger between Agrium Inc. (Agrium) and Potash Corporation of Saskatchewan Inc. (PotashCorp), was announced. This resulted in the creation of the world's premier provider of crop inputs and services. Nutrien, [www.nutrien.com] headquartered in Saskatoon, with nearly 20,000 employees and operations and investments in 14 countries produces and distributes over 26 million tonnes of potash, nitrogen and phosphate products for agricultural, industrial and feed customers globally. The company has an agriculture retail network that services over 500,000 growers helping them optimize crop yields and their returns.

Ontario has announced $713M in research funding to the University of Guelph to help support innovation in food and agriculture. As Malcolm Campbell the Vice-President of Research at the University stated "it is not just about making discoveries that push back the frontier of your discipline….but it is also about converting those discoveries into action and creating innovations that are going to create jobs, grow the economy and make us more competitive in a global market-place."

The Globe *and Mail Report on Business* provides a feature article on "The Future of Food" [pp. 21-39. March, 2018. www.theglobeandmail.com/business]. This interesting feature describes how Canadian companies are embracing food innovation enabled by science, engineering, and technology. "Birth of a Cherry" discusses how agricultural engineering is changing the foods we eat. Did you know that 80% of the world's cherry varieties were developed in a Canadian research Centre in BC's Okanagan Valley? "Snacks with Benefits" describes Canadian work to create more healthy grab-and-go foods with nutritional benefits. As stated in the article "Over the past five years Canada has invested over $3B in supporting agricultural innovation, upgrades and market expansion through its Growing Forward 2 program [www.agr.gc.ca]. "Upstream Battle" discusses Canada's first genetically modified animal to be approved for human consumption- Atlantic salmon. Canadian farmers are poised to be one of the world's top producers of plant-based protein.

The April, 2018 issue of *MacLean's Magazine* provides a special 64-page *Canadian Business* [www.canadianbusiness.com] insert report on "Canada's Best Managed Companies". This is an outstanding analysis of the Canadian way of doing business; providing much more than just a list but also authoritative features detailing Canadian business excellence and the importance of outstanding and motivated employees.

The Canadian National Institute for the Blind [www.cnib.ca] is celebrating its 100th birthday. Originally created in response to the needs of soldiers returning from the First World War, the organization has for 100 years been an established leader in advocating for and providing services to Canadians who are blind or partially sighted. The CNIB is energetically building on its past and taking on difficult challenges with innovative research, engineering, technology and human solutions. Technology is seen to be a major focus in the future of the CNIB; eliminating barriers to those with visual impairment.

The recent passing of Roger Bannister and Stephen Hawking reminds us of outstanding examples of the human spirit. Roger Bannister in 1954 was the first human to run a mile in less than four minutes; an event which is considered to be one of the milestone achievements in athletic history. Retiring from running he had a long and celebrated career as a neurologist. Stephen Hawking is regarded as one of the greatest theoretical physicists of all time and wrote the international bestseller "A Brief History of Time." Hawking had been an inspiration to others with his lifelong battle with the disease amyotrophic lateral sclerosis. Imprisoned within his body he had a relentless spirit, joy for life, and made a difference bringing science to the public. In 2009 he took up a research position with the Perimeter Institute for Theoretical Physics in Waterloo, Ontario. The Stephen Hawking Centre in Waterloo Ont. is the only building in the world to bear the late physicist's name.

The managing director of McKinsey & Company and chair of the Canadian Government's Advisory Committee on Economic Growth, Dominic Barton is predicting massive change that will disrupt millions of Canadian jobs in the next twelve years. "There is a good chance that not just your job, but also the kind of job you do will be eliminated". The Advisory Council suggests that the challenge must be met with a major revamping of job training and lifelong education. This will require multi-billion dollar funding and significant public-policy changes that create employment pathways. The widely cited 2017 study by McKinsey & Company "A Future That Works: Automation, Employment and Productivity" provides further information.

Toronto was the only Canadian city to make the short list of 20 finalists for selection of Amazon's second headquarters. 238 cities globally applied for this $5B investment and 50,000 new jobs opportunity. Feedback received on the Calgary bid strongly suggested that our workforce did not possess the skills needed for the workplace and economy of the future. Many of us have known and spoken-out for many years that basic and applied research policy in Canada has failed to meet the needs of our youth by inhibiting their creative abilities and not providing them with the resources necessary to compete successfully and engage in the hard but important rewarding career paths that grow the national economy. This feedback from one of the world's most successful companies is a catalyst for necessary change.

The Globe *and Mail* co-published its 16th annual list of "Canada's Top Employers for Young People" [February 9, 2018. www.ct100.ca/yp]. The employers on this list are Canadian leaders in attracting and retaining young employees. Kristina Leung, Senior Editor of the Canada's Top 100 Employers project stated "In the competition for talent, a key variable for millennials and Gen-Z is the ability to connect their work with greater meaning – that's where winners of this year's competition excel." Most importantly the report provides many insights into the organizational culture that reaps rewards by effectively motivating and empowering youth towards achieving their potential.

The five winning bids of public funding for "high-technology superclusters" were named by the federal government on February 15. These clusters are hoped to promote economic growth and job creation. The five superclusters include:

- The Ocean supercluster in Atlantic Canada will use innovation to improve ocean-based industries, including fisheries, oil and gas and clean energy.
- The Scale AI supercluster in Quebec will work on building intelligent supply chains through artificial intelligence and robotics.
- The Advanced Manufacturing supercluster in Ontario will connect technology strengths to the manufacturing industry to prepare for the economy of tomorrow.
- The Protein Industries supercluster in the Prairies will work on making the country a leading source of plant proteins.
- The Digital Technology Supercluster in British Columbia will use big data and digital technologies to unlock new potential in sectors such as health care, forestry, and manufacturing.

(Continued on page 26)

by **Dario Schor**

As noted in my last column, the 1967 Outer Space Treaty (OST) is justifiably called the Magna Carta of Space Law. Since its signing 50 years ago, its vision — to promote the peaceful and collaborative uses of outer space for all humankind — has been and remains the guiding principle for the use of space in the present and future. It sets out important principles for space exploration and use, prohibits national appropriation of space territory and resources, and prevents national ownership of both. Three articles referring to nations' responsibilities for space assets limit the options of private enterprises to profit from space activity. In this column, I discuss profiting from space resources and explore the more immediate concerns of removal of active space debris and on-orbit servicing. As we project what the next 50 years will look like, most believe the OST will continue to provide a strong legal foundation, and new international agreements will emerge to respond to technological and commercial developments.

Ad adstra,

Dario Schor; schor@ieee.org

It is hard to believe the authors of the OST were able to differentiate between science fiction and achievable technological developments that needed to be formally addressed through legislation. The principles from the treaty laid the foundation that enabled exploration, commercial applications, and fomented collaborations. However, as Dr. David Kendall, Chair of UNCOPUOS in 2016-17 points out, "space is changing rapidly with new actors, especially with respect to the commercial sector, and new technologies that are disrupting the status quo." Some of the technologies currently being discussed within the international law community are mining resources and Active Debris Removal and On-Orbit Servicing (ADR/OOS).

The plans to extract resources from celestial bodies vary in scope and use. At the extreme, there are some people interested in capturing asteroids rich in rare Earth metals, bringing them to a lunar orbit, and mining the resources to use on Earth. This is a high-risk-high-reward scenario that has the greatest potential to impact the mining industry; still, despite efforts from companies like Planetary Resources or Deep Space Industries, it is far from becoming a reality. A more probable manifestation of this technology is for In-Situ Resource Utilization (ISRU) for sustained habitation on another celestial body. An example would be the Moon Village concept from the European Space Agency where lunar regolith is used to protect habitats from radiation.

...the Outer Space Treaty is a remarkable document that guides humankind's exploration of outer space.

In anticipation of missions that will utilize resources, and encouraged by economic investments from industry, the government of the US introduced the 2015 Commercial Space Launch Competitiveness Act. In short, this legislation encourages the use of space resources for commercial applications in accordance with international law, and, as expected, provoked mixed reactions from other nations. As the President Emerita of the International Institute of Space Law (IISL), Tanja Masson-Zwaan, suggested, "some states are quite vocal in condemning these laws as being contrary to the OST, while others recognize them as being necessary to provide legal certainty to industries who plan to invest." And, the arguments go beyond issues of appropriation from Article II. Some states are challenging whether "the free exploration and use of outer space and celestial bodies" as described in Article I accounts for taking non-renewable resources. To that extent, Christopher Johnson, Space Law Advisor at the Secure World Foundation, reminds readers that "the use of resources exists along a spectrum, and somewhere in the middle there is something that is politically justifiable." This may involve new legislation agreeing on whether nations can take all or only a portion of the resources, different rules depending on the materials extracted, and potential differentiation based on whether those are used in space or brought back to Earth.

For many years, space has endured the tragedy of the commons problem, in which nations benefit from a large number of satellite missions, but no one spent the resources to clean up the mess from pieces of launch vehicles and decommissioned spacecraft left behind. Despite being in low-Earth-orbit, many of these objects will take decades before they re-enter and, hopefully, burn up in the atmosphere. These pieces of space debris increase the risk of collisions with human or spacecraft missions like the 2009 case between Iridium 33 and Kosmos 2251 spacecraft.

The "law of salvage" exists in maritime law to reward individuals who recover old shipwrecks by allowing them to keep the findings as a reward. This concept encourages many diving expeditions looking for treasures. Yet, actors would need permission from the owners of spacecraft relics because registering states retain jurisdiction even if objects are no longer operational. As Masson-Zwaan reminds us, this is for "reasons of not wishing to disclose sensitive technology and national security interests." Furthermore, she added that non-profit organizations, like École polytechnique fédérale de Lausanne (EPFL), are investing in technologies to clean up their own state's space junk because they "have an interest in keeping the use of space sustainable." For an extrinsic motivator, Kendall speculates that as the technology matures, "states that own objects in space, especially those that have a high risk of potentially causing damage as defined under the OST, might want to consider the financial trade-off between remediating their objects and being sued for damages that the object might cause." Similar statements can be made about OOS and the liability legal challenges ahead.

As Johnson says, "The Outer Space Treaty is a treaty of principles, and with each new development, limits are being tested and stretched." Resource extraction and ADR/OOS took different paths in reaching the international community. With regards to debris, the draft guidelines from the Inter-Agency Space Debris Coordination Committee (IADC) were adopted with minor modifications by UNCOPUOS in 2007. Like the Principles Declaration from 1963, these guidelines are not binding, however COPUOS Member States were encouraged to implement these voluntary guidelines through national legislation. In contrast, the discussions on resource extraction took a different path by first defining federal laws in the US and Luxemburg. These laws instigated ongoing international discussions and are part of the agenda for the UNCOPUOS Legal Subcommittee. When asked whether any of these negotiations could lead to an amendment to the OST, Kendall, Masson-Zwaan, and Johnson uniformly said no. The main fear is that there would be no end to those discussions. Furthermore, Masson-Zwaan added that, "we risk losing the fragile balance it provides us, the principles are workable and have stood the test of time." Rather than amendments, one can expect supplemental treaties or guidelines depending on the problem and consensus between Member States. To that end, Kendall warns us that "we all have to realize that unless some major changes were to occur, especially in relation to national leaders accepting that new treaties with respect to space activities are a priority—which, frankly, is not likely to happen—the development of new regulations to guide current and future space actors is going to be slow and demanding."

As a final thought, the OST is a remarkable document that has set the principles that have and continue to guide humankind's exploration of outer space. And, like Johnson said, "space law is complex; it is not meant to defeat intentions in space, but rather preserve our freedoms of actions per Article I of the OST." ■

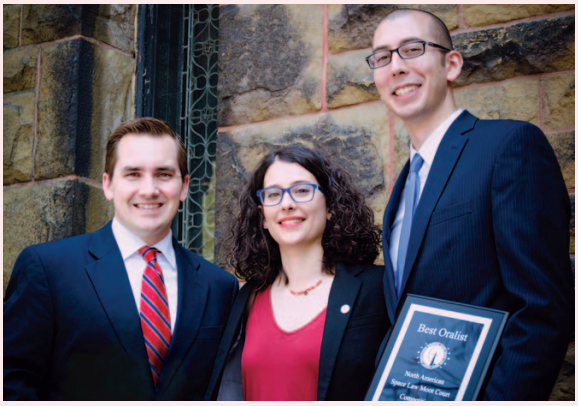
Acknowledgements

Special thanks to David Kendall, Tanja Masson-Zwaan, Christopher Johnson, and Aram Daniel Kerkonian for sharing their knowledge and insights over the past few months. Though their quotes and comments are embedded in the text, I take full responsibility for any errors or omissions in this publication.

Malfred Lachs Space Law Moot Court

In 2016 the following hypothetical scenario was argued

In 2028, the Banché government hired Couleur, a private company, to deorbit its inoperative Lavotto-1 microsatellite. The company used its shuttle-like spacecraft to perform a rendezvous, failed to grapple the satellite, and instead created a cloud of debris that damaged the vehicle endangering the lives of the astronauts. During the emergency landing in the neighbouring country of Rastalia, pieces of the spacecraft broke off and landed in a nearby campsite resulting in two casualties.



Space Law Moot Court 2016 Competition participants (left to right): Adam Newsome, Maria Manoli (coach) and Aram Kerkonian.

While it may seem convoluted and difficult to sort out, this is just a small portion of the problem presented to the participants of the 2016 Malfred Lachs Space Law Moot Court organized by the International Institute of Space Law (IISL). Since its inception in 1992, the competition has challenged university teams of 2-3 law students to argue both sides of the hypothetical case in front of a panel of judges. Regional rounds take place in Africa, Asia Pacific, Europe, and North America and assess both written submissions and debates to select the top teams that will meet at the World Finals taking place in conjunction with the annual International Astronautical Congress. The submissions are judged based on the teams' ability to apply international treaties and customary international law to their arguments and rebuttal statements.

Aram Daniel Kerkonian, a Doctor of Civil Law Candidate with a focus on Space Law at McGill University, was one of the students arguing the Banché v Rastalia case. After months of preparation, his team prevailed over the competition at the regionals in Georgetown University to advance to the World Finals. From April to September 2016, Aram and his teammates revised their arguments in preparations for their trip to the main event in Guadalajara, Mexico. There, the team faced fierce competition reaching the semi-final stage. In the end, they were recognized for the best written submission with the Eilene M. Galloway Award for Best Memorial.

Aside from the educational value, Aram highlights the importance of discussing cases as a means of engaging the legal community in a dialogue on future technologies. The moot court encourages students to follow in the steps of other space law visionaries of the pre-Sputnik era who helped define, study, and understand new technologies and their associated risks. Furthermore, the event is frequented by many industry legal advisors seeking inside knowledge on the reasoning for the courts and legal systems to provide better advice on emerging technologies.

Mr. Kerkonian stressed that for many years we watched government agencies pave the way by launching the first rockets, satellites, and humans into space. These advancements helped define many of the standards and laws applicable to today's industry. However, recent advancements are challenging the current legislation with technologies that have never been tested by space agencies, and thus pose new legal questions like those presented in the moot court. Thus, like Aram said, it is an exciting time for the space law community. ■

Radio Science in Canada

by **David Michelson**

Next year, in 2019, the International Union of Radio Science (abbreviated URSI, after its French name, Union Radio-Scientifique Internationale) will celebrate its centennial. The past one hundred years have borne witness to the tremendous impact that the application of electromagnetic fields and waves have had on society, industry and the economy. From wireless communications to microwave ovens to fibre optics to radar to remote sensing to radio astronomy, it is difficult to imagine today's world without the benefits of electromagnetic technology.

URSI has a long history of cooperating with IEEE to advance international cooperation in the study of electromagnetic fields and waves. One of the best known examples is, of course, the IEEE AP-S Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting that is organized each summer by the IEEE Antennas and Propagation Society and the U.S. National Committee for URSI. With the launch of this regular feature in IEEE Canadian Review, IEEE Canada members will have an opportunity to learn more about URSI, its organization and activities, and how they can both contribute to and benefit from URSI's mission.

Dave Michelson;
dmichelson@ieee.org

A BRIEF INTRODUCTION TO URSI

URSI was formed in 1919 during the Constitutive Assembly of the International Research Council, the predecessor to the International Council for Science (ICSU). One of the four founding members of the ICSU, URSI is currently one of 30 international scientific unions affiliated to it. Other ICSU unions include the International Astronomical Union, the International Mathematics Union, the International Union of Pure and Applied Chemistry, and the International Union of Pure and Applied Physics.

URSI's mission is to stimulate and co-ordinate, on an international basis, studies, research, applications, scientific exchange, and communication on all aspects of electromagnetic fields and waves. In particular, URSI seeks:

- to encourage and promote international activity in radio science and its applications, for the benefit of humanity;
- to encourage the adoption of common methods of measurement, and the comparison and standardisation of the measuring instruments used in scientific work;
- to stimulate and coordinate studies of:
  - the scientific aspects of telecommunications using electromagnetic waves, guided and unguided;
  - the generation, emission, radiation, propagation, reception, and detection of fields and waves, and the processing of the signals embedded in them.
- to represent radio science to the general public, and to public and private organisations.

The URSI Secretariat is based in Brussels, Belgium. The 44 member countries of URSI are each represented by a National Committee. Members of the National Committees are drawn from the ranks of leading researchers in each country and are responsible for both representing the interests of researchers in their country to the URSI Secretariat and the ICSU, and informing researchers of URSI activities and opportunities relevant to their interests. In many cases, national committee members are called upon to serve pro bono as "advisers to the nation" on research and policy matters related to electromagnetic fields and waves.

The technical activities of URSI are conducted through ten scientific commissions that represent the various specializations involving electromagnetic fields and waves. They include:

- 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
- Commission K: Electromagnetics in Biology and Medicine

FOCUS ON

URSI Commission J – Radio Astronomy

Dr. Lewis Knee
Canadian representative to Commission J and Member, Canadian National Committee

URSI Commission J – Radio Astronomy is concerned with observation and interpretation of all radio emissions and reflections from celestial objects. Commission J places emphasis on the technical means for making radio-astronomical observations and data analysis as well as the support for activities to protect radio-astronomical observations from harmful interference.

Atacama Large Millimeter Array in Chile

Like other international scientific unions, URSI pursues its mission by sponsoring publications, hosting conferences, and organizing working groups.

The Radio Science Bulletin (published quarterly in March, June, September and December) contains scientific articles covering the fields of interest of the ten scientific commissions of URSI. Emphasis is placed on non-specialized contributions that are oriented towards the entire radio science community.

Like other international scientific unions, URSI pursues its mission by sponsoring publications, hosting conferences, and organizing working groups.

The journal Radio Science, sponsored by URSI and published by the American Geophysical Union, contains original research articles on all aspects of electromagnetic phenomena including propagation through, and the interaction of electromagnetic waves with, geophysical media, biological media, plasmas, and man-made structures.

URSI has held a general assembly every three years since 1922. The 32nd URSI General Assembly and Scientific Symposium (URSI GASS) was held in Montreal from 19-26 August 2017. The next URSI GASS will be held in Rome in 2020.

In recent years, URSI has begun to organize two other conferences that take place between General Assemblies. The 2018 URSI Atlantic Radio Science Meeting, AT-RASC, will be held in Gran Canaria, Spain from 28 May – 1 June 2018. The 2019 URSI Asia-Pacific Radio Science Conference will be

The largest-ever radio telescope built by Canadian universities, CHIME (Canadian Hydrogen Intensity Mapping Experiment

Photo: Andre Renard/Dunlap Institute for Astronomy and Astrophysics

There is a very high level of activity in Canada within the remit of Commission J. The largest-ever radio telescope built by Canadian universities, CHIME (Canadian Hydrogen Intensity Mapping Experiment), has been completed and has begun initial science operations on the high-frequency side of band, attempting to detect the signature of atomic hydrogen at cosmological distances around a redshift of z ~ 0.4.

CHIME uses innovative FPGA and GPU-based back end systems to handle the multi-terabits per second data rates. At (sub)millimetre wavelengths, the Atacama Large Millimeter Array (ALMA) in Chile is currently in its fifth full year of science operations, with Canadian participation in science user support, science operations, and in the technical maintenance of its W-band receiver suite. ALMA is arguably the astronomy facility having the most scientific impact at the present time. A Canadian astronomer, Sean Dougherty, has just become the international ALMA Director. Canada is also a partner in the Square Kilometre Array (SKA) development program, with NRC leading the mid-frequency Central Signal Processor project and contributing to front end development for both the SKA and its precursor MeerKAT array in South Africa.

The Dunlap Institute has been awarded a major grant to develop a radio astronomy data centre to serve both the Very Large Array (VLA) Sky Survey under way in the United States and the future needs of Canadian SKA users. Canada is also a major partner in the definition phase of the proposed next-generation VLA array proposed to be built in the American southwest: Canadian astronomers are playing prominent roles in the definition of the science case for the array and NRC is working on high-frequency front ends as well as developing a proposed antenna design based on its unique composite materials antenna technology.

(Continued on page 12)

Photo: ESO/C. Malin

held in New Delhi, India from 9-15 March 2019. The URSI Young Scientist Program provides travel grants to new members of the radio science community to attend these meetings as part of a cohort of other young scientists.

URSI IN CANADA

Canada joined URSI in 1952, somewhat later than its sister Commonwealth countries Australia (1922) and New Zealand (1931). During the Second World War, radio research in Canada had grown rapidly under the direction of the National Research Council (NRC) of Canada's Associate Committee on Radio Research. By 1950, with many of NRC's radio researchers no longer involved in defence work, an Associate Committee on Radio Science was formed. In 1951, this became the Canadian Committee for URSI under the chairmanship of D. W. R. McKinley, then Associate Director of the Radio and Electrical Engineering Division of NRC. Canada became a member of URSI the following year.

The Canadian National Committee (CNC) originally consisted of six senior scientists and engineers from government laboratories and departments concerned with radio science and its applications, and five radio physicists, an electrical engineer and a radio astronomer from the universities. By 1968, the size of the committee had grown to 23 members from government, universities and industry. In 1971, the committee assumed its present form, and currently consists of the Committee Chair, a Past Chair, a Secretary and a Chair for each of the URSI Scientific Commissions.

The Canadian National Committee for URSI was very active in 2017. We hosted the 32nd URSI General Assembly and Scientific Symposium in Montreal (19-26 August 2017) which attracted over 2,000 presentations from over 50 countries; Canadian participation in URSI-GASS was second only to the U.S. In addition, Canada ran its first CNC-sponsored summer school (19 August 2017) which attracted some 60 students. Many international attendees commented that this was by far the best attended meeting since the 2003 meeting in Maastrich, Netherlands.

The National Research Council of Canada is the adhering member for Canada in international scientific and technical organizations and was instrumental in the establishment of the Canadian National Committee for URSI. The Canadian National Committee is supported jointly by NRC Government and International Relations and NRC Herzberg Astronomy and Astrophysics Research Centre.

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

To learn about URSI Canada, *please visit http://www.ursi.ca/.* ■

URSI COMMISSION J – RADIO ASTRONOMY

continued from page 11

MeerKAT array in South Africa

Photo: SKA South Africa

Photo: NRAO/AUI/NSF

Through all these disparate activities, Commission J serves to facilitate communication and collaboration through its involvement in scientific and technical meetings. Commission J played a prominent part in the 2017 URSI General Assembly in Montreal, and promoted the participation as exhibitors of the international radio astronomy facilities in which Canada has an interest. In the Commission J scientific sessions there were three invited lectures, fifteen contributed papers, and three poster presentations, all of which had Canadians in the author list. The upcoming ANTEM2018 meeting will be held in Waterloo in August 2018 with Canadian radio astronomy community participation, Commission J also plans a presence at the upcoming meeting of the Canadian Astronomical Society in Victoria. ■

Dr. Lewis Knee is a Senior Research Officer and Team Leader of the Millimetre Instrumentation Group, Astronomy Technology, at the NRC Herzberg Astronomy and Astrophysics Research Centre. His scientific interests include radio and (sub)millimetre observational studies of star formation, young stellar objects, and the structure and evolution of the atomic and molecular components of molecular clouds and the general interstellar medium of the Galaxy. He is experienced in radio telescope operations and the commissioning of single dish and interferometric radio astronomy systems. His technical interests cover centimetre-wave and millimetre-wave radio astronomy instrumentation and systems.

Very Large Array (VLA)

Photo: NRAO/AUI/NSF

About the Author

Prof. David Michelson is Chair of the Canadian National Committee of the International Union of Radio Science (2018-2020). He has led the Radio Science Lab at the University of British Columbia, Dept. of Electrical and Computer Engineering since 2003. His current research focuses on short-range/low-power wireless networks for smart utility, smart transportation and natural resource applications, millimeter-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 Communications Society (2017-2019) and the IEEE Vehicular Technology Society, as a member of the Steering Committee of the NIST-sponsored 5G mm-Wave Channel Model Alliance., and as co-director of the AURORA Connected Vehicle Technology Testbed at UBC.

IEEE Canada

EPEC 2018 Clean Technologies for Smart Cities

Toronto > October 10–11 > epec2018.ieee.ca

Learn, share and connect

The 18th annual IEEE Canada Electrical Power and Energy Conference (EPEC 2018) will take place in Toronto, Ontario, Canada in October 2018. With 82 per cent of Canadians now living in urban areas, the theme will be "Clean Technologies for Smart Cities". EPEC 2018 is a conference that provides an opportunity for experts from the private sector, academia, government and other interested organizations from Canada and abroad to present and discuss the latest developments in electric power and energy systems, including research and development, industrial and business trends, as well as emerging regulatory and policy challenges. This includes debate on the potential impact of these developments on society. The conference provides an international forum for the exchange of ideas with thought leaders and the presentation of peer-reviewed papers on the latest power and energy R&D initiatives, applications and implementations.

Topics

EPEC 2018 will include presentations on topics including the following:

- Asset management
- Climate change
- Cyber security
- Data analytics
- Demand management
- Efficiency and conservation
- Electric vehicles
- Electricity markets and models
- Energy storage
- Generation and transmission
- Microgrids
- Modeling and design
- Net-zero buildings
- Policies, regulation and planning
- Power converters
- Power quality
- Renewable energy
- Resilient energy infrastructure
- Smart grids
- Standards and safety

The paper submission deadline has now passed and the review process has begun. However, we have opened up a special track for late-breaking papers through June 15, 2018 to ensure that we capture the very latest research and developments in power and energy. We encourage you to visit EDAS to submit your papers using this track, but please note that priority during the review process will be given to papers submitted before April 30. The technical committee would like to thank all authors for their submissions.

Authors whose papers have been accepted are invited to submit extended versions of their presented papers for consideration in the EPEC 2018 Special Issue of the IEEE *Canadian Journal of Electrical and Computer Engineering* (*CJECE*) within four weeks of the conference final day. *CJECE* is indexed on IEEE *Xplore* and accepts submissions via the ScholarOne Manuscript portal. Please see http://journal.ieee.ca/ for more information.

General inquiries: info@epec2018.ieee.ca

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Robotics

APPLICATIONS FOR TODAY AND TOMORROW

(PART 2 OF 2)

Andrew Goldenberg
PhD, PEng, CEng, FIEEE, FASME, FAAAS, FCAE, FEIC

Chief Technology Officer:
- SuperRobotics Ltd., Hong Kong, China
- ANZER Intelligent Systems Co. Ltd., Shenzhen, Guangdong, China
- Engineering Services Inc., Toronto, Ontario, Canada

Professor Emeritus,
University of Toronto

N.Ed.: Dr. Andrew Goldenberg is the 2016 recipient of the IEEE Canada McNaughton Gold Medal, the highest award given by IEEE Canada.

There are numerous applications of robotics in a wide range of sectors. Most of the robots offered on the market are product lines that need to be adapted to the desired applications. In some cases, when the complexity of requirements cannot be met with standard off-the-shelf products, custom robots are developed and used.

Most robotic businesses are focused on specific lines of products, ex. medical robot. A minority of businesses offer products over a range of applications including customized products.

This article introduces a selected number of applications originated in the company I founded. These products have reached their development maturity, and further work is now focused on enhancing the products by embedding modern technology such as Artificial Intelligence (AI). AI provides methods and tools that enhance the products in terms of their usability, reliability and performance.

The products that would be enhanced are Mobile, Security and Personal Robots, which would embed autonomous navigation capability. Industrial and Collaborative Robots would be enhanced by embedding image recognition capability as applied to identification of parts and objects near the robot. Face and Voice Recognition are technologies that would further enhance the Personal Robots.

Security Robots

MOBILE ROBOT FOR EXPLOSIVE AND ORDNANCE DISPOSAL (EOD)

Police, Military, Emergency Response Team (ERT), Fire, Nuclear, and other hazardous response personnel require remote controlled equipment for stand-offs in dealing with explosives, ordnance, and other hazardous materials. The remote-controlled equipment consists of a mobile platform, video equipment, a robot arm mounted on the platform, and a series of auxiliary operational tools such as firearms, disrupters, x-ray units, etc. and associated means of attaching them to the arm or platform. In addition, such a system includes an operator control unit (OCU) that includes cable and wireless communication with the platform, video monitors, means of controlling the platform and arm, as well as activating the operational tools. The communication covers data, video, and audio links.

The platforms and arms come in various sizes. The platforms are usually anywhere from 60 to 135 cm in length, and from 45 to 66 cm in width. The arms can have a reach from 0.8 cm to 2-3 m. The payload capacity varies from 5 kg to over 75

Police, Military, Emergency Response Team (ERT), Fire, Nuclear, and other hazardous response personnel require remote controlled equipment for stand-off in dealing with explosives, ordnance, and other hazardous materials.

kg depending on the configuration of the arm. The total weight varies from 25 kg to 350 kg. The speed of the platform varies from 2 Km/hour to more than 10 Km/hour.

This class of robots is subdivided in three major groups: small, medium, and large. There are commercial suppliers for each category. The small category is mainly used for reconnaissance, and surveillance. It is usually not used with an arm. The large category addresses large payloads, ammunition firing, and other hazardous tasks involving heavy payloads. The medium category is used for a mix of operations, some pertinent to the small robots, and others to the large ones.

These mobile robots could be used for surveillance, reconnaissance, handling of hazardous items, manipulation of suspected packages, neutralizing and handling such items as Improvised Explosive Devices (IED's), Hazardous Chemicals, and Radioactive Materials. They are all-weather, all-terrain mobile robots that can be used in both indoor (buildings, public institutions, airports, homes, etc.) and outdoor environments (terrain cluttered with obstacles, ditches, gravel, snow, mud).

The mobile robots are fitted with different means of traction: some use only wheels for traction, others use tracks, yet others use quick-removable tracks that can be mounted or dismounted very easily. The tracks, permanent or removable, are necessary for climbing stairs and obstacles.

Other features are related to precise independent joint control, high dexterity of arm, long reach, high payload, open computer architecture for integrating bio-chem sensors, and options for autonomous navigation. In terms of control, the operator has the option to control the arm in joint or task space. The platform is always controlled in task space, by coordinating the motion of the wheels. Typically, the platform has two motors, actuating two wheels, one on each side. The other wheels are rotated by chain or other means of transmission.

The robots are remotely controlled by a wireless or cable link; cable link has an on-board automatic winding cable system, or an independent reeled cable system. Two-way data and audio and one-way video links are usually available. Up to four cameras and a microphone provide the operator with images and sounds of the environment. A surveillance camera can be mounted on the arm (low to the ground, high in the air, close or far from the gripper) or on a separate articulated boom (usually positioned vertically up).

(Continued on page 21)

Mobile Robots

Articulated track mobile robots have mechanical means activated by remote control or autonomously that change the shape of the tracks. These robots also have arms that are fully modular with self-contained electronics. The arms have up to six joints, a medium size gripper and a variety of operational tools and accessories. The robots are all-weather and can operate indoor (buildings, public institutions, airports, homes) and outdoors (obstacle-cluttered terrains).

The arm modules are plug-and-play. The arms have distinctive features, enabling them to access hard to reach areas in airplanes, subways, buses, buildings, homes, airports, and train stations. The main functionalities and applications of the articulated track mobile robots are:

- Handling a wide variety of payloads and security mission tools operated by ERTs, Special Weapons and Tactics (SWAT), Fire Department Personnel, Hazardous Goods Response Units and Emergency Measures Units
- Handling a wide variety of payloads and security mission tools for Surveillance, Reconnaissance, Manipulation of hazardous items, Handling of suspected packages, Neutralization of security concerns
- Handling and manipulating security concerns:
  - Explosive Ordnance Disposal (EOD)
  - Explosive Ordnance Removal (EOR)
  - Improvised Explosive Device (IED)
  - Hazardous Chemicals, Radioactive Materials, Biochemical Waste (CBRNE/HAZMAT)
- Remote Control of handling and manipulating operations:
  - Handling of payloads over large workspace
  - Visual assessment, measurements and clean-up in hazardous environments.

The technology includes the following features:

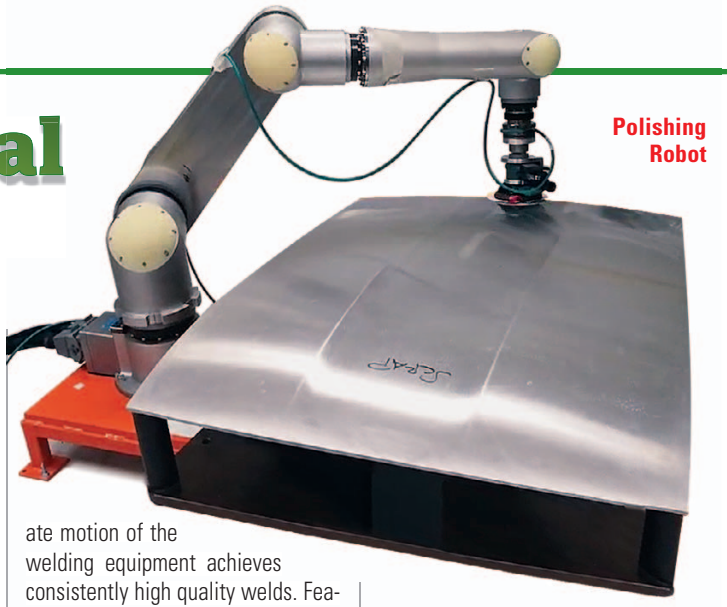
Arm: High dexterity arm can be configured to perform grasping and manipulating objects, aiming disrupters, pushing payloads, reaching under cars or through car windows, breaking windows, inserting a car key to open car doors.

Precise Motion: To approach, hit and handle a sensitive target with high accuracy. Programmable in task space coordinates.

Dexterity: Gripper can rotate continuously, Shoulder, elbow and wrist joints are rotary and allow large ranges of motion.

Modular Design: Arm can be easily disassembled and re-assembled for repair and maintenance. Multiple Payload Mounting: Disrupter, shotgun, X-ray unit, biosensors and radiation sensors, window breaker, charge drop assembly. ■

Industrial Robots



Polishing Robot

POLISHING ROBOT

The advent of modern polishing techniques emerged in the early 1900s. Advances in automation technology have allowed equipment builders to develop automated equipment to process more complex shape parts.

In the 50s, 60s and 70s, some automated polishing applications were implemented, but only the simple shape applications could be accomplished. More complex shaped parts required many media processing heads, each head working on a specific part area.

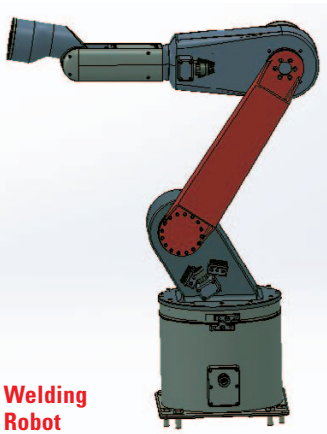
The development of robotic technology has further improved automation of finishing applications for both simple and complex shape parts. The robot with its six axes of motion can maneuver complex shaped parts, and with the proper head and tooling design can successfully polish six sides of most part surfaces.

The industrial robot can replicate the motions a human would make during the manual finishing process. Robots, while lacking the human senses of sight and touch, do possess the ability to replay their programmed path with a great deal of repeatability. Through the implementation of force control a constant polishing pressure can be applied to the work piece.

Last but not least, robots produce consistent, high-quality finishing with greater throughput while reducing the exposure of workers to the contaminants, noise and monotony of grinding, polishing, buffing and sanding processes.

WELDING ROBOT

The robot is for automatic arc welding or spot welding applications. The robot arm moves the welding gun over the surface to be welded while maintaining a proper distance, speed, and orientation relative to the surface. The smooth and accurate motion of the welding equipment achieves consistently high quality welds. Featuring lightweight aluminum alloys, the arm integrates welding wire feed cabling and mounting holes for the welding gun in proximity of the welding location. This allows effective welding process control. The controller includes easy-to-use arc welding and spot welding functions. The system has high accuracy positioning and path tracking, arm dexterity for complex welding processes, and is easy to program. Possible usage in other application areas are dispensing and cutting.

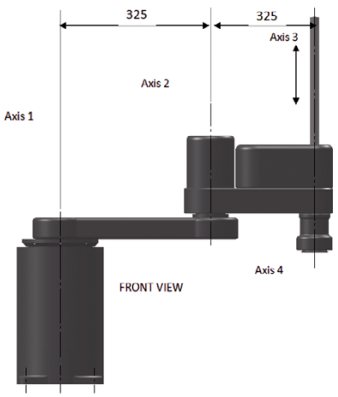


Welding Robot

SCARA ROBOT FOR ASSEMBLY MANUFACTURING

The SCARA robot consists of base, first axis joint, link arm, second axis joint, link arm, third axis and fourth axis joints. The arm is for small-footprint, light-payload applications where high precision, high speed, and high performance are required. It has a modular design including: single-joint modules, compliant joints and has high payload/weight ratio.

The robot is configured out of four modules: a large joint module, a medium size module, and a two-joint wrist module. An "extended" SCARA robot can be configured with five joints by adding one more joint to the wrist to allow tilting of the end-effector that does not exist in the standard SCARA robot. Other configurations are possible as well.



SCARA Robot

The modular joints are controlled by an embedded fully digital servo drive. By connecting several modules together one obtains a robot. The robot can be used for assembly manufacturing, and can work side-by-side with a human. The robot is light weight, and has high speed, high accuracy, small footprint, integrated force/torque sensor interface for force and impedance control and integrated vision sensor interface for visual servoing.

HIGH PAYLOAD ROBOT

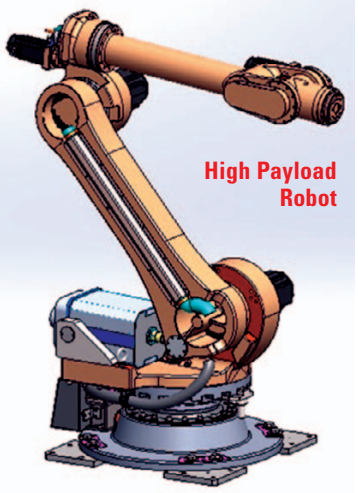
Applications of the high payload robot are in machine tending, palletising, packaging, part transferring, pick and place, grinding, deburring, and polishing. The arm has large payload, large working space, high speed, high accuracy, and integrated force/torque sensor interface for force and impedance control, integrated vision sensor interface for visual servoing.

The robot achieves high strength and agility with high payloads without sacrificing speed and accuracy. It consists of base, turret, shoulder tilt, upper link, elbow tilt, lower link, wrist, first roll, wrist pitch and wrist second roll, and gripper.

Turret and shoulder have the same internal layout, motor, input gear and reducer. The rotation of elbow joint is realized through a servomotor with a fixedly attached input gear to drive a reducer directly.

The wrist assembly consists of three joints: wrist-first roll, pitch, and second roll. Three identical motors are used for the three joints of the wrist assembly. They are mounted on the back of the upper link to conveniently maintain and ease the balancing of the robotic system. However, it is a challenge for the mechanical design to transmit the motion and torque of the three motors to the wrist.

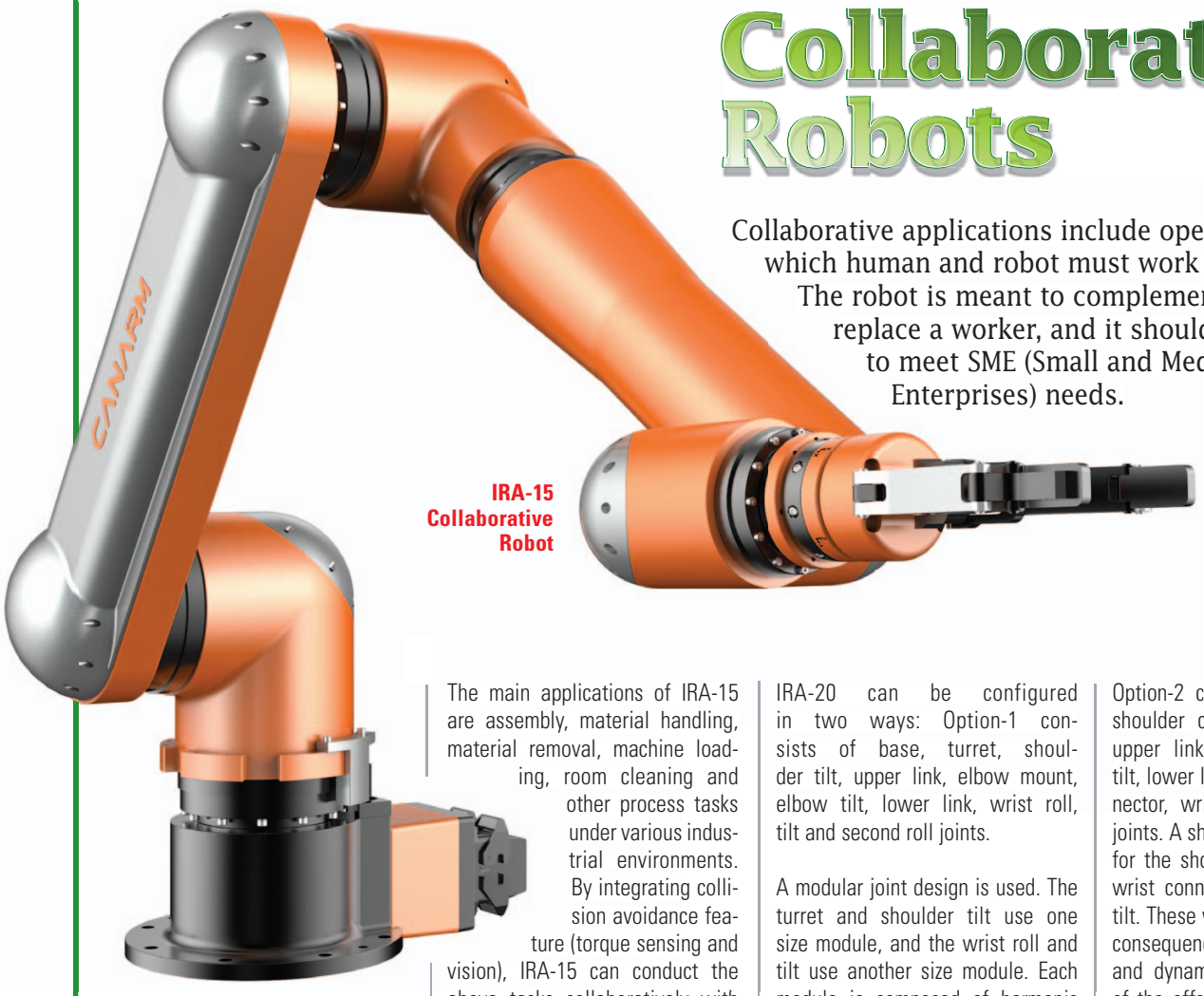
A counterbalancing system is used to compensate the load moments of each axle such that the axle drive is not overloaded statically, thus it can provide the maximum moment available for the acceleration of the axle. The balancing device is arranged to counteract a gravitational force upon relative movement of the robot arms. ■



High Payload Robot

Collaborative Robots

Collaborative applications include operations in which human and robot must work side-by-side. The robot is meant to complement and not replace a worker, and it should be flexible to meet SME (Small and Medium sized Enterprises) needs.



IRA-15 Collaborative Robot

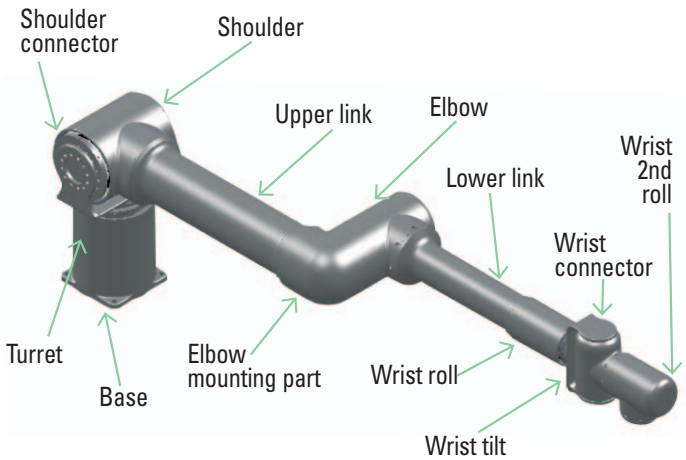
COLLABORATIVE 1-JOINT MODULES ROBOTS

IRA-15 is designed for collaborative applications where the required safety, dexterity and flexibility are very demanding. IRA-15 is a 6-DOF collaborative robot arm with single-joint modular modules. The compact and modular design of the IRA-15 ensures the lightweight, ease of installation and maintenance of the robot.

The IRA-15 uses combo actuators, which contain output bearings, gearhead, servomotor, encoder and brake all in one assembly. In addition, these components are hollow structured and that is very convenient for cable harness routing. Due to the use of combo actuators, the entire robot structure of joint and arm is very compact, and the total weight is lower than products on the market at the same payload level.

The main applications of IRA-15 are assembly, material handling, material removal, machine loading, room cleaning and other process tasks under various industrial environments. By integrating collision avoidance feature (torque sensing and vision), IRA-15 can conduct the above tasks collaboratively with humans.

IRA-20 is a 6-DOF modular arm comprising of single-joint compliant modules, reconfigurable, with a high payload to weight ratio (payload = 20 kg), suitable for collaborative human-robot operations.



IRA-20 (Option 2) Configuration

IRA-20 can be configured in two ways: Option-1 consists of base, turret, shoulder tilt, upper link, elbow mount, elbow tilt, lower link, wrist roll, tilt and second roll joints.

A modular joint design is used. The turret and shoulder tilt use one size module, and the wrist roll and tilt use another size module. Each module is composed of harmonic drive, brushless motor, brake, encoder, motor drivers, interface boards, and peripheral components. These features make the IRA-20 installation or replacement easier during operation or service. The harness passes through the inside of the links and through the center of the joints.

Option-2 consists of base, turret, shoulder connector, shoulder tilt, upper link, elbow mount, elbow tilt, lower link, wrist roll, wrist connector, wrist tilt and second roll joints. A shoulder connector is used for the shoulder and turret, and a wrist connector for wrist roll and tilt. These would have only minimal consequences for the kinematics and dynamics due to the change of the offset from the base to the upper arm and from elbow to wrist second roll.

Option-2 would be slightly heavier than Option-1 because of two connectors' weight. However, Option-2 kinematics and dynamics are simpler. Also, the stiffness and deformation of shoulder and wrist tilt joints in Option-2 would be easier to control.

Option-1 turret and shoulder would use same size module, and wrist roll, tilt and second roll would use same module. Option-2 would not use same size modules.

The main features of the robot are: (i) active compliance: force and impedance control; (ii) passive compliance: built-in joint compliance; (iii) small footprint; (iv) lightweight; (v) high dexterity; (vi) integrated force/torque sensor interface for force control; and (vii) integrated vision sensor interface for visual servoing.

(Continued on page 21)

Personal Robots

Personal Security Robot

THIS ROBOT is for execution of full or partially autonomous patrolling of dwellings and support to personnel in various security operations.

The application is focused on public and private security services in both indoor and outdoor environments, such as schools, office buildings, private rental and condominium dwellings, hotels, stadiums, bus and train stations, ports and airports. The robot moves through programmed routes independently: it will call and enter elevators; it will do reconnaissance in underground parking garages, detect objects and issue emergency signals related to fire-sensors and human-detecting sensors. It can be mounted on various mobile platforms.

The robot provides the following functionalities and applications:

- Mobile navigation in private premises
- Remote viewing, inspection of surroundings, transfer of images
- Auto docking and power charging with operation of more than 6 hours
- Automatic detection of obstacles and automatic stop for safety
- Mobile video surveillance
- Detection of intruder, fire, smoke, water, gas and chemicals
- People detection and tracking
- Parking garage vehicle plate scanning and licence checking
- Scheduled patrolling of private premises.

VIDEO CONFERENCING AND TELEPRESENCE ROBOT

THE VIDEO TELECONFERENCING and telepresence robot has a wide range of active and passive applications: office-to-office communication, remote business-to-business communication, remote viewing, inspection of environment, transfer of images, and other.

The user can listen, talk, see and be virtually seen.

It provides access to locations by remote control, and it provides feedback to the operator through video, audio and data. Typically, the robot APM can be mounted on various mobile platforms (MP).

The main functionalities and applications are:

- Office-to-office communication, remote business-to-business communication
- Remote viewing, inspection of environments, transfer of images
- Auto docking and power charging with operation of more than 6hrs.
- Automatic detection of obstacles and automatic stop for safety
- Local touch-screen display
- Application in commercial, public and private environments.

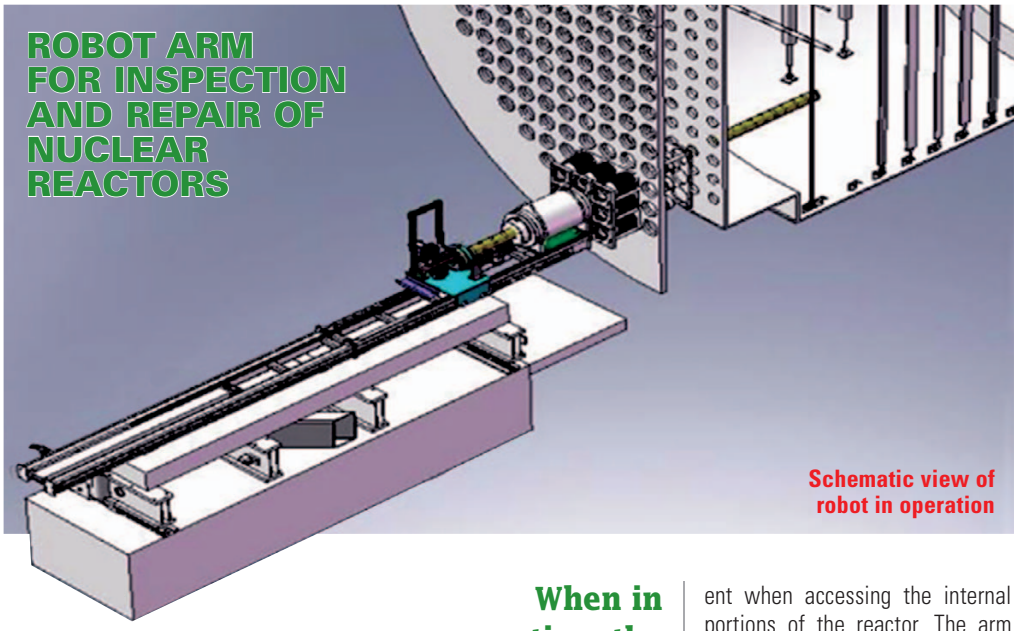
HEALTH ASSISTANT ROBOT

This robot can meet many care receivers' health and security needs in non-acute health care environments such as elderly care centres, rehabilitation centres and home elder care.

It can manage massive personal information, enabling autonomous ward rounds. It has intelligent care receiver indentification capability, fetching in care databases including medication and meal schedules. It can also monitor and collect health indicator data, e.g., heart rate, blood pressure, body temperature and blood glucose. Immediate warning is given of abnormal situations and remote help sought. ■

Nuclear Plant Robots

Nuclear robots enable maintenance procedures to be conducted without risk to human health. Their capacity for very precise movement also ensures that delicate tubing is not damaged during the process.



Schematic view of robot in operation

At the core of CANDU (CANada Deuterium Uranium) nuclear reactors is the Calandria vessel. It contains a network of horizontal tubes for fuelling the reactor. After several decades of service these fuelling tubes must be replaced in a process known as "re-tubing" of the reactor. It is of utmost importance that during this operation no debris or foreign matter remains inside the Calandria.

With robots for such operations the user can pick up and remove any debris, and can also inspect the interior of the nuclear reactor core. A robot system for operation inside the Calandria vessel is used for both visual inspection and hardness inspection. The robot is also a contingency tool to be used to collect foreign material created during the re-tubing process. The robot is inserted through a lattice sleeve tube in the shielding wall of the reactor after the fuelling and pressure tubes have been removed.

The Calandria Vessel Inspection (CVI) robot consists of a long two joints boom with a manipulator arm attached to its end. The robot is equipped with radiation-hardened camera system for visual inspection and guiding of the robot arm, a vacuum nozzle for removing of small shavings and dust-like debris, and a gripper for removing larger items – up to approximately 1 kg. The arm is fitted with an ultrasonic hardness tester.

When in operation, the tool built-in shielding mitigates and essentially eliminates the "open channel of radiation" that is inherent when accessing the internal portions of the reactor.

The arm is constructed of radiation hardened material and components. When in operation, the tool built-in shielding mitigates and essentially eliminates the "open channel of radiation" that is inherent when accessing the internal portions of the reactor. The arm comes with a modular end-effector that can be used to pick up small debris visually located during the inspection process.

The robot enters the Calandria vessel through any of the fuel channels. Servo-controlled boom extension and roll combined with robot manipulator elbow rotation and front link extension allow the end-effector to reach any point within the Calandria vessel. The robot arm is controlled by a combination of electric and pneumatic actuators that incorporate force control and position feedback. The elbow joint is driven by a radiation hardened stepper motor. The forearm is extensible with a pneumatic cylinder through a range of 400 mm. The position of this link is monitored with a custom magnetic encoder. The end-effector is comprised of a pneumatic gripper and a vacuum nozzle. Smaller debris are removed by vacuuming; larger debris can be picked up with the gripper and dropped into a shielded flask mounted directly in front of the tube sheet. The boom is designed to provide radiation shielding during the operation of the robot system. ■

Biotechnology and Laboratory Automation Robots

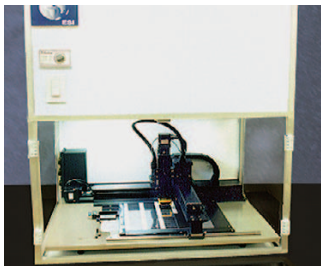
DNA MICRO-ARRAYER

DNA array is a generic name covering different molecular biology products and techniques. It can be described as a manifold of DNA fragments (spots) of oligonucleotides at low, medium or high density. DNA arrays are used as research and diagnostic tools. The array of DNA fragments on a solid surface allows detection of the expression of thousands of genes in a single experiment. Gene array technology is becoming one of the most common techniques used in all molecular biology laboratories.

The advantages of DNA array technology are: simultaneous analysis of many genes in a single experiment; quantitative and reproducible results; speeding up basic biological research and disease diagnosis; reduction of time, cost, and risks associated with discovery and development.

In terms of the technology used to make DNA arrays, there are three methods: (i) photolithography method that is based on-site oligonucleotide synthesis; (ii) micro-spotting with quill pins; and (iii) ink jetting. The spotting tools are: split/quill pins, solid pins, piezoelectric pins, capillary, ring-and-pin systems. The support used for DNA arrays can be: nylon membrane, polypropylene membrane, or glass slides. The methods of DNA binding to the support are based on electrostatic and hydrophobic interactions with covalent links. For detection of gene expression, complementary DNA (cDNA) is spotted first onto the slides, then the target DNA is hybridized with the cDNA, and the expression is identified through probe labeling: radioactivity (33P) and fluorescence (CY 3 and CY 5), and subsequent detection (reading of color intensity).

Robot spotters have been developed for DNA spotting on glass slides. A spotter has a large spotting surface (75 or 126 slides), modular & reconfigurable structure, able to spot up to 83,000 spots per 25 mm x 75 mm slide, and capable of performing other bio-laboratory tasks such as arraying, gridding, re-arraying, and pipetting. The robot system is based on a high quality three axis gantry robot, with 1.25 µm resolution of motion along each axis, and impedance control to avoid high impact forces at the contact between the slide and the pin.

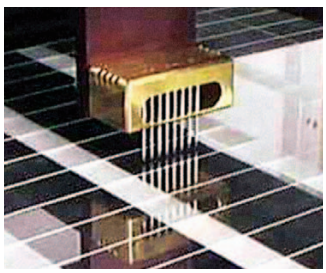


DNA Microarrayer

The system has a repeatability of 2.50 µm, and high bandwidth communication with the controller. There is no heating, vibration, and the speed is 1 spot/slide/pin (61,000 genes are spotted in 3.5 h). The slides can be of 25 x 75 mm, 25 x 25 mm, or 50 x 75 mm. 1 to 8 micro-titter source plates and 1 to 6 small membrane holders can be used along with up to 126 slides. The cleaning of the pins between loads is done in a water bath that uses active water pump for cleaning.

The robot is designed to collect DNA from 96-well and 384-well source plates. 1 to 48 pins can be used simultaneously. Each pin collects 250 nl of solution and spots 0.6 nl per dot on 75 to 126 microscope glass slides. The center-to-center distance is 120 µm.

A vacuum chamber is used to dry out excess material from the quill pins, and dry off the water after washing them. A blotting pad is used to eliminate excess material from the pins before spotting. The quill pins have long life (1,000,000 spots). They generate 75 or 90 µm diameter spots. Each pin can be replaced individually, and up to 250 dots per sample/one dip can be obtained.



Manifold of up to 48 quill pins

Environmental control is provided with a positive pressure HEPA Fun Filter and PPHC humidity controller (limits evaporation and fast drying of the spots).

The motion controller is based on an embedded PC-104/Pentium. A Graphical User Interface is used to program the spotter and monitor the execution. The host computer is based on Pentium/Windows NT. The host controller module can be at a remote location. The Graphical User Interface is intuitive and Windows-based for easy control of number of slides, rows, columns, array pattern, dots per row or column, speed, spotting order, type and direction of source plate or membranes, number of pins, etc. Simple robotic language is used for programming the robot.

ROBOTIC CELL SAMPLE PREPARATION OF LIQUID SCINTILLATION ANALYSIS

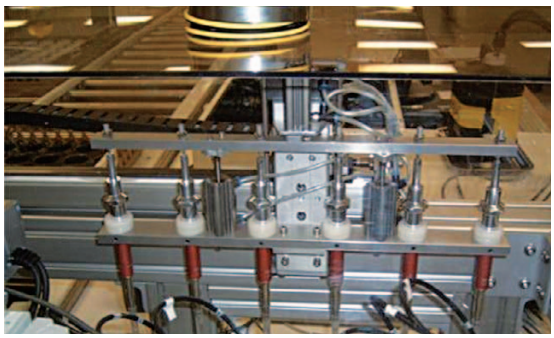
Managing employees who work at nuclear power stations presents some unique challenges. One of the issues that requires close monitoring is employees' exposure to radiation. Quick and accurate detection of any anomalous radiation exposure can improve the health and safety of the employees as well as the operational safety of the power station.

One of the common methods of monitoring radiation exposure is performing a daily scintillation count of an employee's urine sample. A precise amount of sample is mixed with a known chemical for analysis. This process is tedious and time consuming.

Typically, the amount of sample is in the 1000 µl range and the cocktail is in the 8ml range. While these volumes are not unduly small, they are too small to dispense accurately into the vial without proper laboratory equipment.

A turnkey robot system was developed for the bioassay sample preparation, handling and analysis. The robot takes a very small quantity of the sample from a container, puts it into a sample vial, adds reagents, caps and seals the vial, mixes it, and places it into a cassette for analysis. More than 500 samples per day can be processed.

Processing laboratory vials



Picking up samples from vials

(Continued on page 22)

Security Robots continued from page 15 »

MOBILE ROBOT FOR IN-GROUND MINE DETECTION

An articulated remote controlled mobile manipulator has been developed to scan autonomously off-road and unstructured terrain for buried landmines and explosives. The robot consists of a dual-arm manipulator mounted on a six-wheel mobile platform, mine or explosive detector, range sensors, terrain mapping software, and hardware and software for communication, data transfer and control. The platform can also be used with tracks mounted over the wheels. The tracks help climb steep slopes, and move over very rough terrain. The platform can be operated in remote control, semi-autonomous, and autonomous modes. The terrain map is generated with respect to a range sensor frame to minimize the computational load in real-time. Sensors scan and measure the range with respect to the terrain and relative to the reference coordinate frame. Also, the normal direction to the terrain is computed in real-time. Based upon the terrain map that is generated in real-time, the mine detector's position and orientation is controlled such that a desired (constant) separation and orientation with respect to the terrain is maintained.

One of the dual-arms (Detector Arm – DA) holds the mine or explosive detector (e.g. metal detector, Ground Penetrating Radar source, or a nuclear quadrupole resonance instrument) that is manipulated autonomously. A plurality of mine detectors can be mounted on the DA. The autonomous motion of the DA is synthesized and controlled on-line based on a 3D map of the terrain. The map is generated in real-time by fusion of sensory data acquired from a scanning laser rangefinder, an array of four ultrasonic sensors, and joint encoders of the dual arm.

The rangefinder, a motorized scanning mirror, and ultrasonic sensors are mounted on the other articulated arm (Sensor Arm – SA). The SA has a pan joint allowing it to be positioned relative to the DA such that it always scans "ahead" of the DA.

The rangefinder, a motorized scanning mirror, and ultrasonic sensors are mounted on the other articulated arm (Sensor Arm – SA). The SA has a pan joint allowing it to be positioned relative to the DA such that it always scans "ahead" of the DA.

The DA holds and maintains the detector at a desired constant vertical distance from the ground irrespective of undulations of the a priori unknown terrain profile. As well, the DA can maintain the detector orientation constant with respect to the unknown terrain. ■

Collaborative Robots continued from page 17 »

COLLABORATIVE 2-JOINT MODULES ROBOT

IRA-10 is a two-joint compliant modules modular, reconfigurable, high payload/weight ratio robot arm for collaborative human-robot operations. The robot is a 6-DOF robot arm that can be reconfigured in multiple ways.

The robot manipulator comprises turret, shoulder, elbow, first wrist roll, wrist tilt and second wrist roll. The robot includes two links, the upper-arm, and the forearm.

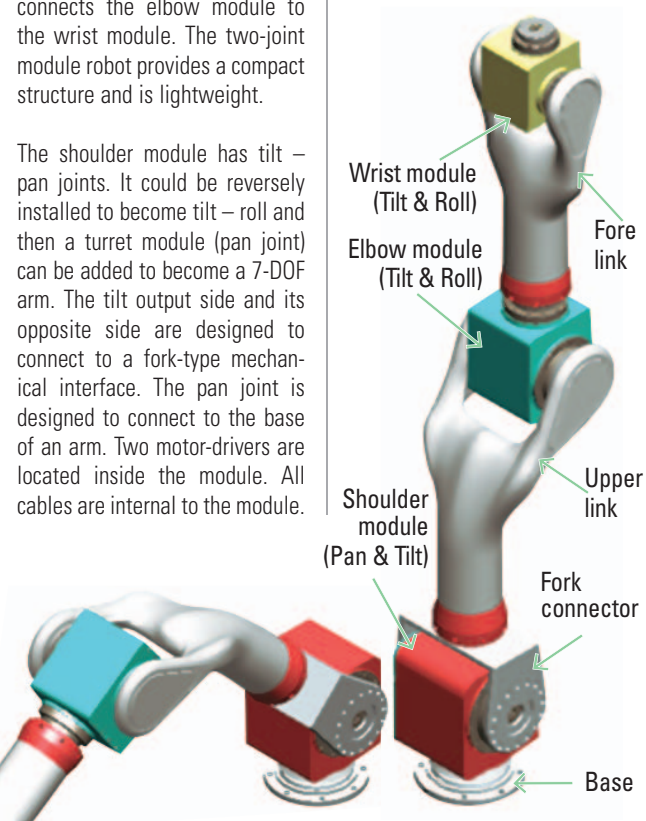
The robot has modular shoulder, elbow, and wrist whereby each module is composed of two rotary joints with their motor drivers and their interface boards installed in the module housing. These features make the robot installation or replacement easier during operation or servicing. Another feature is the internal cabling design, in which all cables pass through inside of the links and through the modules. The upper link connects the shoulder module to the elbow module, and the fore link connects the elbow module to the wrist module. The two-joint module robot provides a compact structure and is lightweight.

The shoulder module has tilt – pan joints. It could be reversely installed to become tilt – roll and then a turret module (pan joint) can be added to become a 7-DOF arm. The tilt output side and its opposite side are designed to connect to a fork-type mechanical interface. The pan joint is designed to connect to the base of an arm. Two motor-drivers are located inside the module. All cables are internal to the module.

The elbow two-joint module has tilt-roll joints. The tilt joint output and mechanical interface assemblies on the opposite side of the housing connect to the upper arm. The roll joint output connects to the forearm. Two motor-drivers, two electronic interface boards and all wirings are located inside of the module. To keep consistent with robot shapes, this module has the same shape as the wrist module.

The use of frameless motors is to reduce weight and size; other features are similar to IRA-20. ■

It could be reversely installed to become tilt – roll and then a turret module (pan joint) can be added to become a 7-DOF arm.



Collaborative 2-Joint Modules Robot

Biotechnology and Laboratory Automation Robots continued from page 20 »

All personnel are issued a unique barcode for their samples. These samples are collected in bar-coded trays distributed throughout the power station. Each evening these trays arrive at the health physics laboratory for analysis. An operator simply should place these trays on the input conveyor section of the robot system and the robotic cell takes care of the rest.

For each sample the robotic cell performs the following basic operations:

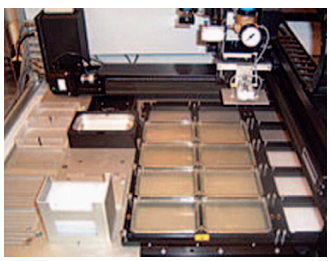
- Reads the barcodes on the incoming bottles containing urine samples
- Transfers a measured amount of sample material from sample bottle into an empty scintillation analyzer vial
- Adds measured amount of liquid scintillation cocktail into the vial
- Seals the vial and thoroughly mixes the contents
- Deposits the vials into the scintillation analyzer cassette
- Provides the data relating the sample code to the location of the vial

HIGH-DENSITY COLONY REPLICATOR

The High-Density Colony Replicator is a dispensable, very high density biosample array replicator as an attachment to colony picking robots.

Experimental work conducted in biotechnology laboratories requires replicating large numbers of yeast colonies. The colonies are grown in regular arrays on standard gel plates. One task of the experimental process involves transferring an array of samples from a library plate onto a mating plate, followed by transferring of another array of samples from a bait plate onto the same mating plate, in such a way that the samples in the corresponding locations overlap. Another task requires creating "copies" of sample arrays: cells from each colony on the source plate are transferred onto one or more target plates.

The common process of replicating large numbers of yeast colonies is relatively inefficient. The density of yeast colony array is limited primarily by the accuracy and repeatability of the equipment used to manipulate the samples. The commonly used "bed-of-nails" print heads can reproduce an array of 768 colonies on a standard gel plate. There is a need to increase the array density by increasing the number of metal pins in a print head. However, the pins in such print heads need to be considerably smaller, positioned more accurately, and machined with more precision. Therefore, the print head is much costlier to manufacture and difficult to maintain. Moreover, metal pins need to be washed after every transfer, which requires additional time and equipment, and introduces the risk of sample cross-contamination.



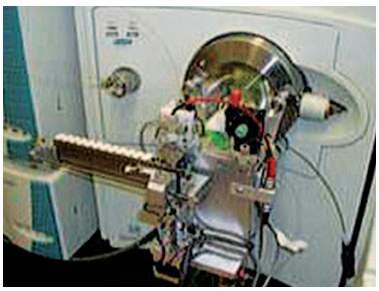
High density replicator attached to colony arrayer robot

A new print head was developed that would use disposable replicating pads. Such a print head can replicate high-density arrays and does not require washing of the surfaces that encounter sample material. In addition, disposable pads with density, pin-tip size and pin configuration corresponding to the currently used metal-pin print head have also been developed.

HIGH-PERFORMANCE AUTO-SAMPLER FOR MASS SPECTROMETRY

Mass Spectrometers (MS) in biotechnology and pharmaceutical laboratories are used to process large numbers of protein samples. They operate 24 hours a day, 7 days a week. It is necessary to automate the process, so that unattended operation over an extended period is possible.

Auto-Samplers can automatically pick up samples from vials, or from 96-well plates; however, the sample loss is very high, as these instruments cannot efficiently handle very small (20 to 50µl) quantities.



Mass spectrometer with the mounted auto-sampler

Auto-Samplers can operate in two modes: full-loop and partial-loop injection. Only partial loop injection is suitable for small samples. However, even in this mode sample loss can be as high as 50% due primarily to large dead volume (approximately 40µl) on the intake side of the sample loop. Although manufacturers provide dead volume compensation procedures, in practice a significant part of each sample is lost because of fluid dynamics and protein absorption in the intake line, as well as other factors.

The accuracy of MS measurement is also affected by high protein absorption inside the stainless-steel sample loop, and relatively large dwell volume between the buffer pump and the column.

An auto-sampler for very low-loss automatic injection of samples into the mass spectrometer column was developed. The system is placed directly in front of the mass spectrometer. It includes a compressed air supply system and control system. It is based on a micro-cross assembly mounted on an X-Y-Z positioning mechanism. The mechanism is used to manually adjust the position of the column tip in front of the MS opening. The required range of adjustment is approximately ±3 mm for each DOF. Positioning accuracy is 0.2 mm.

An Injection Head Assembly is mounted on a vertical linear actuator. The actuator inserts the injection head into the sample vials, or into the waste line coupler. The injection head has two sealed ports: one for the 100µm liquid line that connects the injection head to the micro-cross, the other one for the compressed air line.

The method of sample injection into the column assumes that the sample will not flow into the line connecting the micro-cross to the buffer pump. If significant backflow into the buffer pump line is found, a cut-off valve installed on the pump line next to the micro-cross prevents it.

A Vials Handling Mechanism is used to position the selected sample vial or the waste line coupler underneath the injection head. The vials sit in the matching nests in the vial blocks. The blocks will provide necessary mechanical support when high pressure is applied to a vial. ■

About the Author

Dr. Goldenberg is the founder of the field of Robotics at the University of Toronto where he has been since 1982 as a Professor of Mechanical and Industrial Engineering (now Emeritus), cross-appointed in the Institute of Biomaterials and Biomedical Engineering, and formerly cross-appointed in the Department of Electrical and Computer Engineering. He has supervised to date many graduate students, 46 PhD and 64 MASc. From 1975-1981 he has been an employee of SPAR Aerospace Ltd., of Toronto, working on the development of the first Space Shuttle Remote Manipulator System (Canadarm).

Dr. Goldenberg is also the founder of Engineering Services Inc. (ESI) established in 1982 and operating in the development of robotics-based automation. Under his leadership, the company has achieved significant growth and a global leading role in a wide range of industrial sectors. In 2015 ESI has been acquired by a Shenzhen-based Chinese consortium, and as of November 2016 the company become public listed in Hong Kong. Dr. Goldenberg is the CTO of the public company.

TAB teams up with WIE to encourage women's involvement in engineering

By **Vawn Himmelsbach**

Women in Engineering (WIE) was created to support women in a field dominated by men and give them a voice within the IEEE. In every region of IEEE there are now strong networks. More recently there's a move within IEEE to encourage participation and reward achievement at the Society level.

When Celia Desmond—now having just completed her term as Division III Director (Communications Tech.)—first joined the organization about three decades ago as Chapter chair in Ottawa, she saw a need for more women sitting on boards. This hasn't changed much, she says. In between, she has been IEEE Canada President, IEEE Communications Society President, IEEE Secretary and IEEE VP Technical Activities.

Early on, Desmond sat on the boards for the IEEE Computer Society and the predecessor to the Technology and Engineering Management Society (TEMS). "Sometimes there was another woman around and sometimes not," she said. "At that time there wasn't even a WIE group — it got started around 1994." And while WIE didn't have much clout at first, "over the years people did start to realize women are in engineering and it started to get more prominent."

A factor in how WIE is promoted internally is its "home" in the organization. It was decided, for administrative purposes, WIE would fall under Member and Geographic Activities (MGA). Every Region would have a WIE rep that sat on the WIE Committee and reported to MGA. In Canada, Desmond says WIE does a lot of great work for the Region and beyond.

"At the same time, we have these 46 Societies and Technical Councils, and they reach a whole different level of IEEE members," she said. "They should also be active in WIE; they should be encouraging women to go into engineering, encouraging women engineers to become active in IEEE."

Considering the percentage of engineering graduates versus the percentage of female IEEE members, "we're not doing too bad, but we could do better," said Desmond. "If 12 per cent of graduates are women, it doesn't mean we can't get more than 12 per cent women members. We could do better if we reached out more — on the Society side we would reach different people and give recognition to those women who have moved up in their technical area."

"If 12 per cent of graduates are women, it doesn't mean we can't get more than 12 per cent women members. We could do better if we reached out more — on the Society side we should give recognition to those women who have moved up in their technical area."

The Societies, which range in size from 2,000 to 50,000 members, tend to have a technical focus, and provide a home for many of IEEE's volunteers. "When I was the Communications Society president, we had 45,000 members from 160 countries, and more than 50 per cent of our members were in industry," said Desmond. "They all worked in a communications field of some sort."

Technical Activities Board (TAB)

- ✓ **Increases efforts to drive technology within IEEE. Promotes, facilitates and supports a global volunteer organization of innovative and agile technical communities.**
- ✓ **Uses the best technologies to attract, access, and disseminate the highest quality technical information in the areas of interest to IEEE.**

Since WIE was in its early stages, the Society came up with a Women in Communications Engineering (WICE) group, which still exists. "They aren't really conflicting with each other, but maybe collectively if we all worked together we could do better," she said.

The Technical Activities Board (TAB) has become involved, out of concern that more women aren't pursuing STEM careers or getting involved with IEEE. The aim of Technical Activities (TA) communities is to develop a volunteer-led environment where thought leaders converge and solicit, refine and disseminate quality technical information while nurturing and promoting innovative ideas and new fields.

One of TAB's goals is to nurture underserved segments of technical communities, including women. As a result, TAB created a one-year technical committee to conduct research into women in engineering, looking into issues such as why fewer than 25 per cent of WIE reps attended TAB meetings.

The results were interesting: In the IEEE brochure encouraging membership, for example, you didn't see any women. "You do now," said Desmond. "If you're looking at who got awards, and you go back the last 10 years, you don't find very many women there. You can find awards that have never been won by a woman." Those findings have led to a set of ideas and practices to improve women's involvement in IEEE.

This temporary committee was made into a permanent committee last year under the Strategic Planning division within TAB, with five members. The idea is to continually update best practices, which include flagship conferences, networking receptions and professional development activities. Publications will highlight prominent women and a dedicated WIE website is to be created.

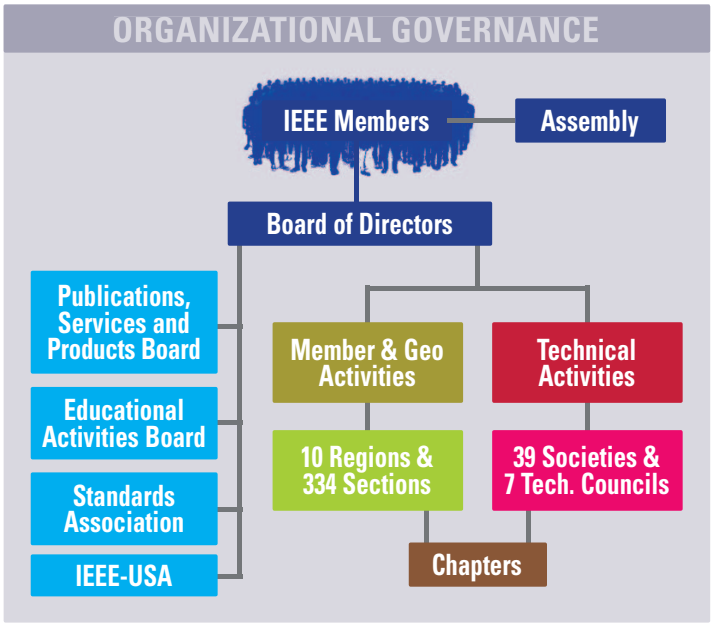
To date, they have formed a subcommittee to identify and nominate women for awards, created the Ambassadors program, organized WIE presentations at schools, invited women to assume roles within IEEE, and worked on cross-Society or cross-Council activities.

They're also educating women on the value proposition of IEEE. "We want to get an inter-

relationship between the TA Committee and WIE Committee — that's already started," said Desmond.

That relationship could become more formalized. "If you look at the WIE group as a whole, they have been running leadership conferences, and those conferences have been extremely successful," said Desmond. "People who are Society members have been helping, it just wasn't structured. But those conferences are attracting a lot of attention and viewed very positively and giving good information to women."

The Societies have stepped up their support for WIE — most, if not all, have a WIE rep. But Desmond says they're still defining what those reps should do, alongside Region WIE reps. "They don't have strong guidelines yet," she said. "We're at the beginning of pulling all the wheels together and getting them aligned in the same direction." That involves developing best practices that are available to all Societies.



Still, women have plenty of challenges within engineering and other STEM fields, and that's what the relationship between TAB and WIE is hoping to address. "Why is it that we aren't seeing women get the awards and why can't they get ahead in the C-suite? We're not there yet," said Desmond. However, she believes the word is getting out, and the time is right to get more women active in IEEE.

"We need to get them to go into engineering in the first place," she said, pointing to research that shows when girls are five to eight, they do at least as well in math and science as boys, but when they turn 14 they decide they don't like math and science. "Why do they go away? We're also losing them in business: There are good numbers coming in at the lower levels, then they dwindle down as they move up. Women leave engineering and don't come back; women feel they're not being heard."

That's where TAB and WIE are stepping in — to listen to those voices, to recognize and reward achievements, and to provide role models and mentorship — in hopes of encouraging more women to pursue life-long engineering careers. ■

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

What's New in the Literature?

by Terrance Malkinson

The February 2018 issue *FORTUNE* published its annual ranking of "The World's Most Admired Companies" [pp. 67-82. www.fortune.com]. Selected from a poll of 3,000 executives, analysts, directors, and experts; the leader was Apple followed by Amazon, Alphabet, Berkshire Hathaway and Starbucks. The most significant change was General Electric which plunged to 30th place as it stock plummeted 45% in 2017. Industry sector rankings are also provided. Also provided in the February issue is an article by Geoff Colvin "Ready, Set, Jump" [pp. 44-52]. The author provides many useful insights for those looking for new opportunities. General Electric was also the cover story of the February, 2018 issue of Bloomberg Businessweek. Authored by Drake Bennett "How General Electric Lost the Plot" [pp. 42-49] discusses how for most of its 126 year history its diversity of invention and commercialization produced many of the engineering technologies that have changed our world.

Selected from a poll of 3,000 executives, analysts, directors, and experts; the leader was Apple followed by Amazon, Alphabet, Berkshire Hathaway and Starbucks.

The January-February issue of *Harvard Business Review* [96(1) www.hbr.org] spotlights organizational culture. Five articles: "The Leaders Guide to Corporate Culture" "What's Your Organization's Cultural Profile?" "How to Shape Your Culture" "Convergence Matters", and "Context Conditions, and Culture" discuss many important issues to help manage the cultural factor of an organization. These include values and behaviours that contribute to the unique social and psychological environment of an organization including expectations, experiences, philosophy, and values that hold it together. These are expressed in its self-image, inner workings, interactions with the outside world, and future expectations.

Founded in 2002 by Toby Heaps and Paul Fengler, *Corporate Knights* [www.corporateknights.com] magazine is distributed quarterly as an insert in the *Globe and Mail* and the *Washington Post*. It is one of the world's largest circulation magazines that is focused on the intersection of business and society, promoting clean capitalism with the vision of providing information that empowers markets to enable a better world. "Clean Capitalism" is defined as an economic system in which prices incorporate social, economic and ecological benefits and costs, and all stakeholders know the full impacts of their actions. The Winter, 2018 issue [Vol. 16(4)] contains a number of interesting articles including a discussion of how electrification is set to sweep through the Canadian municipal bus system over the next decade ["The e-bus Revolution has Arrived" pp. 22-24], as well as its annual global corporate leadership index of the most sustainable corporations in the world.

First published in December, 1984 *Up Here* was published eight times a year. In January 2015 *Up Here* absorbed its sister magazine, *Up Here Business*, and currently is a quarterly magazine. The magazine exclusively features articles on Canada's North, including the territories north of the 60th parallel, Yukon, NWT and Nunavut, as well as areas in Canada's provinces that are part of the Arctic. Its articles are in the genre of creative non-fiction, and cover social, political, historical, aboriginal, travel and geographical details of Canada's North. The Winter, 2018 issue features articles on the top fifteen business influences in the North, and on bringing innovation to the North. [https://uphere.ca]

"How to Live Longer and Better" is the focus of the February 26, 2018 issue of *Time*. [191(7/8):46-83. www.time.com]. In this special report a variety of authoritative authors discuss the cutting-edge research on the subject of longevity. Globally the average lifespan is 71.4 years and to the best of our knowledge the oldest human was the French women Jeanne Calment who lived 122 years. Advances in medicine are helping to extend our lifespans with a better quality of life than previous generations. Exercise, proper nutrition, moderation, recognition, the reduction of or the ability to cope with life stressors, and coming to terms with the inevitability of death are seen as key factors for longevity.

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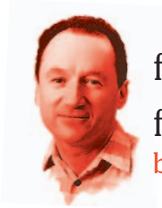
The January-February issue of *Wings Magazine* [www.wingsmagazine.com] provides its annual feature focusing on "Careers in Aviation." David Carr discusses education, training and job prospects in Canada's aviation and aerospace sector in this 31-page insert. All aspects of careers in aviation are covered including becoming a pilot, aircraft design and maintenance engineering, and specialized aviation support services. Comprehensive information on aviation education providers is a most valuable feature.

In the cover story in the February 2018 issue of *National Geographic* ["They are Watching You" 233(2):30-65. www.nationalgeographic.com] Robert Draper details how the demand for security is increasing and how new monitoring technology is proliferating with the result that we are all under surveillance. This is a very informative and detailed account of the incredible innovations in technology that are enabling real-time high-resolution watching of every part of our planet.

The editors of *MIT Technology Review* provide their assessment of new technologies that will have a profound effect on our lives in "Ten Breakthrough Technologies 2018" [121(2):36-71. March-April, 2018. www.technologyreview.com]. Technologies selected as "breakthrough" include: 3-D metal printing, artificial embryos, sensing city, AI for everybody, dueling neural networks, babel-fish earbuds, zero-carbon natural gas, perfect online privacy, genetic fortune-telling and materials' quantum leap. Included in the issue is a feature article on each of these new technologies. ■

About the Author

Terrance Malkinson is a communications specialist, business analyst and futurist. His career path includes technical supervisor and medical researcher at the University of Calgary, business proposal manager for the General Electric Company, and research administrator with the School of Health and Public Safety at SAIT Polytechnic in Calgary. He is currently an international correspondent for IEEE-USA *Today's Engineer*, contributing editor for *IEEE Canadian Review*, and a member of the editorial advisory board of IEEE *The Institute*. He was Vice-Chair of the IEEE-USA Communications Committee (2004-2010), and editor-in-chief of IEEE-USA Today's *Engineer Digest* (2004-2008). He was an elected Governor of the IEEE Engineering Management Society as well as past editor of *IEEE Engineering Management*. He is the author of more than 550 earned publications, and an accomplished triathlete. malkinst@telus.net



A competitive edge for athletes from leading-edge technology

by Terrance Malkinson

Quebec-based Apogee [www.apogee-sports.com] designer of Canada's long-track speed skaters suits for the 2014 Winter Olympics continued development for the 2018 Games. Development costs were funded by "Own the Podium" and the new design was tested in the wind-tunnel at the National Research Council of Canada in Ottawa. As stated by suit designer Stephane Roy, "We have brought into the arms of the suits small ceramic dots, of diameter 1.5 millimetres that give upload very much like the wings on a plane, bringing speed into the suit." Cara Thibaut, Speed Skating Canada's long-track high performance director stated that each suit costs roughly $1,200 to make and is custom fitted to each athlete's body.

Photo: Nathan Denette/The Canadian Press

A George Brown College student originally from Saskatoon created the unique graphics emblazoned on Team Canada's bobsleighs and skeleton sleds. Joshua Dornan, set to graduate in Graphic Design this spring was inspired by a Canada 150 CF18 Hornet that toured across the country last year. Dornan's designs which provide the sleds with their own identities, were unveiled in Calgary in January when the Team Canada bobsleigh and skeleton teams were announced. Kallie Humphries a bobsleigh multiple gold medallist who competed for Team Canada at the 2018 Winter Games, said "it's probably the most Canadian sled we've had at the Games."

Photo: trainwithpush.com

PUSH [www.trainwithpush.com] a Toronto sports technology company, has developed a device that tracks the power of an athlete's movements to complement training methods already used, called velocity-based training. Using a sensor attached to an armband the velocity of an athlete's movements can be tracked. The hardware is made in Mississauga and in Quebec. An app provides instant information to the coach who can then give feedback to the athlete. The companies client list includes NBA, NHL, major league baseball and several Olympic teams.

Two Kitchener entrepreneurs, Andrew Flemming and Geoff Fowler along with business partner Will Hamilton used their creativity to develop an innovative high-tech training device, "SmartBroom" [www.smartbroom.ca] was used by eight of the thirteen national curling federations competing in the Pyeongchang Olympics. Four sensors in the broom head relay instantaneous data to a display unit that includes force in pounds, stroke rate in hertz, and "sweeping performance index," a metric that combines power and speed.

Photo: smartbroom.ca

Precision in timekeeping is essential in athletics. As an example, the difference between the Canadian and Norwegian speed skaters was so small that it took advanced photo-finish technology, which captures 10,000 digital images per second, to determine that the tip of Canadian Ted-Jan Bloemen's skate blade crossed the finish line two one-thousands of a second ahead, earning him the Gold Medal. Omega [www.omegatiming.com], the Olympic timekeeper at the Winter Games since 1936, has by necessity moved well beyond just timing and scoring events. They have expanded their responsibilities to capture all kinds of data for athletes, coaches and viewers, and also produce performance-based data for athletes, coaches and analysts.

In ski race competitions such as downhill, Super-G and slalom, aerodynamics are most important. A podium finish comes down to a hundredth or even a thousandth of a second. The air resistance (drag) of an athlete's clothing influences performance. Before Canada's Winter Olympic team headed to South Korea for the 2018 Games, they worked inside the ACE Climatic Wind Tunnel [ace.uoit.ca] at the University of Ontario Institute of Technology. Alpine Canada and performance wear partner Qwixskinz [qwixskinz.com] used the Wind Tunnel in early October to help tailor Canada's alpine ski suit. Fabrics were tested for fit and performance. Data helped Qwixskinz determine which clothing was fastest and readjusted each athlete's individual suit to ensure optimal aerodynamics. ■

Photo: University of Ontario Institute of Technology

Humboldt Broncos

The Humboldt Broncos Hockey Team tragic bus crash in northeastern Saskatchewan killing 15 young individuals and leaving many other athletes critically injured is one of the worst events in Canadian sports history. The Canadian unit of IEEE expresses its condolences and support to all affected by this event. As evidence of the importance of athletics, Ryan Stranschnitzki, a Bronco defenseman from Airdrie, Alberta, was paralyzed from the waist down. He is already dreaming of one day suiting up for Canada's Paralympic sledge hockey team. Considerable physical and mental challenges will face this young man in pursuit of this new goal. Hockey Canada has indicated that it "looks forward to helping him learn the sport of sledge hockey when the time comes" and further support will come from fellow athletes and the public. The strength of character, which athletes learn through participation, will serve him and the other surviving athletes well in overcoming the effects of this tragedy that has shaken many globally.

For **Terrance Malkinson**'s biography please see page 25.

BizTech Report BY **TERRANCE MALKINSON** continued from page 7 ›

Retired Canadian women's hockey star Hayley Wickenheiser announced on February 7 that she will donate her brain to concussion research after her death. She is one of many athletes who desire to help increase understanding of concussion injury and the resulting chronic traumatic encephalopathy. The Concussion Legacy Foundation [www.concussionfoundation.org] which supports CTE and concussion research says that more than 2,800 former athletes and military veterans have promised to donate their brains since 2008. Many of their stories are profiled on the foundations website. As Ms. Wickenheiser states "by pledging my brain to the Concussion Legacy Foundation I hope to support the best science and accelerate the development of ways to prevent and treat CTE." Halley Wickenheiser, a four-time Olympic gold medalist in women's hockey travelled to North Korea following the Winter Olympic Games and ran practices as a volunteer for North Korea's national women's and men's hockey teams.

A recent article published in *the Globe and Mail* [March 20, 2018. page B9] written by Jennifer Lewington "Niche Degrees Allow Grads to Stand Out"] discusses the growing number of Canadian business schools who are creating new specialty graduate degrees. Many of these are a blend of residential and online program delivery in diverse fields such as data analytics and artificial intelligence to name but two. ■

CALL FOR PAPERS

IEEE Consumer Electronics MAGAZINE

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The manuscripts need to be submitted online at **http://mc.manuscriptcentral.com/cemag**. The authors need to select "***Special Section: Implementable Humanitarian Technology (IHT)***" in Step-1 of the submission process to ensure the article is reviewed for this Special Call.

For any questions, please contact guest editors:

Xavier Fernando,
Chair, IEEE Humanitarian Initiatives Committee, Ryerson University
(xavier@ieee.org)

Rozita Dara,
University of Guelph,
(drozita@uoguelph.ca)

Schedule (Tentative):	
• Submission Deadline:	May 31, 2018
• Author Notification:	August, 2018
• Publication Date:	Mid 2019

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La revue canadienne de l'IEEE

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